

Final_raisin

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1. Load data

```
library(readxl)
library(car)
```

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

```
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()
## x dplyr::recode()  masks car::recode()
## x purrr::some()    masks car::some()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
raisin<-read_excel("Raisin_Dataset.xlsx")
raisin$Class<-factor(raisin$Class)
str(raisin)
```

```
## tibble [900 x 8] (S3: tbl_df/tbl/data.frame)
## $ Area      : num [1:900] 87524 75166 90856 45928 79408 ...
## $ MajorAxisLength: num [1:900] 442 407 442 287 352 ...
## $ MinorAxisLength: num [1:900] 253 243 266 209 291 ...
## $ Eccentricity   : num [1:900] 0.82 0.802 0.798 0.685 0.564 ...
## $ ConvexArea     : num [1:900] 90546 78789 93717 47336 81463 ...
## $ Extent         : num [1:900] 0.759 0.684 0.638 0.7 0.793 ...
## $ Perimeter      : num [1:900] 1184 1122 1209 844 1073 ...
## $ Class         : Factor w/ 2 levels "Besni","Kecimen": 2 2 2 2 2 2 2 2 2 2 ...
```

2. EDA (Exploratory Data Analysis)

```
options(scipen = 999)
#Summary table
library(skimr)
library(gt)
skim_tb<-skim(raisin)

raisin_summary<-data.frame(
  Type = skim_tb$skim_type,
  Variables = skim_tb$skim_variable,
  Missing = skim_tb$n_missing,
  Min = skim_tb$numeric.p0,
  Mean = skim_tb$numeric.mean,
  Median = skim_tb$numeric.p50,
  Max = skim_tb$numeric.p100,
  SD = skim_tb$numeric.sd
)
raisin_summary[2:8,4:8]<-round(raisin_summary[2:8,4:8],2)
gt(raisin_summary)%>%
  tab_header(
    title = "STATISTICAL SUMMARY TABLE"
  )
```

STATISTICAL SUMMARY TABLE

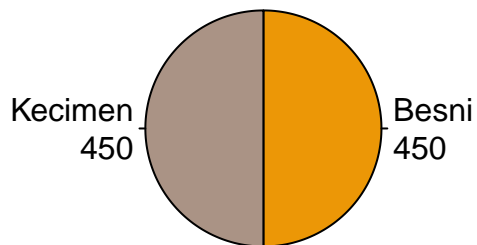
Type	Variables	Missing	Min	Mean	Median	Max	SD
factor	Class	0	NA	NA	NA	NA	NA
numeric	Area	0	25387.00	87804.13	78902.00	235047.00	39002.11
numeric	MajorAxisLength	0	225.63	430.93	407.80	997.29	116.04
numeric	MinorAxisLength	0	143.71	254.49	247.85	492.28	49.99
numeric	Eccentricity	0	0.35	0.78	0.80	0.96	0.09
numeric	ConvexArea	0	26139.00	91186.09	81651.00	278217.00	40769.29
numeric	Extent	0	0.38	0.70	0.71	0.84	0.05
numeric	Perimeter	0	619.07	1165.91	1119.51	2697.75	273.76

```
raisin[c(86,291),]
```

```
## # A tibble: 2 x 8
##   Area MajorAxisLength MinorAxisLength Eccentricity ConvexArea Extent
##   <dbl>         <dbl>         <dbl>         <dbl>         <dbl> <dbl>
## 1 180898           844.           323.           0.924         221396 0.454
## 2 136340           723.           311.           0.902         176818 0.530
## # i 2 more variables: Perimeter <dbl>, Class <fct>
```

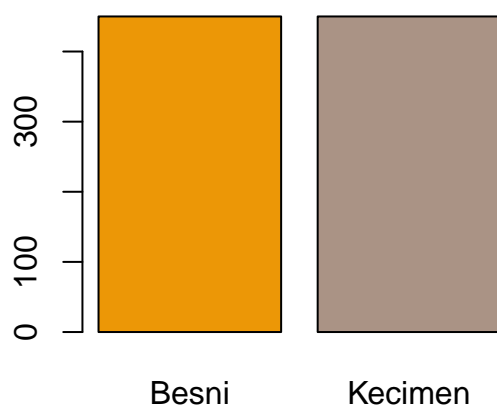
```
# Pie Chart from data frame with Appended Sample Sizes
mytable <- table(raisin$Class)
lbls <- paste(names(mytable), "\n", mytable, sep="")
pie(mytable, labels = lbls, clockwise = T, col=c("#EC9706", "#AA9385"),
    main="Pie Chart of Raisin's Class")
```

Pie Chart of Raisin's Class



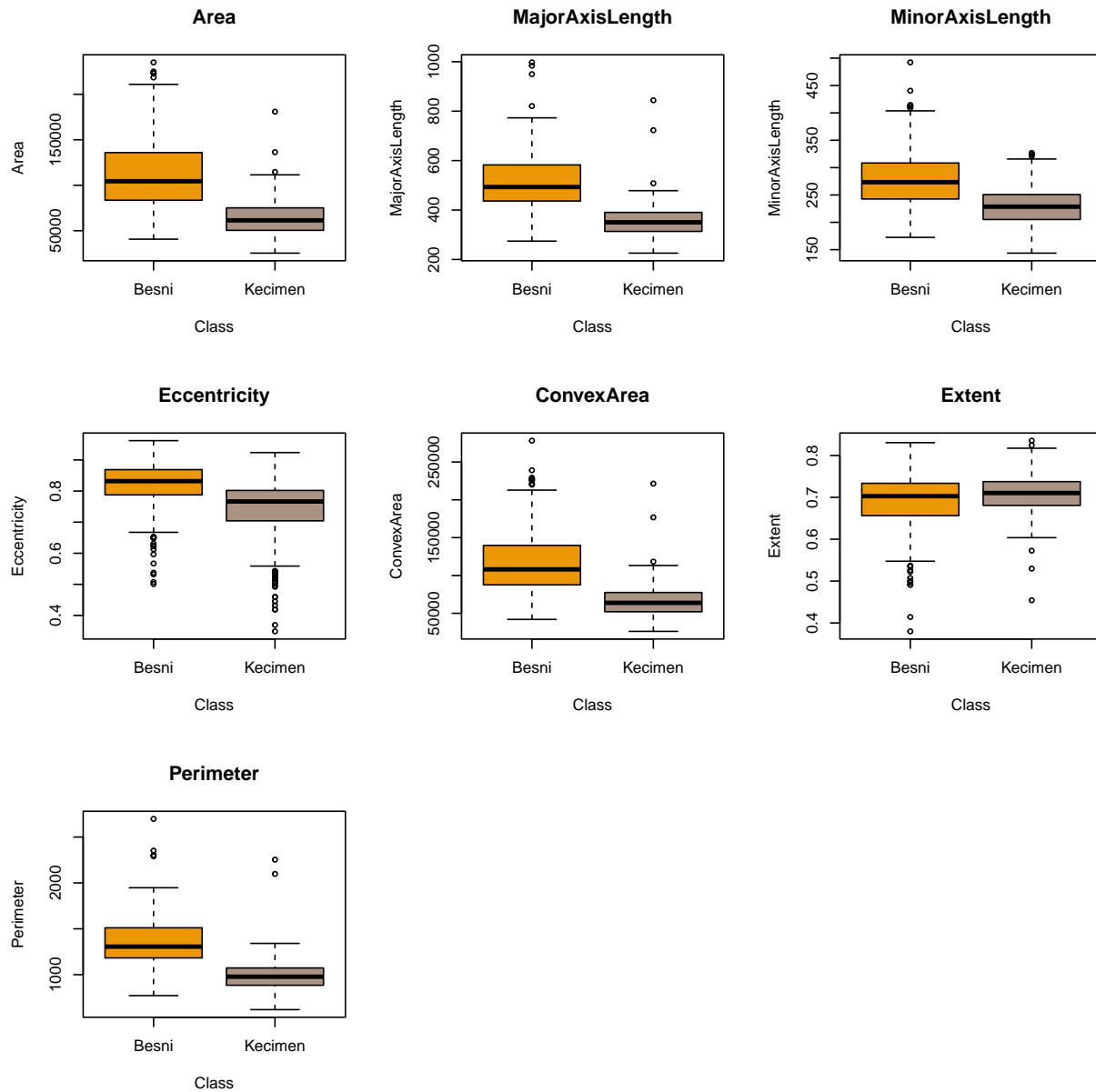
```
# Histogram of raisin
plot(raisin$Class, col=c("#EC9706", "#AA9385"), main= "Histogram of the Raisin's types")
```

Histogram of the Raisin's types



```
# Multiple side-by side boxplot
par(mfrow=c(3,3)) # Set up the layout

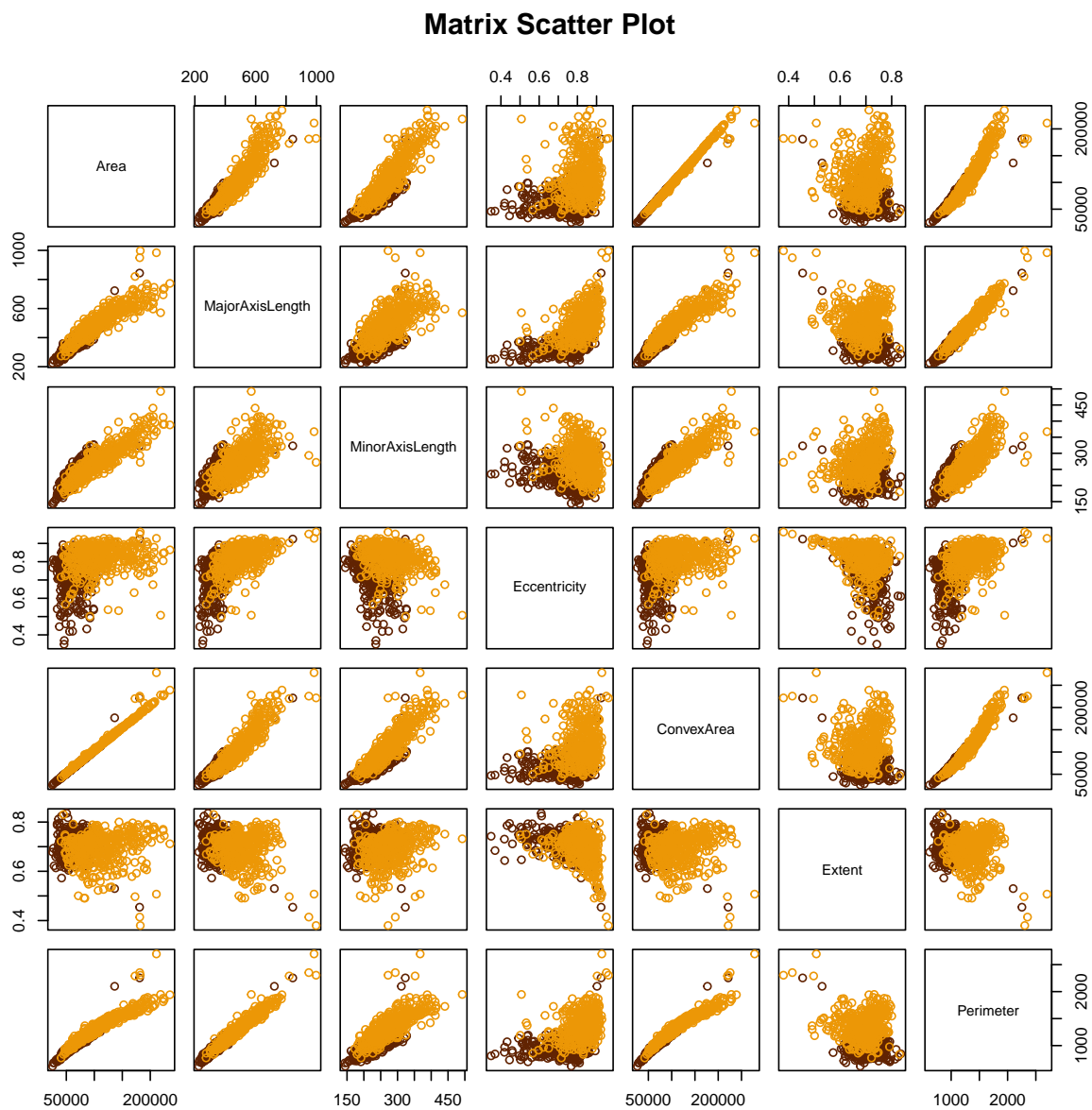
for (col_name in names(raisin)[1:7]) {
  boxplot(raisin[[col_name]] ~ raisin$Class,
    data = raisin,
    main = col_name,
    xlab = "Class",
    ylab = col_name,
    col = c("#EC9706", "#AA9385"))
}
```



According to the multiple boxplot, the Besni raisin seems to have higher median in each measurement than the Kecimen raisin.

c. Matrix Scatter plot

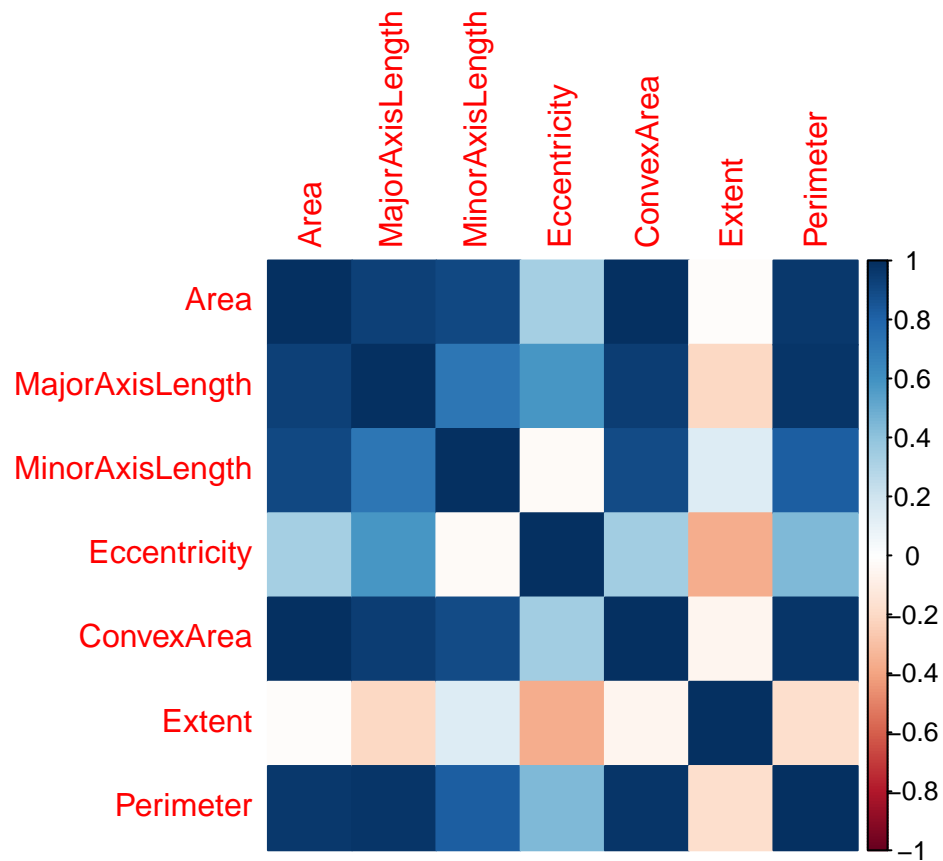
```
class_col<-ifelse(raisin$Class=="Besni","#EC9706","#612302")
pairs(raisin[1:7],
      pch = 21,
      col = class_col,
      main = "Matrix Scatter Plot")
```



```
# Correlation Heatmap  
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
corr_matrix<-cor(raisin[,1:7])  
corrplot(corr_matrix, method="color")
```



3. Statistic Analysis

a. Full model

```
fullmodel<-glm(Class ~ . ,data = raisin, family = binomial)
summary(fullmodel)

##
## Call:
## glm(formula = Class ~ ., family = binomial, data = raisin)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  2.2319880  7.0449015   0.317   0.751378
## Area        -0.0005010  0.0001244  -4.027 0.0000566058 ***
## MajorAxisLength 0.0445871  0.0159710   2.792   0.005242 **
## MinorAxisLength 0.0910874  0.0269403   3.381   0.000722 ***
## Eccentricity   3.8908609  4.9124257   0.792   0.428335
## ConvexArea     0.0004089  0.0001191   3.434   0.000594 ***
## Extent         0.6828128  2.7159964   0.251   0.801502
## Perimeter     -0.0361306  0.0066136  -5.463 0.0000000468 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##    Null deviance: 1247.66  on 899  degrees of freedom
## Residual deviance:  608.98  on 892  degrees of freedom
## AIC: 624.98
##
## Number of Fisher Scoring iterations: 7
```

```
nullmodel<-glm(Class~1,data=raisin,family=binomial)
summary(nullmodel)

##
## Call:
## glm(formula = Class ~ 1, family = binomial, data = raisin)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) 0.0000000000000003901 0.0666666666666666574      0      1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##    Null deviance: 1247.7  on 899  degrees of freedom
## Residual deviance: 1247.7  on 899  degrees of freedom
## AIC: 1249.7
##
## Number of Fisher Scoring iterations: 2
```

b. Variable selection:

AIC backward:

```
model1<-step(fullmodel,trace=0)
summary(model1)

##
## Call:
## glm(formula = Class ~ Area + MajorAxisLength + MinorAxisLength +
##      ConvexArea + Perimeter, family = binomial, data = raisin)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    6.7317525   4.4215966   1.522   0.127891
## Area          -0.0004777   0.0001159  -4.120 0.0000378603 ***
## MajorAxisLength  0.0467310   0.0156343   2.989   0.002799 **
## MinorAxisLength  0.0788838   0.0212508   3.712   0.000206 ***
## ConvexArea      0.0003990   0.0001127   3.540   0.000401 ***
## Perimeter      -0.0360055   0.0063523  -5.668 0.0000000144 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 1247.66  on 899  degrees of freedom
## Residual deviance:  609.64  on 894  degrees of freedom
## AIC: 621.64
##
## Number of Fisher Scoring iterations: 7
```

```
# Multicollinearity
vif(model1)
```

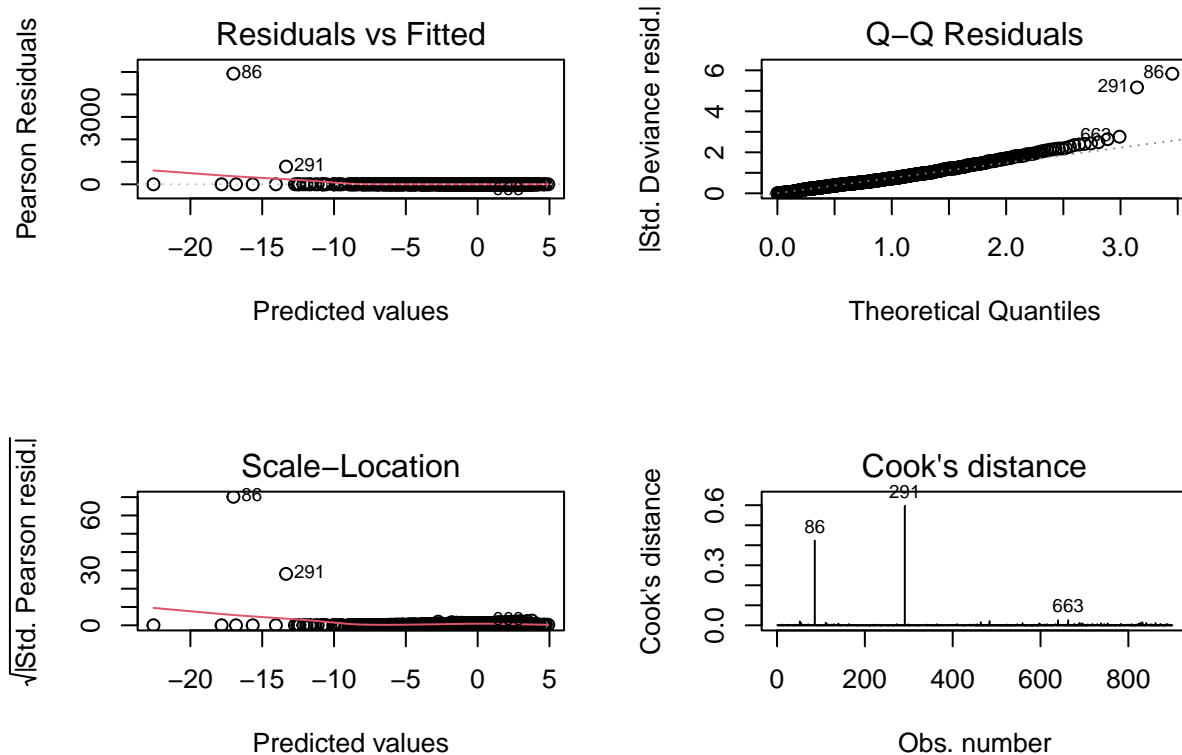
	Area	MajorAxisLength	MinorAxisLength	ConvexArea	Perimeter
	429.59691	68.26062	51.69712	431.27441	65.34105

Since the Area and CovexArea has a high multi colinearity. We decide to drop ConvexArea in the model1


```
model2<-glm(formula = Class ~Area+ MajorAxisLength + MinorAxisLength + Perimeter,
             family = binomial, data = raisin)
summary(model2)
```

```
##
## Call:
## glm(formula = Class ~ Area + MajorAxisLength + MinorAxisLength +
##      Perimeter, family = binomial, data = raisin)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    3.3473160  4.2360894   0.790   0.4294
## Area          -0.0001113  0.0000562  -1.981   0.0476 *
## MajorAxisLength 0.0321112  0.0148931   2.156   0.0311 *
## MinorAxisLength 0.0682675  0.0209138   3.264   0.0011 **
## Perimeter      -0.0219106  0.0044520  -4.921 0.000000859 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 1247.7  on 899  degrees of freedom
## Residual deviance:  618.6  on 895  degrees of freedom
## AIC: 628.6
##
## Number of Fisher Scoring iterations: 7
```

```
par(mfrow=c(2,2))
plot(model2,1:4)
```



c. Transformation:

```
PT<-powerTransform(cbind(Area,MajorAxisLength,MinorAxisLength, Perimeter)~1,data=raisin)
summary(PT)
```

```
## bcPower Transformations to Multinormality
##           Est Power Rounded Pwr Wald Lwr Bnd Wald Up Bnd
## Area      -0.1786      -0.18   -0.2181   -0.1392
## MajorAxisLength -0.3810     -0.33  -0.4475   -0.3145
## MinorAxisLength -0.4007     -0.33  -0.4985   -0.3029
## Perimeter    -0.4228     -0.50  -0.5112   -0.3344
##
## Likelihood ratio test that transformation parameters are equal to 0
## (all log transformations)
##           LRT df           pval
## LR test, lambda = (0 0 0 0) 141.9336  4 < 0.000000000000000222
##
## Likelihood ratio test that no transformations are needed
##           LRT df           pval
## LR test, lambda = (1 1 1 1) 3101.776  4 < 0.000000000000000222
```

```
transform1<-glm(Class ~ I((Area^(-1/5)-1)/(-1/5))+I((MajorAxisLength^(-1/3)-1)/(-1/3)) + I((MinorAxisLength^(-1/3)-1)/(-1/3)) + I((Perimeter^(-1/2)-1)/(-1/2)),
  data = raisin, family = binomial)
summary(transform1)
```

```
##
## Call:
## glm(formula = Class ~ I((Area^(-1/5) - 1)/(-1/5)) + I((MajorAxisLength^(-1/3) - 1)/(-1/3)) + I((MinorAxisLength^(-1/3) - 1)/(-1/3)) + I((Perimeter^(-1/2) - 1)/(-1/2)), family = binomial, data = raisin)
##
## Coefficients:
##
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      1662.99      291.67   5.702 0.0000000119
## I((Area^(-1/5) - 1)/(-1/5))      -65.64       90.47  -0.726      0.468
## I((MajorAxisLength^(-1/3) - 1)/(-1/3))    106.12       84.36   1.258      0.208
## I((MinorAxisLength^(-1/3) - 1)/(-1/3))    107.08       66.29   1.615      0.106
## I((Perimeter^(-1/2) - 1)/(-1/2))     -986.90      177.39  -5.564 0.0000000264
##
## (Intercept)                ***
## I((Area^(-1/5) - 1)/(-1/5))
## I((MajorAxisLength^(-1/3) - 1)/(-1/3))
## I((MinorAxisLength^(-1/3) - 1)/(-1/3))
## I((Perimeter^(-1/2) - 1)/(-1/2))      ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##    Null deviance: 1247.66  on 899  degrees of freedom
## Residual deviance:  606.66  on 895  degrees of freedom
## AIC: 616.66
##
## Number of Fisher Scoring iterations: 6
```

d. Evaluation:

```
library(pROC)
```

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

```
##
```

```
## Attaching package: 'pROC'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
##      cov, smooth, var
```

```
# Prediction
```

```
logistic_models <- list(fullmodel,model1,model2,transform1, nullmodel)
```

```
Accuracy_score <- c()
```

```

confusion_matrix <-list()
AUC_score<-c()
AIC_score<-c()

for (i in seq_along(logistic_models)) {
  probabilities <- predict(logistic_models[[i]], newdata = raisin, type="response")
  predictions <- ifelse(probabilities>0.5,"Kecimen","Besni")
  cm<-table(prediction =predictions, actual=raisin$Class )
  confusion_matrix[[i]]<-cm
  acc<-sum(diag(cm))/900
  Accuracy_score[[i]]<-acc
  roc_obj<-roc(raisin$Class,probabilities)
  auc_score<-auc(roc_obj)
  AUC_score[[i]]<-auc_score
  aic_score<-AIC(logistic_models[[i]])
  AIC_score[[i]]<-aic_score
}

```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```

models=c('fullmodel','model1','model2','transform1', 'nullmodel')
cbind(models,Accuracy_score,AUC_score,AIC_score)

```

```

##      models      Accuracy_score AUC_score AIC_score
## [1,] "fullmodel"  0.8577778      0.9279111 624.9814
## [2,] "model1"    0.8555556      0.9278864 621.6371
## [3,] "model2"    0.8611111      0.9333531 628.6019
## [4,] "transform1" 0.87          0.9345333 616.6606
## [5,] "nullmodel" 0.5           0.5         1249.665

```

```
logic_tb<-data.frame(Models=models,
  Num.Predictors= c(7,5,4,4,0),
  Accuracy=array(unlist(Accuracy_score), dim = c(length(Accuracy_score))),
  AUC=array(unlist(AUC_score), dim = c(length(AUC_score))),
  AIC=array(unlist(AIC_score), dim = c(length(AIC_score)))
)

gt(logic_tb)%>%
  tab_header(
    title = "MULTIPLE LOGISTICS REGRESSION MODELS"
  )
```

MULTIPLE LOGISTICS REGRESSION MODELS

Models	Num.Predictors	Accuracy	AUC	AIC
fullmodel	7	0.8577778	0.9279111	624.9814
model1	5	0.8555556	0.9278864	621.6371
model2	4	0.8611111	0.9333531	628.6019
transform1	4	0.8700000	0.9345333	616.6606
nullmodel	0	0.5000000	0.5000000	1249.6649

=> Conclusion: ‘transform1’ has the good value in most of metrics, however the p_value in the summary table shows that the coefficient are not significant. The full model also did a great job in clasification of the raisin model, however the evaluate metric is lower than ‘model2’. In conclusion, we choose ‘model2’ which has 4 predictors (Area, MajorAxisLength, MinorAxisLength, Perimeter) as the final model.

4. Cross validation:

a. Split data:

```
set.seed(666)
n<-nrow(raisin)
train_index<-sample(1:n,round(0.7*n))
trainset<-raisin[train_index,]
testset<-raisin[-train_index,]
```

b. Our model:

```
# Fit model on train set
glm.train<-glm(Class ~ Area + MajorAxisLength + MinorAxisLength +
  Perimeter, data = trainset, family = binomial)
summary(glm.train)

##
## Call:
## glm(formula = Class ~ Area + MajorAxisLength + MinorAxisLength +
##      Perimeter, family = binomial, data = trainset)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -0.21208366  4.88890062  -0.043 0.965398
## Area         -0.00015278  0.00006573  -2.325 0.020099 *
## MajorAxisLength  0.03336397  0.01723271   1.936 0.052857 .
## MinorAxisLength  0.07633034  0.02431499   3.139 0.001694 **
## Perimeter     -0.01798013  0.00504396  -3.565 0.000364 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 873.37  on 629  degrees of freedom
## Residual deviance: 449.78  on 625  degrees of freedom
## AIC: 459.78
##
## Number of Fisher Scoring iterations: 7
```

```

# Evaluate
prob.test <- predict (glm.train, newdata=testset, type= "response")
preds.test<- ifelse(prob.test >0.5, "Kecimen", "Besni")
# Confusion matrix
cm1<- table (prediction = preds.test,
             actual= testset$Class)
addmargins(cm1)

```

```

##           actual
## prediction Besni Kecimen Sum
##   Besni      109         9 118
##   Kecimen    26       126 152
##   Sum        135       135 270

```

```

# Accuracy
Accuracy1<-sum(diag(cm1))/270
#Sensitivity (TP) identify Kecimen type of raisin
Sensitivity1 <-cm1[2,2]/135
# Specificity (TF)
Specificity1<-cm1[1,1]/135
# AUC
roc.test <- roc(testset$Class,prob.test)

```

```

## Setting levels: control = Besni, case = Kecimen

```

```

## Setting direction: controls < cases

```

```

auc_glm<-auc(roc.test)

```

c. Decision Tree:

```
# Fit trainset with decision tree
library(rpart)
tree.train<-rpart(Class~.,data=trainset, method= "class")

# Evaluate
tree_prob <- predict (tree.train, newdata=testset)[,2]
tree_pred <- predict (tree.train, newdata=testset, type="class")
# Confusion matrix
cm2<- table (prediction = tree_pred,
              actual= testset$Class)
addmargins(cm2)

##           actual
## prediction Besni Kecimen Sum
##   Besni      108         9 117
##   Kecimen    27       126 153
##   Sum        135       135 270

# Accuracy
Accuracy2<-sum(diag(cm2))/270
#Sensitivity (TP) identify Kecimen type of raisin
Sensitivity2 <-cm2[2,2]/135
# Specificity (TF)
Specificity2<-cm2[1,1]/135
# AUC
tree.roc <- roc(testset$Class,tree_prob)

## Setting levels: control = Besni, case = Kecimen

## Setting direction: controls < cases

auc_tree<-auc(tree.roc)
```


d. Random Forest:

```
# Fit trainset with random forest
# library(randomForest)
set.seed(123)
rf.train<-randomForest(Class~.,data=trainset,type="classification")
```

```
# Evaluate
rf_prob <- predict (rf.train, newdata=testset,type="prob")[,2]
rf_pred <- predict (rf.train, newdata=testset, type="class")
# Confusion matrix
cm3<- table (prediction = rf_pred,
              actual= testset$Class)
addmargins(cm3)
```

```
##           actual
## prediction Besni Kecimen Sum
##   Besni      108      11 119
##   Kecimen    27     124 151
##   Sum        135     135 270
```

```
# Accuracy
Accuracy3<-sum(diag(cm3))/270
#Sensitivity (TP) identify Kecimen type of raisin
Sensitivity3 <-cm3[2,2]/135
# Specificity (TF)
Specificity3<-cm3[1,1]/135
# AUC
rf.roc <- roc(testset$Class,rf_prob)
```

```
## Setting levels: control = Besni, case = Kecimen
```

```
## Setting direction: controls < cases
```

```
auc_rf<-auc(rf.roc)
```

e. Comparative table:

```
tb1<-data.frame(Models= c("Logistic Regression","Decision Tree","Random Forest"),
  Accuracy= c(round(Accuracy1,3),round(Accuracy2,3),round(Accuracy3,3)),
  Sensitivity=c(round(Sensitivity1,3),round(Sensitivity2,3),round(Sensitivity3,3)),
  Specificity=c(round(Specificity1,3),round(Specificity2,3),round(Specificity3,3)),
  AUC= c(round(auc_glm,3),round(auc_tree,3),round(auc_rf,3)))
gt(tb1)%>%
  tab_header(
    title = "MODELS COMPARATIVE TABLE"
  )
```

MODELS COMPARATIVE TABLE

Models	Accuracy	Sensitivity	Specificity	AUC
Logistic Regression	0.870	0.933	0.807	0.934
Decision Tree	0.867	0.933	0.800	0.867
Random Forest	0.859	0.919	0.800	0.932

Conclusion: Our final model did a great job in predicting the model, most of the metrics are higher than other machine learning method (decision tree, random forest)