Final Exam

Part 1

```
if (!requireNamespace("tidyverse")) install.packages('tidyverse')
```

```
## Loading required namespace: tidyverse
```

```
if (!requireNamespace("caret")) install.packages('caret')
```

```
## Loading required namespace: caret
```

```
if (!requireNamespace("neuralnet")) install.packages('neuralnet')
```

```
## Loading required namespace: neuralnet
```

```
if (!requireNamespace("keras")) install.packages('keras')
```

```
## Loading required namespace: keras
```

```
if (!requireNamespace("randomForest")) install.packages('randomForest')
```

```
## Loading required namespace: randomForest
```

```
if (!requireNamespace("rpart")) install.packages('rpart')
if (!requireNamespace("rattle")) install.packages('rattle')
```

```
## Loading required namespace: rattle
```

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.0     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(caret)
```

```
## Loading required package: lattice
##
## Attaching package: 'caret'
##
## The following object is masked from 'package:purrr':
##
##     lift
```

```
library(neuralnet)
```

```
## Warning: package 'neuralnet' was built under R version 4.3.3
```

```
##
## Attaching package: 'neuralnet'
##
## The following object is masked from 'package:dplyr':
##
##     compute
```

```
library(keras)
```

```
## Warning: package 'keras' was built under R version 4.3.3
```

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 4.3.3
```

```
## randomForest 4.7-1.1
## Type rfNews() to see new features/changes/bug fixes.
##
## Attaching package: 'randomForest'
##
## The following object is masked from 'package:dplyr':
##
##     combine
##
## The following object is masked from 'package:ggplot2':
##
##     margin
```

```
library(rpart)
```

```
## Warning: package 'rpart' was built under R version 4.3.3
```

```
library(rattle)
```

```
## Warning: package 'rattle' was built under R version 4.3.3
```

```
## Loading required package: bitops
## Rattle: A free graphical interface for data science with R.
## Version 5.5.1 Copyright (c) 2006-2021 Togaware Pty Ltd.
## Type 'rattle()' to shake, rattle, and roll your data.
##
## Attaching package: 'rattle'
##
## The following object is masked from 'package:randomForest':
##
##     importance
```

```
library(MASS)
```

```
##
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##
##     select
```

```r
library(caTools)
```

```
## Warning: package 'caTools' was built under R version 4.3.3
```

Q1)

```r
loq <- read.csv("C:/Users/MSP/Downloads/loq.csv")
loq <- na.omit(loq)
dim(loq)[1]
```

```
## [1] 4601
```

```r
set.seed(123)
training.samples <- loq$y %>% createDataPartition(p = 0.75, list = FALSE)
train.data  <- loq[training.samples, ]
test.data <- loq[-training.samples, ]
```

Q2)

```r
logistic_model <- glm( y ~., data = train.data, family = binomial)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
summary(logistic_model)
```

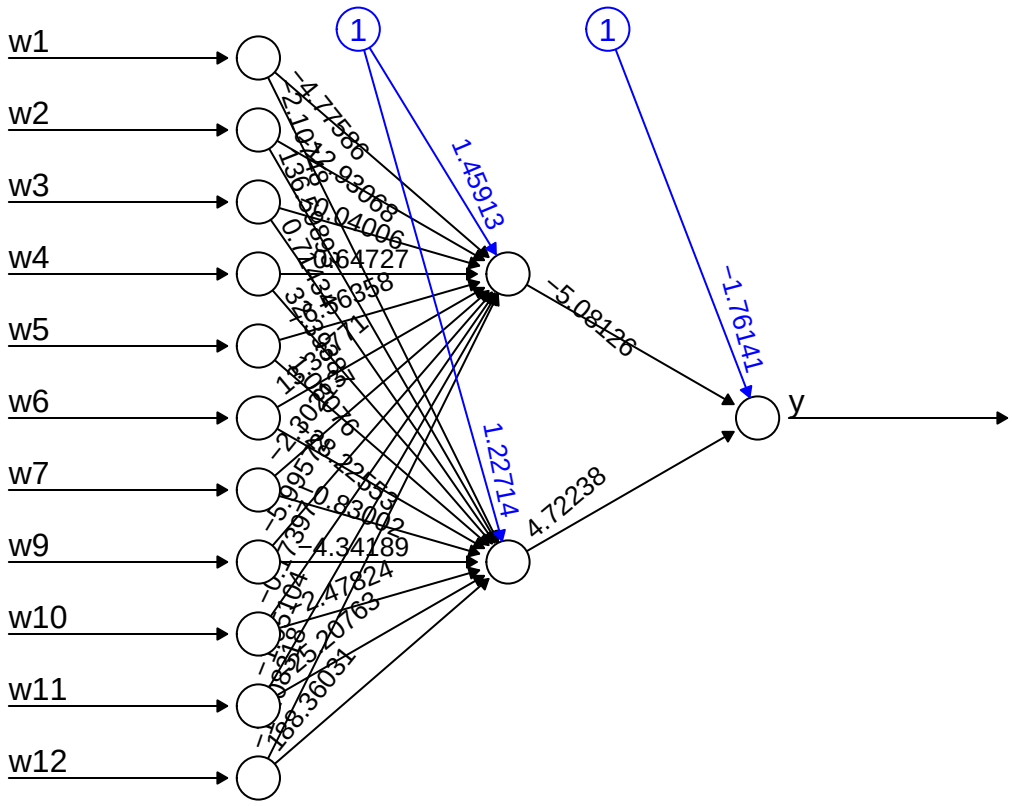
```
##
## Call:
## glm(formula = y ~ ., family = binomial, data = train.data)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.40677    0.07306 -19.254  < 2e-16 ***
## w1           0.49570    0.07623   6.503 7.89e-11 ***
## w2           4.70144    0.47175   9.966  < 2e-16 ***
## w3           0.32666    0.07851   4.161 3.17e-05 ***
## w4           0.87598    0.10423   8.404  < 2e-16 ***
## w5           2.10615    0.44757   4.706 2.53e-06 ***
## w6          -2.50340    0.27996  -8.942  < 2e-16 ***
## w7           0.13652    0.26018   0.525   0.5998
## w9          -0.30523    0.26483  -1.153   0.2491
## w10         -0.48121    0.26209  -1.836   0.0663 .
## w11         -1.02241    0.86149  -1.187   0.2353
## w12         11.53530    0.77363  14.911  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4625.5  on 3450  degrees of freedom
## Residual deviance: 2406.7  on 3439  degrees of freedom
## AIC: 2430.7
##
## Number of Fisher Scoring iterations: 8
```

```r
probabilities <- logistic_model %>% predict(test.data, type = "response")
predicted.classes <- ifelse(probabilities > 0.5, 1, 0)
confusionMatrix(factor(predicted.classes), factor(test.data$y), positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 657 121
##          1  37 335
##
##                Accuracy : 0.8626
##                  95% CI : (0.8413, 0.882)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7036
##
##  Mcnemar's Test P-Value : 4.026e-11
##
##             Sensitivity : 0.7346
##             Specificity : 0.9467
##          Pos Pred Value : 0.9005
##          Neg Pred Value : 0.8445
##              Prevalence : 0.3965
##          Detection Rate : 0.2913
##    Detection Prevalence : 0.3235
##       Balanced Accuracy : 0.8407
##
##        'Positive' Class : 1
##
```

Q3)

```
set.seed(123)
model <- neuralnet(y~., data = train.data, hidden = 2, err.fct = "sse", linear.output = F)
plot(model, rep = "best")
```

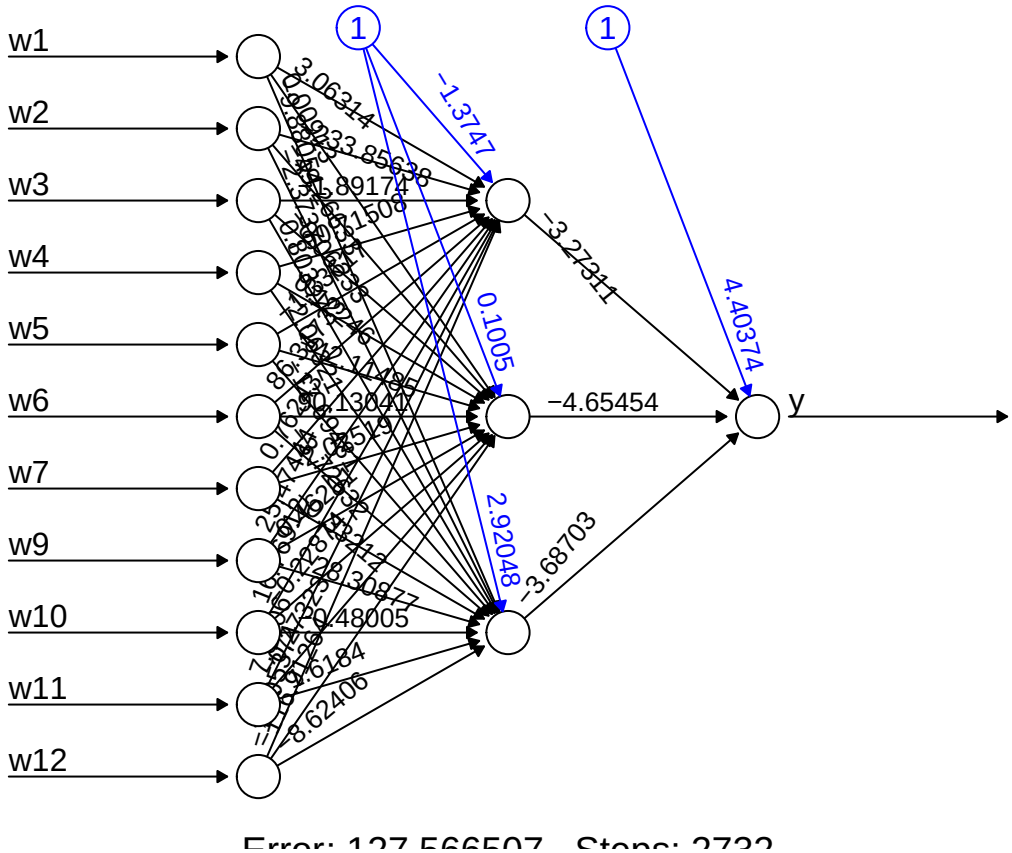



```
probabilities <- model %>% predict(test.data) %>% as.vector()
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
nn.y <- predicted.y
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 653  73
##          1  41 383
##
##                Accuracy : 0.9009
##                  95% CI : (0.8821, 0.9175)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7903
##
##  Mcnemar's Test P-Value : 0.003691
##
##             Sensitivity : 0.8399
##             Specificity : 0.9409
##          Pos Pred Value : 0.9033
##          Neg Pred Value : 0.8994
##              Prevalence : 0.3965
```

```
##          Detection Rate : 0.3330
##    Detection Prevalence : 0.3687
##       Balanced Accuracy : 0.8904
##
##        'Positive' Class : 1
##
```

```
set.seed(123)
model <- neuralnet(y~., data = train.data, hidden = 3, err.fct = "sse", linear.output = F)
plot(model, rep = "best")
```



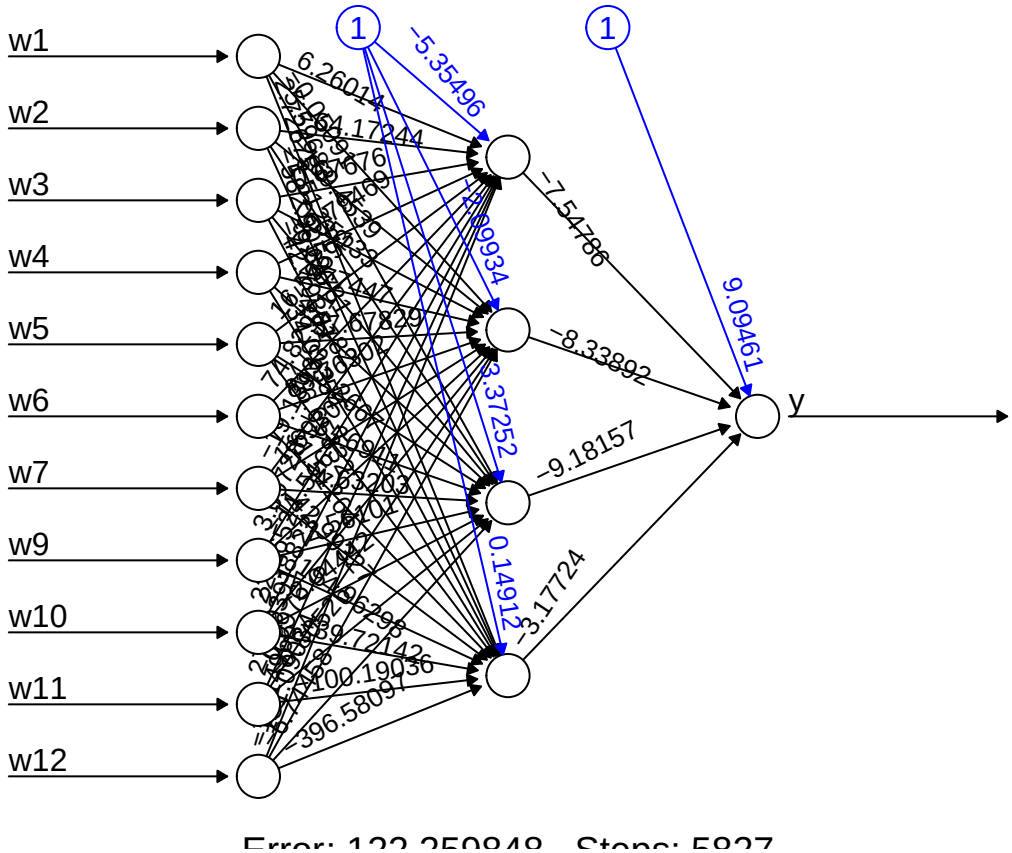
Error: 127.566507 Steps: 2722

```
probabilities <- model %>% predict(test.data) %>% as.vector()
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
nn.y <- predicted.y
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 653  74
##          1  41 382
##
##                Accuracy : 0.9
##                  95% CI : (0.8812, 0.9167)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
```

```
##
##                  Kappa : 0.7884
##
##  Mcnemar's Test P-Value : 0.002845
##
##             Sensitivity : 0.8377
##             Specificity : 0.9409
##          Pos Pred Value : 0.9031
##          Neg Pred Value : 0.8982
##              Prevalence : 0.3965
##          Detection Rate : 0.3322
##    Detection Prevalence : 0.3678
##       Balanced Accuracy : 0.8893
##
##        'Positive' Class : 1
##
```

```
set.seed(123)
model <- neuralnet(y~., data = train.data, hidden = 4, err.fct = "sse", linear.output = F)
plot(model, rep = "best")
```




```
probabilities <- model %>% predict(test.data) %>% as.vector()
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
nn.y <- predicted.y
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

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

```
##
##           Reference
## Prediction   0   1
##          0 645  68
##          1  49 388
##
##                Accuracy : 0.8983
##                  95% CI : (0.8793, 0.9151)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.7859
##
##  Mcnemar's Test P-Value : 0.09609
##
##             Sensitivity : 0.8509
##             Specificity : 0.9294
##          Pos Pred Value : 0.8879
##          Neg Pred Value : 0.9046
##              Prevalence : 0.3965
##          Detection Rate : 0.3374
##    Detection Prevalence : 0.3800
##       Balanced Accuracy : 0.8901
##
##        'Positive' Class : 1
##
```

3.b

set.seed(123)

model <- neuralnet(y ~ ., data = train.data, hidden = 2, err.fct = "ce", linear.output = F)

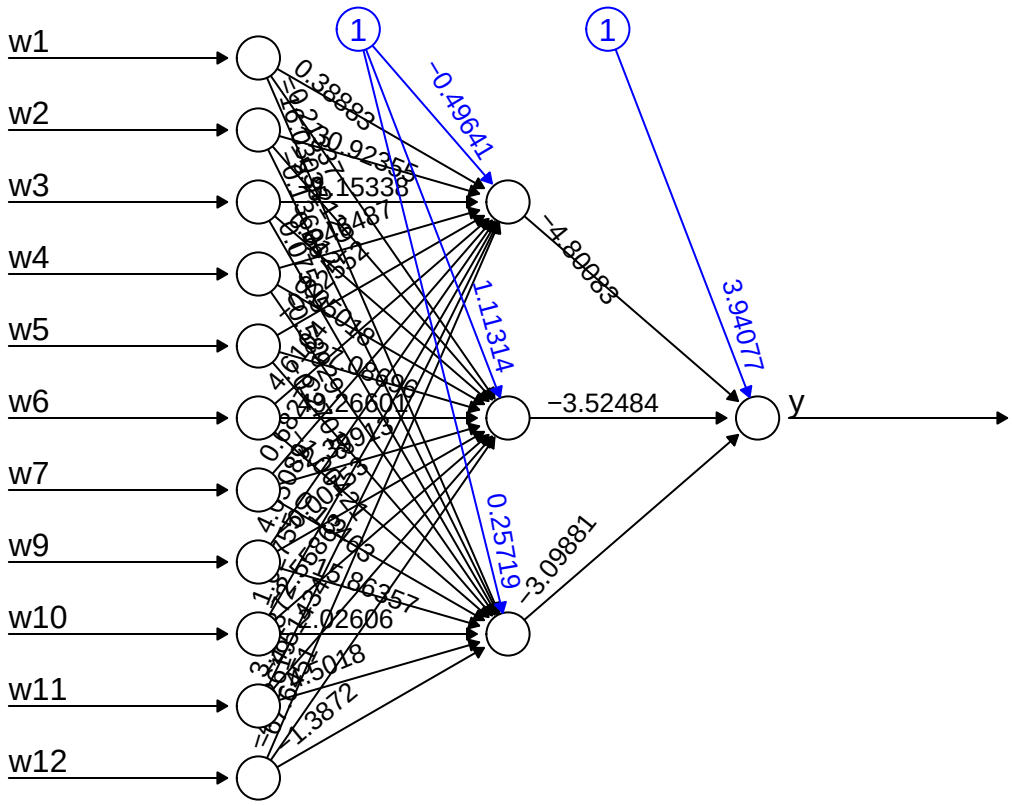
plot(model, rep = "best")

probabilities <- model %>% predict(test.data)

predicted.y <- ifelse(probabilities > 0.5, 1, 0)

confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')

```
set.seed(123)
model <- neuralnet(y ~ ., data = train.data, hidden = 3, err.fct = "ce", linear.output = F)
plot(model, rep = "best")
```

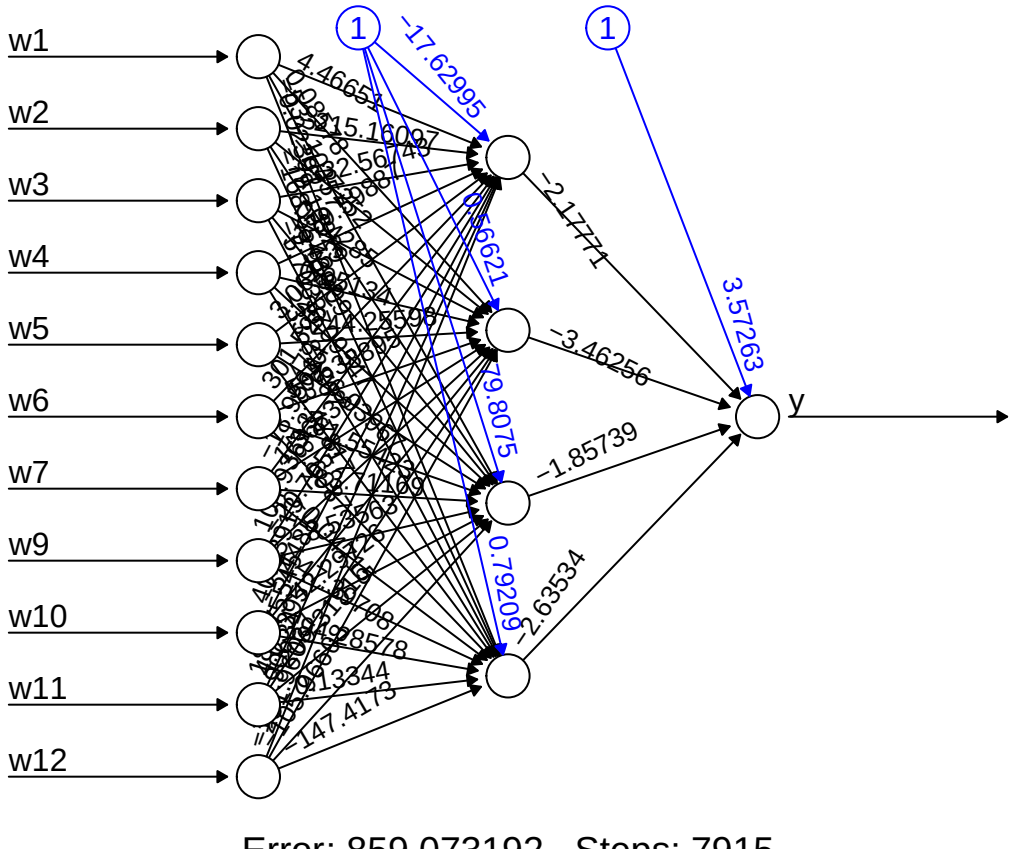



```
probabilities <- model %>% predict(test.data)
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 651  74
##          1  43 382
##
##                Accuracy : 0.8983
##                  95% CI : (0.8793, 0.9151)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7849
##
##  Mcnemar's Test P-Value : 0.005546
##
##             Sensitivity : 0.8377
##             Specificity : 0.9380
##          Pos Pred Value : 0.8988
##          Neg Pred Value : 0.8979
##              Prevalence : 0.3965
##          Detection Rate : 0.3322
```

```
##    Detection Prevalence : 0.3696
##       Balanced Accuracy : 0.8879
##
##        'Positive' Class : 1
##
```

```
set.seed(123)
model <- neuralnet(y~., data = train.data, hidden = 4, err.fct = "ce", linear.output = F)
plot(model, rep = "best")
```




```
probabilities <- model %>% predict(test.data)
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 648  78
##          1  46 378
##
##                Accuracy : 0.8922
##                  95% CI : (0.8728, 0.9095)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.772
```

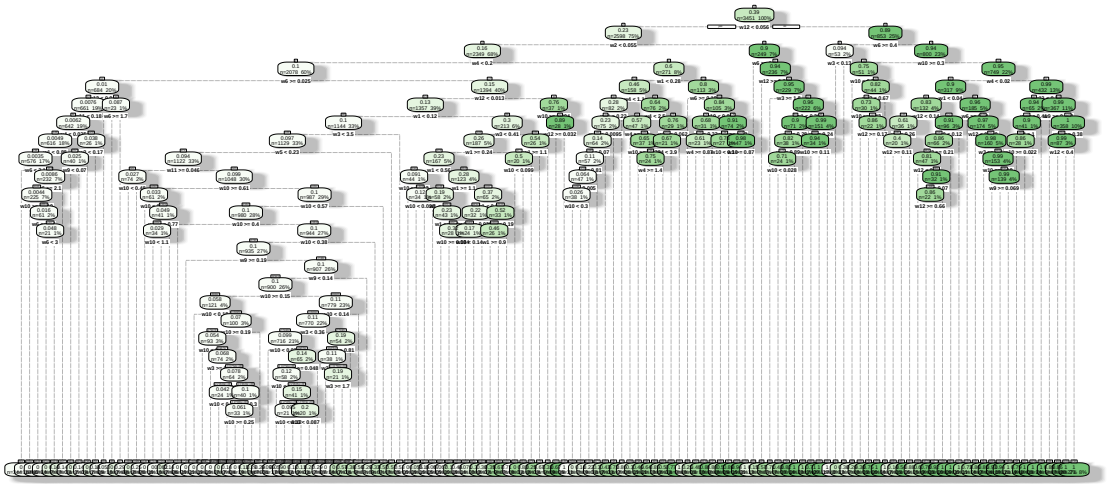
```
##
##  Mcnemar's Test P-Value : 0.005371
##
##             Sensitivity : 0.8289
##             Specificity : 0.9337
##          Pos Pred Value : 0.8915
##          Neg Pred Value : 0.8926
##              Prevalence : 0.3965
##          Detection Rate : 0.3287
##    Detection Prevalence : 0.3687
##       Balanced Accuracy : 0.8813
##
##        'Positive' Class : 1
##
```

#3c The model with error factor sse has better accuracy and is prefered.

Q4)

```
model <- rpart(y ~., data = train.data, control = rpart.control(cp=0))
par(xpd = NA)
fancyRpartPlot(model)
```

```
## Warning: labs do not fit even at cex 0.15, there may be some overplotting
```



Rattle 2024−May−14 10:55:34 MSP

```
pred <- predict(model,newdata = test.data)
pred <- ifelse(pred == 1, 'predict_1', 'predict_0')
table(pred,test.data$y)
```

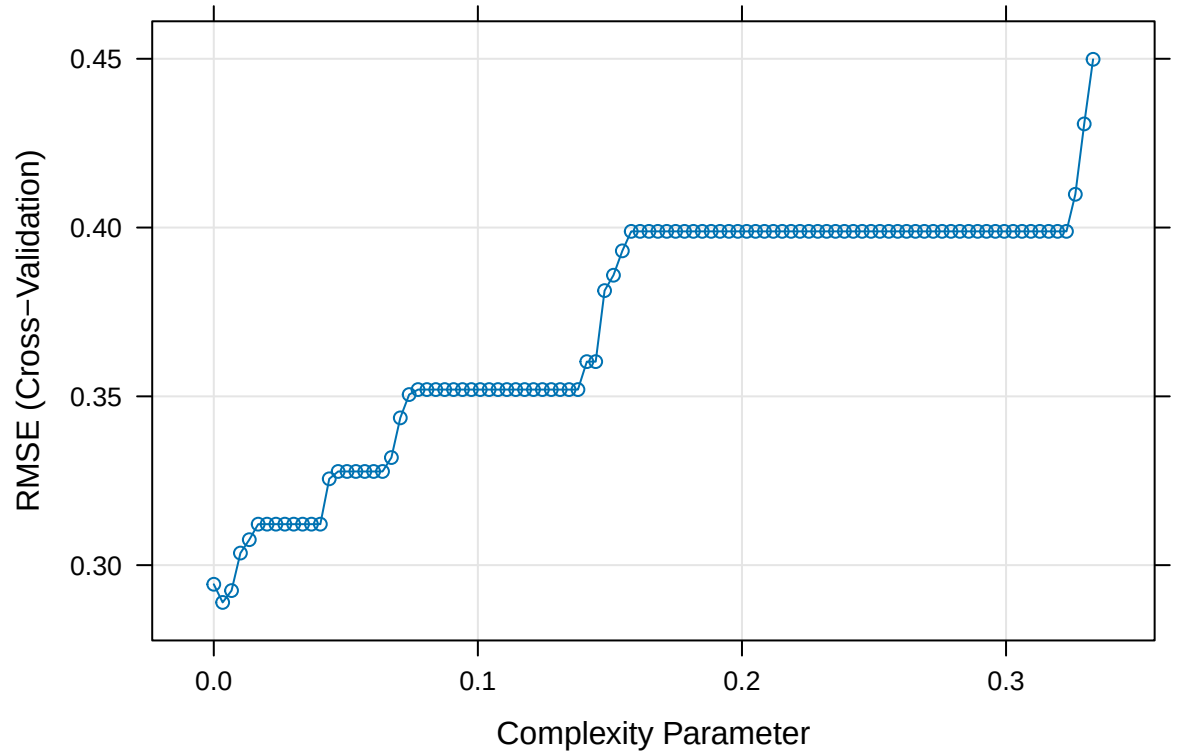
```
##
## pred          0   1
##   predict_0 679 184
##   predict_1  15 272
```

```
set.seed(123)
model2 <- train(
  y ~., data = train.data, method = "rpart",
  trControl = trainControl("cv", number = 10),
  tuneLength = 100)
```

```
## Warning in train.default(x, y, weights = w, ...): You are trying to do
## regression and your outcome only has two possible values Are you trying to do
## classification? If so, use a 2 level factor as your outcome column.
```

```
## Warning in nominalTrainWorkflow(x = x, y = y, wts = weights, info = trainInfo,
## : There were missing values in resampled performance measures.
```

```
plot(model2)
```




```
probabilities <- model %>% predict(test.data)
predicted.y <- ifelse(probabilities > 0.5, 1, 0)
cart.y <- predicted.y
confusionMatrix(factor(predicted.y), factor(test.data$y), positive = '1')
```

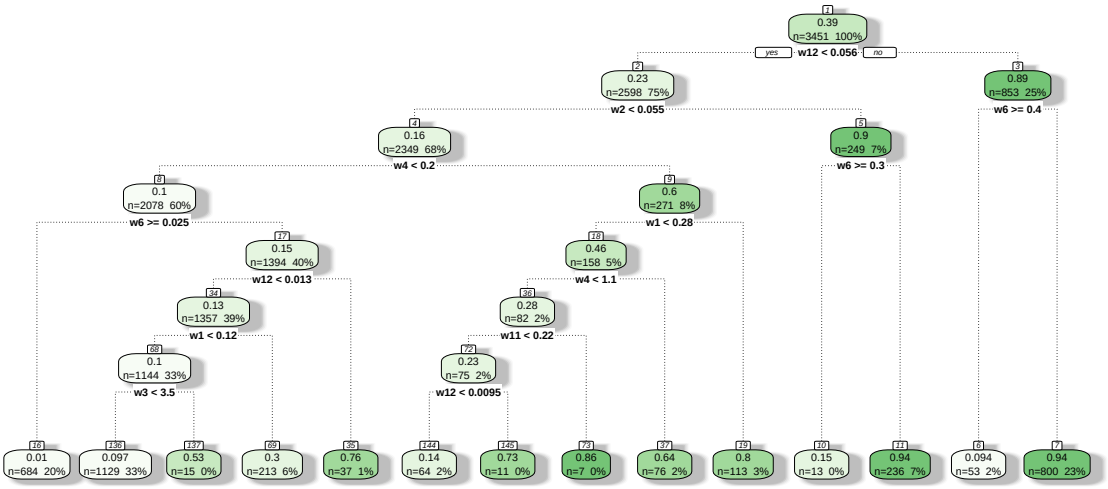
```
## Confusion Matrix and Statistics
##
##           Reference
```

```
## Prediction   0   1
##          0 644  95
##          1  50 361
##
##                Accuracy : 0.8739
##                  95% CI : (0.8533, 0.8926)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.732
##
##  Mcnemar's Test P-Value : 0.0002582
##
##             Sensitivity : 0.7917
##             Specificity : 0.9280
##          Pos Pred Value : 0.8783
##          Neg Pred Value : 0.8714
##              Prevalence : 0.3965
##          Detection Rate : 0.3139
##    Detection Prevalence : 0.3574
##       Balanced Accuracy : 0.8598
##
##        'Positive' Class : 1
##
```

```
model2$bestTune
```

```
##            cp
## 2 0.003363161
```

```
fancyRpartPlot(model2$finalModel)
```



Rattle 2024−May−14 10:55:40 MSP

```
pred <- predict(model2, newdata = test.data)
pred <- ifelse(pred == 1, '1' , '0')
table(pred,test.data$y)
```

```
##
## pred   0   1
##    0 694 456
```

Q5)

5.a

```
train.data$y <- factor(train.data$y)
test.data$y <- factor(test.data$y)
###################################

set.seed(123)
model <- train(
  y ~., data = train.data, method = "rf",
  trControl = trainControl("cv", number = 10),
  importance = TRUE
  )
# Best tuning parameter
model$bestTune
```

```
##   mtry
## 2    6
```

```
model$finalModel
```

```
##
## Call:
##  randomForest(x = x, y = y, mtry = param$mtry, importance = TRUE)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 6
##
##         OOB estimate of  error rate: 8.92%
## Confusion matrix:
##      0    1 class.error
## 0 1974  120  0.05730659
## 1  188 1169  0.13854090
```

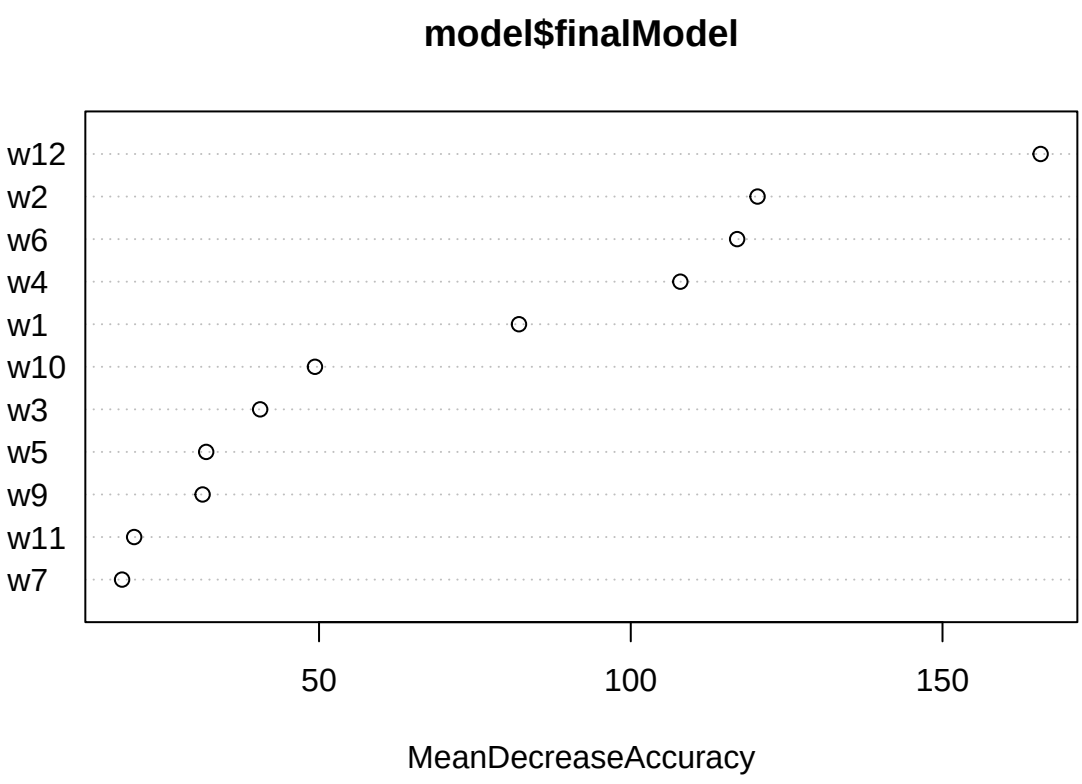
5.b

```
pred <- model %>% predict(test.data)
rf.y = pred
confusionMatrix(pred, test.data$y, positive = '1')
```

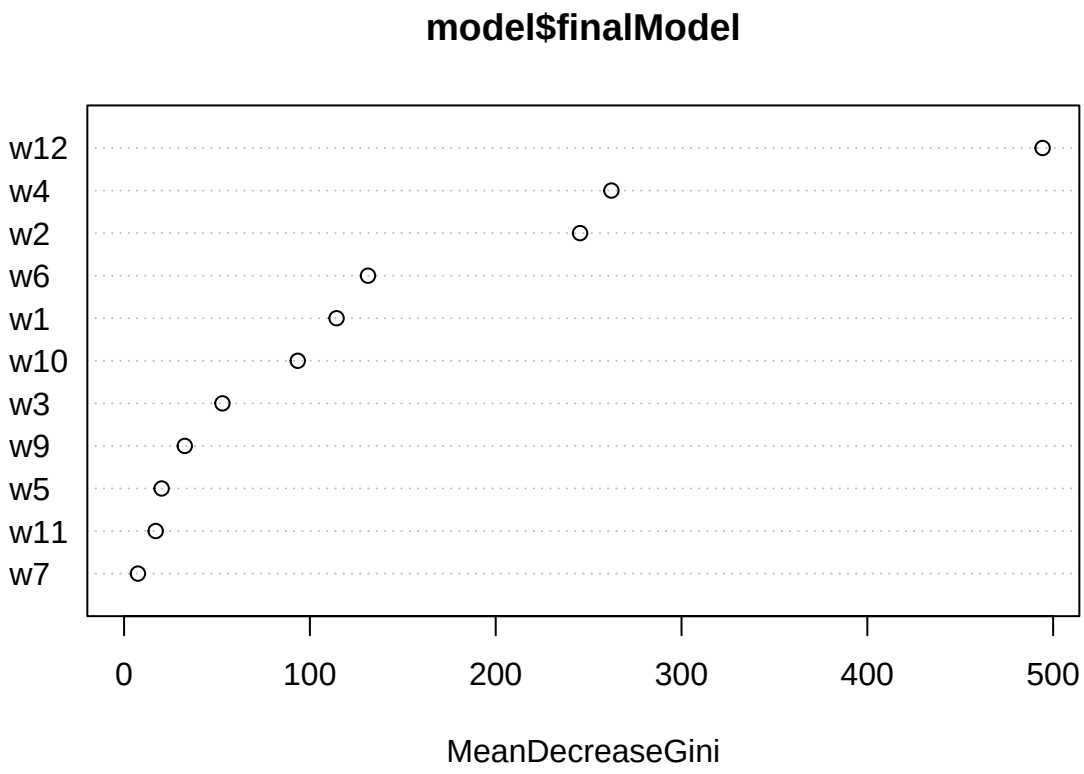
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 652  77
##          1  42 379
##
##                Accuracy : 0.8965
##                  95% CI : (0.8775, 0.9135)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7809
##
##  Mcnemar's Test P-Value : 0.001828
##
##             Sensitivity : 0.8311
##             Specificity : 0.9395
##          Pos Pred Value : 0.9002
##          Neg Pred Value : 0.8944
##              Prevalence : 0.3965
##          Detection Rate : 0.3296
##    Detection Prevalence : 0.3661
##       Balanced Accuracy : 0.8853
##
##        'Positive' Class : 1
##
```

5.c

```
# Plot MeanDecreaseAccuracy
varImpPlot(model$finalModel, type = 1)
```




```
# Plot MeanDecreaseGini
varImpPlot(model$finalModel, type = 2)
```



5.d

```
varImp(model, type = 2)
```

```
## rf variable importance
##
##     Overall
## w12 100.000
## w4   52.334
## w2   48.872
## w6   25.428
## w1   21.956
## w10  17.665
## w3    9.342
## w9    5.176
## w5    2.618
## w11   1.963
## w7    0.000
```

Q6)

{r} # set.seed(123) # model <- train(#   y ~., data = train.data, method = "svmPoly", #   trControl = trainControl("cv", number = 10), #   tuneLength = 4 #   ) # plot(model) #

{r} # model$bestTune #

{r} # svm.y <- predict(model, newdata = test.data) # confusionMatrix(svm test.data$y) #

Q7)

```
pred = cbind( nn.y, cart.y, rf.y)
pred.m = apply(pred,1,function(x) names(which.max(table(x)))) # Majority vote
pred.m = factor(pred.m)

confusionMatrix(pred.m, test.data$y, positive = '1')
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 639  87
##          1  55 369
##
##                Accuracy : 0.8765
##                  95% CI : (0.8561, 0.895)
##     No Information Rate : 0.6035
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7389
##
##  Mcnemar's Test P-Value : 0.009283
##
##             Sensitivity : 0.8092
##             Specificity : 0.9207
##          Pos Pred Value : 0.8703
##          Neg Pred Value : 0.8802
##              Prevalence : 0.3965
##          Detection Rate : 0.3209
##    Detection Prevalence : 0.3687
##       Balanced Accuracy : 0.8650
##
##        'Positive' Class : 1
##
```

PART 2

```
if (!requireNamespace("factoextra")) install.packages('factoextra')
```

```
## Loading required namespace: factoextra
```

```
if (!requireNamespace("cluster")) install.packages('cluster')
```

```
## Loading required namespace: cluster
```

```
if (!requireNamespace("devtools")) install.packages('devtools')
```

```
## Loading required namespace: devtools
```

```
if (!requireNamespace("ggbiplot")) install.packages('ggbiplot')
```

```
## Loading required namespace: ggbiplot
```

```
library(factoextra)
```

```
## Warning: package 'factoextra' was built under R version 4.3.3
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```
library(cluster)
library(devtools)
```

```
## Warning: package 'devtools' was built under R version 4.3.3
```

```
## Loading required package: usethis
```

```
## Warning: package 'usethis' was built under R version 4.3.3
```

```
library(ggbiplot)
```

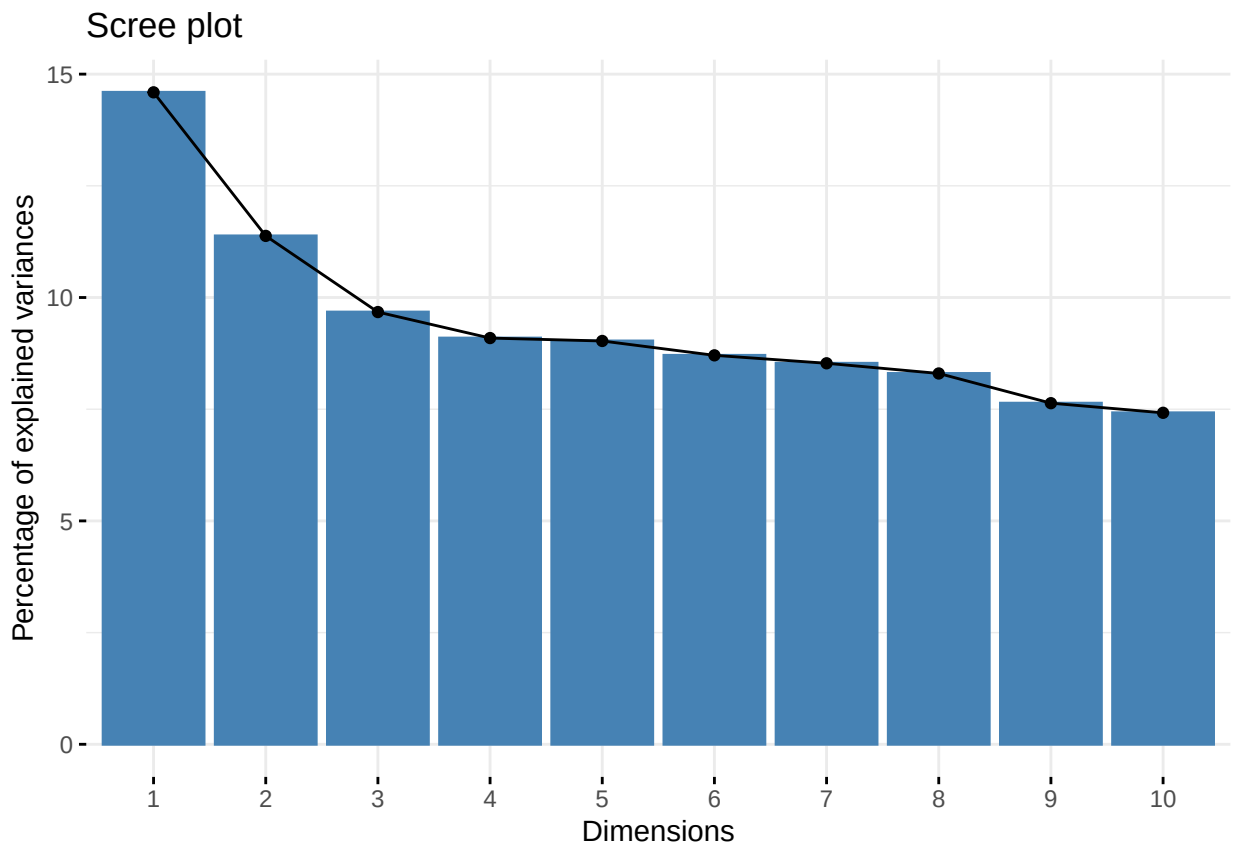
```
## Warning: package 'ggbiplot' was built under R version 4.3.3
```

```
##
## Attaching package: 'ggbiplot'
```

```
## The following object is masked from 'package:rattle':
##
##     wine
```

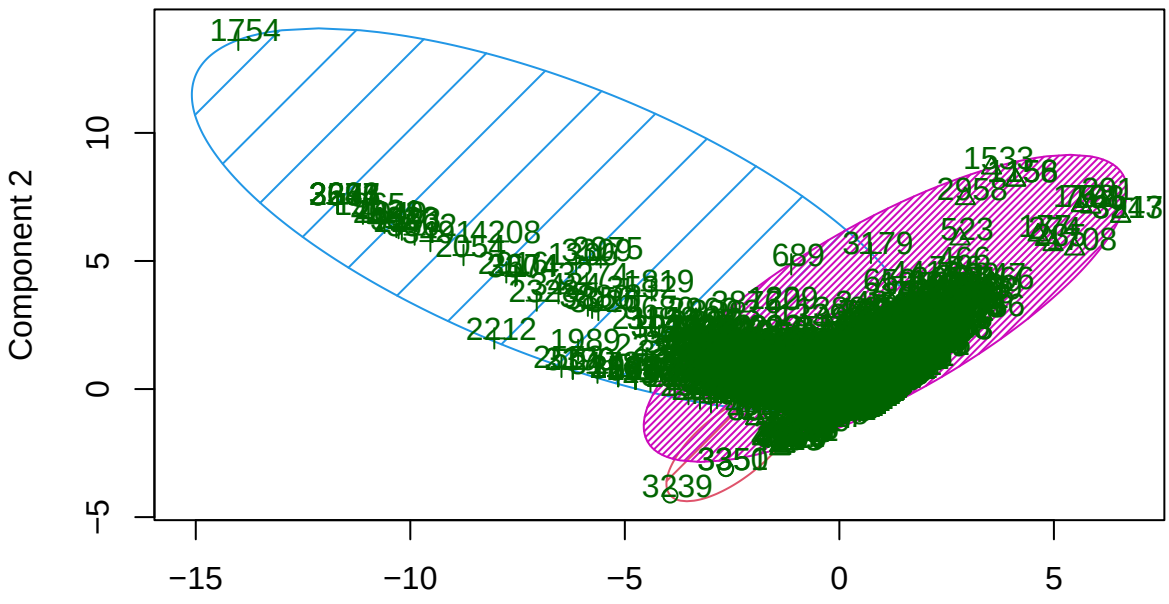
```
loq <- read.csv("C:/Users/MSP/Downloads/loq.csv")
loq <- na.omit(loq)
loq <- scale(loq[,-12])

# (a)-(d)
pc = princomp(loq, cor = T)
# Scree-plot
fviz_eig(pc)
```




```
# 3 clusters looks reasonable

# K means
k.means.fit <- kmeans(loq, 3)
clusplot(loq, k.means.fit$cluster, main='2D representation of the Cluster solution',color=TRUE, shade=T
```




```
Kmeans.cm <- table(k.means.fit$cluster, loq[,ncol(loq)])
print(Kmeans.cm)
```

```
##
##     -0.308321429912146 -0.296120456023935 -0.292053464727865 -0.287986473431794
##   1                  5                  0                  0                  0
##   2               3053                  1                  1                  4
##   3                143                  0                  0                  0
##
##     -0.283919482135724 -0.279852490839654 -0.275785499543584 -0.271718508247513
##   1                  0                  0                  0                  0
##   2                  2                  2                  3                  3
##   3                  0                  0                  0                  0
##
##     -0.267651516951443 -0.263584525655373 -0.259517534359303 -0.255450543063232
##   1                  0                  0                  0                  0
##   2                  2                  4                  2                  8
##   3                  0                  0                  0                  0
##
##     -0.251383551767162 -0.247316560471092 -0.243249569175022 -0.239182577878951
##   1                  0                  0                  0                  0
##   2                 12                  6                  9                  6
##   3                  0                  0                  0                  0
##
##     -0.235115586582881 -0.231048595286811 -0.226981603990741 -0.22291461269467
##   1                  0                  0                  0                  0
```

```
##   2                 4                 4                 2                 8
##   3                 0                 0                 0                 0
##
##     -0.2188476213986 -0.21478063010253 -0.21071363880646 -0.206646647510389
##   1                0                 0                 0                 0
##   2                9                 6                 8                 3
##   3                0                 0                 0                 0
##
##     -0.202579656214319 -0.198512664918249 -0.194445673622179 -0.190378682326108
##   1                  0                 0                 0                 0
##   2                  3                 6                 3                 6
##   3                  0                 0                 0                 0
##
##     -0.186311691030038 -0.182244699733968 -0.178177708437898 -0.174110717141827
##   1                  0                 0                 0                 0
##   2                  8                13                 8                 5
##   3                  0                 0                 0                 0
##
##     -0.170043725845757 -0.165976734549687 -0.161909743253617 -0.157842751957546
##   1                  0                 0                 0                 0
##   2                  4                 1                 7                 7
##   3                  0                 0                 0                 0
##
##     -0.153775760661476 -0.149708769365406 -0.145641778069336 -0.141574786773265
##   1                  0                 0                 0                 0
##   2                  4                 3                 5                 7
##   3                  0                 0                 0                 0
##
##     -0.137507795477195 -0.133440804181125 -0.129373812885055 -0.125306821588985
##   1                  0                 0                 0                 0
##   2                  3                 6                 4                 5
##   3                  0                 0                 0                 0
##
##     -0.121239830292914 -0.117172838996844 -0.113105847700774 -0.109038856404704
##   1                  0                 0                 0                 0
##   2                  8                 3                 6                 3
##   3                  0                 0                 1                 0
##
##     -0.104971865108633 -0.100904873812563 -0.0968378825164928
##   1                  0                 0                  0
##   2                  5                 4                  3
##   3                  1                 0                  0
##
##     -0.0927708912204226 -0.0887038999243523 -0.0846369086282821
##   1                   0                   0                   0
##   2                   7                   7                   4
##   3                   0                   0                   1
##
##     -0.0805699173322118 -0.0765029260361416 -0.0724359347400713
##   1                   0                   0                   0
##   2                   9                   4                   4
##   3                   0                   0                   0
##
##     -0.0683689434440011 -0.0643019521479309 -0.0602349608518606
```

```
##   1                   0                   0                   0
##   2                   7                   2                  15
##   3                   0                   0                   0
##
##     -0.0561679695557904 -0.0521009782597201 -0.0480339869636499
##   1                   0                   0                   0
##   2                  10                   9                   3
##   3                   0                   0                   0
##
##     -0.0439669956675796 -0.0399000043715094 -0.0358330130754392
##   1                   0                   0                   0
##   2                   7                   4                   5
##   3                   0                   0                   0
##
##     -0.0317660217793689 -0.0276990304832987 -0.0236320391872284
##   1                   0                   0                   0
##   2                   4                   5                   2
##   3                   0                   0                   0
##
##     -0.0195650478911582 -0.015498056595088 -0.0114310652990177
##   1                   0                  0                   0
##   2                   6                  2                   2
##   3                   0                  0                   0
##
##     -0.00736407400294748 -0.00329708270687723 0.000769908589193018
##   1                    0                   0                   0
##   2                    1                   6                   2
##   3                    0                   0                   0
##
##     0.00483689988526327 0.00890389118133351 0.0129708824774038
##   1                   0                   0                   0
##   2                   3                   2                   6
##   3                   0                   0                   0
##
##     0.017037873773474 0.0211048650695443 0.0251718563656145 0.0292388476616848
##   1                 0                  0                  0                   0
##   2                 5                  1                  4                   2
##   3                 0                  0                  0                   0
##
##     0.033305838957755 0.0373728302538252 0.0414398215498954 0.0455068128459657
##   1                 0                  0                  0                   0
##   2                 3                  5                  4                   3
##   3                 0                  0                  0                   0
##
##     0.0495738041420359 0.0536407954381062 0.0577077867341764 0.0617747780302467
##   1                  0                  0                  0                   0
##   2                  4                  1                  3                   1
##   3                  0                  0                  0                   0
##
##     0.0658417693263169 0.0699087606223872 0.0739757519184574 0.0780427432145277
##   1                  0                  0                  0                   0
##   2                  2                  4                  5                   2
##   3                  0                  0                  0                   0
##
```

```
##     0.0861767258066682 0.0943107083988086 0.0983776996948789 0.102444690990949
## 1                   0                  0                  0                  0
## 2                   3                  4                  2                  5
## 3                   0                  0                  0                  0
##
##     0.106511682287019 0.11057867358309 0.11464566487916 0.11871265617523
## 1                   0                0                0                0
## 2                   1                7                3                9
## 3                   0                0                0                0
##
##     0.1227796474713 0.126846638767371 0.130913630063441 0.134980621359511
## 1               0                 0                 0                 0
## 2               5                 9                 3                 7
## 3               0                 0                 0                 0
##
##     0.139047612655581 0.143114603951652 0.147181595247722 0.151248586543792
## 1                   0                 0                 0                 0
## 2                   4                 5                 4                 2
## 3                   0                 0                 0                 0
##
##     0.155315577839862 0.163449560432003 0.167516551728073 0.171583543024143
## 1                   0                 0                 0                 0
## 2                   8                 5                 5                16
## 3                   0                 0                 0                 0
##
##     0.175650534320213 0.179717525616284 0.183784516912354 0.187851508208424
## 1                   0                 0                 0                 0
## 2                   1                 3                 7                 1
## 3                   0                 0                 0                 0
##
##     0.191918499504494 0.195985490800565 0.200052482096635 0.204119473392705
## 1                   0                 0                 0                 0
## 2                   2                 6                 2                 2
## 3                   0                 0                 0                 0
##
##     0.208186464688775 0.212253455984846 0.216320447280916 0.220387438576986
## 1                   0                 0                 0                 0
## 2                   6                 7                 4                 2
## 3                   0                 0                 0                 0
##
##     0.224454429873056 0.228521421169127 0.232588412465197 0.236655403761267
## 1                   0                 0                 0                 0
## 2                   2                 7                 4                 4
## 3                   0                 0                 0                 0
##
##     0.240722395057337 0.244789386353408 0.248856377649478 0.252923368945548
## 1                   0                 0                 0                 0
## 2                   5                 3                 1                 3
## 3                   0                 0                 0                 0
##
##     0.256990360241618 0.261057351537689 0.265124342833759 0.269191334129829
## 1                   0                 0                 0                 0
## 2                   1                 1                 8                 3
## 3                   0                 0                 0                 0
```

```
##
##     0.273258325425899 0.27732531672197 0.28139230801804 0.28545929931411
##   1                 0                0                0                0
##   2                 2                1                4                3
##   3                 0                0                0                0
##
##     0.28952629061018 0.293593281906251 0.297660273202321 0.301727264498391
##   1                0                 0                 0                 0
##   2                5                 1                 4                 5
##   3                0                 0                 0                 0
##
##     0.305794255794461 0.309861247090532 0.313928238386602 0.317995229682672
##   1                 0                 0                 0                 0
##   2                 4                 2                 1                 3
##   3                 0                 0                 0                 0
##
##     0.322062220978742 0.326129212274813 0.330196203570883 0.334263194866953
##   1                 0                 0                 0                 0
##   2                 3                 5                 9                12
##   3                 0                 0                 0                 0
##
##     0.338330186163023 0.342397177459094 0.346464168755164 0.350531160051234
##   1                 0                 0                 0                 0
##   2                 7                 9                 6                 6
##   3                 0                 0                 0                 0
##
##     0.354598151347304 0.358665142643375 0.362732133939445 0.366799125235515
##   1                 0                 0                 0                 0
##   2                 6                 2                 8                 6
##   3                 0                 0                 0                 0
##
##     0.370866116531585 0.374933107827655 0.379000099123726 0.383067090419796
##   1                 0                 0                 0                 0
##   2                 8                 8                 6                 5
##   3                 0                 0                 0                 0
##
##     0.387134081715866 0.391201073011936 0.395268064308007 0.399335055604077
##   1                 0                 0                 0                 0
##   2                 6                 1                 4                 4
##   3                 0                 0                 0                 0
##
##     0.403402046900147 0.407469038196217 0.411536029492288 0.415603020788358
##   1                 0                 0                 0                 0
##   2                 5                 3                 3                 1
##   3                 0                 0                 0                 0
##
##     0.419670012084428 0.423737003380498 0.427803994676569 0.431870985972639
##   1                 0                 0                 0                 0
##   2                 1                 5                 2                 7
##   3                 0                 0                 0                 0
##
##     0.435937977268709 0.440004968564779 0.44407195986085 0.44813895115692
##   1                 0                 0                0                0
##   2                 3                 6                2                5
```

```
##   3                 0                 0                 0                 0
##
##     0.45220594245299 0.45627293374906 0.460339925045131 0.468473907637271
##   1                 0                 0                 0                 0
##   2                 1                 4                 4                 9
##   3                 0                 0                 0                 0
##
##     0.472540898933341 0.476607890229412 0.480674881525482 0.484741872821552
##   1                 0                 0                 0                 0
##   2                 3                 3                 1                 1
##   3                 0                 0                 0                 0
##
##     0.488808864117622 0.492875855413693 0.496942846709763 0.501009838005833
##   1                 0                 0                 0                 0
##   2                 6                 5                 2                 4
##   3                 0                 0                 0                 0
##
##     0.505076829301903 0.509143820597974 0.513210811894044 0.517277803190114
##   1                 0                 0                 0                 0
##   2                 1                 3                 2                 2
##   3                 0                 0                 0                 0
##
##     0.521344794486184 0.525411785782254 0.529478777078325 0.533545768374395
##   1                 0                 0                 0                 0
##   2                 2                 2                 4                 5
##   3                 0                 0                 0                 0
##
##     0.537612759670465 0.541679750966535 0.545746742262606 0.549813733558676
##   1                 0                 0                 0                 0
##   2                 3                 1                 7                 6
##   3                 0                 0                 0                 0
##
##     0.553880724854746 0.557947716150816 0.562014707446887 0.566081698742957
##   1                 0                 0                 0                 0
##   2                 7                 3                 2                 4
##   3                 0                 0                 0                 0
##
##     0.570148690039027 0.574215681335097 0.578282672631168 0.582349663927238
##   1                 0                 0                 0                 0
##   2                 3                 2                 4                 1
##   3                 0                 0                 0                 0
##
##     0.590483646519378 0.594550637815449 0.598617629111519 0.602684620407589
##   1                 0                 0                 0                 0
##   2                 4                 3                 7                 6
##   3                 0                 0                 0                 0
##
##     0.606751611703659 0.61895258559187 0.62301957688794 0.627086568184011
##   1                 0                0                0                 0
##   2                 2                2                4                 7
##   3                 0                0                0                 0
##
##     0.631153559480081 0.635220550776151 0.639287542072221 0.643354533368292
##   1                 0                 0                 0                 0
```

```
##   2                2                4                5                2
##   3                0                0                0                0
##
##     0.647421524664362 0.651488515960432 0.659622498552572 0.663689489848643
##   1                 0                 0                 0                 0
##   2                 2                 2                 2                 3
##   3                 0                 0                 0                 0
##
##     0.667756481144713 0.671823472440783 0.675890463736853 0.679957455032924
##   1                 0                 0                 0                 0
##   2                 1                 1                 3                 2
##   3                 0                 0                 0                 0
##
##     0.684024446328994 0.688091437625064 0.692158428921135 0.696225420217205
##   1                 0                 0                 0                 0
##   2                 2                 1                 1                 1
##   3                 0                 0                 0                 0
##
##     0.700292411513275 0.704359402809345 0.708426394105416 0.712493385401486
##   1                 0                 0                 0                 0
##   2                 2                 1                 1                 2
##   3                 0                 0                 0                 0
##
##     0.716560376697556 0.720627367993626 0.724694359289696 0.728761350585767
##   1                 0                 0                 0                 0
##   2                 2                 3                 6                 3
##   3                 0                 0                 0                 0
##
##     0.732828341881837 0.740962324473977 0.745029315770048 0.749096307066118
##   1                 0                 0                 0                 0
##   2                 2                 2                 3                 2
##   3                 0                 0                 0                 0
##
##     0.753163298362188 0.761297280954329 0.765364272250399 0.769431263546469
##   1                 0                 0                 0                 0
##   2                 4                 3                 1                 4
##   3                 0                 0                 0                 0
##
##     0.773498254842539 0.77756524613861 0.78569922873075 0.793833211322891
##   1                 0                0               0                 0
##   2                 2                4               2                 4
##   3                 0                0               0                 0
##
##     0.797900202618961 0.801967193915031 0.818235159099312 0.822302150395382
##   1                 0                 0                 0                 0
##   2                 1                 2                 1                 2
##   3                 0                 0                 0                 0
##
##     0.826369141691453 0.850771089467874 0.862972063356085 0.867039054652155
##   1                 0                 0                 0                 0
##   2                 3                 1                 1                 2
##   3                 0                 0                 0                 0
##
##     0.871106045948225 0.875173037244295 0.887374011132506 0.891441002428576
```

```
##   1                0                0                0                0
##   2                2                4                2                1
##   3                0                0                0                0
##
##     0.899574985020717 0.907708967612857 0.911775958908928 0.915842950204998
##   1                 0                 0                 0                 0
##   2                 1                 1                 3                 1
##   3                 0                 0                 0                 0
##
##     0.919909941501068 0.923976932797138 0.928043924093209 0.932110915389279
##   1                 0                 0                 0                 0
##   2                 3                 1                 1                 3
##   3                 0                 0                 0                 0
##
##     0.936177906685349 0.94431188927749 0.94837888057356 0.95244587186963
##   1                 0                0                0                0
##   2                 2                1                1                2
##   3                 0                0                0                0
##
##     0.960579854461771 0.964646845757841 0.972780828349981 0.976847819646052
##   1                 0                 0                 0                 0
##   2                 3                 2                 1                 1
##   3                 0                 0                 0                 0
##
##     0.980914810942122 0.984981802238192 0.997182776126403 1.00124976742247
##   1                 0                 0                 0                0
##   2                 1                 1                 1                2
##   3                 0                 0                 0                0
##
##     1.01751773260675 1.02158472390282 1.03378569779104 1.03785268908711
##   1                0                0                0                0
##   2                1                1                1                2
##   3                0                0                0                0
##
##     1.04191968038318 1.04598667167925 1.05818764556746 1.0663216281596
##   1                0                0                0               0
##   2                1                2                4               4
##   3                0                0                0               0
##
##     1.07038861945567 1.07445561075174 1.07852260204781 1.08258959334388
##   1                0                0                0                0
##   2                1                2                3                2
##   3                0                0                0                0
##
##     1.09479056723209 1.10292454982423 1.11105853241637 1.11512552371244
##   1                0                0                0                0
##   2                4                4                2                2
##   3                0                0                0                0
##
##     1.11919251500851 1.12325950630458 1.12732649760065 1.13139348889672
##   1                0                0                0                0
##   2                1                1                2                1
##   3                0                0                0                0
##
```

```
##     1.147661454081 1.15579543667314 1.15986242796921 1.17206340185742
##   1              0                0                0                0
##   2              1                1                2                1
##   3              0                0                0                0
##
##     1.17613039315349 1.18426437574563 1.19239835833777 1.19646534963384
##   1                0                0                0                0
##   2                1                1                1                7
##   3                0                0                0                0
##
##     1.22493428870634 1.22900128000241 1.23713526259455 1.24120225389062
##   1                0                0                0                0
##   2                1                1                1                2
##   3                0                0                0                0
##
##     1.24933623648276 1.25340322777883 1.26967119296311 1.27373818425918
##   1                0                0                0                0
##   2                2                1                2                2
##   3                0                0                0                0
##
##     1.27780517555525 1.28187216685132 1.30220712333167 1.30627411462774
##   1                0                0                0                0
##   2                2                1                2                4
##   3                0                0                0                0
##
##     1.32660907110809 1.33067606240416 1.34287703629237 1.34694402758844
##   1                0                0                0                0
##   2                2                2                1                1
##   3                0                0                0                0
##
##     1.35101101888451 1.35914500147665 1.36321199277272 1.36727898406879
##   1                0                0                0                0
##   2                1                2                1                2
##   3                0                0                0                0
##
##     1.38354694925308 1.39981491443736 1.40388190573343 1.41608287962164
##   1                0                0                0                0
##   2                1                2                1                1
##   3                0                0                0                0
##
##     1.42828385350985 1.43641783610199 1.44048482739806 1.44455181869413
##   1                0                0                0                0
##   2                1                1                1                2
##   3                0                0                0                0
##
##     1.4486188099902 1.45268580128627 1.45675279258234 1.46895376647055
##   1               0                0                0                0
##   2               1                1                1                1
##   3               0                0                0                0
##
##     1.47302075776662 1.47708774906269 1.5299586359116 1.5584275749841
##   1                0                0               0               0
##   2                1                0               1               1
##   3                0                1               0               0
```

```
##
##     1.56249456628017 1.57469554016838 1.57876253146445 1.58282952276052
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     1.58689651405659 1.59096350535266 1.60723147053694 1.61129846183301
##   1                0                0                0                0
##   2                1                3                1                1
##   3                0                0                0                0
##
##     1.61536545312908 1.62349943572122 1.63570040960943 1.6397674009055
##   1                0                0                0                0
##   2                1                2                2                1
##   3                0                0                0                0
##
##     1.64383439220157 1.64790138349764 1.65603536608978 1.66823633997799
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     1.69670527905048 1.7089062529387 1.72110722682691 1.72517421812298
##   1                0               0                0                0
##   2                1               2                1                2
##   3                0               1                0                0
##
##     1.72924120941905 1.74144218330726 1.74550917460333 1.76177713978761
##   1                0                0                0                0
##   2                0                1                2                1
##   3                1                0                0                0
##
##     1.76584413108368 1.78211209626796 1.78617908756403 1.80244705274831
##   1                0                0                0                0
##   2                1                1                1                2
##   3                0                0                0                0
##
##     1.81871501793259 1.82278200922866 1.83498298311687 1.83904997441294
##   1                0                0                0                0
##   2                2                2                1                1
##   3                0                0                0                0
##
##     1.84311696570901 1.85125094830115 1.85531793959722 1.86751891348544
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     1.87158590478151 1.89192086126186 1.900054843854 1.92038980033435
##   1                0                0              0                0
##   2                1                3              1                1
##   3                0                0              0                0
##
##     1.92445679163042 1.93665776551863 2.0220645827361 2.07086847828895
##   1                0                0                0                0
##   2                3                1                1                1
```

```
##   3                0                0                0                0
##
##     2.09933741736144 2.11560538254572 2.11967237384179 2.12373936513786
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.13594033902607 2.15627529550642 2.16847626939463 2.1725432606907
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.18067724328284 2.18474423457891 2.23761512142783 2.25388308661211
##   1                0                0                0                0
##   2                1                1                2                1
##   3                0                0                0                0
##
##     2.26201706920425 2.27015105179639 2.33928990382958 2.38402680808636
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.38809379938243 2.39622778197457 2.41656273845492 2.42469672104706
##   1                0                0                0                0
##   2                1                3                1                1
##   3                0                0                0                0
##
##     2.42876371234313 2.4328307036392 2.46129964271169 2.46943362530383
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.50603654696846 2.53043849474488 2.56704141640952 2.60364433807415
##   1                0                0                0                0
##   2                1                1                2                2
##   3                0                0                0                0
##
##     2.61584531196236 2.61991230325843 2.6239792945545 2.63618026844271
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.65651522492306 2.67685018140341 2.70125212917983 2.72158708566019
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.75005602473268 2.75412301602875 2.75819000732482 2.76632398991696
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     2.78665894639731 2.79479292898945 2.79885992028552 2.86393178102264
##   1                0                0                0                0
```

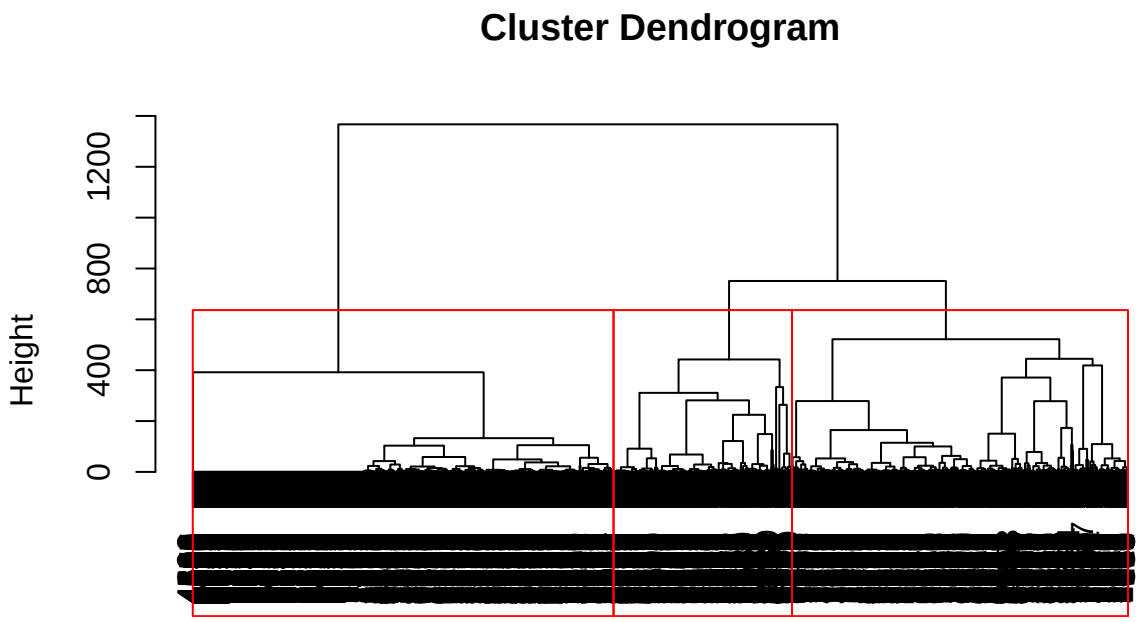
```
##   2                1                2                1                1
##   3                0                0                0                0
##
##     2.88019974620693 2.89240072009514 2.90460169398335 2.91680266787156
##   1                0                0                0                0
##   2                2                1                1                1
##   3                0                0                0                0
##
##     2.92086965916763 2.94120461564798 2.94527160694405 2.98187452860868
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     3.01034346768117 3.03881240675366 3.05914736323402 3.06321435453009
##   1                0                0                0                0
##   2                3                1                1                1
##   3                0                0                0                0
##
##     3.06728134582616 3.13642019785935 3.17709011082005 3.18115710211612
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     3.1974250673004 3.22182701507683 3.29096586711002 3.30316684099823
##   1               0                0                0                0
##   2               1                2                1                1
##   3               0                0                0                0
##
##     3.32756878877465 3.33570277136679 3.36417171043928 3.46584649284104
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     3.48211445802532 3.52685136228209 3.58378924042708 3.67326304894062
##   1                0                0                0                0
##   2                2                1                1                2
##   3                0                0                0                0
##
##     3.74646889226989 3.85221066596771 3.96201943096161 4.2507758129826
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     4.62087202092499 4.64934095999748 4.66560892518176 4.72254680332675
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     4.85269052480099 4.90149442035384 4.91369539424205 4.99910221145952
##   1                0                0                0                0
##   2                1                2                1                1
##   3                0                0                0                0
##
##     5.01130318534773 5.0153701766438 5.01943716793987 5.02350415923594
```

```
##   1                0                0                0                0
##   2                1                1                2                1
##   3                0                0                0                0
##
##     5.03163814182808 5.10077699386128 5.11704495904556 5.21058575885518
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     5.45460523661939 5.6172848884622 5.75962958382466 6.24360154805702
##   1                0                0                0                0
##   2                1                1                1                1
##   3                0                0                0                0
##
##     6.95125803357324 7.6670485016816 7.98020683147901 9.16776828993152
##   1                0                0                0                0
##   2                0                1                1                1
##   3                1                0                0                0
##
##     12.4010263703074 12.9500701952768 13.1330848036 16.028782606402
##   1                0                0             0                0
##   2                1                1             1                1
##   3                0                0             0                0
##
##     21.2467324392601 24.1058273203975
##   1                0                0
##   2                2                1
##   3                0                0
```

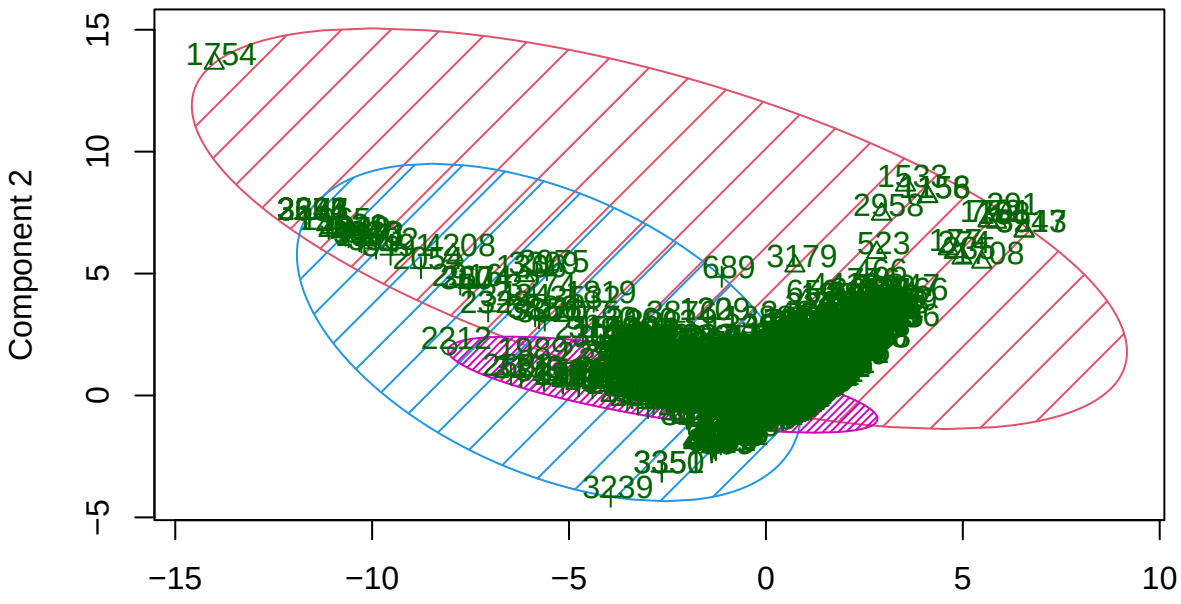
```
Kmeans.accuracy <- sum(diag(Kmeans.cm)) / sum(Kmeans.cm)
print(Kmeans.accuracy)
```

```
## [1] 0.001304064
```

```
set.seed(123)
# H.Ward
d <- dist(loq, method = "euclidean")
H.fit <- hclust(d, method="ward.D")
plot(H.fit)
rect.hclust(H.fit, k=3, border="red")
```




```
groups <- cutree(H.fit, k=3)
clusplot(loq, groups, main='2D representation of the Cluster solution',color=TRUE, shade=TRUE,labels=3,
```



These two components explain 25.97 % of the point variability.

```
clusters = factor(groups)
H.ward.cm <- table(clusters, loq[,ncol(loq)])
print(H.ward.cm)
```

```
##
## clusters -0.308321429912146 -0.296120456023935 -0.292053464727865
##        1                1595                  1                  1
##        2                 815                  0                  0
##        3                 791                  0                  0
##
## clusters -0.287986473431794 -0.283919482135724 -0.279852490839654
##        1                   4                  1                  2
##        2                   0                  1                  0
##        3                   0                  0                  0
##
## clusters -0.275785499543584 -0.271718508247513 -0.267651516951443
##        1                   2                  0                  1
##        2                   0                  0                  1
##        3                   1                  3                  0
##
## clusters -0.263584525655373 -0.259517534359303 -0.255450543063232
##        1                   2                  1                  6
##        2                   0                  0                  0
##        3                   2                  1                  2
##
## clusters -0.251383551767162 -0.247316560471092 -0.243249569175022
```

```
##        1                 11                  5                  6
##        2                  1                  1                  2
##        3                  0                  0                  1
##
## clusters -0.239182577878951 -0.235115586582881 -0.231048595286811
##        1                  5                  2                  3
##        2                  0                  0                  1
##        3                  1                  2                  0
##
## clusters -0.226981603990741 -0.22291461269467 -0.2188476213986
##        1                  1                 6                 7
##        2                  0                 1                 1
##        3                  1                 1                 1
##
## clusters -0.21478063010253 -0.21071363880646 -0.206646647510389
##        1                  2                 7                   1
##        2                  2                 1                   2
##        3                  2                 0                   0
##
## clusters -0.202579656214319 -0.198512664918249 -0.194445673622179
##        1                  1                  3                  1
##        2                  0                  2                  0
##        3                  2                  1                  2
##
## clusters -0.190378682326108 -0.186311691030038 -0.182244699733968
##        1                  4                  5                 12
##        2                  2                  2                  0
##        3                  0                  1                  1
##
## clusters -0.178177708437898 -0.174110717141827 -0.170043725845757
##        1                  6                  3                  2
##        2                  1                  2                  2
##        3                  1                  0                  0
##
## clusters -0.165976734549687 -0.161909743253617 -0.157842751957546
##        1                  0                  5                  4
##        2                  1                  2                  3
##        3                  0                  0                  0
##
## clusters -0.153775760661476 -0.149708769365406 -0.145641778069336
##        1                  3                  1                  2
##        2                  0                  0                  2
##        3                  1                  2                  1
##
## clusters -0.141574786773265 -0.137507795477195 -0.133440804181125
##        1                  3                  1                  1
##        2                  3                  2                  2
##        3                  1                  0                  3
##
## clusters -0.129373812885055 -0.125306821588985 -0.121239830292914
##        1                  2                  3                  2
##        2                  0                  2                  4
##        3                  2                  0                  2
##
```

```
## clusters -0.117172838996844 -0.113105847700774 -0.109038856404704
##        1                  1                  0                  1
##        2                  2                  5                  2
##        3                  0                  2                  0
##
## clusters -0.104971865108633 -0.100904873812563 -0.0968378825164928
##        1                  3                  1                   0
##        2                  2                  2                   2
##        3                  1                  1                   1
##
## clusters -0.0927708912204226 -0.0887038999243523 -0.0846369086282821
##        1                   4                   2                   0
##        2                   1                   5                   2
##        3                   2                   0                   3
##
## clusters -0.0805699173322118 -0.0765029260361416 -0.0724359347400713
##        1                   2                   1                   3
##        2                   6                   2                   0
##        3                   1                   1                   1
##
## clusters -0.0683689434440011 -0.0643019521479309 -0.0602349608518606
##        1                   1                   0                   6
##        2                   4                   2                   6
##        3                   2                   0                   3
##
## clusters -0.0561679695557904 -0.0521009782597201 -0.0480339869636499
##        1                   7                   3                   1
##        2                   3                   4                   2
##        3                   0                   2                   0
##
## clusters -0.0439669956675796 -0.0399000043715094 -0.0358330130754392
##        1                   5                   2                   1
##        2                   2                   2                   4
##        3                   0                   0                   0
##
## clusters -0.0317660217793689 -0.0276990304832987 -0.0236320391872284
##        1                   3                   2                   1
##        2                   1                   2                   1
##        3                   0                   1                   0
##
## clusters -0.0195650478911582 -0.015498056595088 -0.0114310652990177
##        1                   4                  0                   1
##        2                   1                  2                   1
##        3                   1                  0                   0
##
## clusters -0.00736407400294748 -0.00329708270687723 0.000769908589193018
##        1                    0                    0                    0
##        2                    1                    3                    2
##        3                    0                    3                    0
##
## clusters 0.00483689988526327 0.00890389118133351 0.0129708824774038
##        1                   2                   1                   6
##        2                   1                   0                   0
##        3                   0                   1                   0
```

```
##
## clusters 0.017037873773474 0.0211048650695443 0.0251718563656145
##        1                 2                  0                 3
##        2                 3                  1                 1
##        3                 0                  0                 0
##
## clusters 0.0292388476616848 0.033305838957755 0.0373728302538252
##        1                  1                 0                  2
##        2                  1                 2                  3
##        3                  0                 1                  0
##
## clusters 0.0414398215498954 0.0455068128459657 0.0495738041420359
##        1                  2                  3                  2
##        2                  2                  0                  2
##        3                  0                  0                  0
##
## clusters 0.0536407954381062 0.0577077867341764 0.0617747780302467
##        1                  0                  1                  0
##        2                  1                  1                  1
##        3                  0                  1                  0
##
## clusters 0.0658417693263169 0.0699087606223872 0.0739757519184574
##        1                  0                  0                  1
##        2                  2                  4                  4
##        3                  0                  0                  0
##
## clusters 0.0780427432145277 0.0861767258066682 0.0943107083988086
##        1                  1                  2                  2
##        2                  1                  1                  2
##        3                  0                  0                  0
##
## clusters 0.0983776996948789 0.102444690990949 0.106511682287019
##        1                  1                 1                 0
##        2                  0                 4                 0
##        3                  1                 0                 1
##
## clusters 0.11057867358309 0.11464566487916 0.11871265617523 0.1227796474713
##        1                0                2                2               0
##        2                7                1                6               5
##        3                0                0                1               0
##
## clusters 0.126846638767371 0.130913630063441 0.134980621359511
##        1                  6                 1                 2
##        2                  3                 1                 4
##        3                  0                 1                 1
##
## clusters 0.139047612655581 0.143114603951652 0.147181595247722
##        1                  1                 1                 1
##        2                  3                 4                 2
##        3                  0                 0                 1
##
## clusters 0.151248586543792 0.155315577839862 0.163449560432003
##        1                  1                 1                 2
##        2                  1                 7                 3
```

```
##        3                 0                 0                 0
##
## clusters 0.167516551728073 0.171583543024143 0.175650534320213
##        1                 1                 7                 0
##        2                 3                 9                 1
##        3                 1                 0                 0
##
## clusters 0.179717525616284 0.183784516912354 0.187851508208424
##        1                 2                 2                 0
##        2                 0                 5                 1
##        3                 1                 0                 0
##
## clusters 0.191918499504494 0.195985490800565 0.200052482096635
##        1                 1                 5                 1
##        2                 1                 1                 0
##        3                 0                 0                 1
##
## clusters 0.204119473392705 0.208186464688775 0.212253455984846
##        1                 2                 4                 3
##        2                 0                 2                 4
##        3                 0                 0                 0
##
## clusters 0.216320447280916 0.220387438576986 0.224454429873056
##        1                 1                 0                 0
##        2                 3                 2                 2
##        3                 0                 0                 0
##
## clusters 0.228521421169127 0.232588412465197 0.236655403761267
##        1                 1                 1                 0
##        2                 6                 3                 4
##        3                 0                 0                 0
##
## clusters 0.240722395057337 0.244789386353408 0.248856377649478
##        1                 1                 1                 0
##        2                 3                 2                 1
##        3                 1                 0                 0
##
## clusters 0.252923368945548 0.256990360241618 0.261057351537689
##        1                 1                 1                 1
##        2                 2                 0                 0
##        3                 0                 0                 0
##
## clusters 0.265124342833759 0.269191334129829 0.273258325425899 0.27732531672197
##        1                 5                 2                 2                 0
##        2                 3                 1                 0                 1
##        3                 0                 0                 0                 0
##
## clusters 0.28139230801804 0.28545929931411 0.28952629061018 0.293593281906251
##        1                1                 1                 2                 0
##        2                3                 2                 3                 1
##        3                0                 0                 0                 0
##
## clusters 0.297660273202321 0.301727264498391 0.305794255794461
##        1                 2                 2                 1
```

```
##        2                 1                 3                 3
##        3                 1                 0                 0
##
## clusters 0.309861247090532 0.313928238386602 0.317995229682672
##        1                 1                 1                 1
##        2                 1                 0                 2
##        3                 0                 0                 0
##
## clusters 0.322062220978742 0.326129212274813 0.330196203570883
##        1                 0                 0                 0
##        2                 3                 5                 9
##        3                 0                 0                 0
##
## clusters 0.334263194866953 0.338330186163023 0.342397177459094
##        1                 1                 2                 4
##        2                11                 5                 5
##        3                 0                 0                 0
##
## clusters 0.346464168755164 0.350531160051234 0.354598151347304
##        1                 1                 1                 1
##        2                 4                 5                 5
##        3                 1                 0                 0
##
## clusters 0.358665142643375 0.362732133939445 0.366799125235515
##        1                 1                 5                 1
##        2                 1                 3                 5
##        3                 0                 0                 0
##
## clusters 0.370866116531585 0.374933107827655 0.379000099123726
##        1                 1                 0                 0
##        2                 7                 8                 6
##        3                 0                 0                 0
##
## clusters 0.383067090419796 0.387134081715866 0.391201073011936
##        1                 2                 0                 1
##        2                 3                 6                 0
##        3                 0                 0                 0
##
## clusters 0.395268064308007 0.399335055604077 0.403402046900147
##        1                 1                 2                 3
##        2                 3                 2                 2
##        3                 0                 0                 0
##
## clusters 0.407469038196217 0.411536029492288 0.415603020788358
##        1                 2                 0                 0
##        2                 1                 3                 1
##        3                 0                 0                 0
##
## clusters 0.419670012084428 0.423737003380498 0.427803994676569
##        1                 0                 1                 0
##        2                 1                 4                 2
##        3                 0                 0                 0
##
## clusters 0.431870985972639 0.435937977268709 0.440004968564779 0.44407195986085
```

```
##        1                 3                 1                 1                 1
##        2                 4                 2                 5                 1
##        3                 0                 0                 0                 0
##
## clusters 0.44813895115692 0.45220594245299 0.45627293374906 0.460339925045131
##        1                 1                 0                 2                 2
##        2                 4                 1                 2                 2
##        3                 0                 0                 0                 0
##
## clusters 0.468473907637271 0.472540898933341 0.476607890229412
##        1                 0                 0                 3
##        2                 9                 3                 0
##        3                 0                 0                 0
##
## clusters 0.480674881525482 0.484741872821552 0.488808864117622
##        1                 1                 0                 4
##        2                 0                 1                 2
##        3                 0                 0                 0
##
## clusters 0.492875855413693 0.496942846709763 0.501009838005833
##        1                 2                 2                 4
##        2                 3                 0                 0
##        3                 0                 0                 0
##
## clusters 0.505076829301903 0.509143820597974 0.513210811894044
##        1                 0                 3                 1
##        2                 1                 0                 1
##        3                 0                 0                 0
##
## clusters 0.517277803190114 0.521344794486184 0.525411785782254
##        1                 1                 1                 1
##        2                 1                 1                 1
##        3                 0                 0                 0
##
## clusters 0.529478777078325 0.533545768374395 0.537612759670465
##        1                 1                 3                 3
##        2                 3                 2                 0
##        3                 0                 0                 0
##
## clusters 0.541679750966535 0.545746742262606 0.549813733558676
##        1                 0                 5                 3
##        2                 1                 2                 2
##        3                 0                 0                 1
##
## clusters 0.553880724854746 0.557947716150816 0.562014707446887
##        1                 6                 3                 1
##        2                 1                 0                 1
##        3                 0                 0                 0
##
## clusters 0.566081698742957 0.570148690039027 0.574215681335097
##        1                 1                 0                 1
##        2                 3                 3                 1
##        3                 0                 0                 0
##
```

```
## clusters 0.578282672631168 0.582349663927238 0.590483646519378
##        1                 2                 1                 1
##        2                 2                 0                 3
##        3                 0                 0                 0
##
## clusters 0.594550637815449 0.598617629111519 0.602684620407589
##        1                 0                 1                 2
##        2                 3                 5                 4
##        3                 0                 1                 0
##
## clusters 0.606751611703659 0.61895258559187 0.62301957688794 0.627086568184011
##        1                 1                 0                 1                 4
##        2                 1                 2                 3                 3
##        3                 0                 0                 0                 0
##
## clusters 0.631153559480081 0.635220550776151 0.639287542072221
##        1                 1                 1                 0
##        2                 1                 3                 5
##        3                 0                 0                 0
##
## clusters 0.643354533368292 0.647421524664362 0.651488515960432
##        1                 0                 0                 0
##        2                 2                 2                 2
##        3                 0                 0                 0
##
## clusters 0.659622498552572 0.663689489848643 0.667756481144713
##        1                 2                 0                 0
##        2                 0                 3                 1
##        3                 0                 0                 0
##
## clusters 0.671823472440783 0.675890463736853 0.679957455032924
##        1                 0                 0                 0
##        2                 1                 3                 2
##        3                 0                 0                 0
##
## clusters 0.684024446328994 0.688091437625064 0.692158428921135
##        1                 0                 0                 1
##        2                 2                 1                 0
##        3                 0                 0                 0
##
## clusters 0.696225420217205 0.700292411513275 0.704359402809345
##        1                 1                 0                 0
##        2                 0                 2                 1
##        3                 0                 0                 0
##
## clusters 0.708426394105416 0.712493385401486 0.716560376697556
##        1                 0                 0                 0
##        2                 1                 2                 2
##        3                 0                 0                 0
##
## clusters 0.720627367993626 0.724694359289696 0.728761350585767
##        1                 1                 0                 2
##        2                 2                 6                 1
##        3                 0                 0                 0
```

```
##
## clusters 0.732828341881837 0.740962324473977 0.745029315770048
##        1                 2                 0                 1
##        2                 0                 2                 2
##        3                 0                 0                 0
##
## clusters 0.749096307066118 0.753163298362188 0.761297280954329
##        1                 1                 0                 0
##        2                 1                 4                 3
##        3                 0                 0                 0
##
## clusters 0.765364272250399 0.769431263546469 0.773498254842539 0.77756524613861
##        1                 1                 3                 1                2
##        2                 0                 1                 1                2
##        3                 0                 0                 0                0
##
## clusters 0.78569922873075 0.793833211322891 0.797900202618961 0.801967193915031
##        1                0                 2                 0                0
##        2                2                 2                 1                2
##        3                0                 0                 0                0
##
## clusters 0.818235159099312 0.822302150395382 0.826369141691453
##        1                 1                 0                 0
##        2                 0                 2                 2
##        3                 0                 0                 1
##
## clusters 0.850771089467874 0.862972063356085 0.867039054652155
##        1                 1                 0                 1
##        2                 0                 1                 1
##        3                 0                 0                 0
##
## clusters 0.871106045948225 0.875173037244295 0.887374011132506
##        1                 0                 1                 0
##        2                 2                 3                 2
##        3                 0                 0                 0
##
## clusters 0.891441002428576 0.899574985020717 0.907708967612857
##        1                 0                 1                 1
##        2                 1                 0                 0
##        3                 0                 0                 0
##
## clusters 0.911775958908928 0.915842950204998 0.919909941501068
##        1                 2                 1                 1
##        2                 1                 0                 2
##        3                 0                 0                 0
##
## clusters 0.923976932797138 0.928043924093209 0.932110915389279
##        1                 0                 0                 0
##        2                 0                 1                 3
##        3                 1                 0                 0
##
## clusters 0.936177906685349 0.94431188927749 0.94837888057356 0.95244587186963
##        1                 1                1                0                2
##        2                 1                0                1                0
```

```
##        3                 0                0                0                0
##
## clusters 0.960579854461771 0.964646845757841 0.972780828349981
##        1                 1                1                0
##        2                 2                1                1
##        3                 0                0                0
##
## clusters 0.976847819646052 0.980914810942122 0.984981802238192
##        1                 1                1                0
##        2                 0                0                1
##        3                 0                0                0
##
## clusters 0.997182776126403 1.00124976742247 1.01751773260675 1.02158472390282
##        1                 0                0                0                0
##        2                 1                2                1                1
##        3                 0                0                0                0
##
## clusters 1.03378569779104 1.03785268908711 1.04191968038318 1.04598667167925
##        1                 0                0                0                0
##        2                 1                2                1                2
##        3                 0                0                0                0
##
## clusters 1.05818764556746 1.0663216281596 1.07038861945567 1.07445561075174
##        1                 1                3                0                0
##        2                 3                1                1                2
##        3                 0                0                0                0
##
## clusters 1.07852260204781 1.08258959334388 1.09479056723209 1.10292454982423
##        1                 0                0                1                0
##        2                 3                2                3                4
##        3                 0                0                0                0
##
## clusters 1.11105853241637 1.11512552371244 1.11919251500851 1.12325950630458
##        1                 0                0                0                0
##        2                 2                2                1                1
##        3                 0                0                0                0
##
## clusters 1.12732649760065 1.13139348889672 1.147661454081 1.15579543667314
##        1                 1                0              0                0
##        2                 1                1              1                1
##        3                 0                0              0                0
##
## clusters 1.15986242796921 1.17206340185742 1.17613039315349 1.18426437574563
##        1                 0                0                0                1
##        2                 2                1                1                0
##        3                 0                0                0                0
##
## clusters 1.19239835833777 1.19646534963384 1.22493428870634 1.22900128000241
##        1                 0                5                0                0
##        2                 1                2                0                1
##        3                 0                0                1                0
##
## clusters 1.23713526259455 1.24120225389062 1.24933623648276 1.25340322777883
##        1                 0                0                0                0
```

```
##        2                1                2                2                1
##        3                0                0                0                0
##
## clusters 1.26967119296311 1.27373818425918 1.27780517555525 1.28187216685132
##        1                2                0                0                0
##        2                0                2                1                1
##        3                0                0                1                0
##
## clusters 1.30220712333167 1.30627411462774 1.32660907110809 1.33067606240416
##        1                0                0                1                2
##        2                2                4                1                0
##        3                0                0                0                0
##
## clusters 1.34287703629237 1.34694402758844 1.35101101888451 1.35914500147665
##        1                0                0                0                0
##        2                1                1                1                2
##        3                0                0                0                0
##
## clusters 1.36321199277272 1.36727898406879 1.38354694925308 1.39981491443736
##        1                0                0                0                0
##        2                1                2                1                2
##        3                0                0                0                0
##
## clusters 1.40388190573343 1.41608287962164 1.42828385350985 1.43641783610199
##        1                1                0                1                0
##        2                0                1                0                1
##        3                0                0                0                0
##
## clusters 1.44048482739806 1.44455181869413 1.4486188099902 1.45268580128627
##        1                0                0               0                0
##        2                1                2               1                1
##        3                0                0               0                0
##
## clusters 1.45675279258234 1.46895376647055 1.47302075776662 1.47708774906269
##        1                0                0                1                0
##        2                1                1                0                0
##        3                0                0                0                1
##
## clusters 1.5299586359116 1.5584275749841 1.56249456628017 1.57469554016838
##        1               0               0                0                0
##        2               1               1                1                1
##        3               0               0                0                0
##
## clusters 1.57876253146445 1.58282952276052 1.58689651405659 1.59096350535266
##        1                0                0                0                0
##        2                1                1                1                3
##        3                0                0                0                0
##
## clusters 1.60723147053694 1.61129846183301 1.61536545312908 1.62349943572122
##        1                0                0                0                0
##        2                1                1                1                2
##        3                0                0                0                0
##
## clusters 1.63570040960943 1.6397674009055 1.64383439220157 1.64790138349764
```

```
##        1                0               0                0                1
##        2                2               1                1                0
##        3                0               0                0                0
##
## clusters 1.65603536608978 1.66823633997799 1.69670527905048 1.7089062529387
##        1                0               0                1                1
##        2                1               1                0                1
##        3                0               0                0                1
##
## clusters 1.72110722682691 1.72517421812298 1.72924120941905 1.74144218330726
##        1                0               1                0                1
##        2                1               1                0                0
##        3                0               0                1                0
##
## clusters 1.74550917460333 1.76177713978761 1.76584413108368 1.78211209626796
##        1                0               0                0                0
##        2                2               1                1                1
##        3                0               0                0                0
##
## clusters 1.78617908756403 1.80244705274831 1.81871501793259 1.82278200922866
##        1                0               0                0                0
##        2                1               2                2                2
##        3                0               0                0                0
##
## clusters 1.83498298311687 1.83904997441294 1.84311696570901 1.85125094830115
##        1                0               0                0                0
##        2                1               1                1                1
##        3                0               0                0                0
##
## clusters 1.85531793959722 1.86751891348544 1.87158590478151 1.89192086126186
##        1                0               0                0                0
##        2                1               1                1                3
##        3                0               0                0                0
##
## clusters 1.900054843854 1.92038980033435 1.92445679163042 1.93665776551863
##        1               0               0                0                0
##        2               1               1                3                1
##        3               0               0                0                0
##
## clusters 2.0220645827361 2.07086847828895 2.09933741736144 2.11560538254572
##        1               0               0                0                0
##        2               1               1                1                1
##        3               0               0                0                0
##
## clusters 2.11967237384179 2.12373936513786 2.13594033902607 2.15627529550642
##        1                0               0                0                0
##        2                1               1                1                1
##        3                0               0                0                0
##
## clusters 2.16847626939463 2.1725432606907 2.18067724328284 2.18474423457891
##        1                0               0                0                0
##        2                1               1                1                1
##        3                0               0                0                0
##
```

```
## clusters 2.23761512142783 2.25388308661211 2.26201706920425 2.27015105179639
##        1                0                0                0                0
##        2                2                1                1                1
##        3                0                0                0                0
##
## clusters 2.33928990382958 2.38402680808636 2.38809379938243 2.39622778197457
##        1                0                0                0                0
##        2                1                1                1                3
##        3                0                0                0                0
##
## clusters 2.41656273845492 2.42469672104706 2.42876371234313 2.4328307036392
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 2.46129964271169 2.46943362530383 2.50603654696846 2.53043849474488
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 2.56704141640952 2.60364433807415 2.61584531196236 2.61991230325843
##        1                0                0                0                0
##        2                2                2                1                1
##        3                0                0                0                0
##
## clusters 2.6239792945545 2.63618026844271 2.65651522492306 2.67685018140341
##        1               0                0                0                0
##        2               1                1                1                1
##        3               0                0                0                0
##
## clusters 2.70125212917983 2.72158708566019 2.75005602473268 2.75412301602875
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 2.75819000732482 2.76632398991696 2.78665894639731 2.79479292898945
##        1                0                0                0                0
##        2                1                1                1                2
##        3                0                0                0                0
##
## clusters 2.79885992028552 2.86393178102264 2.88019974620693 2.89240072009514
##        1                0                0                0                0
##        2                1                1                2                1
##        3                0                0                0                0
##
## clusters 2.90460169398335 2.91680266787156 2.92086965916763 2.94120461564798
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 2.94527160694405 2.98187452860868 3.01034346768117 3.03881240675366
##        1                0                0                0                0
##        2                1                1                3                1
##        3                0                0                0                0
```

```
##
## clusters 3.05914736323402 3.06321435453009 3.06728134582616 3.13642019785935
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 3.17709011082005 3.18115710211612 3.1974250673004 3.22182701507683
##        1                0                0               0                0
##        2                1                1               1                2
##        3                0                0               0                0
##
## clusters 3.29096586711002 3.30316684099823 3.32756878877465 3.33570277136679
##        1                0                0                0                0
##        2                1                1                1                1
##        3                0                0                0                0
##
## clusters 3.36417171043928 3.46584649284104 3.48211445802532 3.52685136228209
##        1                0                0                0                0
##        2                1                1                2                1
##        3                0                0                0                0
##
## clusters 3.58378924042708 3.67326304894062 3.74646889226989 3.85221066596771
##        1                0                0                0                0
##        2                1                2                1                1
##        3                0                0                0                0
##
## clusters 3.96201943096161 4.2507758129826 4.62087202092499 4.64934095999748
##        1                0               0                0                0
##        2                1               1                1                1
##        3                0               0                0                0
##
## clusters 4.66560892518176 4.72254680332675 4.85269052480099 4.90149442035384
##        1                0                0                0                0
##        2                1                1                1                2
##        3                0                0                0                0
##
## clusters 4.91369539424205 4.99910221145952 5.01130318534773 5.0153701766438
##        1                0                0                0               0
##        2                1                1                1               1
##        3                0                0                0               0
##
## clusters 5.01943716793987 5.02350415923594 5.03163814182808 5.10077699386128
##        1                0                0                0                0
##        2                2                1                1                1
##        3                0                0                0                0
##
## clusters 5.11704495904556 5.21058575885518 5.45460523661939 5.6172848884622
##        1                0                0                0               0
##        2                1                1                1               1
##        3                0                0                0               0
##
## clusters 5.75962958382466 6.24360154805702 6.95125803357324 7.6670485016816
##        1                0                0                0               0
##        2                1                1                1               1
```

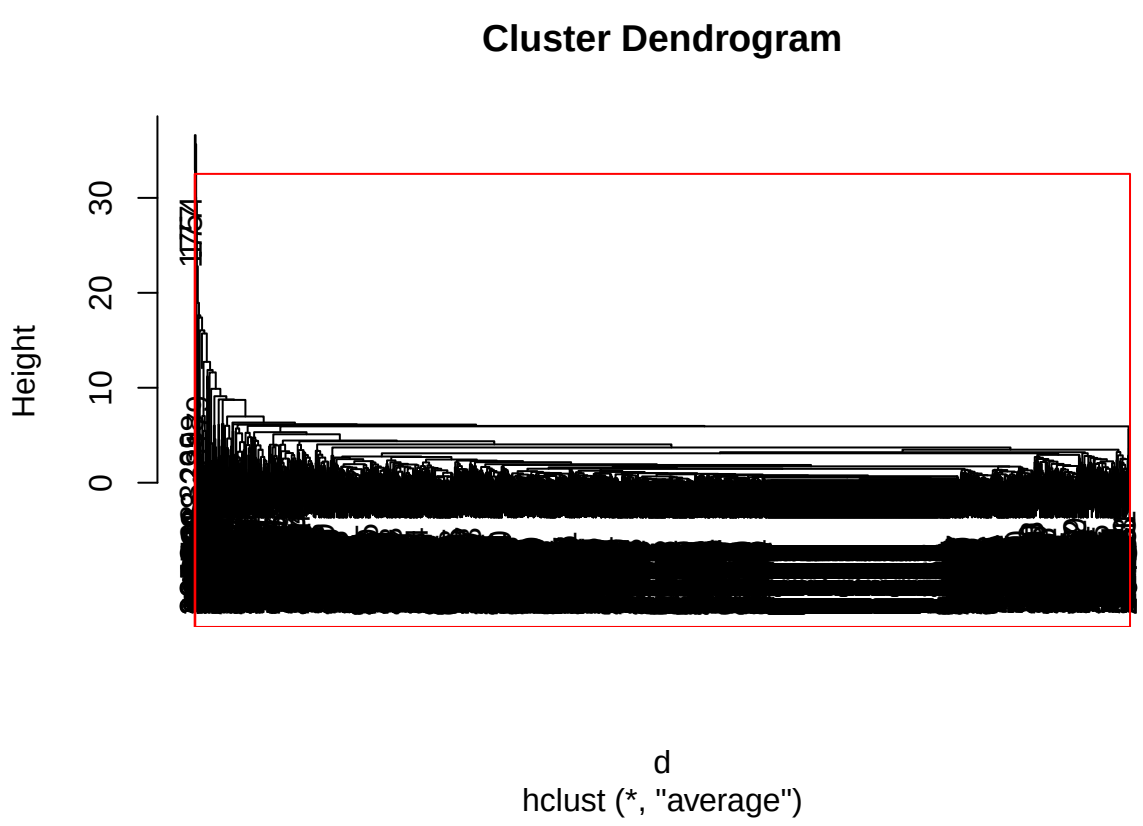
```
##         3                0                0                0                0
##
## clusters 7.98020683147901 9.16776828993152 12.4010263703074 12.9500701952768
##         1                0                0                0                0
##         2                1                1                1                1
##         3                0                0                0                0
##
## clusters 13.1330848036 16.028782606402 21.2467324392601 24.1058273203975
##         1             0               0               0               0
##         2             1               1               2               1
##         3             0               0               0               0
```

```
H.ward.accuracy <- sum(diag(H.ward.cm)) / sum(H.ward.cm)
print(H.ward.accuracy)
```

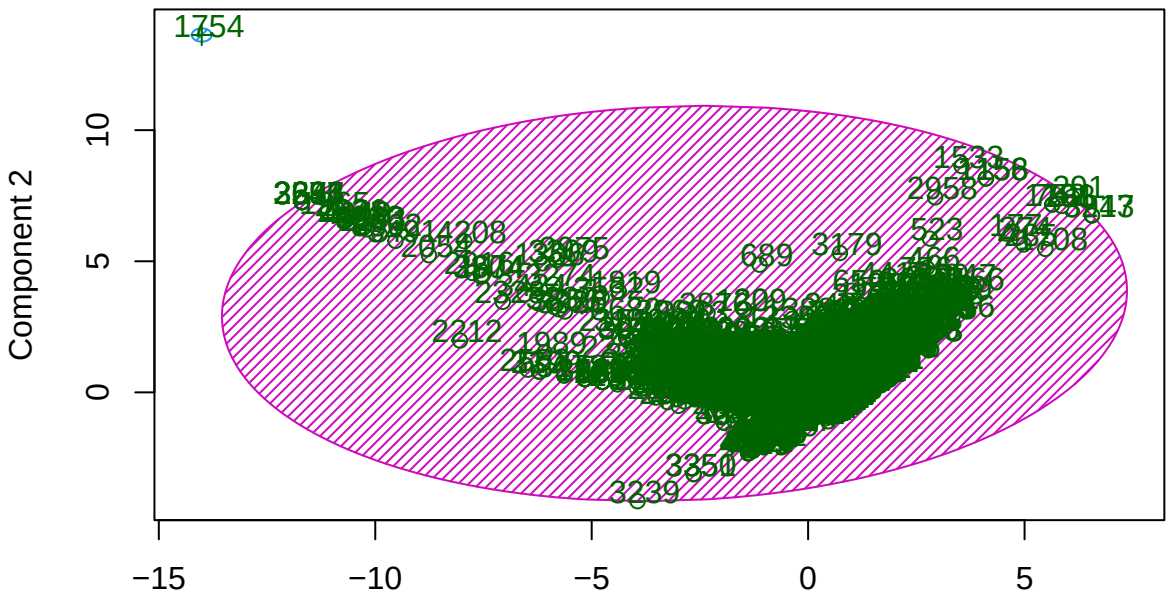
```
## [1] 0.3466638
```

```
# H.Average
set.seed(123)

H.fit <- hclust(d, method="average")
plot(H.fit)
rect.hclust(H.fit, k=3, border="red")
```




```
groups <- cutree(H.fit, k=3)
clusplot(loq, groups, main='2D representation of the Cluster solution',color=TRUE, shade=TRUE,labels=3,
```



These two components explain 25.97 % of the point variability.

```
clusters = factor(groups)

H.average.cm <- table(clusters , loq[,ncol(loq)])
print(H.average.cm)
```

```
##
## clusters -0.308321429912146 -0.296120456023935 -0.292053464727865
##        1                3200                   1                   1
##        2                   1                   0                   0
##        3                   0                   0                   0
##
## clusters -0.287986473431794 -0.283919482135724 -0.279852490839654
##        1                   4                   2                   2
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.275785499543584 -0.271718508247513 -0.267651516951443
##        1                   3                   3                   2
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.263584525655373 -0.259517534359303 -0.255450543063232
##        1                   4                   2                   8
##        2                   0                   0                   0
##        3                   0                   0                   0
##
```

```
## clusters -0.251383551767162 -0.247316560471092 -0.243249569175022
##        1                  12                   6                   9
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.239182577878951 -0.235115586582881 -0.231048595286811
##        1                   6                   4                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.226981603990741 -0.22291461269467 -0.2188476213986
##        1                   2                  8                9
##        2                   0                  0                0
##        3                   0                  0                0
##
## clusters -0.21478063010253 -0.21071363880646 -0.206646647510389
##        1                  6                  8                  3
##        2                  0                  0                  0
##        3                  0                  0                  0
##
## clusters -0.202579656214319 -0.198512664918249 -0.194445673622179
##        1                   3                   6                   3
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.190378682326108 -0.186311691030038 -0.182244699733968
##        1                   6                   8                  13
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.178177708437898 -0.174110717141827 -0.170043725845757
##        1                   8                   5                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.165976734549687 -0.161909743253617 -0.157842751957546
##        1                   1                   7                   7
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.153775760661476 -0.149708769365406 -0.145641778069336
##        1                   4                   3                   5
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.141574786773265 -0.137507795477195 -0.133440804181125
##        1                   7                   3                   6
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.129373812885055 -0.125306821588985 -0.121239830292914
##        1                   4                   5                   8
##        2                   0                   0                   0
##        3                   0                   0                   0
```

```
##
## clusters -0.117172838996844 -0.113105847700774 -0.109038856404704
##        1                  3                  7                  3
##        2                  0                  0                  0
##        3                  0                  0                  0
##
## clusters -0.104971865108633 -0.100904873812563 -0.0968378825164928
##        1                  6                  4                  3
##        2                  0                  0                  0
##        3                  0                  0                  0
##
## clusters -0.0927708912204226 -0.0887038999243523 -0.0846369086282821
##        1                   7                   7                   5
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0805699173322118 -0.0765029260361416 -0.0724359347400713
##        1                   9                   4                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0683689434440011 -0.0643019521479309 -0.0602349608518606
##        1                   7                   2                  15
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0561679695557904 -0.0521009782597201 -0.0480339869636499
##        1                  10                   9                   3
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0439669956675796 -0.0399000043715094 -0.0358330130754392
##        1                   7                   4                   5
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0317660217793689 -0.0276990304832987 -0.0236320391872284
##        1                   4                   5                   2
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters -0.0195650478911582 -0.015498056595088 -0.0114310652990177
##        1                   6                  2                   2
##        2                   0                  0                   0
##        3                   0                  0                   0
##
## clusters -0.00736407400294748 -0.00329708270687723 0.000769908589193018
##        1                    1                    6                    2
##        2                    0                    0                    0
##        3                    0                    0                    0
##
## clusters 0.00483689988526327 0.00890389118133351 0.0129708824774038
##        1                   3                   2                   6
##        2                   0                   0                   0
```

```
##        3                   0                   0                   0
##
## clusters 0.017037873773474 0.0211048650695443 0.0251718563656145
##        1                   5                   1                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0292388476616848 0.033305838957755 0.0373728302538252
##        1                   2                   3                   5
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0414398215498954 0.0455068128459657 0.0495738041420359
##        1                   4                   3                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0536407954381062 0.0577077867341764 0.0617747780302467
##        1                   1                   3                   1
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0658417693263169 0.0699087606223872 0.0739757519184574
##        1                   2                   4                   5
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0780427432145277 0.0861767258066682 0.0943107083988086
##        1                   2                   3                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.0983776996948789 0.102444690990949 0.106511682287019
##        1                   2                   5                   1
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.11057867358309 0.11464566487916 0.11871265617523 0.1227796474713
##        1                7                3                9                5
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 0.126846638767371 0.130913630063441 0.134980621359511
##        1                   9                   3                   7
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.139047612655581 0.143114603951652 0.147181595247722
##        1                   4                   5                   4
##        2                   0                   0                   0
##        3                   0                   0                   0
##
## clusters 0.151248586543792 0.155315577839862 0.163449560432003
##        1                   2                   8                   5
```

```
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.167516551728073 0.171583543024143 0.175650534320213
##        1                 5                16                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.179717525616284 0.183784516912354 0.187851508208424
##        1                 3                 7                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.191918499504494 0.195985490800565 0.200052482096635
##        1                 2                 6                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.204119473392705 0.208186464688775 0.212253455984846
##        1                 2                 6                 7
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.216320447280916 0.220387438576986 0.224454429873056
##        1                 4                 2                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.228521421169127 0.232588412465197 0.236655403761267
##        1                 7                 4                 4
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.240722395057337 0.244789386353408 0.248856377649478
##        1                 5                 3                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.252923368945548 0.256990360241618 0.261057351537689
##        1                 3                 1                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.265124342833759 0.269191334129829 0.273258325425899 0.27732531672197
##        1                 8                 3                 2                1
##        2                 0                 0                 0                0
##        3                 0                 0                 0                0
##
## clusters 0.28139230801804 0.28545929931411 0.28952629061018 0.293593281906251
##        1                4                3                5                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 0.297660273202321 0.301727264498391 0.305794255794461
```

```
##        1                 4                 5                 4
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.309861247090532 0.313928238386602 0.317995229682672
##        1                 2                 1                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.322062220978742 0.326129212274813 0.330196203570883
##        1                 3                 5                 9
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.334263194866953 0.338330186163023 0.342397177459094
##        1                12                 7                 9
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.346464168755164 0.350531160051234 0.354598151347304
##        1                 6                 6                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.358665142643375 0.362732133939445 0.366799125235515
##        1                 2                 8                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.370866116531585 0.374933107827655 0.379000099123726
##        1                 8                 8                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.383067090419796 0.387134081715866 0.391201073011936
##        1                 5                 6                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.395268064308007 0.399335055604077 0.403402046900147
##        1                 4                 4                 5
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.407469038196217 0.411536029492288 0.415603020788358
##        1                 3                 3                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.419670012084428 0.423737003380498 0.427803994676569
##        1                 1                 5                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
```

```
## clusters 0.431870985972639 0.435937977268709 0.440004968564779 0.44407195986085
##        1                 7                 3                 6                2
##        2                 0                 0                 0                0
##        3                 0                 0                 0                0
##
## clusters 0.44813895115692 0.45220594245299 0.45627293374906 0.460339925045131
##        1                5                 1                 4                4
##        2                0                 0                 0                0
##        3                0                 0                 0                0
##
## clusters 0.468473907637271 0.472540898933341 0.476607890229412
##        1                 9                 3                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.480674881525482 0.484741872821552 0.488808864117622
##        1                 1                 1                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.492875855413693 0.496942846709763 0.501009838005833
##        1                 5                 2                 4
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.505076829301903 0.509143820597974 0.513210811894044
##        1                 1                 3                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.517277803190114 0.521344794486184 0.525411785782254
##        1                 2                 2                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.529478777078325 0.533545768374395 0.537612759670465
##        1                 4                 5                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.541679750966535 0.545746742262606 0.549813733558676
##        1                 1                 7                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.553880724854746 0.557947716150816 0.562014707446887
##        1                 7                 3                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.566081698742957 0.570148690039027 0.574215681335097
##        1                 4                 3                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
```

```
##
## clusters 0.578282672631168 0.582349663927238 0.590483646519378
##        1                 4                 1                 4
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.594550637815449 0.598617629111519 0.602684620407589
##        1                 3                 7                 6
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.606751611703659 0.61895258559187 0.62301957688794 0.627086568184011
##        1                 2                2                4                 7
##        2                 0                0                0                 0
##        3                 0                0                0                 0
##
## clusters 0.631153559480081 0.635220550776151 0.639287542072221
##        1                 2                 4                 5
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.643354533368292 0.647421524664362 0.651488515960432
##        1                 2                 2                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.659622498552572 0.663689489848643 0.667756481144713
##        1                 2                 3                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.671823472440783 0.675890463736853 0.679957455032924
##        1                 1                 3                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.684024446328994 0.688091437625064 0.692158428921135
##        1                 2                 1                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.696225420217205 0.700292411513275 0.704359402809345
##        1                 1                 2                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.708426394105416 0.712493385401486 0.716560376697556
##        1                 1                 2                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.720627367993626 0.724694359289696 0.728761350585767
##        1                 3                 6                 3
##        2                 0                 0                 0
```

```
##        3                 0                 0                 0
##
## clusters 0.732828341881837 0.740962324473977 0.745029315770048
##        1                 2                 2                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.749096307066118 0.753163298362188 0.761297280954329
##        1                 2                 4                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.765364272250399 0.769431263546469 0.773498254842539 0.77756524613861
##        1                 1                 4                 2                 4
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 0.78569922873075 0.793833211322891 0.797900202618961 0.801967193915031
##        1                2                 4                 1                 2
##        2                0                 0                 0                 0
##        3                0                 0                 0                 0
##
## clusters 0.818235159099312 0.822302150395382 0.826369141691453
##        1                 1                 2                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.850771089467874 0.862972063356085 0.867039054652155
##        1                 1                 1                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.871106045948225 0.875173037244295 0.887374011132506
##        1                 2                 4                 2
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.891441002428576 0.899574985020717 0.907708967612857
##        1                 1                 1                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.911775958908928 0.915842950204998 0.919909941501068
##        1                 3                 1                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.923976932797138 0.928043924093209 0.932110915389279
##        1                 1                 1                 3
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.936177906685349 0.94431188927749 0.94837888057356 0.95244587186963
##        1                 2                 1                 1                 2
```

```
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 0.960579854461771 0.964646845757841 0.972780828349981
##        1                 3                 2                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.976847819646052 0.980914810942122 0.984981802238192
##        1                 1                 1                 1
##        2                 0                 0                 0
##        3                 0                 0                 0
##
## clusters 0.997182776126403 1.00124976742247 1.01751773260675 1.02158472390282
##        1                 1                 2                 1                 1
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.03378569779104 1.03785268908711 1.04191968038318 1.04598667167925
##        1                 1                 2                 1                 2
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.05818764556746 1.0663216281596 1.07038861945567 1.07445561075174
##        1                 4                 4                 1                 2
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.07852260204781 1.08258959334388 1.09479056723209 1.10292454982423
##        1                 3                 2                 4                 4
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.11105853241637 1.11512552371244 1.11919251500851 1.12325950630458
##        1                 2                 2                 1                 1
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.12732649760065 1.13139348889672 1.147661454081 1.15579543667314
##        1                 2                 1               1                 1
##        2                 0                 0               0                 0
##        3                 0                 0               0                 0
##
## clusters 1.15986242796921 1.17206340185742 1.17613039315349 1.18426437574563
##        1                 2                 1                 1                 1
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.19239835833777 1.19646534963384 1.22493428870634 1.22900128000241
##        1                 1                 7                 1                 1
##        2                 0                 0                 0                 0
##        3                 0                 0                 0                 0
##
## clusters 1.23713526259455 1.24120225389062 1.24933623648276 1.25340322777883
```

```
##        1                1                2                2                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.26967119296311 1.27373818425918 1.27780517555525 1.28187216685132
##        1                2                2                2                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.30220712333167 1.30627411462774 1.32660907110809 1.33067606240416
##        1                2                4                2                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.34287703629237 1.34694402758844 1.35101101888451 1.35914500147665
##        1                1                1                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.36321199277272 1.36727898406879 1.38354694925308 1.39981491443736
##        1                1                2                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.40388190573343 1.41608287962164 1.42828385350985 1.43641783610199
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.44048482739806 1.44455181869413 1.4486188099902 1.45268580128627
##        1                1                2                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.45675279258234 1.46895376647055 1.47302075776662 1.47708774906269
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.5299586359116 1.5584275749841 1.56249456628017 1.57469554016838
##        1               1               1                1                1
##        2               0               0                0                0
##        3               0               0                0                0
##
## clusters 1.57876253146445 1.58282952276052 1.58689651405659 1.59096350535266
##        1                1                1                1                3
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 1.60723147053694 1.61129846183301 1.61536545312908 1.62349943572122
##        1                1                1                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
```

```
## clusters 1.63570040960943 1.6397674009055 1.64383439220157 1.64790138349764
##        1                2               1                1                 1
##        2                0               0                0                 0
##        3                0               0                0                 0
##
## clusters 1.65603536608978 1.66823633997799 1.69670527905048 1.7089062529387
##        1                1                1                1                 3
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.72110722682691 1.72517421812298 1.72924120941905 1.74144218330726
##        1                1                2                1                 1
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.74550917460333 1.76177713978761 1.76584413108368 1.78211209626796
##        1                2                1                1                 1
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.78617908756403 1.80244705274831 1.81871501793259 1.82278200922866
##        1                1                2                2                 2
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.83498298311687 1.83904997441294 1.84311696570901 1.85125094830115
##        1                1                1                1                 1
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.85531793959722 1.86751891348544 1.87158590478151 1.89192086126186
##        1                1                1                1                 3
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 1.900054843854 1.92038980033435 1.92445679163042 1.93665776551863
##        1               1                1                3                 1
##        2               0                0                0                 0
##        3               0                0                0                 0
##
## clusters 2.0220645827361 2.07086847828895 2.09933741736144 2.11560538254572
##        1                1                1                1                 1
##        2                0                0                0                 0
##        3                0                0                0                 0
##
## clusters 2.11967237384179 2.12373936513786 2.13594033902607 2.15627529550642
##        1                 1                1                1                 1
##        2                 0                0                0                 0
##        3                 0                0                0                 0
##
## clusters 2.16847626939463 2.1725432606907 2.18067724328284 2.18474423457891
##        1                 1               1                1                 1
##        2                 0               0                0                 0
##        3                 0               0                0                 0
```

```
##
## clusters 2.23761512142783 2.25388308661211 2.26201706920425 2.27015105179639
##        1                2                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.33928990382958 2.38402680808636 2.38809379938243 2.39622778197457
##        1                1                1                1                3
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.41656273845492 2.42469672104706 2.42876371234313 2.4328307036392
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.46129964271169 2.46943362530383 2.50603654696846 2.53043849474488
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.56704141640952 2.60364433807415 2.61584531196236 2.61991230325843
##        1                2                2                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.6239792945545 2.63618026844271 2.65651522492306 2.67685018140341
##        1               1                1                1                1
##        2               0                0                0                0
##        3               0                0                0                0
##
## clusters 2.70125212917983 2.72158708566019 2.75005602473268 2.75412301602875
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.75819000732482 2.76632398991696 2.78665894639731 2.79479292898945
##        1                1                1                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.79885992028552 2.86393178102264 2.88019974620693 2.89240072009514
##        1                1                1                2                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.90460169398335 2.91680266787156 2.92086965916763 2.94120461564798
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 2.94527160694405 2.98187452860868 3.01034346768117 3.03881240675366
##        1                1                1                3                1
##        2                0                0                0                0
```

```
##        3                0                0                0                0
##
## clusters 3.05914736323402 3.06321435453009 3.06728134582616 3.13642019785935
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 3.17709011082005 3.18115710211612 3.1974250673004 3.22182701507683
##        1                1                1                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 3.29096586711002 3.30316684099823 3.32756878877465 3.33570277136679
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 3.36417171043928 3.46584649284104 3.48211445802532 3.52685136228209
##        1                1                1                2                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 3.58378924042708 3.67326304894062 3.74646889226989 3.85221066596771
##        1                1                2                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 3.96201943096161 4.2507758129826 4.62087202092499 4.64934095999748
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 4.66560892518176 4.72254680332675 4.85269052480099 4.90149442035384
##        1                1                1                1                2
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 4.91369539424205 4.99910221145952 5.01130318534773 5.0153701766438
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 5.01943716793987 5.02350415923594 5.03163814182808 5.10077699386128
##        1                2                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 5.11704495904556 5.21058575885518 5.45460523661939 5.6172848884622
##        1                1                1                1                1
##        2                0                0                0                0
##        3                0                0                0                0
##
## clusters 5.75962958382466 6.24360154805702 6.95125803357324 7.6670485016816
##        1                1                1                0                1
```

```
##        2                0                0                0               0
##        3                0                0                1               0
##
## clusters 7.98020683147901 9.16776828993152 12.4010263703074 12.9500701952768
##        1                1                1                1               1
##        2                0                0                0               0
##        3                0                0                0               0
##
## clusters 13.1330848036 16.028782606402 21.2467324392601 24.1058273203975
##        1             1               1                2               1
##        2             0               0                0               0
##        3             0               0                0               0
```

```
H.average.accuracy <- sum(diag(H.average.cm)) / sum(H.average.cm)
print(H.average.accuracy)
```

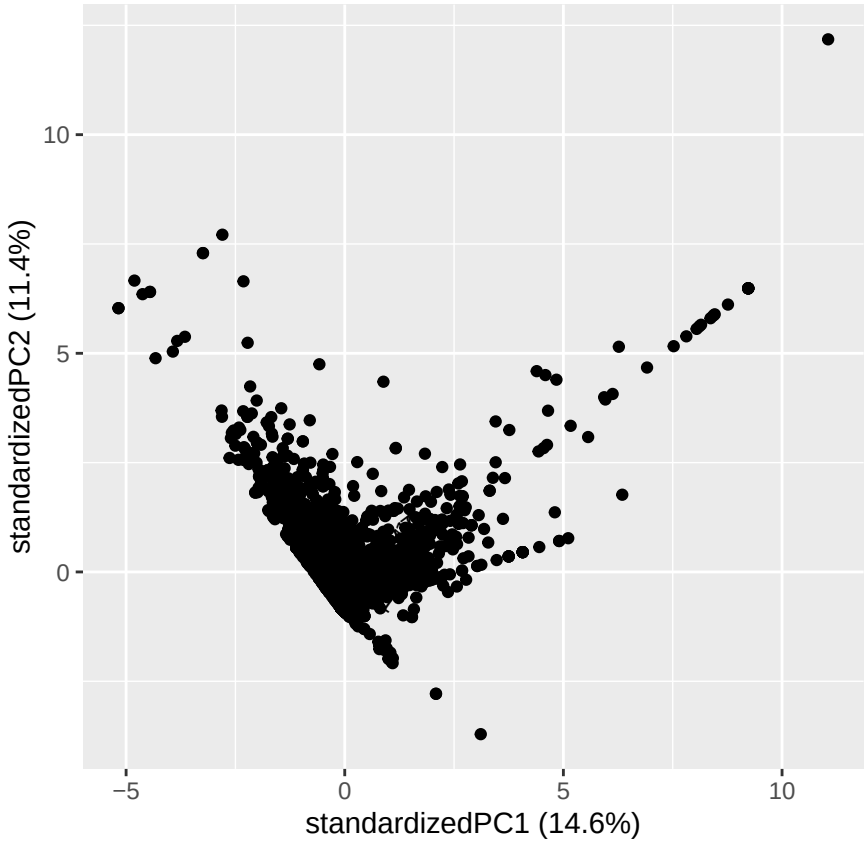
```
## [1] 0.695501
```

Question-2

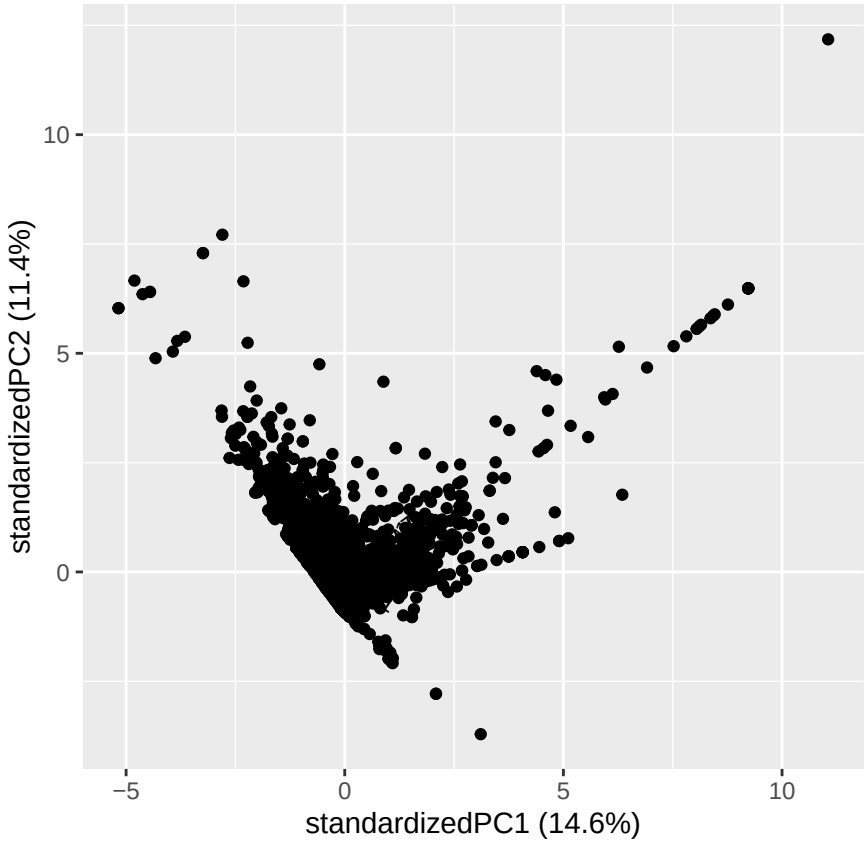
```
#(a)
loq.pca = prcomp(loq, center = TRUE,scale. = TRUE)
summary(loq.pca)
```

```
## Importance of components:
##                           PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     1.2670 1.1188 1.03159 1.00008 0.99649 0.97860 0.96854
## Proportion of Variance 0.1459 0.1138 0.09674 0.09092 0.09027 0.08706 0.08528
## Cumulative Proportion  0.1459 0.2597 0.35646 0.44738 0.53765 0.62471 0.70999
##                           PC8     PC9    PC10    PC11
## Standard deviation     0.9555 0.91644 0.90340 0.78808
## Proportion of Variance 0.0830 0.07635 0.07419 0.05646
## Cumulative Proportion  0.7930 0.86934 0.94354 1.00000
```

```
#(b)
ggbiplot(loq.pca)
```




```
#(c)
ggbiplot(loq.pca, ellipse=TRUE)
```




```
#(d)
print("PC1 as linear combinations of the original variables")
```

```
## [1] "PC1 as linear combinations of the original variables"
```

```
print(loq.pca$rotation[,1]) #PC1
```

```
##          w1          w2          w3          w4          w5          w6
## -0.25436092 -0.29741834 -0.09984371 -0.26575648 -0.12651794  0.52916921
##          w7          w9         w10         w11         w12
##  0.50550385  0.08761412  0.41304460  0.10883783 -0.15671266
```