

breast_cancer_model_analysis.R

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Sat Nov 03 17:35:10 2018

```
setwd("C:/Users/tsraj/Desktop/Acadgild students projects/project4")
library(readr)
CancerData <- read_csv("CancerData.csv")

## Warning: Missing column names filled in: 'X33' [33]

## Parsed with column specification:
## cols(
##   .default = col_double(),
##   id = col_integer(),
##   diagnosis = col_character(),
##   X33 = col_character()
## )

## See spec(...) for full column specifications.

## Warning in rbind(names(probs), probs_f): number of columns of result is
not
## a multiple of vector length (arg 1)

## Warning: 569 parsing failures.
## row # A tibble: 5 x 5 col      row col   expected   actual   file
expected  <int> <chr> <chr>      <chr>      <chr>      actual 1      1
<NA> 33 columns 32 columns 'CancerData.csv' file 2      2 <NA> 33 columns 32
columns 'CancerData.csv' row 3      3 <NA> 33 columns 32 columns
'CancerData.csv' col 4      4 <NA> 33 columns 32 columns 'CancerData.csv'
expected 5      5 <NA> 33 columns 32 columns 'CancerData.csv'

dim(CancerData)

## [1] 569 33

library(mice)

## Loading required package: lattice

##
## Attaching package: 'mice'
```

```
## The following objects are masked from 'package:base':
##
##      cbind, rbind

library(readr,dplyr)
library("ggplot2")
library("corrplot")

## corrplot 0.84 loaded

library("gridExtra")
library("pROC")

## Type 'citation("pROC")' for a citation.

##
## Attaching package: 'pROC'

## The following objects are masked from 'package:stats':
##
##      cov, smooth, var

library("MASS")
library("caTools")
library("caret")
library(randomForest)

## randomForest 4.6-14

## Type rfNews() to see new features/changes/bug fixes.

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:gridExtra':
##
##      combine

## The following object is masked from 'package:ggplot2':
##
##      margin

library(rpart)
library(rpart.plot)
library(rattle)

## Rattle: A free graphical interface for data science with R.
## Version 5.2.0 Copyright (c) 2006-2018 Togaware Pty Ltd.
## Type 'rattle()' to shake, rattle, and roll your data.

##
## Attaching package: 'rattle'
```

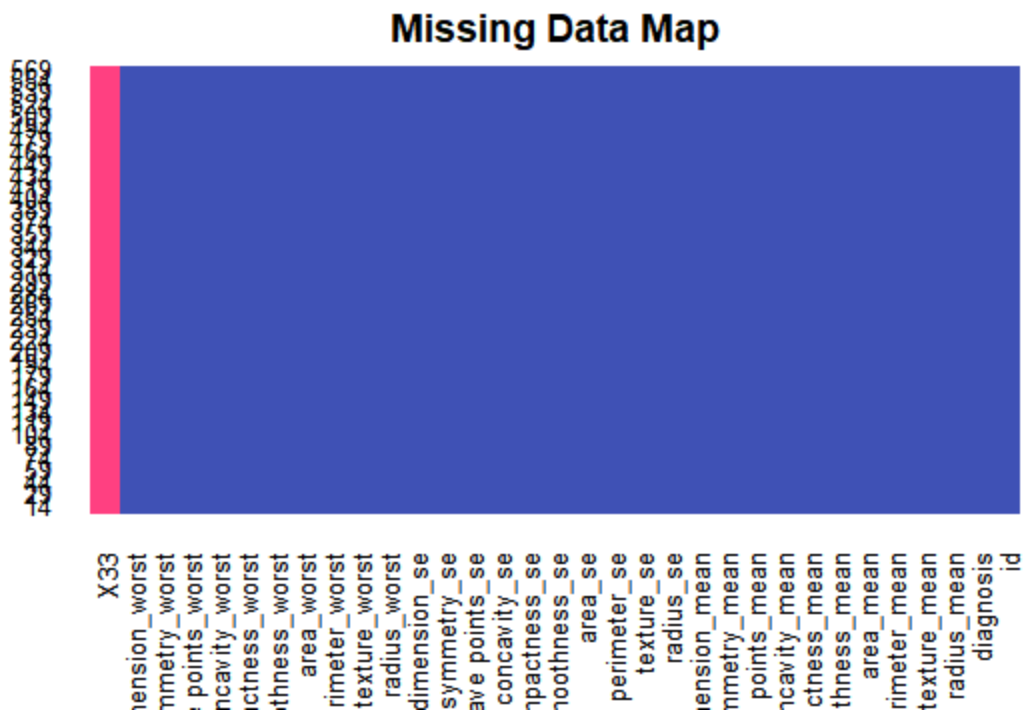
```
## The following object is masked from 'package:randomForest':
##
##      importance

data<-CancerData
library(Amelia)

any(is.na(data))

## [1] TRUE

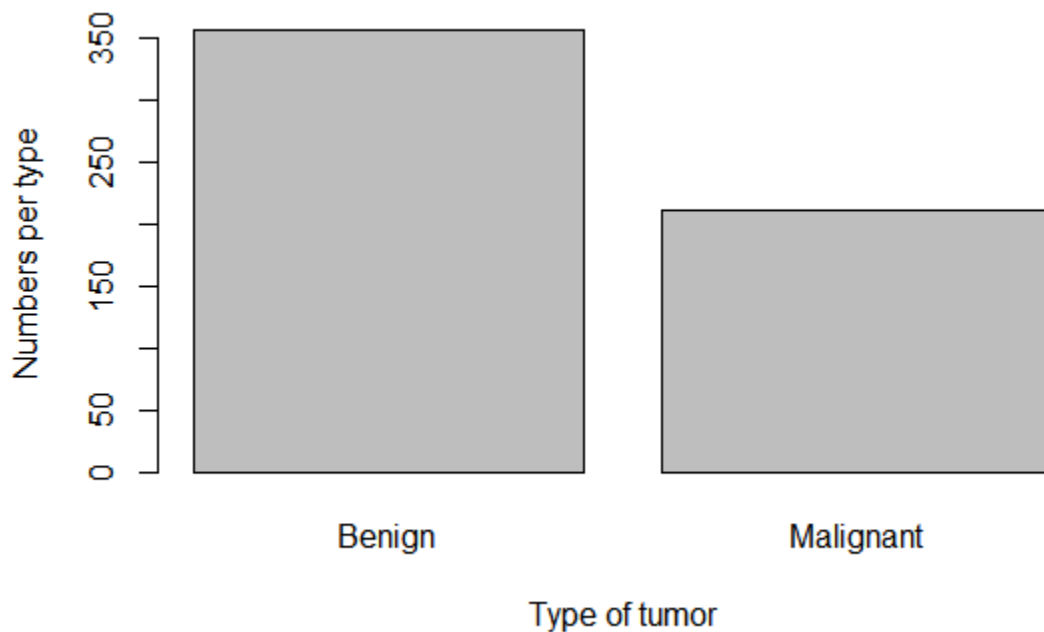
missmap(CancerData, main="Missing Data Map", col=c("#FF4081", "#3F51B5"),
        legend=FALSE)
```



```
data<-CancerData

data[,33]<-NULL

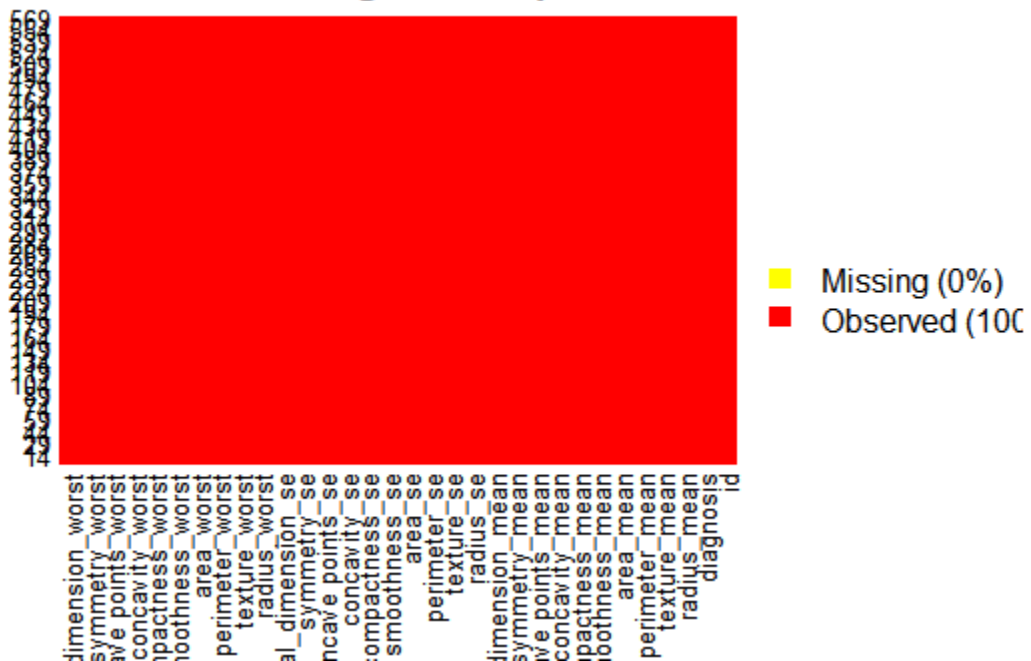
barplot(table(data$diagnosis), xlab = "Type of tumor", ylab="Numbers per type")
```



```
# visualize the missing values using the missing map from the Amelia package
missmap(data,col=c("yellow","red"))
```

```
## Warning in if (class(obj) == "amelia") {: the condition has length > 1 and
## only the first element will be used
```

Missingness Map



```
data$diagnosis<-as.factor(data$diagnosis)
```

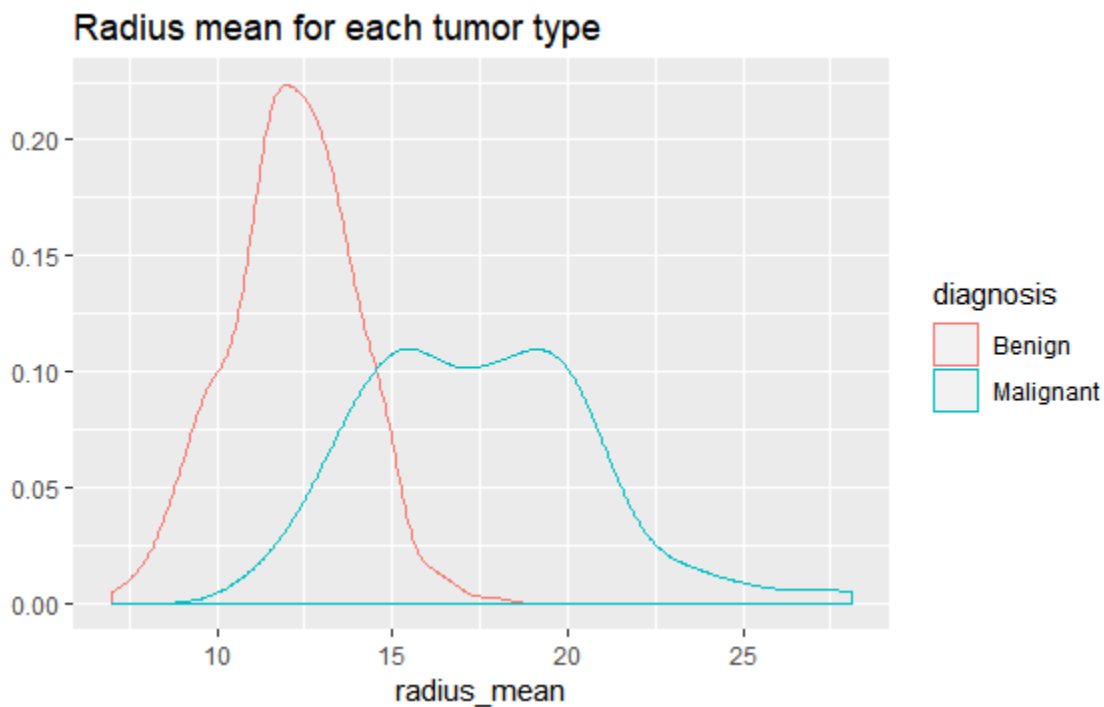
```
data[,33]<-NULL
```

```
summary(data)
```

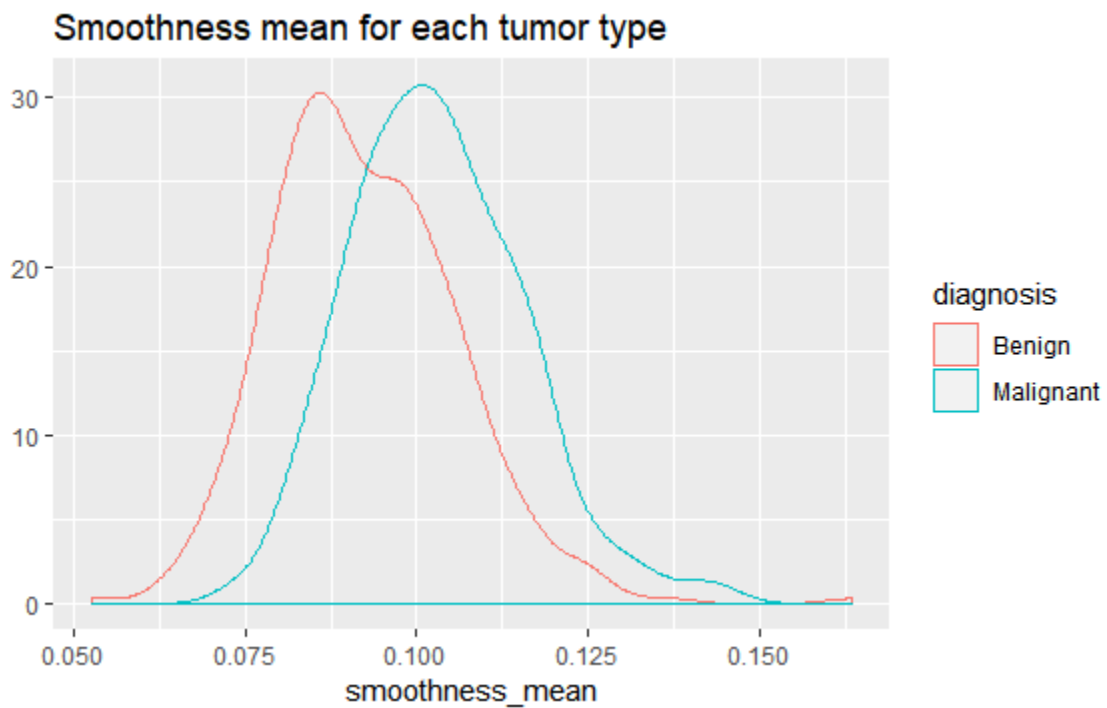
```
##      id      diagnosis radius_mean texture_mean
## Min.   :    8670    B:357   Min.   : 6.981   Min.   : 9.71
## 1st Qu.:   869218   M:212   1st Qu.:11.700  1st Qu.:16.17
## Median :    906024           Median :13.370  Median :18.84
## Mean   :  30371831           Mean   :14.127  Mean   :19.29
## 3rd Qu.:   8813129           3rd Qu.:15.780  3rd Qu.:21.80
## Max.   :911320502           Max.   :28.110  Max.   :39.28
## perimeter_mean area_mean smoothness_mean compactness_mean
## Min.   : 43.79   Min.   : 143.5   Min.   :0.05263   Min.   :0.01938
## 1st Qu.: 75.17   1st Qu.: 420.3   1st Qu.:0.08637   1st Qu.:0.06492
## Median : 86.24   Median : 551.1   Median :0.09587   Median :0.09263
## Mean   : 91.97   Mean   : 654.9   Mean   :0.09636   Mean   :0.10434
## 3rd Qu.:104.10   3rd Qu.: 782.7   3rd Qu.:0.10530   3rd Qu.:0.13040
## Max.   :188.50   Max.   :2501.0   Max.   :0.16340   Max.   :0.34540
## concavity_mean concave points_mean symmetry_mean
## Min.   :0.00000   Min.   :0.00000   Min.   :0.1060
## 1st Qu.:0.02956   1st Qu.:0.02031   1st Qu.:0.1619
## Median :0.06154   Median :0.03350   Median :0.1792
## Mean   :0.08880   Mean   :0.04892   Mean   :0.1812
## 3rd Qu.:0.13070   3rd Qu.:0.07400   3rd Qu.:0.1957
## Max.   :0.42680   Max.   :0.20120   Max.   :0.3040
## fractal_dimension_mean radius_se texture_se perimeter_se
## Min.   :0.04996   Min.   :0.1115   Min.   :0.3602   Min.   : 0.757
## 1st Qu.:0.05770   1st Qu.:0.2324   1st Qu.:0.8339   1st Qu.: 1.606
## Median :0.06154   Median :0.3242   Median :1.1080   Median : 2.287
## Mean   :0.06280   Mean   :0.4052   Mean   :1.2169   Mean   : 2.866
## 3rd Qu.:0.06612   3rd Qu.:0.4789   3rd Qu.:1.4740   3rd Qu.: 3.357
## Max.   :0.09744   Max.   :2.8730   Max.   :4.8850   Max.   :21.980
## area_se smoothness_se compactness_se concavity_se
## Min.   : 6.802   Min.   :0.001713   Min.   :0.002252   Min.   :0.00000
## 1st Qu.: 17.850   1st Qu.:0.005169   1st Qu.:0.013080   1st Qu.:0.01509
## Median : 24.530   Median :0.006380   Median :0.020450   Median :0.02589
## Mean   : 40.337   Mean   :0.007041   Mean   :0.025478   Mean   :0.03189
## 3rd Qu.: 45.190   3rd Qu.:0.008146   3rd Qu.:0.032450   3rd Qu.:0.04205
## Max.   :542.200   Max.   :0.031130   Max.   :0.135400   Max.   :0.39600
## concave points_se symmetry_se fractal_dimension_se
## Min.   :0.000000   Min.   :0.007882   Min.   :0.0008948
## 1st Qu.:0.007638   1st Qu.:0.015160   1st Qu.:0.0022480
## Median :0.010930   Median :0.018730   Median :0.0031870
## Mean   :0.011796   Mean   :0.020542   Mean   :0.0037949
## 3rd Qu.:0.014710   3rd Qu.:0.023480   3rd Qu.:0.0045580
## Max.   :0.052790   Max.   :0.078950   Max.   :0.0298400
```

```
## radius_worst texture_worst perimeter_worst area_worst
## Min. : 7.93 Min. :12.02 Min. : 50.41 Min. : 185.2
## 1st Qu.:13.01 1st Qu.:21.08 1st Qu.: 84.11 1st Qu.: 515.3
## Median :14.97 Median :25.41 Median : 97.66 Median : 686.5
## Mean :16.27 Mean :25.68 Mean :107.26 Mean : 880.6
## 3rd Qu.:18.79 3rd Qu.:29.72 3rd Qu.:125.40 3rd Qu.:1084.0
## Max. :36.04 Max. :49.54 Max. :251.20 Max. :4254.0
## smoothness_worst compactness_worst concavity_worst concave points_worst
## Min. :0.07117 Min. :0.02729 Min. :0.00000 Min. :0.00000
## 1st Qu.:0.11660 1st Qu.:0.14720 1st Qu.:0.1145 1st Qu.:0.06493
## Median :0.13130 Median :0.21190 Median :0.2267 Median :0.09993
## Mean :0.13237 Mean :0.25427 Mean :0.2722 Mean :0.11461
## 3rd Qu.:0.14600 3rd Qu.:0.33910 3rd Qu.:0.3829 3rd Qu.:0.16140
## Max. :0.22260 Max. :1.05800 Max. :1.2520 Max. :0.29100
## symmetry_worst fractal_dimension_worst
## Min. :0.1565 Min. :0.05504
## 1st Qu.:0.2504 1st Qu.:0.07146
## Median :0.2822 Median :0.08004
## Mean :0.2901 Mean :0.08395
## 3rd Qu.:0.3179 3rd Qu.:0.09208
## Max. :0.6638 Max. :0.20750
```

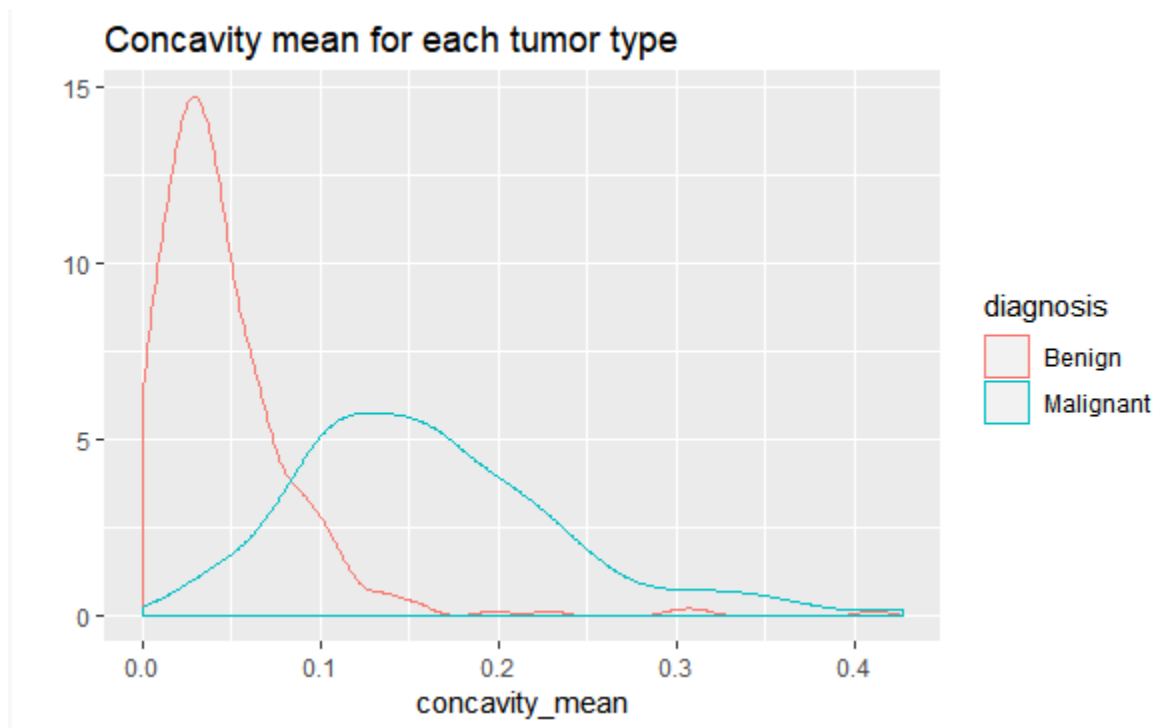
```
qplot(radius_mean, data=data, colour=diagnosis, geom="density",
      main="Radius mean for each tumor type")
```



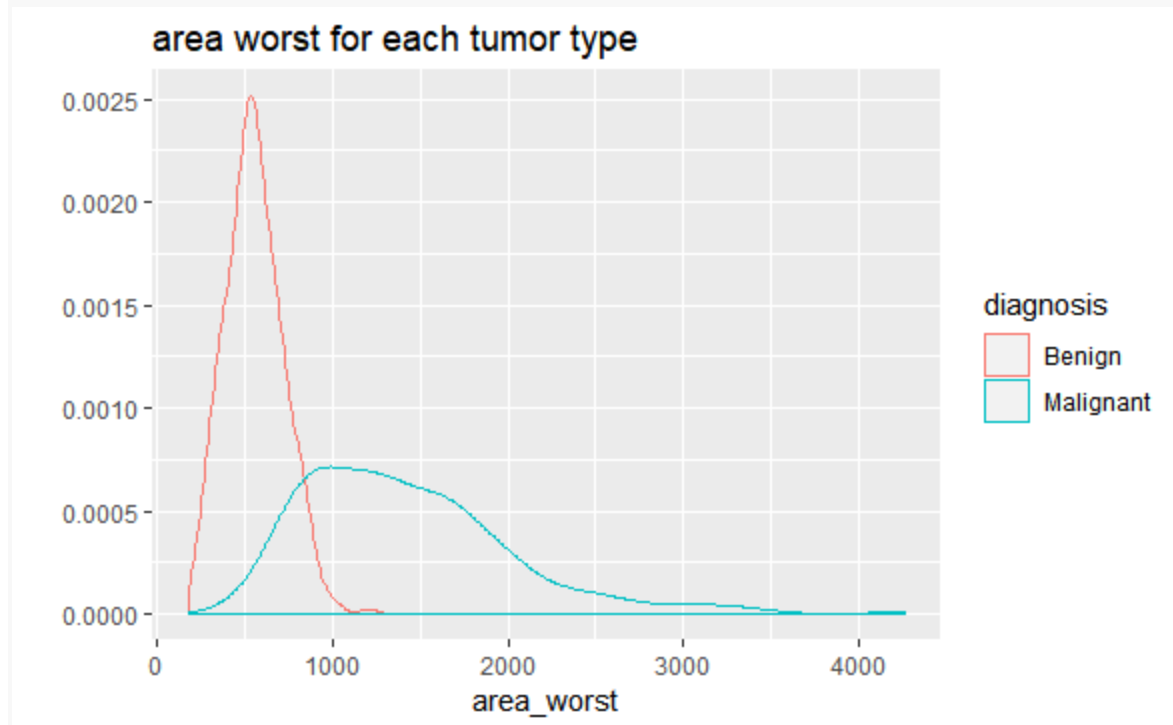
```
qplot(smoothness_mean, data=data, colour=diagnosis, geom="density",  
      main="Smoothness mean for each tumor type")
```



```
qplot(concavity_mean, data=data, colour=diagnosis, geom="density",  
      main="Concavity mean for each tumor type")
```



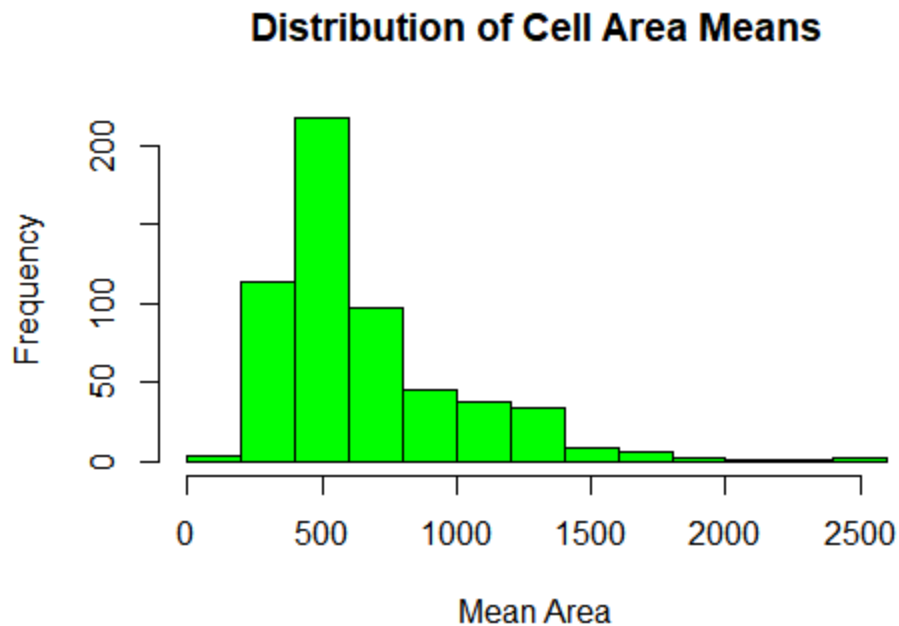
```
qplot(area_worst , data=data, colour=diagnosis, geom="density",  
      main="area worst for each tumor type")
```



```
# Looking at distribution for area.mean variable  
plot.new()
```



```
hist(CancerData$area_mean,
     main = 'Distribution of Cell Area Means',
     xlab = 'Mean Area',
     col = 'green')
```



#we find that the data is imbalanced and also there is a lot of correlation between the attributes

we find that there are no missing values

we find that data is little unbalanced

```
prop.table(table(data$diagnosis))
```

##

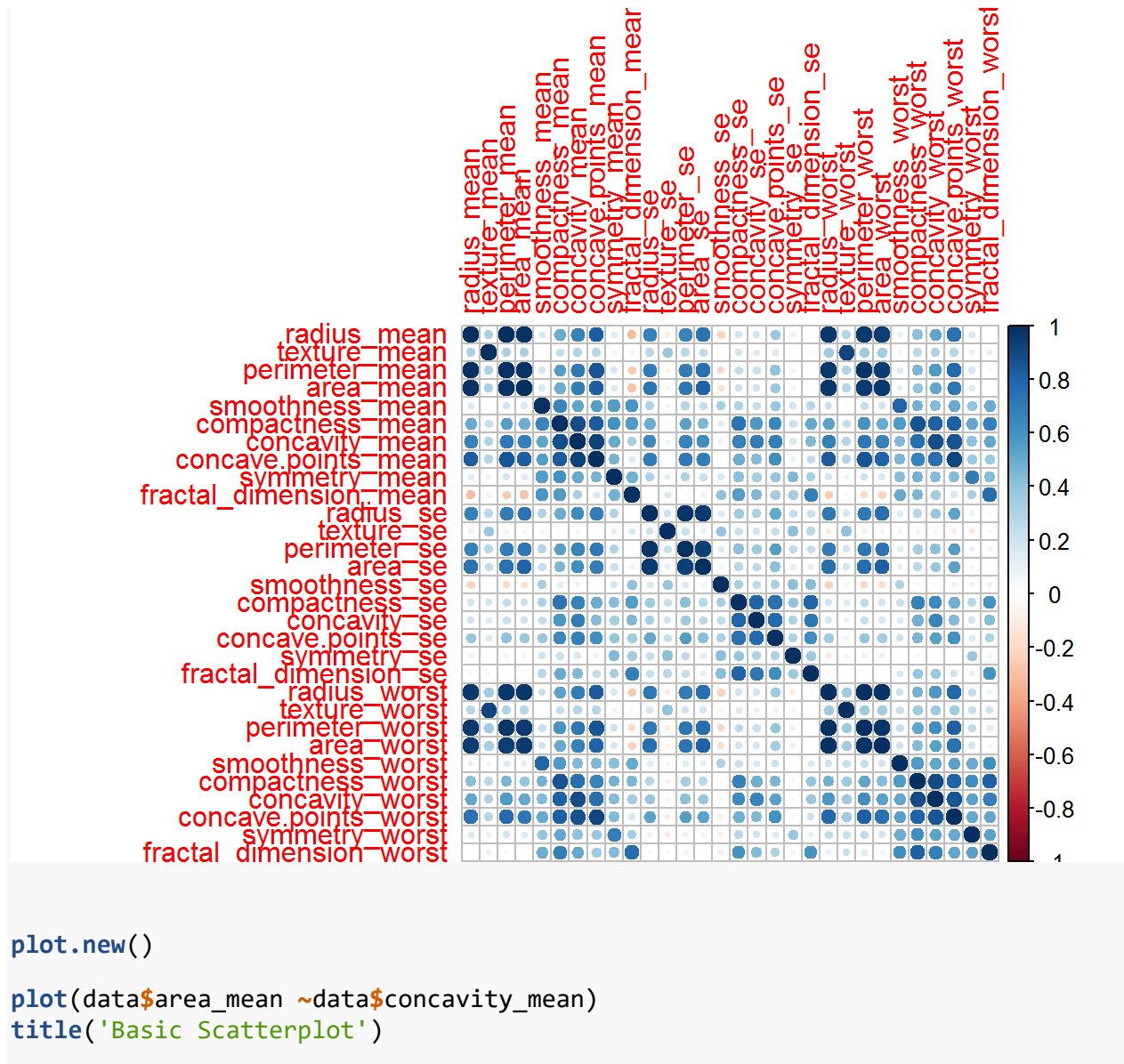
```
##           B           M
```

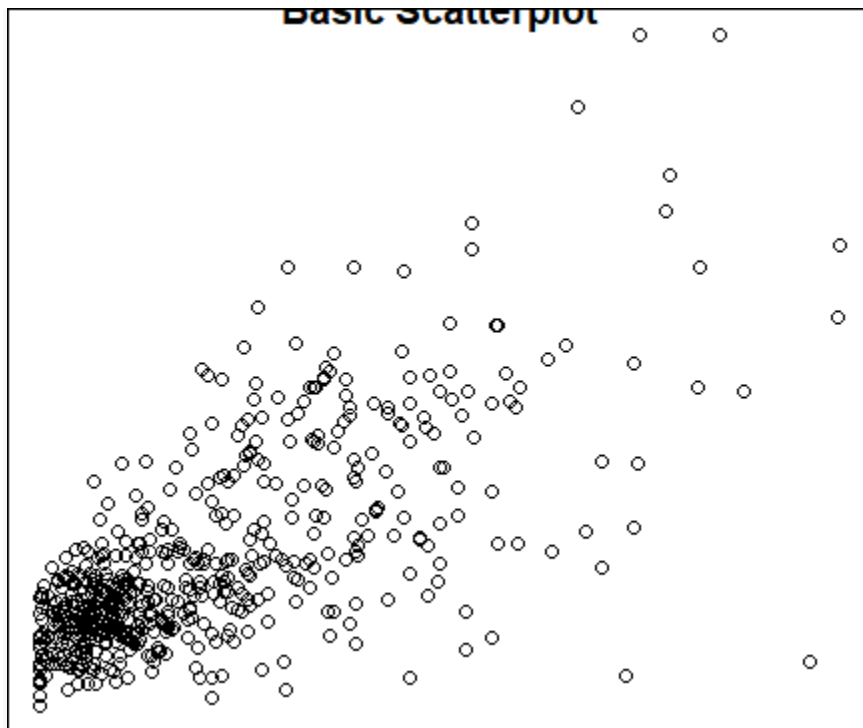
```
## 0.6274165 0.3725835
```

we then show some correlation

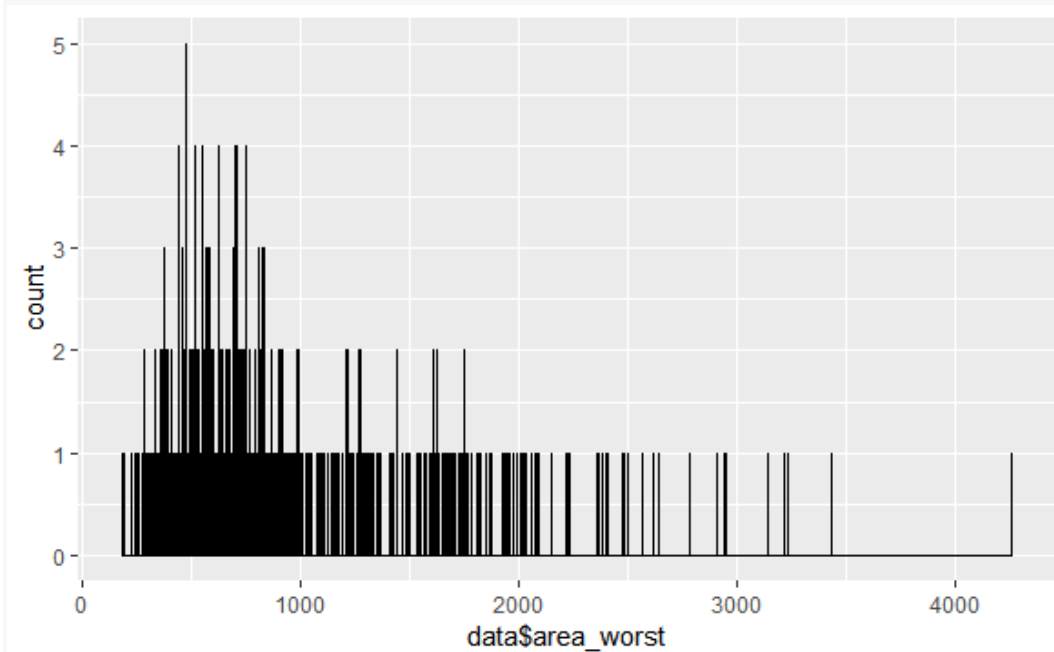
```
corr_mat<-cor(data[,3:ncol(data)])
```

```
corrplot(corr_mat)
```

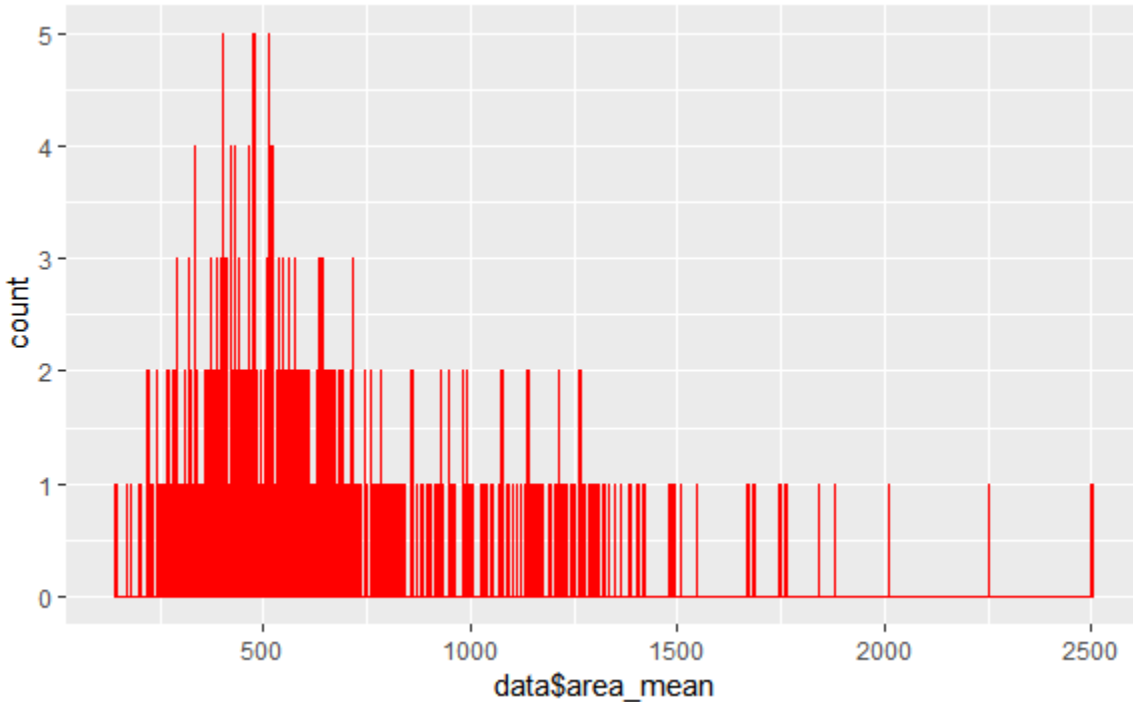




```
ggplot(data, aes(x=data$area_worst)) + geom_histogram(binwidth = 1, fill = "yellow", color = "black")
```



```
ggplot(data, aes(x=data$area_mean)) + geom_histogram(binwidth = 1, fill = "green", color = "red")
```



```
#Modelling
#We are going to get a training and a testing set to use when building some
models:
set.seed(1234)
data_index<-createDataPartition(data$diagnosis,p=0.75,list = FALSE)
train_data<-data[data_index,-1]
test_data<-data[data_index,-1]

## Applying learning models
fitControl <- trainControl(method="cv",
                           number = 5,
                           preProcOptions = list(thresh = 0.99), # threshold
for pca preprocess
                           classProbs = TRUE,
                           summaryFunction = twoClassSummary)

#Model1: Random Forest
#Building the model on the training data
## random forest
model_rf <- train(diagnosis~.,
                  train_data,
                  method="ranger",
                  metric="ROC",
                  #tuneLength=10,
                  #tuneGrid = expand.grid(mtry = c(2, 3, 6)),
                  preProcess = c('center', 'scale'),
                  trControl=fitControl)
```

```

#Testing on the testing data
## testing for random forests
pred_rf <- predict(model_rf, test_data)
cm_rf <- confusionMatrix(pred_rf, test_data$diagnosis, positive = "M")
cm_rf

## Confusion Matrix and Statistics
##
##              Reference
## Prediction    B    M
##           B 268    0
##           M   0 159
##
##              Accuracy : 1
##              95% CI : (0.9914, 1)
##      No Information Rate : 0.6276
##      P-Value [Acc > NIR] : < 2.2e-16
##
##              Kappa : 1
##  Mcnemar's Test P-Value : NA
##
##              Sensitivity : 1.0000
##              Specificity : 1.0000
##              Pos Pred Value : 1.0000
##              Neg Pred Value : 1.0000
##              Prevalence : 0.3724
##              Detection Rate : 0.3724
##      Detection Prevalence : 0.3724
##              Balanced Accuracy : 1.0000
##
##              'Positive' Class : M
##

# We find the accuracy of the model is 100%
#Random forest model- takes decision trees and averages them
normalize<-function(x){return((x-min(x))/(max(x)-min(x)))}
data$diagnosis<-as.numeric(data$diagnosis)
data_n<-as.data.frame(lapply(data,normalize))
traindata_n<-data_n[1:426,]
testdata_n<-data_n[427:569,]
rf <- randomForest(diagnosis ~., data= traindata_n, ntree =300, mtry = 5,
importance = TRUE)

## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values. Are you sure you want to do regression?

print(rf)

##
## Call:
## randomForest(formula = diagnosis ~ ., data = traindata_n, ntree = 300,

```

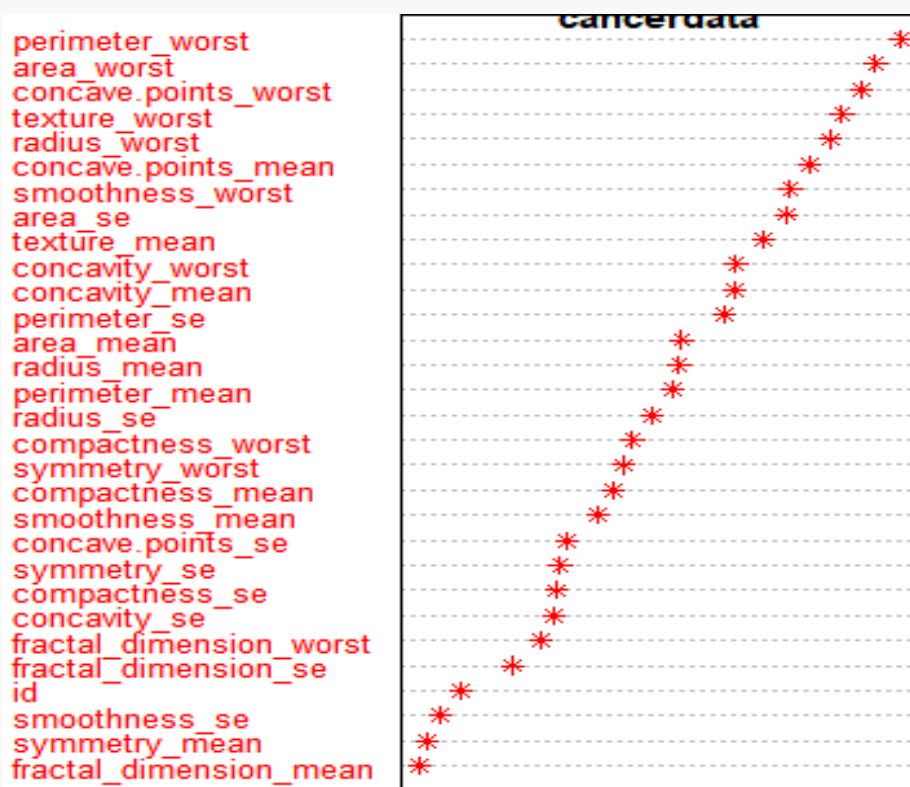
```

mtry = 5, importance = TRUE)
##                               Type of random forest: regression
##                               Number of trees: 300
## No. of variables tried at each split: 5
##
##               Mean of squared residuals: 0.03693862
##                               % Var explained: 84.79

plot.new()

varImpPlot(rf, type = 1, pch = 8, col = 2, cex = 0.8, main = "cancerdata")
abline(v= 45, col= "red")

```

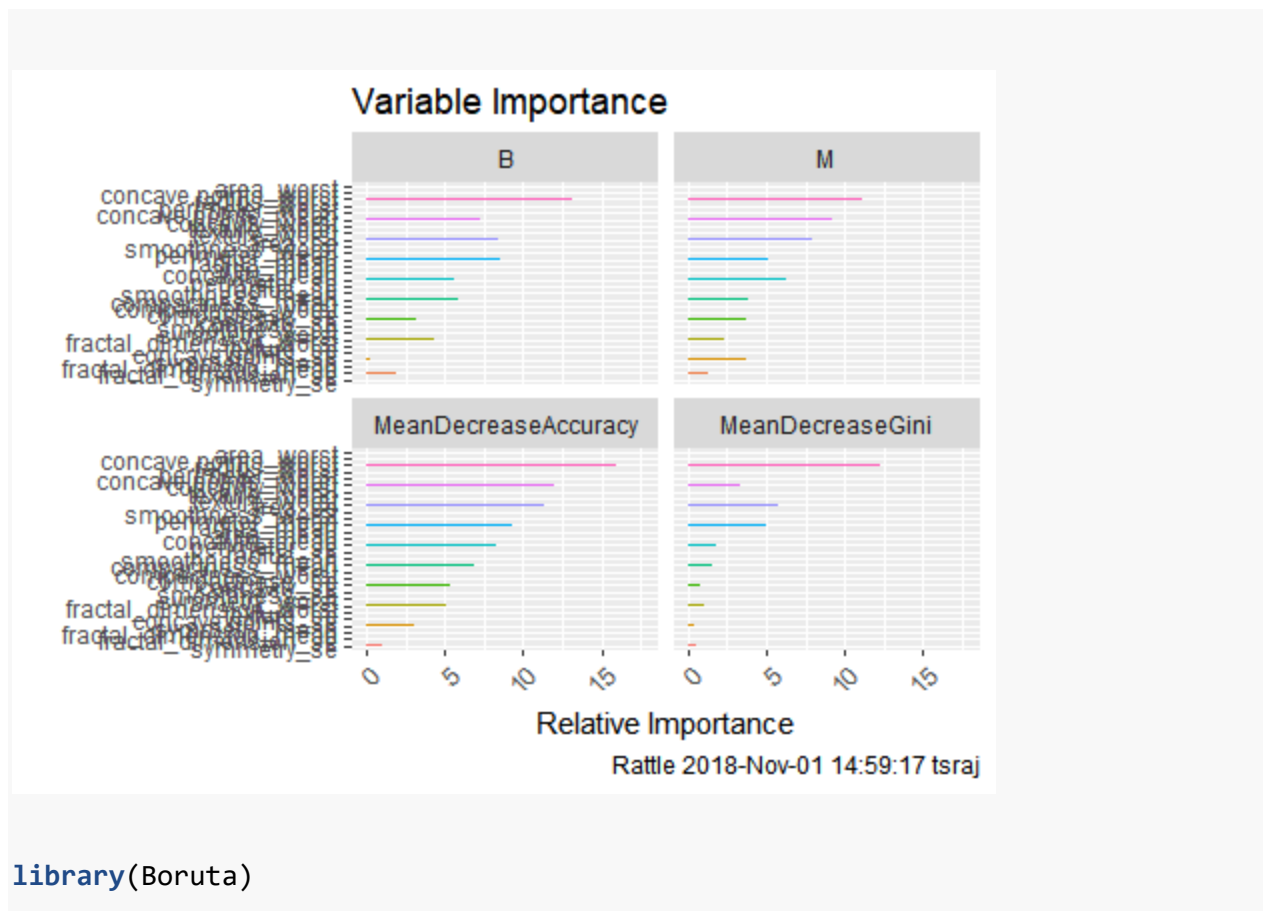


```
library(party)
```

		MeanDecreaseAccuracy	MeanDecreaseGini
area_worst	15.13 10.84	17.79	13.78
concave.points_worst	13.84 11.08	17.58	12.86
radius_worst	13.19 11.08	15.99	12.32

perimeter_worst	13.16 10.67	15.65	14.85
concave.points_mean	9.53 10.94	13.77	13.81
concavity_worst	7.32 9.27	11.99	3.33
texture_mean	8.28 9.79	11.95	2.1
texture_worst	8.63 10.24	11.74	2.3
area_se	8.40 7.98	11.33	5.83
smoothness_worst	6.42 8.05	10.23	1.57
perimeter_mean	8.58 5.62	9.6	7.04
radius_mean	8.55 5.14	9.37	4.99
area_mean	8.50 5.28	9.3	4.07
concavity_mean	5.31 6.54	9.03	3.9
perimeter_se	5.63 6.26	8.33	1.88
radius_se	5.66 4.59	7.6	1.23
smoothness_	4.07 6.30	7.34	0.92
compactness_mean	5.84 3.89	6.92	1.51
compactness_worst	4.29 4.11	6.37	1.44
compactness_se	4.34 2.83	5.35	0.59
concavity_se	3.20 3.77	5.33	0.76
smoothness_se	3.65 3.47	5.3	0.58
symmetry_worst		5.15	1.17

fractal_dimension_worst	4.31 2.39	5.05	1.06
texture_se	3.97 1.92	4.44	0.55
concave.points_se	3.70 2.72	4.39	0.51
symmetry_mean	0.22 3.69	3.03	0.45
fractal_dimension_mean	2.10 1.25	2.57	0.43
fractal_dimension_se	1.96 1.34	2.56	0.64
symmetry_se	0.96 0.48	1.03	0.55




```

## Loading required package: ranger

##
## Attaching package: 'ranger'

## The following object is masked from 'package:rattle':
##
##     importance

## The following object is masked from 'package:randomForest':
##
##     importance

# Decide if a variable is important or not using Boruta

boruta_output <- Boruta( diagnosis~., data=na.omit(train_data), doTrace=2)
# perform Boruta search

## 1. run of importance source...

...

## After 77 iterations, +19 secs:

## rejected 1 attribute: texture_se;

## no more attributes left.

boruta_signif <-
names(boruta_output$finalDecision[boruta_output$finalDecision %in%
c("Confirmed", "Tentative")])
boruta_signif

## [1] "radius_mean"           "texture_mean"
## [3] "perimeter_mean"        "area_mean"
## [5] "smoothness_mean"       "compactness_mean"
## [7] "concavity_mean"        "`concave points_mean`"
## [9] "symmetry_mean"         "fractal_dimension_mean"
## [11] "radius_se"             "perimeter_se"
## [13] "area_se"               "compactness_se"
## [15] "concavity_se"          "`concave points_se`"
## [17] "fractal_dimension_se"  "radius_worst"
## [19] "texture_worst"         "perimeter_worst"
## [21] "area_worst"            "smoothness_worst"
## [23] "compactness_worst"     "concavity_worst"
## [25] "`concave points_worst`" "symmetry_worst"
## [27] "fractal_dimension_worst"

#Model2: Naive Bayes
#Building and testing the model
model_nb <- train(diagnosis~.,
                  train_data,

```

```

        method="nb",
        metric="ROC",
        preprocess=c('center', 'scale'),
        trace=FALSE,
        trControl=fitControl)

cm_nb <- confusionMatrix(pred_nb, test_data$diagnosis, positive = "M")
cm_nb

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  B    M
##           B 259  17
##           M   9 142
##
##           Accuracy : 0.9391
##           95% CI : (0.9121, 0.9598)
##           No Information Rate : 0.6276
##           P-Value [Acc > NIR] : <2e-16
##
##           Kappa : 0.8684
##           McNemar's Test P-Value : 0.1698
##
##           Sensitivity : 0.8931
##           Specificity : 0.9664
##           Pos Pred Value : 0.9404
##           Neg Pred Value : 0.9384
##           Prevalence : 0.3724
##           Detection Rate : 0.3326
##           Detection Prevalence : 0.3536
##           Balanced Accuracy : 0.9297
##
##           'Positive' Class : M
##

#Accuracy of the model is 93.9%
#Model3: glm
#Building and testing the model
model_glm <- train(diagnosis~.,
                  train_data,
                  method="glm",
                  metric="ROC",
                  preprocess=c('center', 'scale'),
                  trace=FALSE,
                  trControl=fitControl)

## predicting for test data
pred_glm <- predict(model_glm, test_data)

```

```

cm_glm <- confusionMatrix(pred_glm, test_data$diagnosis, positive = "M")
cm_glm

## Confusion Matrix and Statistics
##
##              Reference
## Prediction    B    M
##              B 265    4
##              M   3 155
##
##              Accuracy : 0.9836
##              95% CI : (0.9665, 0.9934)
##              No Information Rate : 0.6276
##              P-Value [Acc > NIR] : <2e-16
##
##              Kappa : 0.9649
##              Mcnemar's Test P-Value : 1
##
##              Sensitivity : 0.9748
##              Specificity : 0.9888
##              Pos Pred Value : 0.9810
##              Neg Pred Value : 0.9851
##              Prevalence : 0.3724
##              Detection Rate : 0.3630
##              Detection Prevalence : 0.3700
##              Balanced Accuracy : 0.9818
##
##              'Positive' Class : M
##

#Accuracy of the model is 98.3%
#algorithm for decision tree
library(C50)
data$diagnosis<-as.factor(data$diagnosis)
tree <- C5.0( diagnosis~., data = data)
summary(tree)

##
## Call:
## C5.0.formula(formula = diagnosis ~ ., data = data)
##
##
## C5.0 [Release 2.07 GPL Edition]          Sat Nov 03 17:35:50 2018
## -----
##
## Class specified by attribute `outcome'
##
## Read 569 cases (32 attributes) from undefined.data
##
## Decision tree:

```

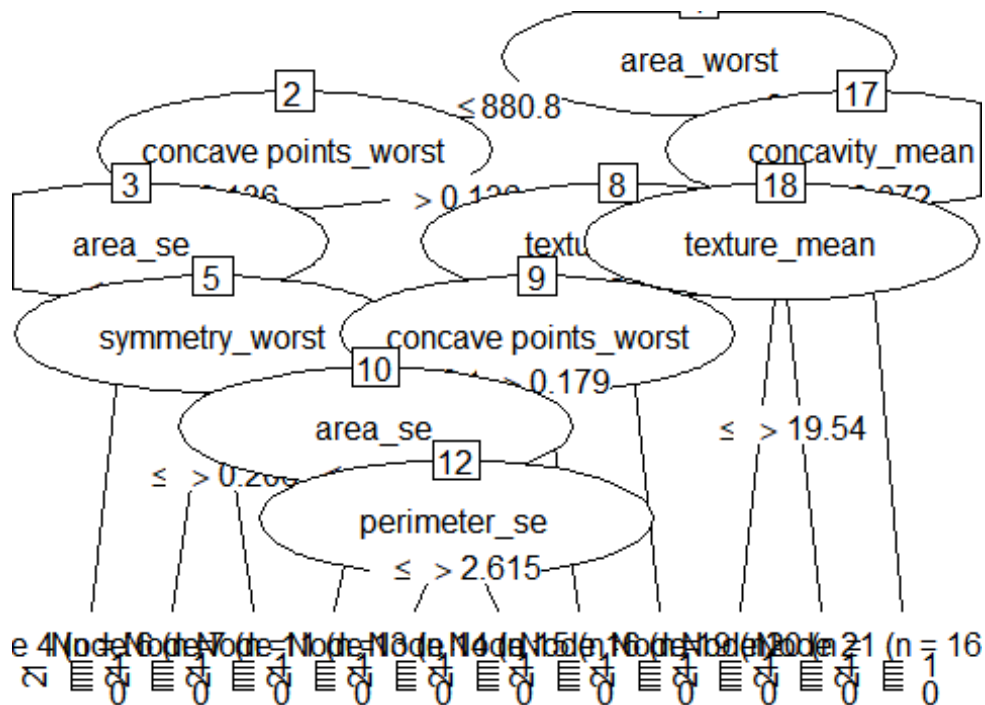
```

##
## area_worst > 880.8:
## :...concavity_mean > 0.0716: 2 (164)
## :   concavity_mean <= 0.0716:
## :     ...texture_mean <= 19.54: 1 (9/1)
## :       texture_mean > 19.54: 2 (10)
## area_worst <= 880.8:
## :...concave points_worst <= 0.1357:
## :   ...area_se <= 36.46: 1 (319/3)
## :     area_se > 36.46:
## :       ...symmetry_worst <= 0.206: 2 (2)
## :         symmetry_worst > 0.206: 1 (16/2)
## concave points_worst > 0.1357:
## :...texture_worst > 27.37: 2 (21)
## :   texture_worst <= 27.37:
## :     ...concave points_worst > 0.1789: 2 (4)
## :       concave points_worst <= 0.1789:
## :         ...area_se <= 21.91: 1 (12)
## :           area_se > 21.91:
## :             ...perimeter_se <= 2.615: 2 (6/1)
## :               perimeter_se > 2.615: 1 (6)
##
##
## Evaluation on training data (569 cases):
##
##      Decision Tree
##      -----
##      Size      Errors
##
##      11      7( 1.2%)  <<
##
##      (a)  (b)    <-classified as
##      ----  ----
##      356    1    (a): class 1
##      6     206   (b): class 2
##
##
## Attribute usage:
##
## 100.00% area_worst
##  67.84% concave points_worst
##  63.44% area_se
##  32.16% concavity_mean
##   8.61% texture_worst
##   3.34% texture_mean
##   3.16% symmetry_worst
##   2.11% perimeter_se
##

```

```
##
## Time: 0.0 secs

plot.new()
plot(tree)
```



```
results <- C5.0(diagnosis ~., data = data, rules = TRUE)
summary(results)

##
## Call:
## C5.0.formula(formula = diagnosis ~ ., data = data, rules = TRUE)
##
##
## C5.0 [Release 2.07 GPL Edition]      Sat Nov 03 17:35:51 2018
## -----
##
## Class specified by attribute `outcome'
##
## Read 569 cases (32 attributes) from undefined.data
##
## Rules:
##
## Rule 1: (223/2, lift 1.6)
##  texture_mean <= 19.54
##  concavity_mean <= 0.0716
```

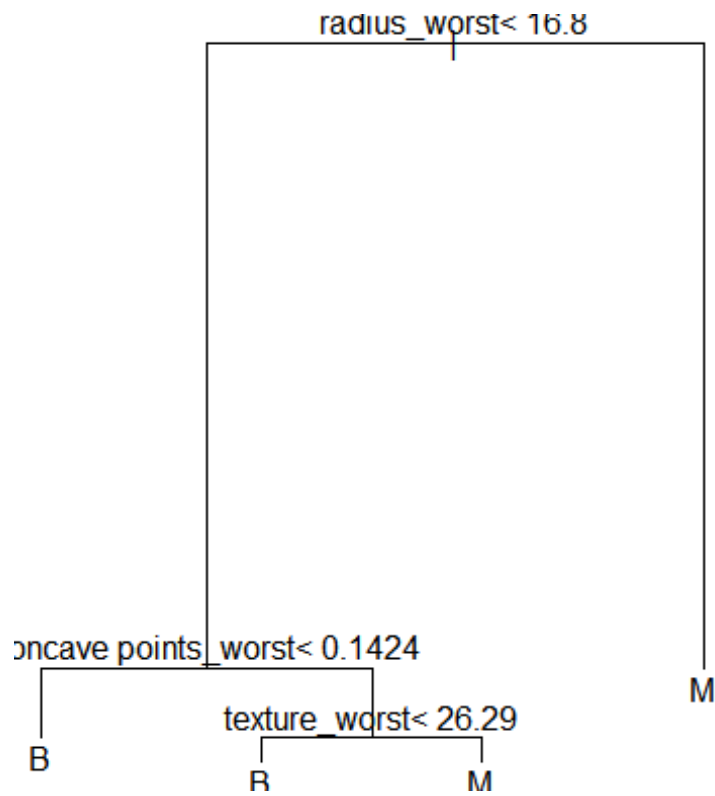
```

## -> class 1 [0.987]
##
## Rule 2: (386/37, lift 1.4)
## area_worst <= 880.8
## -> class 1 [0.902]
##
## Rule 3: (164, lift 2.7)
## concavity_mean > 0.0716
## area_worst > 880.8
## -> class 2 [0.994]
##
## Rule 4: (126, lift 2.7)
## texture_mean > 19.54
## area_worst > 880.8
## -> class 2 [0.992]
##
## Rule 5: (109, lift 2.7)
## concave points_worst > 0.1789
## -> class 2 [0.991]
##
## Rule 6: (114, lift 2.7)
## texture_worst > 27.37
## concave points_worst > 0.1357
## -> class 2 [0.991]
##
## Default class: 1
##
##
## Evaluation on training data (569 cases):
##
##           Rules
##  -----
##      No      Errors
##
##      6    13( 2.3%)  <<
##
##
##      (a)  (b)    <-classified as
##      ----  ----
##      357          (a): class 1
##      13   199    (b): class 2
##
##
## Attribute usage:
##
## 98.42% area_worst
## 68.01% concavity_mean
## 61.34% texture_mean
## 26.89% concave points_worst
## 20.04% texture_worst

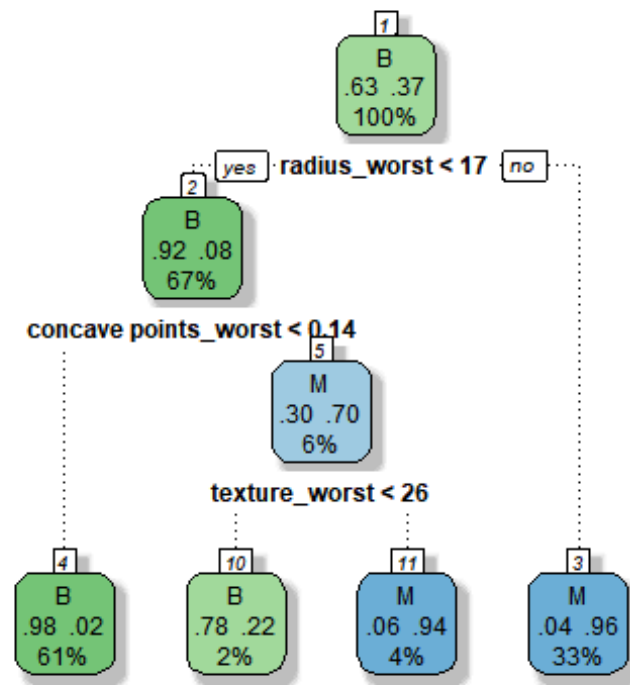
```

```
##
##
## Time: 0.0 secs

data<-as.data.frame(data)
library(rpart)
tree<-rpart(diagnosis~.,data =train_data,method="class")
plot(tree)
text(tree, pretty=0)
library(rattle)
library(rpart.plot)
library(RColorBrewer)
plot.new()
```



```
fancyRpartPlot(tree)
plot.new()
```



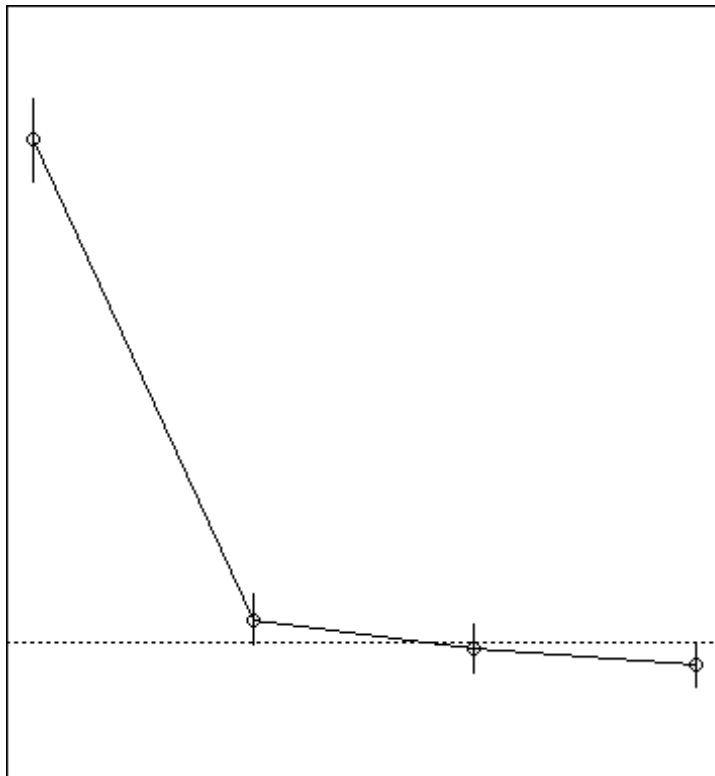
```

printcp(tree)

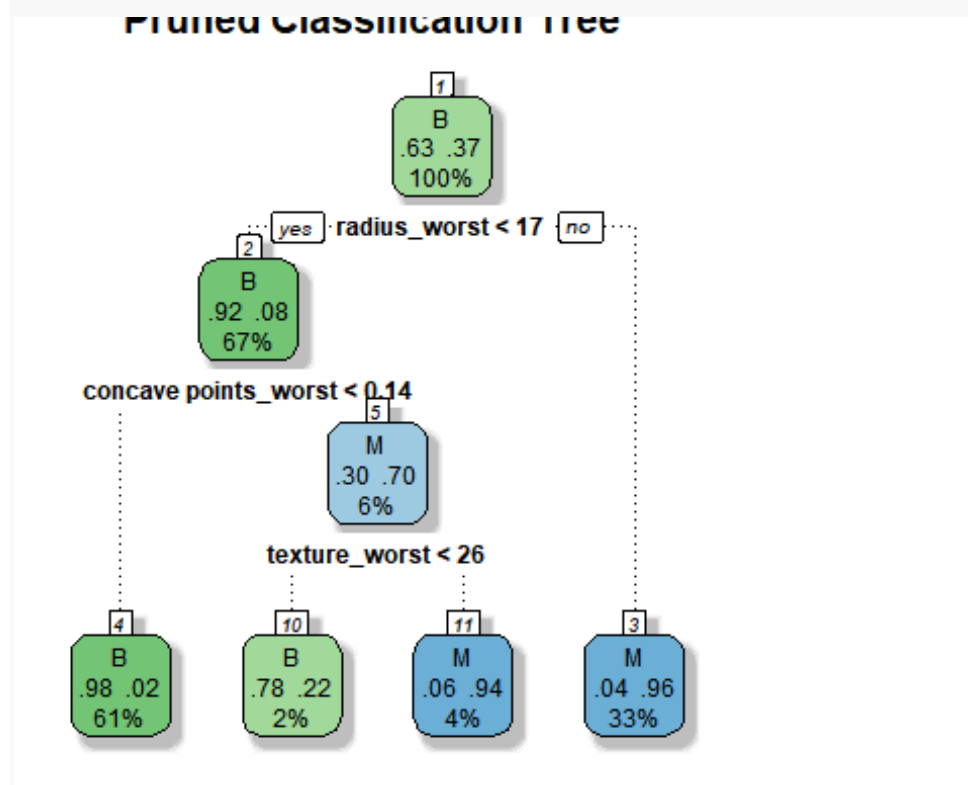
##
## Classification tree:
## rpart(formula = diagnosis ~ ., data = train_data, method = "class")
##
## Variables actually used in tree construction:
## [1] concave points_worst radius_worst      texture_worst
##
## Root node error: 159/427 = 0.37237
##
## n= 427
##
##      CP nsplit rel error  xerror    xstd
## 1 0.811321      0  1.00000 1.00000 0.062828
## 2 0.069182      1  0.18868 0.26415 0.038703
## 3 0.031447      2  0.11950 0.22013 0.035651
## 4 0.010000      3  0.08805 0.19497 0.033722

plotcp(tree)
ptree<- prune(tree, cp=
tree$cptable[which.min(tree$cptable[, "xerror"]), "CP"])
plot.new()

```

```
fancyRpartPlot(ptree, uniform=TRUE, main="Pruned Classification Tree")
```



```
library(rpart)
```

```

fit1 <- rpart(diagnosis~.,data=train_data)
fit1

## n= 427
##
## node), split, n, loss, yval, (yprob)
##      * denotes terminal node
##
## 1) root 427 159 B (0.62763466 0.37236534)
##    2) radius_worst< 16.795 286 24 B (0.91608392 0.08391608)
##      4) concave points_worst< 0.14235 259 5 B (0.98069498 0.01930502) *
##      5) concave points_worst>=0.14235 27 8 M (0.29629630 0.70370370)
##        10) texture_worst< 26.285 9 2 B (0.77777778 0.22222222) *
##        11) texture_worst>=26.285 18 1 M (0.05555556 0.94444444) *
##      3) radius_worst>=16.795 141 6 M (0.04255319 0.95744681) *

summary(fit1)

## Call:
## rpart(formula = diagnosis ~ ., data = train_data)
##    n= 427
##
##           CP nsplit  rel error    xerror      xstd
## 1 0.81132075      0 1.00000000 1.0000000 0.06282824
## 2 0.06918239      1 0.18867925 0.2201258 0.03565053
## 3 0.03144654      2 0.11949686 0.1635220 0.03107762
## 4 0.01000000      3 0.08805031 0.1823899 0.03269862
##
## Variable importance
##           radius_worst           area_worst           perimeter_worst
##                16                16                15
##           area_mean           radius_mean           perimeter_mean
##                14                14                14
## concave points_worst           concavity_worst           concavity_mean
##                3                2                1
## compactness_worst concave points_mean           compactness_mean
##                1                1                1
##           texture_worst
##                1
##
## Node number 1: 427 observations,      complexity param=0.8113208
## predicted class=B expected loss=0.3723653 P(node) =1
## class counts: 268 159
## probabilities: 0.628 0.372
## left son=2 (286 obs) right son=3 (141 obs)
## Primary splits:
##           radius_worst           < 16.795 to the left, improve=144.1264, (0
missing)
##           perimeter_worst           < 112.6 to the left, improve=143.9985, (0
missing)

```

```

##      area_worst          < 884.55   to the left,  improve=140.9804, (0
missing)
##      concave points_worst < 0.14235  to the left,  improve=138.8752, (0
missing)
##      concave points_mean  < 0.05593  to the left,  improve=132.0683, (0
missing)
##      Surrogate splits:
##      area_worst          < 868.2     to the left,  agree=0.993, adj=0.979, (0
split)
##      perimeter_worst < 111.7        to the left,  agree=0.974, adj=0.922, (0
split)
##      area_mean          < 697.8      to the left,  agree=0.960, adj=0.879, (0
split)
##      radius_mean       < 15.045      to the left,  agree=0.958, adj=0.872, (0
split)
##      perimeter_mean    < 96.405      to the left,  agree=0.946, adj=0.837, (0
split)
##
## Node number 2: 286 observations,      complexity param=0.06918239
##      predicted class=B  expected loss=0.08391608  P(node) =0.6697892
##      class counts:    262    24
##      probabilities: 0.916 0.084
##      left son=4 (259 obs) right son=5 (27 obs)
##      Primary splits:
##      concave points_worst < 0.14235  to the left,  improve=22.90582, (0
missing)
##      concavity_mean      < 0.11865   to the left,  improve=19.46751, (0
missing)
##      concavity_worst     < 0.3782    to the left,  improve=19.39395, (0
missing)
##      compactness_worst   < 0.3849    to the left,  improve=17.79391, (0
missing)
##      concave points_mean < 0.05593   to the left,  improve=17.40573, (0
missing)
##      Surrogate splits:
##      concavity_worst     < 0.4383    to the left,  agree=0.969, adj=0.667,
(0 split)
##      compactness_worst   < 0.3849    to the left,  agree=0.955, adj=0.519,
(0 split)
##      concavity_mean      < 0.1563    to the left,  agree=0.951, adj=0.481,
(0 split)
##      concave points_mean < 0.06687   to the left,  agree=0.948, adj=0.444,
(0 split)
##      compactness_mean    < 0.15      to the left,  agree=0.937, adj=0.333,
(0 split)
##
## Node number 3: 141 observations
##      predicted class=M  expected loss=0.04255319  P(node) =0.3302108
##      class counts:      6    135
##      probabilities: 0.043 0.957

```

```

##
## Node number 4: 259 observations
##   predicted class=B   expected loss=0.01930502   P(node) =0.6065574
##   class counts:    254      5
##   probabilities: 0.981 0.019
##
## Node number 5: 27 observations,      complexity param=0.03144654
##   predicted class=M   expected loss=0.2962963   P(node) =0.06323185
##   class counts:      8      19
##   probabilities: 0.296 0.704
##   left son=10 (9 obs) right son=11 (18 obs)
##   Primary splits:
##       texture_worst      < 26.285   to the left,   improve=6.259259, (0
missing)
##       smoothness_worst   < 0.1405   to the left,   improve=4.680312, (0
missing)
##       smoothness_mean    < 0.1083   to the left,   improve=4.402116, (0
missing)
##       texture_mean       < 20.3     to the left,   improve=3.792593, (0
missing)
##       concave points_worst < 0.17175 to the left,   improve=3.792593, (0
missing)
##   Surrogate splits:
##       texture_mean       < 16.22    to the left,   agree=0.852, adj=0.556, (0
split)
##       smoothness_worst   < 0.13145  to the left,   agree=0.815, adj=0.444, (0
split)
##       concavity_mean     < 0.089375 to the left,   agree=0.778, adj=0.333, (0
split)
##       smoothness_se      < 0.005373 to the left,   agree=0.778, adj=0.333, (0
split)
##       concavity_se       < 0.11138  to the right,  agree=0.778, adj=0.333, (0
split)
##
## Node number 10: 9 observations
##   predicted class=B   expected loss=0.2222222   P(node) =0.02107728
##   class counts:      7      2
##   probabilities: 0.778 0.222
##
## Node number 11: 18 observations
##   predicted class=M   expected loss=0.05555556   P(node) =0.04215457
##   class counts:      1      17
##   probabilities: 0.056 0.944

#KernLab Classification
require(kernlab)

## Loading required package: kernlab

```

```

##
## Attaching package: 'kernlab'

## The following object is masked from 'package:modeltools':
##
##     prior

## The following object is masked from 'package:ggplot2':
##
##     alpha

installed.packages("kernlab")

##      Package LibPath Version Priority Depends Imports LinkingTo Suggests
##      Enhances License License_is_FOSS License_restricts_use OS_type Archs
##      MD5sum NeedsCompilation Built

library(kernlab)
data_classifier<-ksvm(diagnosis ~., data =train_data , kernel='vanilladot')

## Setting default kernel parameters

data_classifier

## Support Vector Machine object of class "ksvm"
##
## SV type: C-svc (classification)
## parameter : cost C = 1
##
## Linear (vanilla) kernel function.
##
## Number of Support Vectors : 28
##
## Objective Function Value : -13.7674
## Training error : 0.007026

data_predictions<-predict(data_classifier,test_data)
head(data_predictions)

## [1] M M M M M M
## Levels: B M

table(data_predictions, test_data$diagnosis)

##
## data_predictions      B      M
##                B 267      2
##                M   1 157

agreement<-data_predictions == test_data$diagnosis
table(agreement)

```

```

## agreement
## FALSE TRUE
##      3   424

prop.table(table(agreement))

## agreement
##      FALSE      TRUE
## 0.007025761 0.992974239

Agreement

##      [1] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [12] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [23] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [34] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [342] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [353] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [364] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [375] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [386] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [397] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [408] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
##      [419] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE

set.seed(12345)
data_classifier_rbf<-ksvm(diagnosis ~., data = train_data, kernel='rbfdot')
data_predictions_rbf<-predict(data_classifier_rbf,test_data)
agreement_rbf<-data_predictions_rbf == test_data$diagnosis
table(agreement_rbf)

## agreement_rbf
## FALSE TRUE
##      2   425

prop.table(table(agreement_rbf))

## agreement_rbf
##      FALSE      TRUE
## 0.004683841 0.995316159

# logistic regression model:
fit <- glm(diagnosis~.,data = train_data,family = binomial(link='logit'))

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

summary(fit)

##
## Call:
## glm(formula = diagnosis ~ ., family = binomial(link = "logit"),

```

```

##      data = train_data)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q        Max
## -8.49      0.00      0.00      0.00      8.49
##
## Coefficients:
##              Estimate Std. Error  z value Pr(>|z|)
## (Intercept) -5.487e+15  1.418e+08 -38703923 <2e-16 ***
## radius_mean -1.401e+13  5.949e+07  -235423 <2e-16 ***
## texture_mean -5.783e+13  2.594e+06 -22293459 <2e-16 ***
## perimeter_mean -1.954e+14  8.518e+06 -22935779 <2e-16 ***
## area_mean 7.231e+12  1.723e+05  41962794 <2e-16 ***
## smoothness_mean 1.141e+16  6.970e+08  16374586 <2e-16 ***
## compactness_mean -1.560e+16  4.601e+08 -33898361 <2e-16 ***
## concavity_mean 3.612e+15  3.663e+08  9859481 <2e-16 ***
## `concave points_mean` 3.368e+16  6.496e+08  51839897 <2e-16 ***
## symmetry_mean 7.166e+14  2.485e+08  2883416 <2e-16 ***
## fractal_dimension_mean -1.875e+16  1.853e+09 -10119625 <2e-16 ***
## radius_se -1.780e+14  1.147e+08  -1552350 <2e-16 ***
## texture_se -5.141e+14  1.143e+07 -44982769 <2e-16 ***
## perimeter_se -1.506e+14  1.516e+07  -9929607 <2e-16 ***
## area_se 3.909e+12  4.713e+05  8294154 <2e-16 ***
## smoothness_se 6.741e+16  2.230e+09  30224242 <2e-16 ***
## compactness_se -1.263e+16  7.957e+08 -15868906 <2e-16 ***
## concavity_se -6.112e+15  4.465e+08 -13688233 <2e-16 ***
## `concave points_se` 2.479e+16  1.882e+09  13170418 <2e-16 ***
## symmetry_se 3.309e+16  8.953e+08  36963236 <2e-16 ***
## fractal_dimension_se 2.482e+16  4.032e+09  6155984 <2e-16 ***
## radius_worst 7.751e+14  2.067e+07  37495454 <2e-16 ***
## texture_worst 1.151e+14  2.192e+06  52500738 <2e-16 ***
## perimeter_worst 7.806e+13  2.049e+06  38088467 <2e-16 ***
## area_worst -5.352e+12  1.108e+05 -48313624 <2e-16 ***
## smoothness_worst -4.364e+15  4.930e+08 -8850467 <2e-16 ***
## compactness_worst 1.527e+15  1.306e+08  11684310 <2e-16 ***
## concavity_worst 2.629e+15  9.403e+07  27964084 <2e-16 ***
## `concave points_worst` -5.585e+15  3.231e+08 -17282850 <2e-16 ***
## symmetry_worst -1.380e+15  1.615e+08  -8543749 <2e-16 ***
## fractal_dimension_worst 8.968e+15  7.758e+08  11560246 <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: 563.81  on 426  degrees of freedom
## Residual deviance: 504.61  on 396  degrees of freedom
## AIC: 566.61
##
## Number of Fisher Scoring iterations: 19

```

```

library(MASS)
step_fit <- stepAIC(fit,method='backward')

## Start:  AIC=566.61
## diagnosis ~ radius_mean + texture_mean + perimeter_mean + area_mean +
##      smoothness_mean + compactness_mean + concavity_mean + `concave
points_mean` +
##      symmetry_mean + fractal_dimension_mean + radius_se + texture_se +
##      perimeter_se + area_se + smoothness_se + compactness_se +
##      concavity_se + `concave points_se` + symmetry_se +
fractal_dimension_se +
##      radius_worst + texture_worst + perimeter_worst + area_worst +
##      smoothness_worst + compactness_worst + concavity_worst +
##      `concave points_worst` + symmetry_worst + fractal_dimension_worst

##
##      Df Deviance    AIC
## - perimeter_se      1    0.00  60.00
## - area_mean          1    0.00  60.00
## - radius_mean        1    0.00  60.00
## - area_se            1    0.00  60.00
## - symmetry_se        1    0.00  60.00
## - radius_worst       1    0.00  60.00
## - radius_se          1    0.00  60.00
## - texture_mean       1    0.00  60.00
## - smoothness_worst   1    0.00  60.00
## - compactness_mean   1    0.00  60.00
## - area_worst         1    0.00  60.00
## - smoothness_mean    1    0.00  60.00
## - compactness_se     1    0.00  60.00
## - `concave points_se` 1    0.00  60.00
## - perimeter_worst    1    0.00  60.00
## - compactness_worst  1    0.00  60.00
## - concavity_se       1    0.00  60.00
## - `concave points_mean` 1    0.00  60.00
## - smoothness_se      1    0.00  60.00
## - symmetry_mean      1    0.00  60.00
## - `concave points_worst` 1    0.00  60.00
## - symmetry_worst     1    0.00  60.00
## - fractal_dimension_mean 1    0.00  60.00
## - fractal_dimension_se 1    0.00  60.00
## - texture_se         1    0.00  60.00
## - perimeter_mean     1    0.00  60.00
## - fractal_dimension_worst 1    0.00  60.00
## - texture_worst      1    0.00  60.00
## - concavity_mean     1    0.00  60.00
## - concavity_worst    1    0.00  60.00
## <none>                504.61 566.61

##
## Step:  AIC=22

```



```

## diagnosis ~ concavity_mean + `concave points_mean` + symmetry_mean +
## texture_se + smoothness_se + fractal_dimension_se + texture_worst +
## perimeter_worst + compactness_worst + fractal_dimension_worst

##           Df Deviance    AIC
## - texture_se           1    0.000 20.000
## - `concave points_mean` 1    0.000 20.000
## <none>                  0.000 22.000
## - symmetry_mean        1   11.359 31.359
## - concavity_mean        1   12.771 32.771
## - compactness_worst     1   21.067 41.067
## - fractal_dimension_worst 1   31.257 51.257
## - smoothness_se         1   42.914 62.914
## - fractal_dimension_se   1   46.981 66.981
## - texture_worst         1   47.144 67.144
## - perimeter_worst       1   69.590 89.590

## Warning: glm.fit: algorithm did not converge

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

##
## Step: AIC=20
## diagnosis ~ concavity_mean + `concave points_mean` + symmetry_mean +
## smoothness_se + fractal_dimension_se + texture_worst + perimeter_worst
## +
## compactness_worst + fractal_dimension_worst

##           Df Deviance    AIC
## <none>          0.000  20.000
## - concavity_mean        1   18.073  36.073
## - `concave points_mean` 1   19.949  37.949
## - symmetry_mean         1   25.134  43.134
## - compactness_worst     1   27.324  45.324
## - fractal_dimension_worst 1   43.464  61.464
## - smoothness_se         1   45.694  63.694
## - fractal_dimension_se   1   54.866  72.866
## - texture_worst         1   56.170  74.170
## - perimeter_worst       1  101.702 119.702

summary(step_fit)

##
## Call:
## glm(formula = diagnosis ~ concavity_mean + `concave points_mean` +
## symmetry_mean + smoothness_se + fractal_dimension_se + texture_worst +
## perimeter_worst + compactness_worst + fractal_dimension_worst,
## family = binomial(link = "logit"), data = train_data)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max

```

```
## -9.155e-04 -2.000e-08 -2.000e-08 2.000e-08 1.028e-03
```

```
##
```

```
## Coefficients:
```

```
##
```

	Estimate	Std. Error	z value	Pr(> z)
## (Intercept)	-1.434e+04	3.496e+05	-0.041	0.967
## concavity_mean	4.805e+03	1.196e+05	0.040	0.968
## `concave points_mean`	8.822e+03	2.173e+05	0.041	0.968
## symmetry_mean	7.239e+03	1.808e+05	0.040	0.968
## smoothness_se	1.715e+05	4.174e+06	0.041	0.967
## fractal_dimension_se	-5.041e+05	1.225e+07	-0.041	0.967
## texture_worst	7.016e+01	1.710e+03	0.041	0.967
## perimeter_worst	5.920e+01	1.446e+03	0.041	0.967
## compactness_worst	-6.023e+03	1.469e+05	-0.041	0.967
## fractal_dimension_worst	7.318e+04	1.785e+06	0.041	0.967

```
##
```

```
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
```

```
## Null deviance: 5.6381e+02 on 426 degrees of freedom
```

```
## Residual deviance: 5.6950e-06 on 417 degrees of freedom
```

```
## AIC: 20
```

```
##
```

```
## Number of Fisher Scoring iterations: 25
```

```
confint(step_fit)
```

	2.5 %	97.5 %
## (Intercept)	-2.004980e+05	-22898.638
## concavity_mean	-6.092841e+03	78980.638
## `concave points_mean`	-1.650539e+04	144613.722
## symmetry_mean	-1.076787e+04	121654.932
## smoothness_se	-2.475484e+05	2738198.040
## fractal_dimension_se	-7.894729e+06	765781.958
## texture_worst	-8.660910e+01	1047.087
## perimeter_worst	-5.280658e+01	917.796
## compactness_worst	-9.344200e+04	12900.424
## fractal_dimension_worst	-1.312846e+05	1169411.619

```
#ANOVA on base model
```

```
anova(fit, test = 'Chisq')
```

```
## Model: binomial, link: logit
```

```
##
```

```
## Response: diagnosis
```

```
##
```

```
## Terms added sequentially (first to last)
```

```
##
```

```
##
```

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
## NULL			426	563.81	
## radius_mean	1	312.35	425	251.46	< 2.2e-16 ***
## texture_mean	1	22.22	424	229.24	2.431e-06 ***

```
## perimeter_mean      1      60.59      423      168.65 7.016e-15 ***
## area_mean           1       7.82      422      160.83 0.0051568 **
## smoothness_mean     1      34.03      421      126.79 5.416e-09 ***
## compactness_mean    1       0.02      420      126.77 0.8900612
## concavity_mean      1      11.89      419      114.88 0.0005637 ***
## `concave points_mean` 1       2.64      418      112.24 0.1041743
## symmetry_mean       1       3.55      417      108.69 0.0595695 .
## fractal_dimension_mean 1       0.48      416      108.21 0.4872629
## radius_se          1       4.78      415      103.42 0.0287116 *
## texture_se         1       9.47      414       93.95 0.0020869 **
## perimeter_se        1       0.05      413       93.90 0.8153014
## area_se            1      12.15      412       81.75 0.0004913 ***
## smoothness_se      1       1.73      411       80.02 0.1883121
## compactness_se     1      20.73      410       59.29 5.295e-06 ***
## concavity_se       1       6.22      409       53.07 0.0126083 *
## `concave points_se` 1       1.12      408       51.94 0.2891473
## symmetry_se        1       1.00      407       50.94 0.3161479
## fractal_dimension_se 1       1.34      406       49.59 0.2461846
## radius_worst       1       0.00      405      648.79 1.0000000
## texture_worst      1      648.79      404       0.00 < 2.2e-16 ***
## perimeter_worst    1       0.00      403       0.00 0.9999778
## area_worst         1       0.00      402       0.00 0.9998569
## smoothness_worst   1       0.00      401       0.00 0.9998323
## compactness_worst  1       0.00      400       0.00 0.9998844
## concavity_worst    1       0.00      399       0.00 1.0000000
## `concave points_worst` 1       0.00      398       0.00 0.9999370
## symmetry_worst     1       0.00      397       0.00 1.0000000
## fractal_dimension_worst 1       0.00      396      504.61 1.0000000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

#ANOVA from reduced model after applying the Step AIC

```
anova(step_fit, test = 'Chisq')
```

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

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

```
## Analysis of Deviance Table
```

```
##
```

```
## Model: binomial, link: logit
```

```
##
```

```
## Response: diagnosis
```

```
##
```

```
## Terms added sequentially (first to last)
```

```
##
```

```
##
```

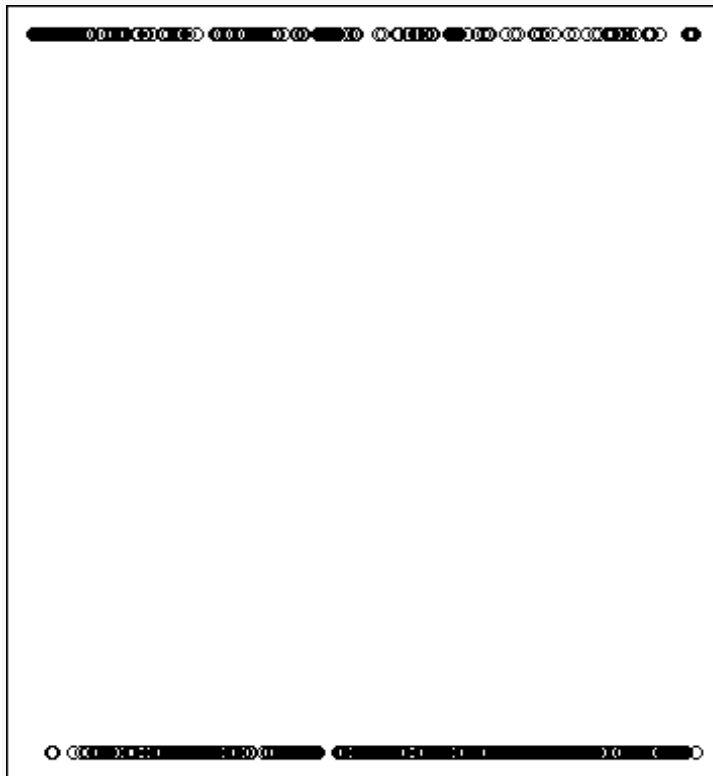
```
##              Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
```

```
## NULL              426      563.81
```

```
## concavity_mean    1   290.218      425      273.60 < 2.2e-16 ***
```

```
## `concave points_mean`      1    76.300      424    197.30 < 2.2e-16 ***
## symmetry_mean             1     4.970      423    192.32  0.02578 *
## smoothness_se             1     6.224      422    186.10  0.01260 *
## fractal_dimension_se      1    33.111      421    152.99 8.706e-09 ***
## texture_worst             1    46.144      420    106.85 1.099e-11 ***
## perimeter_worst           1    59.618      419     47.23 1.152e-14 ***
## compactness_worst         1     3.765      418     43.46  0.05234 .
## fractal_dimension_worst   1    43.464      417      0.00 4.319e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

#plot the fitted model



```
plot.new()
```

```
plot(fit$fitted.values)
```

```
pred_link <- predict(fit,newdata = test_data,type = 'link')
```

#check for multicollinearity

```
library(car)
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```

## The following object is masked from 'package:modeltools':
##
##      Predict

vif(fit)

##           radius_mean          texture_mean      perimeter_mean
##           4231.240532          12.057374         4114.484019
##           area_mean           smoothness_mean    compactness_mean
##           357.762613           9.570587          55.757803
##           concavity_mean      `concave points_mean` symmetry_mean
##           79.562151           59.693761          4.277740
## fractal_dimension_mean      radius_se           texture_se
##           16.406891           100.057360          3.980190
##           perimeter_se        area_se           smoothness_se
##           92.303083           47.935390          4.114137
##           compactness_se      concavity_se      `concave points_se`
##           17.218922           16.063111          13.374578
##           symmetry_se        fractal_dimension_se radius_worst
##           5.415910           11.916743          960.040406
##           texture_worst       perimeter_worst    area_worst
##           18.054760           454.037215          386.858470
##           smoothness_worst    compactness_worst concavity_worst
##           12.427398           37.442475          34.364483
## `concave points_worst`      symmetry_worst fractal_dimension_worst
##           43.557508           9.363305          17.264083

vif(step_fit)

##           concavity_mean      `concave points_mean` symmetry_mean
##           244.05337           99.94645          317.05513
##           smoothness_se      fractal_dimension_se    texture_worst
##           4608.37740          6335.09066          1093.86196
##           perimeter_worst     compactness_worst fractal_dimension_worst
##           1517.71228          5118.72975          6430.41696

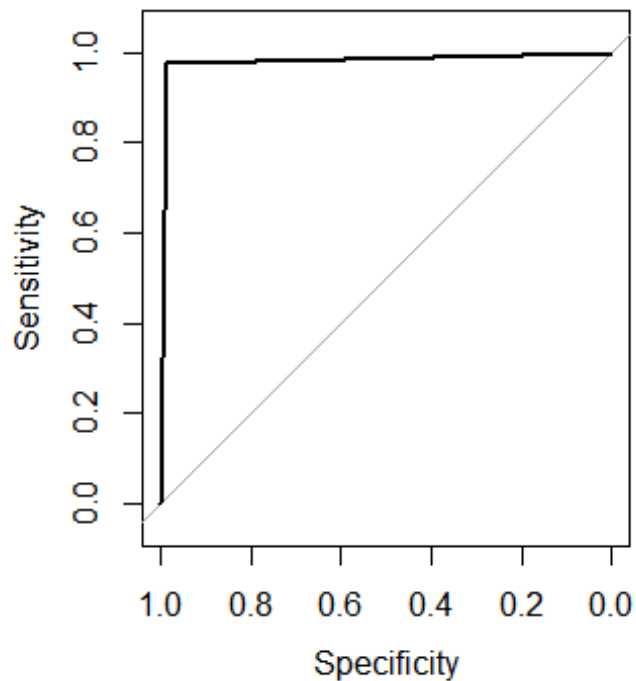
pred <- predict(fit,newdata =test_data ,type ='response')
#check the AUC curve
library(pROC)
g <- roc(diagnosis ~ pred, data = test_data)
g

##
## Call:
## roc.formula(formula = diagnosis ~ pred, data = test_data)
##
## Data: pred in 268 controls (diagnosis B) < 159 cases (diagnosis M).
## Area under the curve: 0.9818

plot.new()

plot(g)

```



```
library(caret)
#with default prob cut 0.50
test_data$pred_diagnosis <- ifelse(pred<0.5,'yes','no')

table(test_data$pred_diagnosis,test_data$diagnosis)

##
##      B   M
## no    3 155
## yes 265   4

#training split of diagnosis classes
round(table(train_data$diagnosis)/nrow(train_data),2)*100

##
## B   M
## 63 37

# test split of diagnosis
round(table(test_data$diagnosis)/nrow(test_data),2)*100

##
## B   M
## 63 37

#predicted split of diagnosis
round(table(test_data$pred_diagnosis)/nrow(test_data),2)*100
```

```

##
## no yes
## 37 63

#create confusion matrix
#confusionMatrix(test_data$diagnosis,test_data$pred_diagnosis)
#how do we create a cross validation scheme
control <- trainControl(method = 'repeatedcv',
                        number = 10,
                        repeats = 3)

seed <-7
metric <- 'Accuracy'
set.seed(seed)
fit_default <- train(diagnosis~.,
                    data = train_data,
                    method = 'glm',
                    metric =metric ,
                    trControl = control)

print(fit_default)

## Generalized Linear Model
##
## 427 samples
## 30 predictor
## 2 classes: 'B', 'M'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 3 times)
## Summary of sample sizes: 384, 384, 385, 384, 385, 384, ...
## Resampling results:
##
## Accuracy Kappa
## 0.9516242 0.8968547

library(caret)
varImp(step_fit)

## Overall
## concavity_mean 0.04016248
## `concave points_mean` 0.04060020
## symmetry_mean 0.04004251
## smoothness_se 0.04107363
## fractal_dimension_se 0.04113828
## texture_worst 0.04104256
## perimeter_worst 0.04095488
## compactness_worst 0.04099049
## fractal_dimension_worst 0.04099415

varImp(fit_default)

```

```
## glm variable importance
##
##   only 20 most important variables shown (out of 30)
##
##                                     Overall
## texture_worst                      100.00
## `\\`concave points_mean\\`        98.74
## area_worst                        91.99
## texture_se                        85.62
## area_mean                        79.84
## perimeter_worst                   72.42
## radius_worst                     71.29
## symmetry_se                       70.27
## compactness_mean                  64.41
## smoothness_se                    57.38
## concavity_worst                   53.05
## perimeter_mean                    43.43
## texture_mean                      42.20
## `\\`concave points_worst\\`       32.62
## smoothness_mean                   30.88
## compactness_se                    29.91
## concavity_se                      25.74
## `\\`concave points_se\\`          24.75
## compactness_worst                 21.91
## fractal_dimension_worst           21.67
```

```
library(woe)
```

```
library(riv)
```

```
train_data<-as.data.frame(train_data)
```

```
iv_df <- iv.mult(train_data, y="diagnosis", summary=TRUE, verbose=TRUE)
```

```
iv_df
```

```
iv <- iv.mult(train_data, y="diagnosis", summary=FALSE, verbose=TRUE)
```

```
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 3.48
Formatting output
Calling iv.num for variable: texture_mean
Building rpart model
Model finished
```


Sending model to tree parser
Rules parsed: 6
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 1.17
Formatting output
Calling iv.num for variable: perimeter_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 4
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 4.96
Formatting output
Calling iv.num for variable: area_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 4
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 3.67
Formatting output
Calling iv.num for variable: smoothness_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 6
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 1.14
Formatting output
Calling iv.num for variable: compactness_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 2.51
Formatting output
Calling iv.num for variable: concavity_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 6

```
Mapping nodes to data
  SQL Merge
  DF Merge
  Calling iv.str for nodes
Information Value 3.04
  Formatting output
Calling iv.num for variable: concave points_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 6.35
  Formatting output
Calling iv.num for variable: symmetry_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 6
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 0.69
  Formatting output
Calling iv.num for variable: fractal_dimension_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 6
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 0.28
  Formatting output
Calling iv.num for variable: radius_se
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 1.84
  Formatting output
Calling iv.num for variable: texture_se
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 6
  Mapping nodes to data
    SQL Merge
```

```
    DF Merge
    Calling iv.str for nodes
Information Value 0.2
    Formatting output
    Calling iv.num for variable: perimeter_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
    SQL Merge
    DF Merge
    Calling iv.str for nodes
Information Value 2.08
    Formatting output
    Calling iv.num for variable: area_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 4
    Mapping nodes to data
    SQL Merge
    DF Merge
    Calling iv.str for nodes
Information Value 3.57
    Formatting output
    Calling iv.num for variable: smoothness_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
    SQL Merge
    DF Merge
    Calling iv.str for nodes
Information Value 0.25
    Formatting output
    Calling iv.num for variable: compactness_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
    SQL Merge
    DF Merge
    Calling iv.str for nodes
Information Value 0.85
    Formatting output
    Calling iv.num for variable: concavity_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
    SQL Merge
    DF Merge
    Calling iv.str for nodes
```

Information Value 1.71
 Formatting output
Calling iv.num for variable: concave points_se
 Building rpart model
 Model finished
 Sending model to tree parser
 Rules parsed: 5
 Mapping nodes to data
 SQL Merge
 DF Merge
 Calling iv.str for nodes
Information Value 1.46
 Formatting output
Calling iv.num for variable: symmetry_se
 Building rpart model
 Model finished
 Sending model to tree parser
 Rules parsed: 6
 Mapping nodes to data
 SQL Merge
 DF Merge
 Calling iv.str for nodes
Information Value 0.17
 Formatting output
Calling iv.num for variable: fractal_dimension_se
 Building rpart model
 Model finished
 Sending model to tree parser
 Rules parsed: 5
 Mapping nodes to data
 SQL Merge
 DF Merge
 Calling iv.str for nodes
Information Value 0.3
 Formatting output
Calling iv.num for variable: radius_worst
 Building rpart model
 Model finished
 Sending model to tree parser
 Rules parsed: 5
 Mapping nodes to data
 SQL Merge
 DF Merge
 Calling iv.str for nodes
Information Value 1.57
 Formatting output
Calling iv.num for variable: texture_worst
 Building rpart model
 Model finished
 Sending model to tree parser
 Rules parsed: 5
 Mapping nodes to data
 SQL Merge
 DF Merge
 Calling iv.str for nodes
Information Value 1.12
 Formatting output

```
Calling iv.num for variable: perimeter_worst
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 3.79
  Formatting output
Calling iv.num for variable: area_worst
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 1.51
  Formatting output
Calling iv.num for variable: smoothness_worst
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 1.23
  Formatting output
Calling iv.num for variable: compactness_worst
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 2.77
  Formatting output
Calling iv.num for variable: concavity_worst
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 4
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 4.49
  Formatting output
Calling iv.num for variable: concave points_worst
  Building rpart model
```

```

Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 3.48
Formatting output
Calling iv.num for variable: symmetry_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 0.98
Formatting output
Calling iv.num for variable: fractal_dimension_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 0.7
Formatting output
Preparing summary
> iv_df

```

	Variable	InformationValue	Bins	ZeroBins	Strength
1	concave points_mean	6.3541081	5	0	Suspicious
2	perimeter_mean	4.9638289	4	0	Suspicious
3	concavity_worst	4.4909270	4	0	Suspicious
4	perimeter_worst	3.7922674	5	1	Suspicious
5	area_mean	3.6702849	4	1	Suspicious
6	area_se	3.5749979	4	0	Suspicious
7	radius_mean	3.4772020	5	1	Suspicious
8	concave points_worst	3.4756344	5	1	Suspicious
9	concavity_mean	3.0356262	6	1	Suspicious
10	compactness_worst	2.7665883	5	0	Suspicious
11	compactness_mean	2.5078805	5	0	Suspicious
12	perimeter_se	2.0849968	6	1	Suspicious
13	radius_se	1.8363325	5	1	Suspicious
14	concavity_se	1.7134338	5	0	Suspicious
15	radius_worst	1.5670693	5	2	Suspicious
16	area_worst	1.5115545	5	2	Suspicious
17	concave points_se	1.4623521	5	0	Suspicious
18	smoothness_worst	1.2334093	5	0	Suspicious
19	texture_mean	1.1714620	6	0	Suspicious
20	smoothness_mean	1.1352591	6	0	Suspicious
21	texture_worst	1.1186736	5	0	Suspicious
22	symmetry_worst	0.9764180	5	0	Very strong
23	compactness_se	0.8494686	6	0	Very strong

24	fractal_dimension_worst	0.6992234	5	0	Very strong
25	symmetry_mean	0.6878786	6	0	Very strong
26	fractal_dimension_se	0.3035412	5	0	Strong
27	fractal_dimension_mean	0.2839318	6	0	Strong
28	smoothness_se	0.2490128	6	0	Strong
29	texture_se	0.2015776	6	0	Strong
30	symmetry_se	0.1679877	6	0	Average

```

> iv <- iv.mult(train_data, y="diagnosis", summary=FALSE, verbose=TRUE)
Started processing of data frame: train_data
Calling iv.num for variable: radius_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 5
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 3.48
  Formatting output
Calling iv.num for variable: texture_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 6
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 1.17
  Formatting output
Calling iv.num for variable: perimeter_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 4
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 4.96
  Formatting output
Calling iv.num for variable: area_mean
  Building rpart model
  Model finished
  Sending model to tree parser
  Rules parsed: 4
  Mapping nodes to data
    SQL Merge
    DF Merge
  Calling iv.str for nodes
Information Value 3.67
  Formatting output
Calling iv.num for variable: smoothness_mean
  Building rpart model
  Model finished
  Sending model to tree parser

```

Rules parsed: 6
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 1.14
Formatting output
Calling iv.num for variable: compactness_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 2.51
Formatting output
Calling iv.num for variable: concavity_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 6
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 3.04
Formatting output
Calling iv.num for variable: concave points_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 6.35
Formatting output
Calling iv.num for variable: symmetry_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 6
Mapping nodes to data
SQL Merge
DF Merge
Calling iv.str for nodes
Information Value 0.69
Formatting output
Calling iv.num for variable: fractal_dimension_mean
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 6
Mapping nodes to data


```
    SQL Merge
    DF Merge
    Calling iv.str for nodes
Information Value 0.28
    Formatting output
Calling iv.num for variable: radius_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.84
    Formatting output
Calling iv.num for variable: texture_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 0.2
    Formatting output
Calling iv.num for variable: perimeter_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 2.08
    Formatting output
Calling iv.num for variable: area_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 4
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 3.57
    Formatting output
Calling iv.num for variable: smoothness_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
        SQL Merge
        DF Merge
```

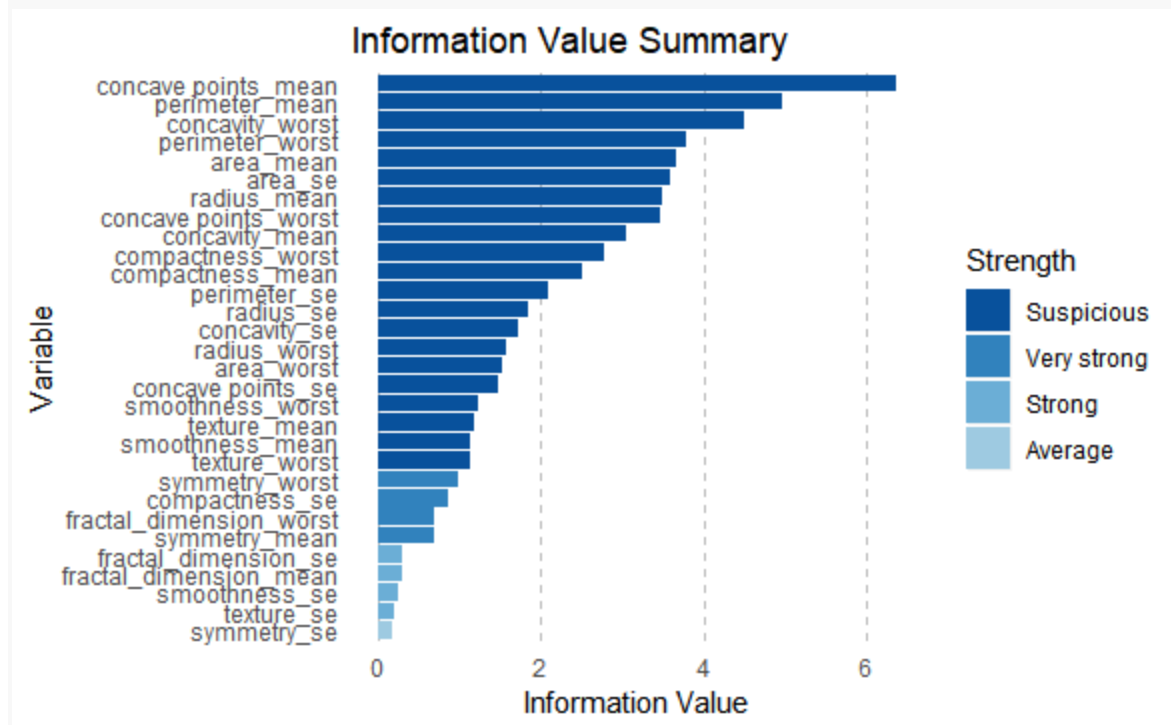
```
    Calling iv.str for nodes
Information Value 0.25
    Formatting output
Calling iv.num for variable: compactness_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 0.85
    Formatting output
Calling iv.num for variable: concavity_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.71
    Formatting output
Calling iv.num for variable: concave points_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.46
    Formatting output
Calling iv.num for variable: symmetry_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 6
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 0.17
    Formatting output
Calling iv.num for variable: fractal_dimension_se
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 0.3
```

```
    Formatting output
Calling iv.num for variable: radius_worst
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.57
    Formatting output
Calling iv.num for variable: texture_worst
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.12
    Formatting output
Calling iv.num for variable: perimeter_worst
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 3.79
    Formatting output
Calling iv.num for variable: area_worst
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.51
    Formatting output
Calling iv.num for variable: smoothness_worst
    Building rpart model
    Model finished
    Sending model to tree parser
    Rules parsed: 5
    Mapping nodes to data
        SQL Merge
        DF Merge
    Calling iv.str for nodes
Information Value 1.23
    Formatting output
Calling iv.num for variable: compactness_worst
```

```
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 2.77
Formatting output
Calling iv.num for variable: concavity_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 4
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 4.49
Formatting output
Calling iv.num for variable: concave points_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 3.48
Formatting output
Calling iv.num for variable: symmetry_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 0.98
Formatting output
Calling iv.num for variable: fractal_dimension_worst
Building rpart model
Model finished
Sending model to tree parser
Rules parsed: 5
Mapping nodes to data
  SQL Merge
  DF Merge
Calling iv.str for nodes
Information Value 0.7
Formatting output
```

```
# Plot information value summary
```

```
iv.plot.summary(iv_df)
```



#4. MARS (earth package)

#The earth package implements variable importance based on Generalized cross validation (GCV),
 #number of subset models the variable occurs (nsubsets) and residual sum of squares (RSS).

```
library(earth)
```

```
## Loading required package: plotmo
```

```
## Loading required package: plotrix
```

```
## Loading required package: TeachingDemos
```

```
marsModel<-earth(diagnosis~ ., data=data) # build model
```

```
ev <- evimp (marsModel) # estimate variable importance
```

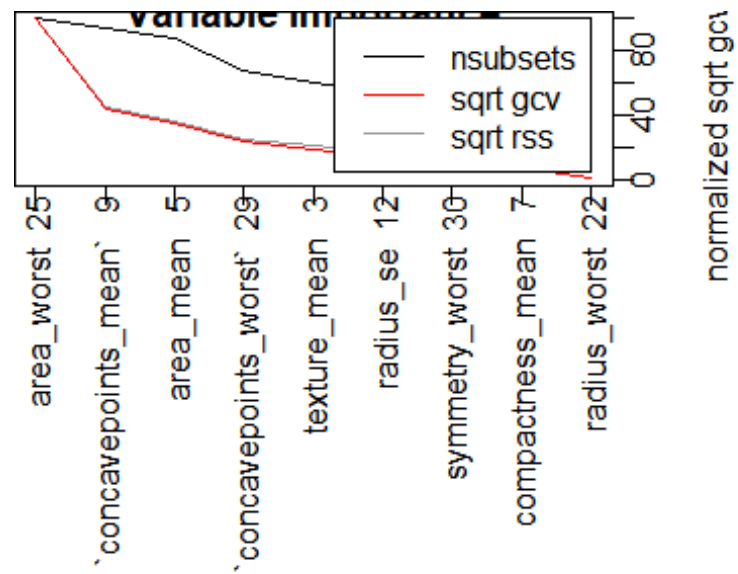
```
ev
```

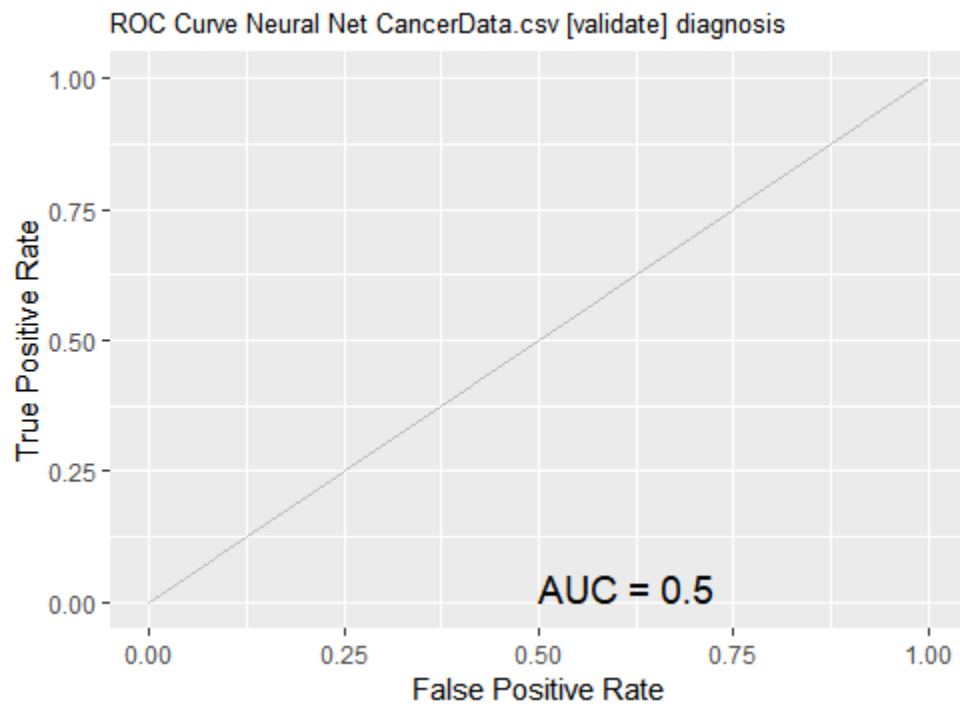
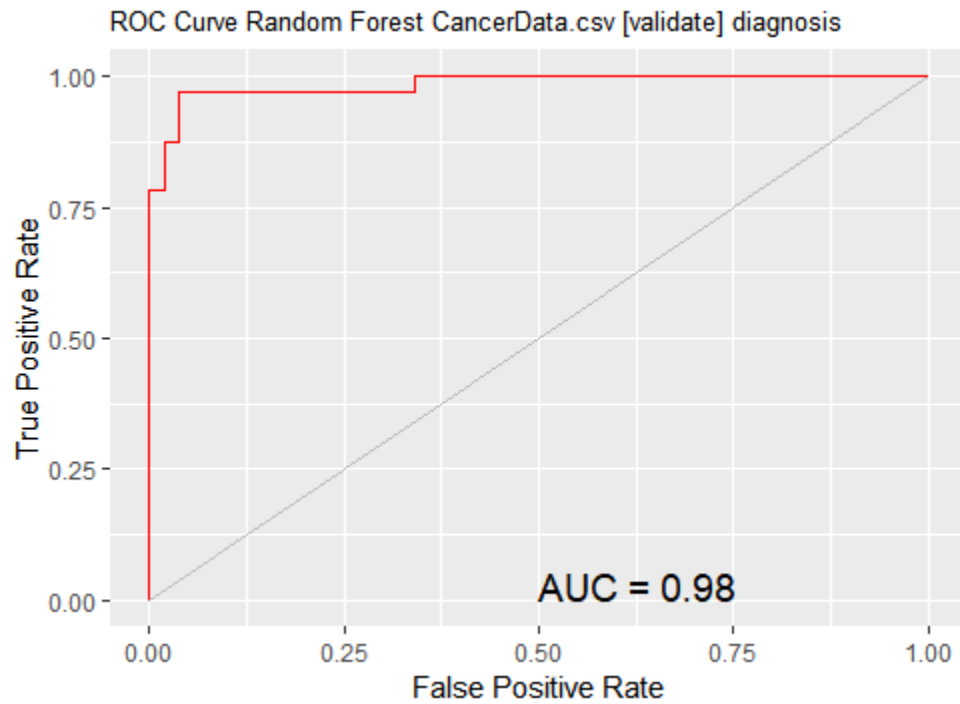
	nsubsets	gcv	rss
## area_worst	15	100.0	100.0
## `concavepoints_mean`	14	43.1	44.5
## area_mean	13	34.5	36.2
## `concavepoints_worst`	10	22.9	24.9
## texture_mean	9	18.2	20.5
## radius_se	8	13.3	16.2
## symmetry_worst	7	9.6	13.0

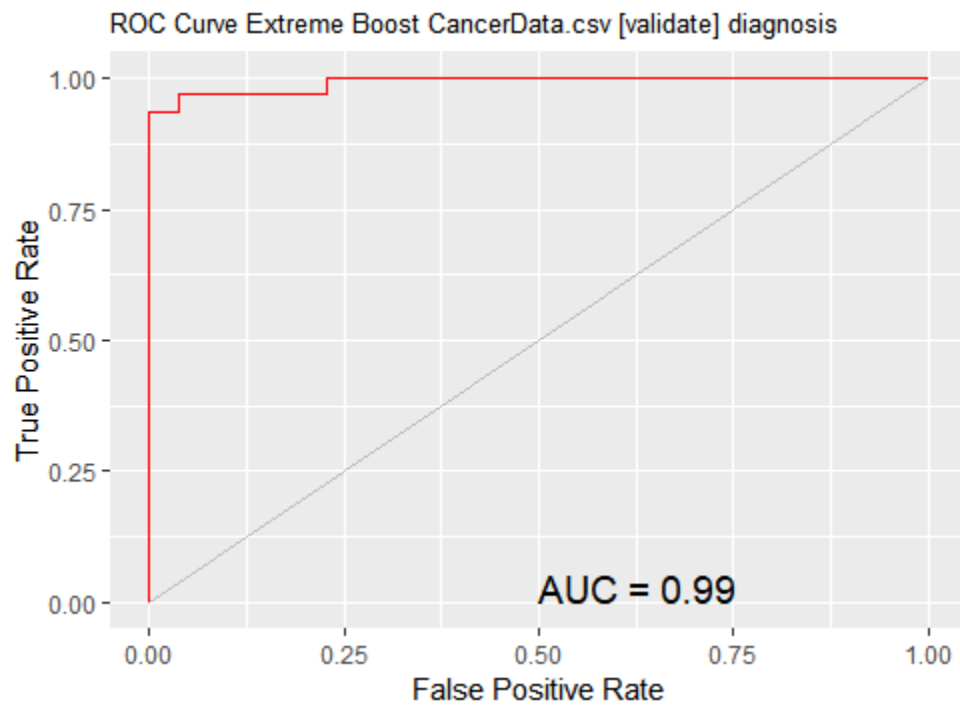
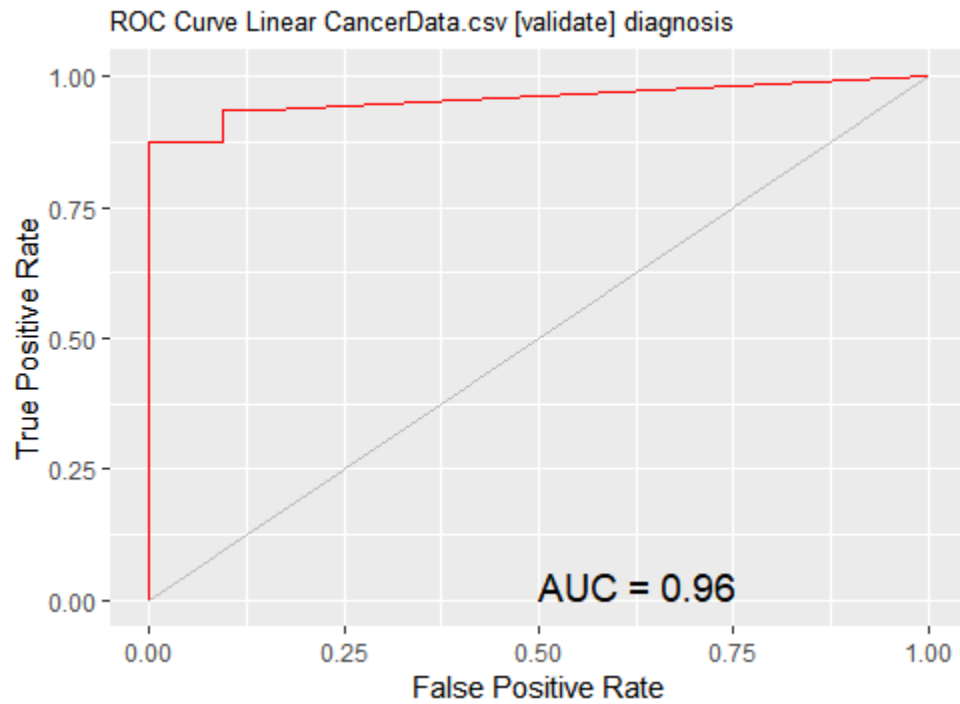
```
## compactness_mean          6   7.6   11.1
## radius_worst              2   1.5    5.1
```

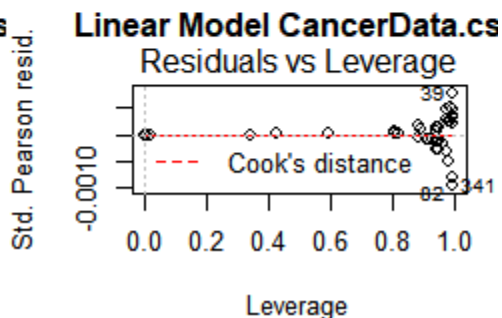
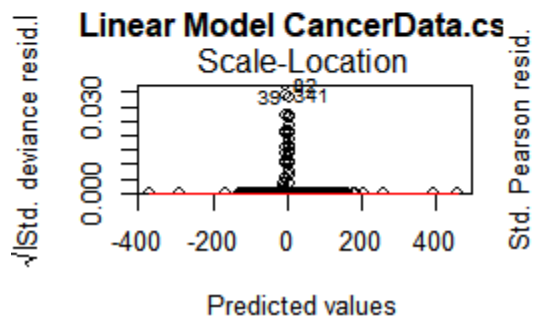
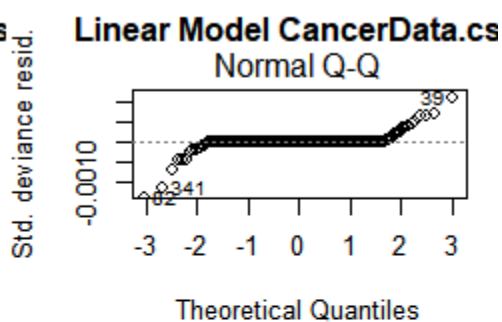
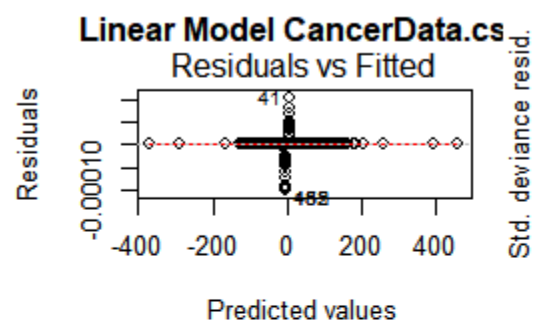
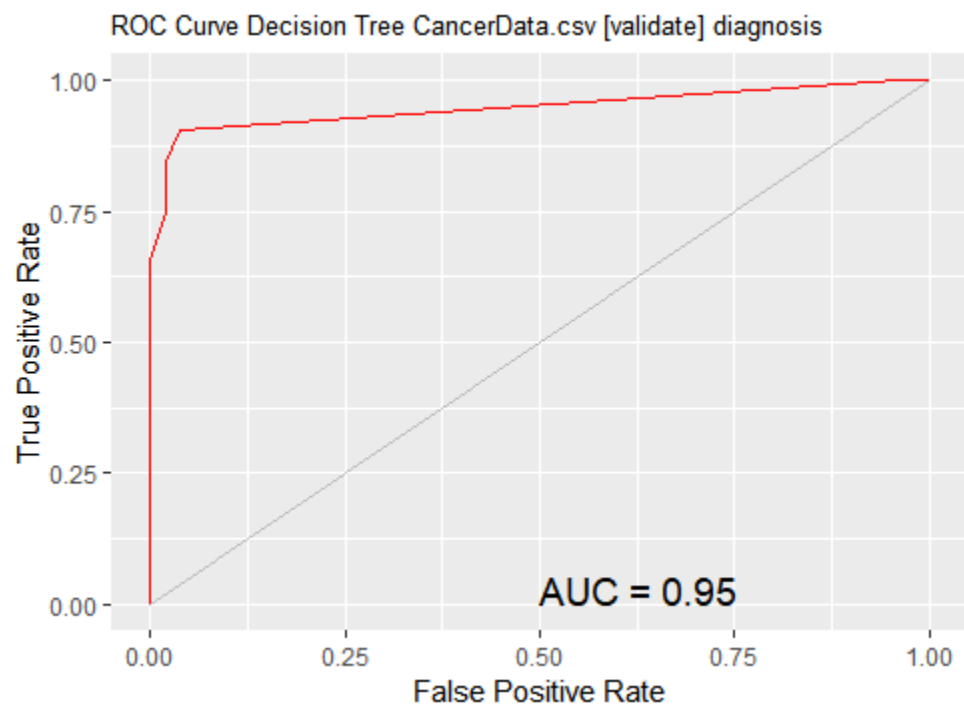
```
plot.new()
```

```
plot (ev)
```

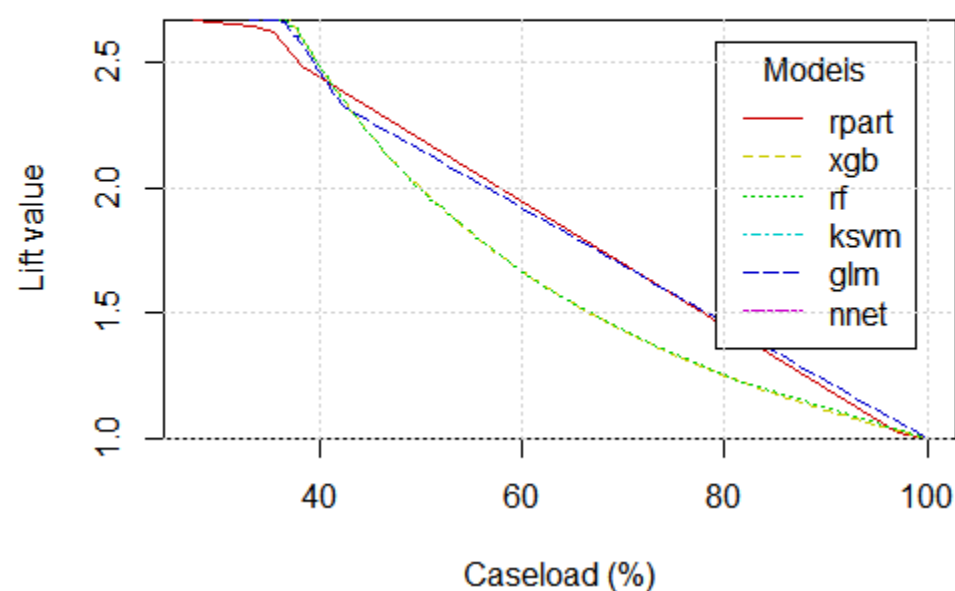




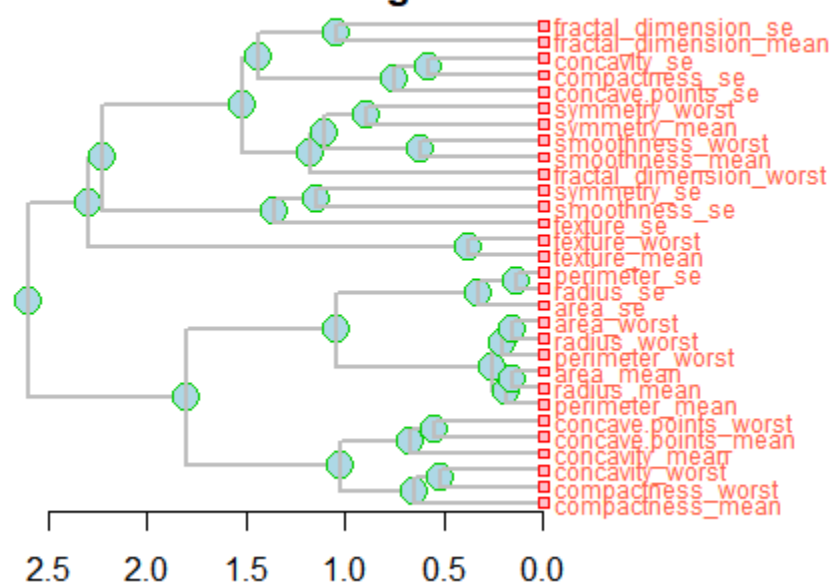




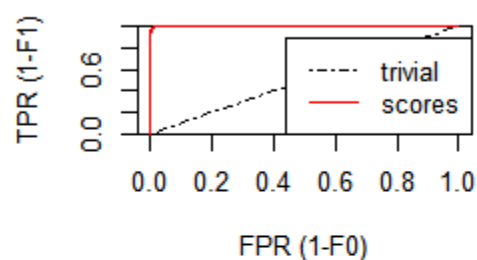
Lift Chart CancerData.csv



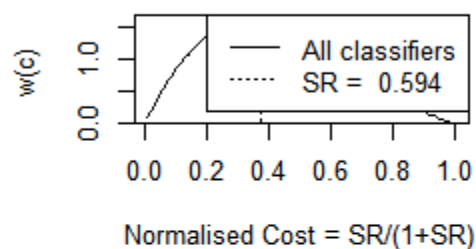
Variable Correlation Clusters CancerData.csv using Pearson



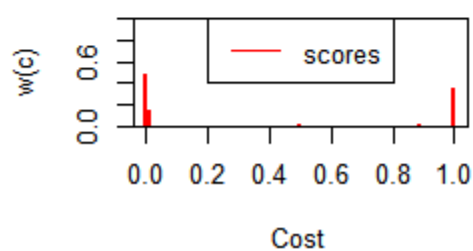
ROC (continuous) and ROCH (discrete)



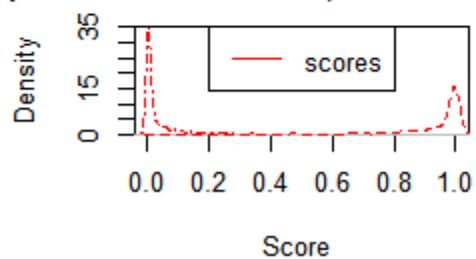
H measure w(c)



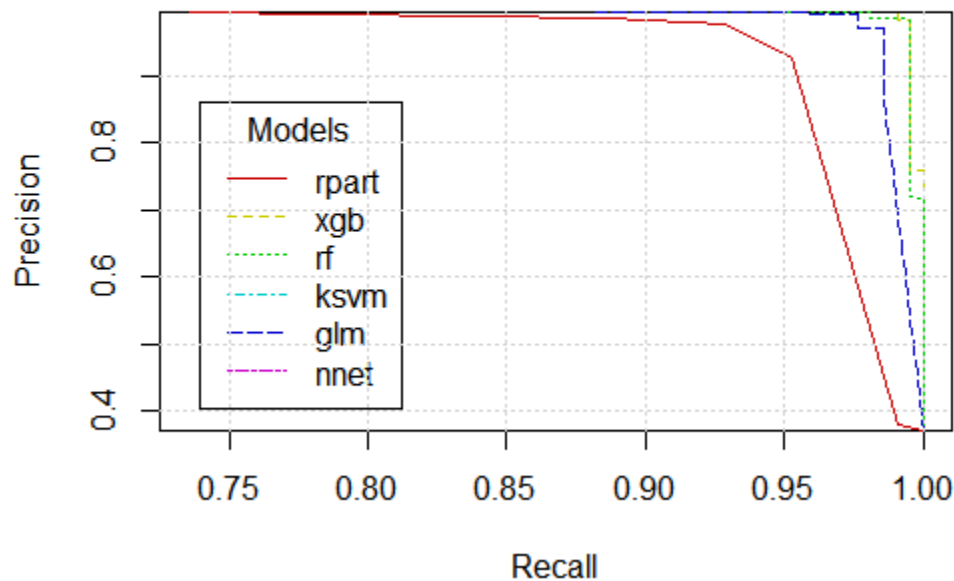
AUC w(c)

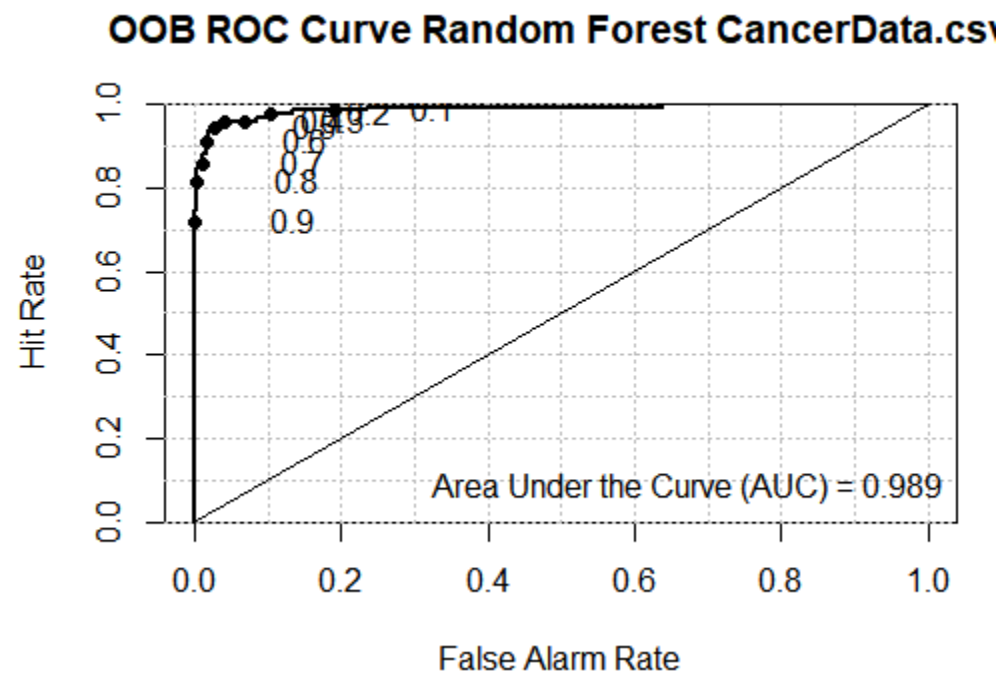
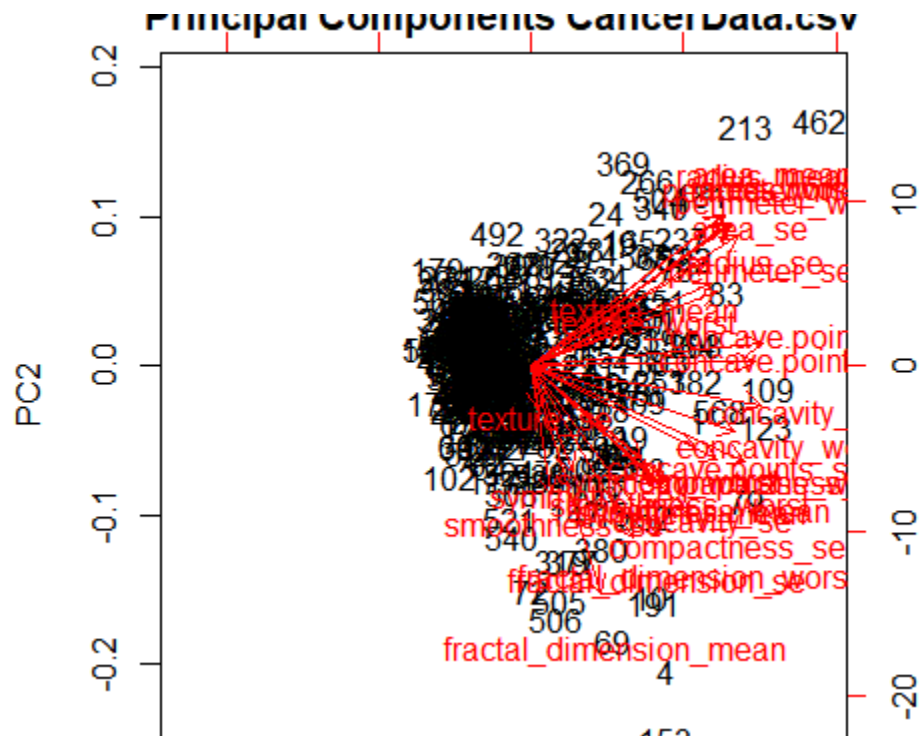


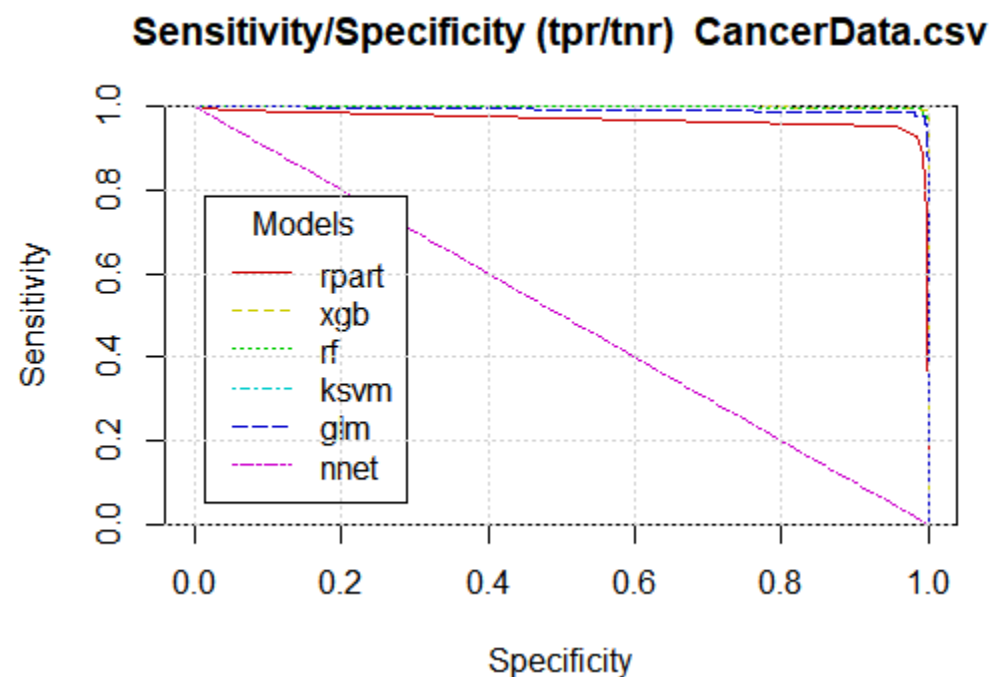
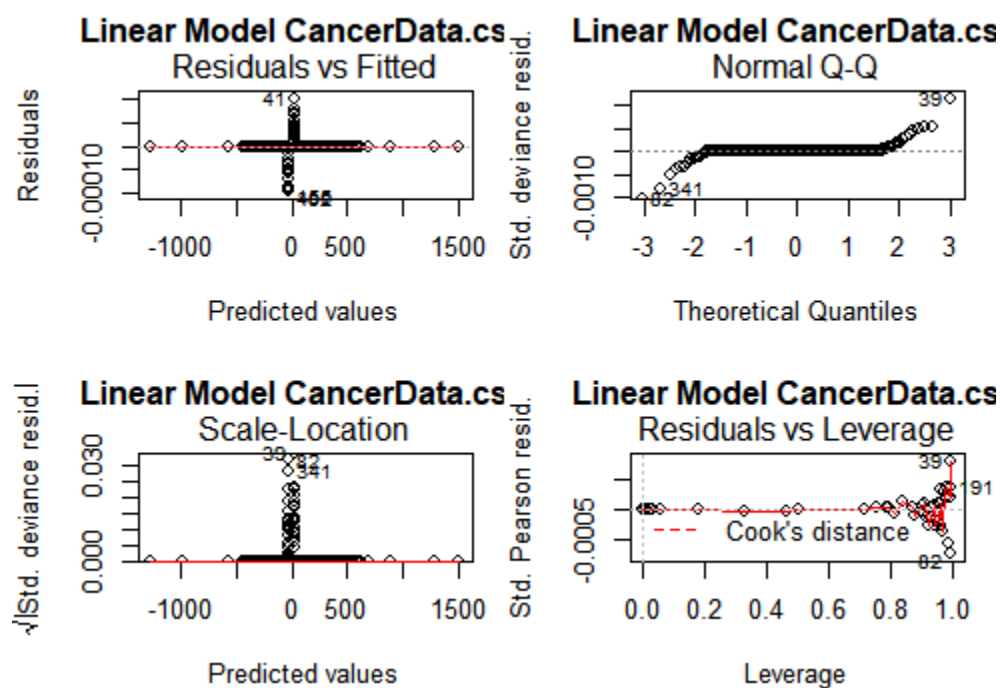
**Smoothed score distribution
(class 0: dash-dotted, class 1: dashed)**

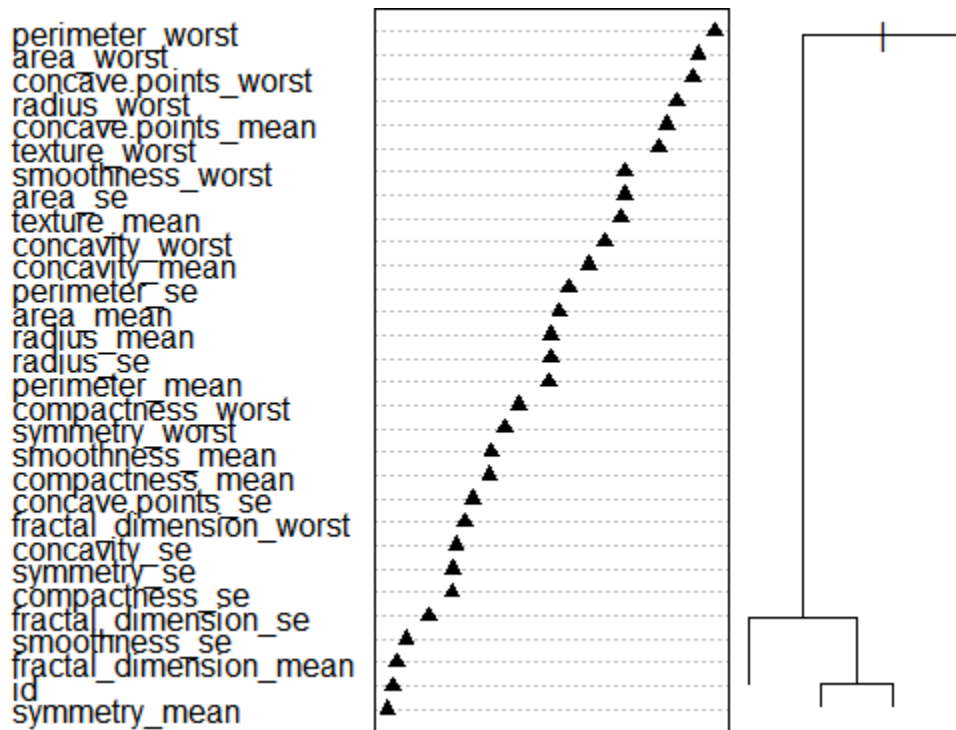


Precision/Recall Plot CancerData.csv

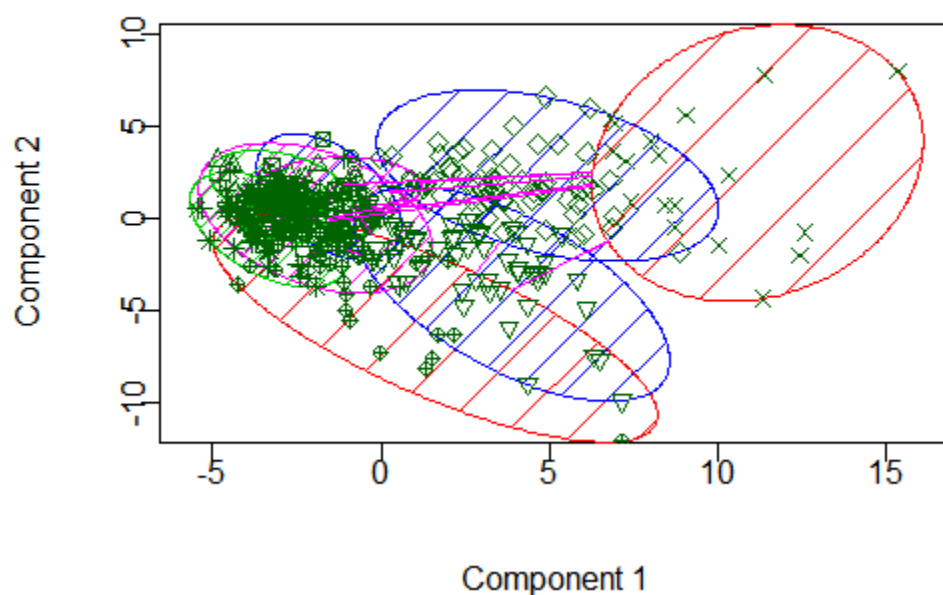


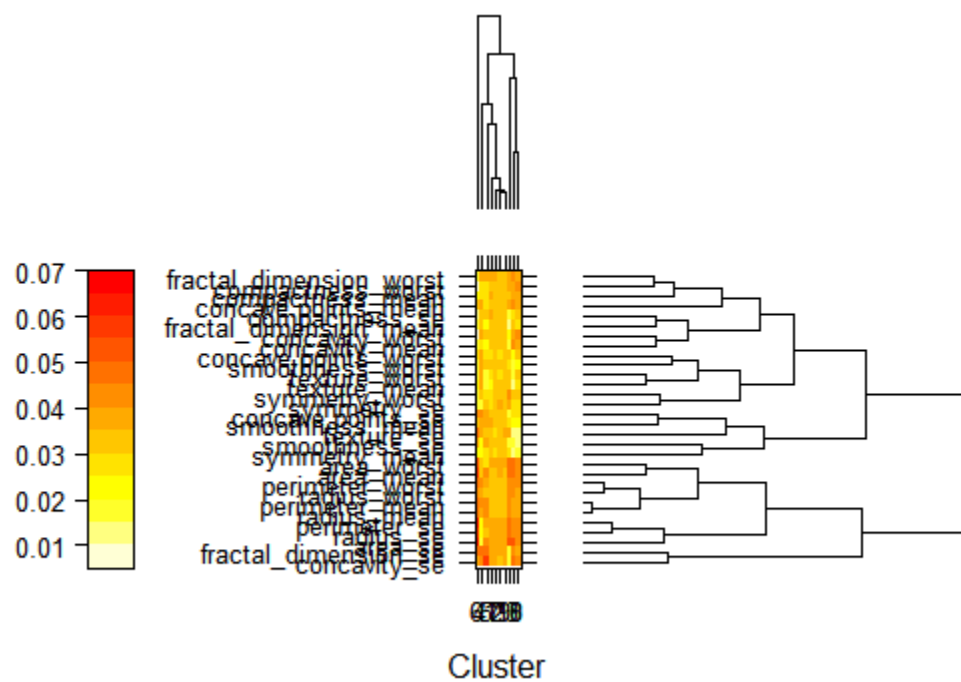




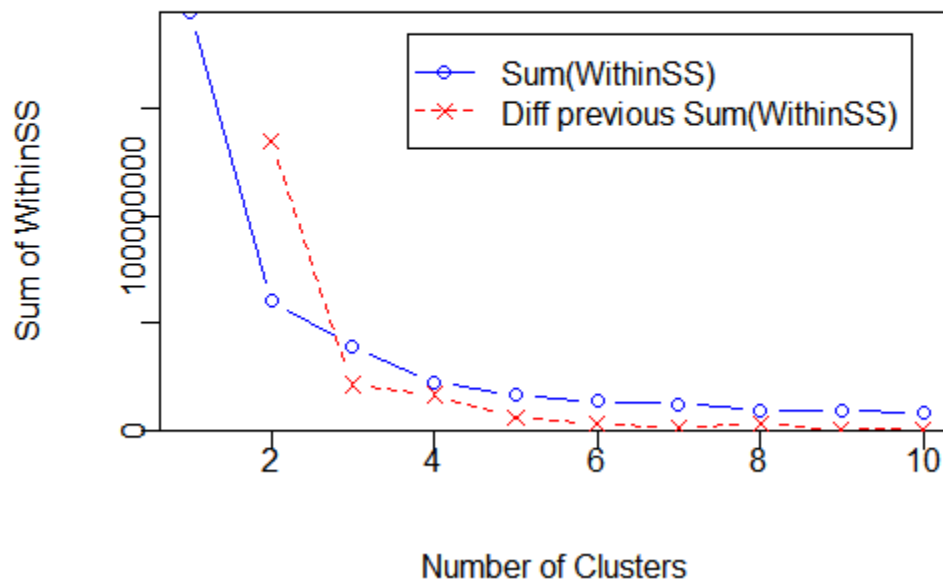


Discriminant Coordinates CancerData.csv

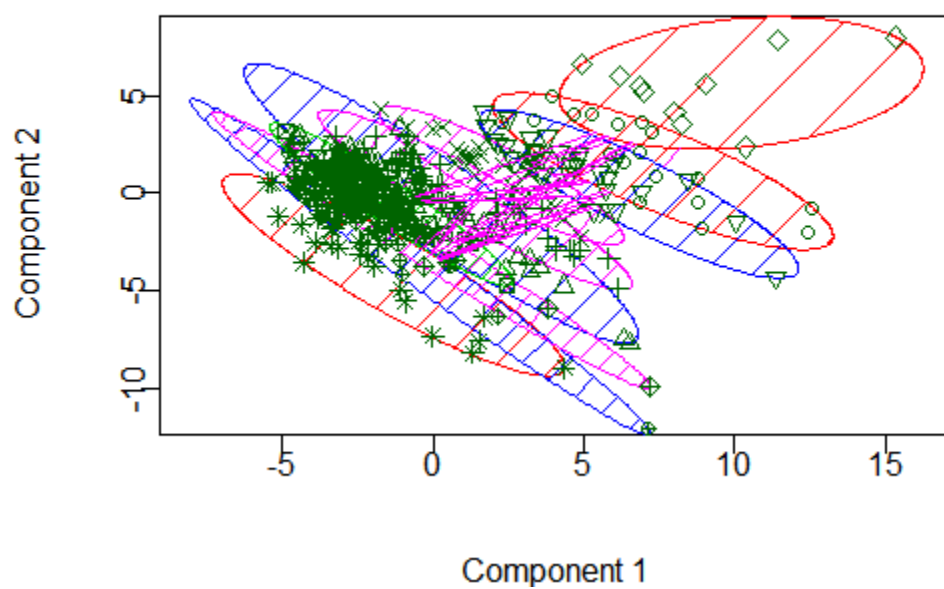




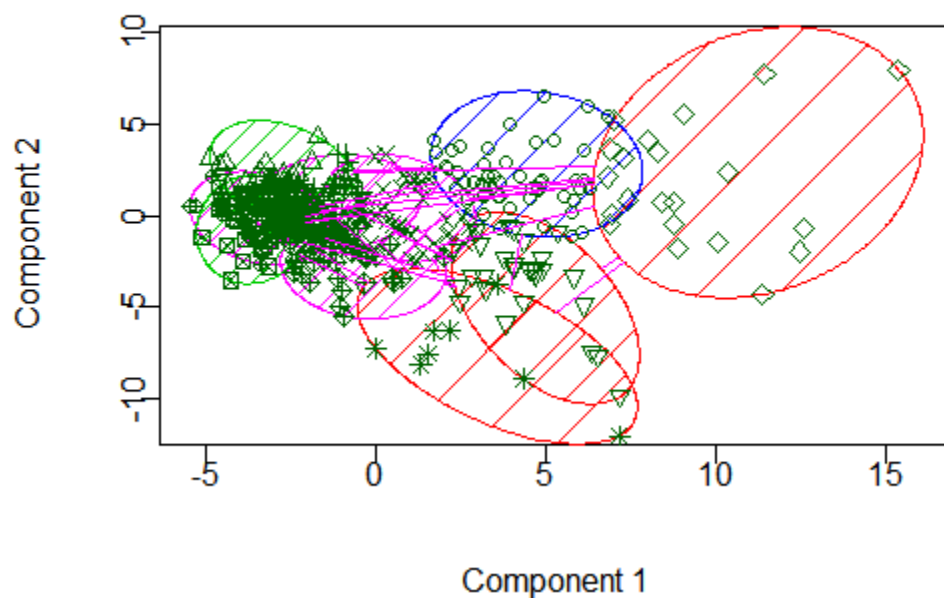
Sum of WithinSS Over Number of Clusters



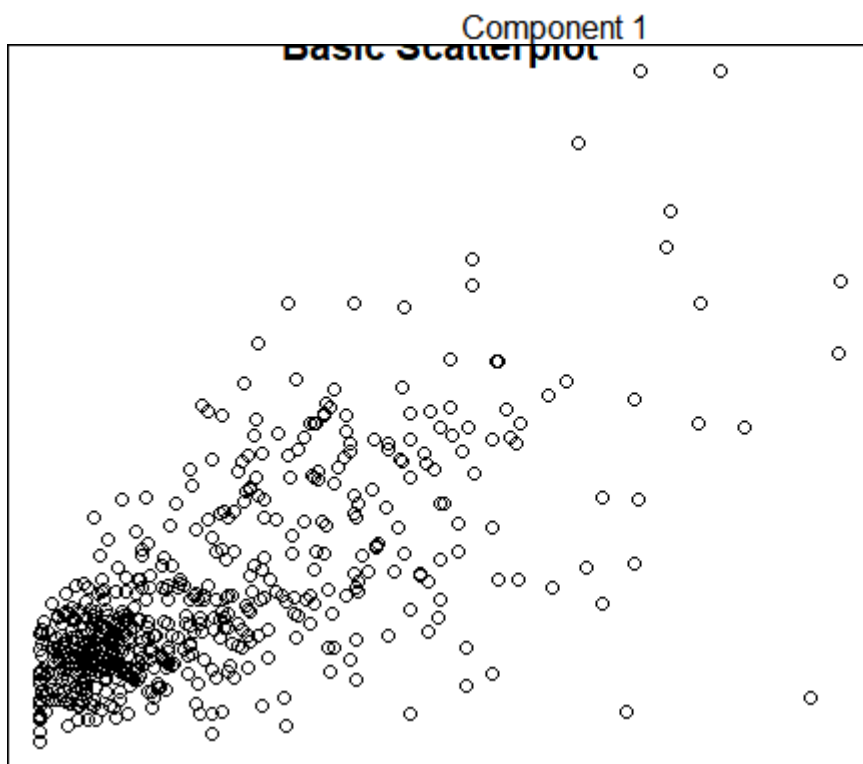
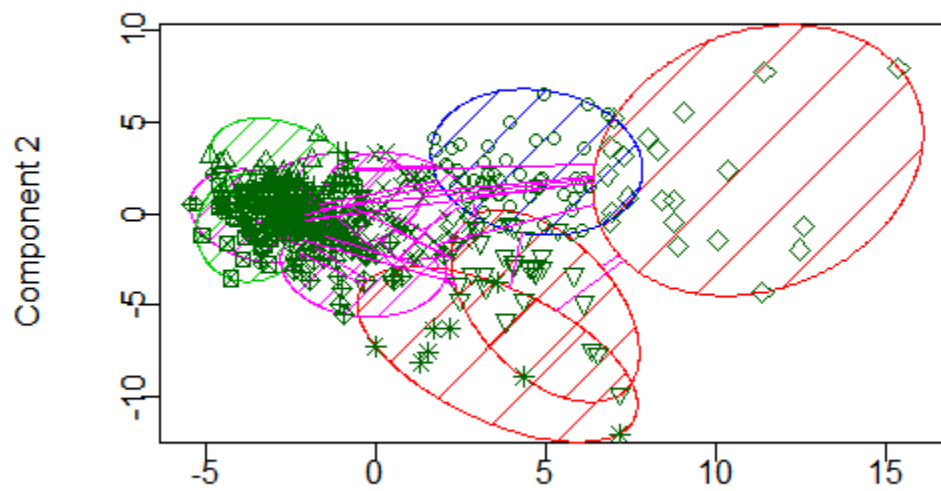
Discriminant Coordinates CancerData.csv



Discriminant Coordinates CancerData.csv

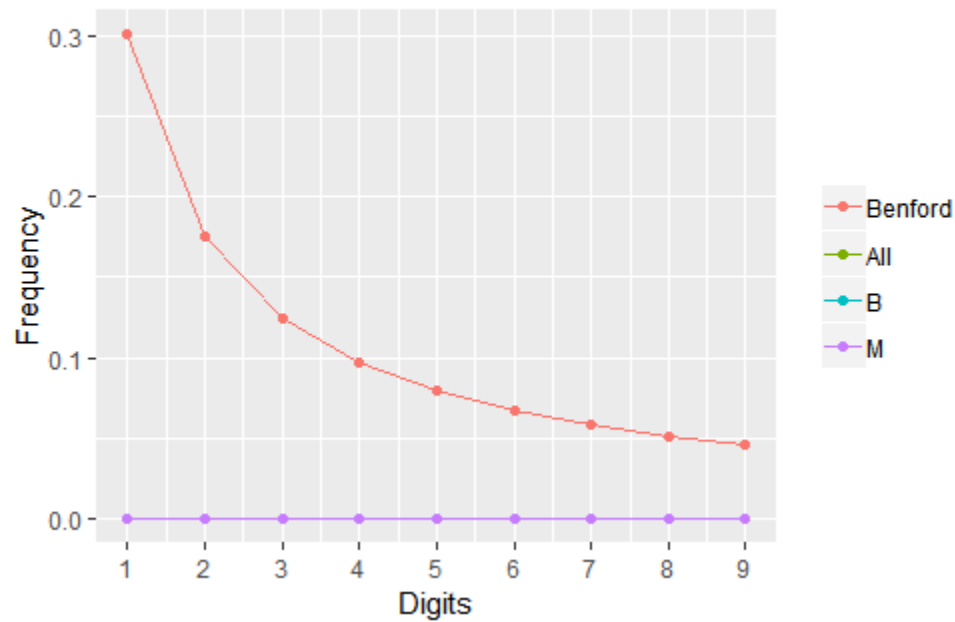


Discriminant Coordinates CancerData.csv

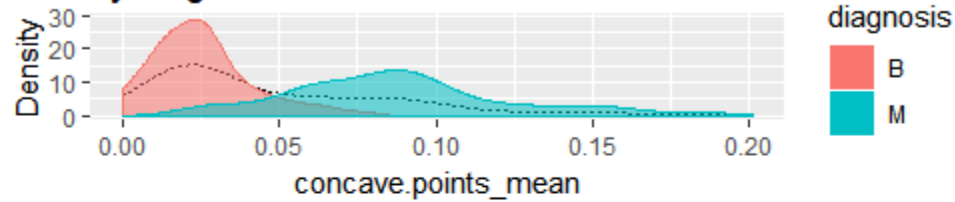


Other plots through Rattle

Digital Analysis of First Digit
of concave.points_mean by diagnosis

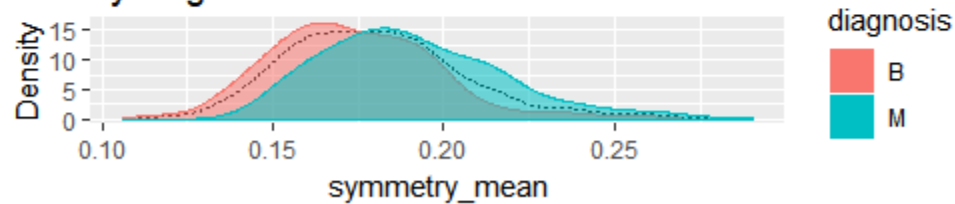


Distribution of concave.points_mean (sample)
by diagnosis



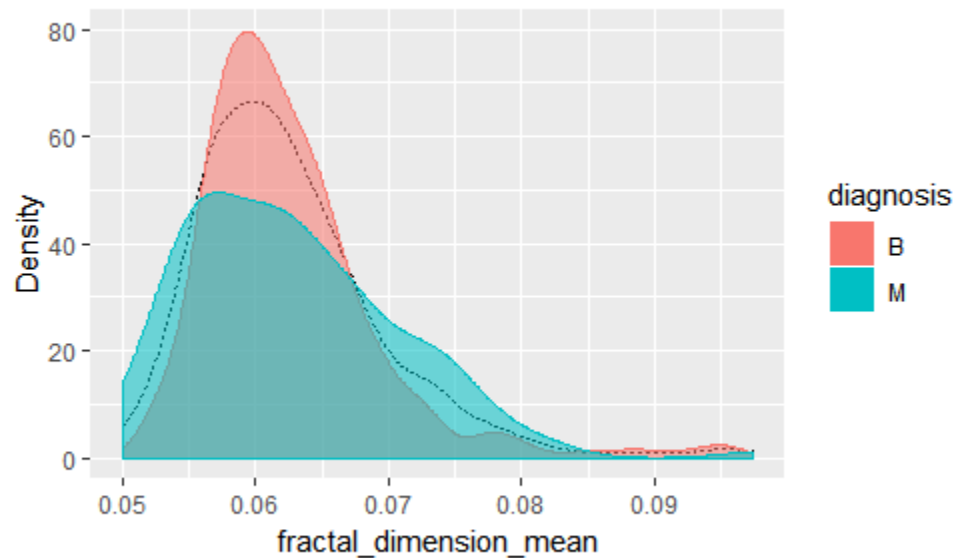
Rattle 2018-Nov-01 14:23:33 tsraj

Distribution of symmetry_mean (sample)
by diagnosis



Rattle 2018-Nov-01 14:23:35 tsraj

Distribution of fractal_dimension_mean (sample)
by diagnosis



Rattle 2018-Nov-01 14:32:06 tsraj

