```
paste("Title: Will the Telcom Customer Churn?- A Classification Analysis")

## [1] "Title: Will the Telcom Customer Churn?- A Classification Analysis"

paste("Authors: Rajdeep Saha & Soumik Karmakar")

## [1] "Authors: Rajdeep Saha & Soumik Karmakar"

rm(list=ls())
set.seed(1)
library(ggplot2)
library(leaps)
library(caret)

## Loading required package: lattice

library(car)

## Loading required package: carData

library(corrplot)

## corrplot 0.89 loaded

library(tree)
library(MASS)
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:ggplot2':
##
##     margin

library(pROC)

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

##
## Attaching package: 'pROC'

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

#data access
df <- read.csv('C:/Users/user/OneDrive/Desktop/Self Project/WA_Fn-UseC_-
Telco-Customer-Churn.csv')
head(df)
```

```
##   customerID gender SeniorCitizen Partner Dependents tenure PhoneService
## 1 7590-VHVEG Female             0     Yes         No      1           No
## 2 5575-GNVDE   Male             0      No         No     34          Yes
## 3 3668-QPYBK   Male             0      No         No      2          Yes
## 4 7795-CFOCW   Male             0      No         No     45           No
## 5 9237-HQITU Female             0      No         No      2          Yes
## 6 9305-CDSKC Female             0      No         No      8          Yes
##      MultipleLines InternetService OnlineSecurity OnlineBackup
DeviceProtection
## 1 No phone service             DSL             No          Yes
No
## 2               No             DSL            Yes           No
Yes
## 3               No             DSL            Yes          Yes
No
## 4 No phone service             DSL            Yes           No
Yes
## 5               No     Fiber optic             No           No
No
## 6              Yes     Fiber optic             No           No
Yes
##   TechSupport StreamingTV StreamingMovies       Contract PaperlessBilling
## 1          No          No              No Month-to-month              Yes
## 2          No          No              No       One year               No
## 3          No          No              No Month-to-month              Yes
## 4         Yes          No              No       One year               No
## 5          No          No              No Month-to-month              Yes
## 6          No         Yes             Yes Month-to-month              Yes
##               PaymentMethod MonthlyCharges TotalCharges Churn
## 1          Electronic check          29.85        29.85    No
## 2              Mailed check          56.95      1889.50    No
## 3              Mailed check          53.85       108.15   Yes
## 4 Bank transfer (automatic)          42.30      1840.75    No
## 5          Electronic check          70.70       151.65   Yes
## 6          Electronic check          99.65       820.50   Yes
```

```
dim(df)
```

```
## [1] 7043   21
```

```
str(df)
```

```
## 'data.frame':    7043 obs. of  21 variables:
##  $ customerID      : chr  "7590-VHVEG" "5575-GNVDE" "3668-QPYBK" "7795-
CFOCW" ...
##  $ gender          : chr  "Female" "Male" "Male" "Male" ...
##  $ SeniorCitizen   : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Partner         : chr  "Yes" "No" "No" "No" ...
##  $ Dependents      : chr  "No" "No" "No" "No" ...
##  $ tenure          : int  1 34 2 45 2 8 22 10 28 62 ...
##  $ PhoneService    : chr  "No" "Yes" "Yes" "No" ...
##  $ MultipleLines   : chr  "No phone service" "No" "No" "No phone service"
...
##  $ InternetService : chr  "DSL" "DSL" "DSL" "DSL" ...
##  $ OnlineSecurity  : chr  "No" "Yes" "Yes" "Yes" ...
##  $ OnlineBackup    : chr  "Yes" "No" "Yes" "No" ...
##  $ DeviceProtection: chr  "No" "Yes" "No" "Yes" ...
##  $ TechSupport     : chr  "No" "No" "No" "Yes" ...
##  $ StreamingTV     : chr  "No" "No" "No" "No" ...
##  $ StreamingMovies : chr  "No" "No" "No" "No" ...
##  $ Contract        : chr  "Month-to-month" "One year" "Month-to-month"
"One year" ...
##  $ PaperlessBilling: chr  "Yes" "No" "Yes" "No" ...
##  $ PaymentMethod   : chr  "Electronic check" "Mailed check" "Mailed check"
"Bank transfer (automatic)" ...
##  $ MonthlyCharges  : num  29.9 57 53.9 42.3 70.7 ...
##  $ TotalCharges    : num  29.9 1889.5 108.2 1840.8 151.7 ...
##  $ Churn           : chr  "No" "No" "Yes" "No" ...
```

```
n <- nrow(df)
```

```
#id column remove
colnames(df)
```

```
##  [1] "customerID"       "gender"           "SeniorCitizen"    "Partner"
##  [5] "Dependents"       "tenure"           "PhoneService"
"MultipleLines"
##  [9] "InternetService"  "OnlineSecurity"   "OnlineBackup"
"DeviceProtection"
## [13] "TechSupport"      "StreamingTV"      "StreamingMovies"  "Contract"
## [17] "PaperlessBilling" "PaymentMethod"    "MonthlyCharges"
"TotalCharges"
## [21] "Churn"
```

```
df <- df[-which(colnames(df) == 'customerID')]
head(df)
```

```
##   gender SeniorCitizen Partner Dependents tenure PhoneService
MultipleLines
## 1 Female             0     Yes         No      1           No No phone
service
## 2   Male             0      No         No     34          Yes
No
## 3   Male             0      No         No      2          Yes
No
## 4   Male             0      No         No     45           No No phone
service
## 5 Female             0      No         No      2          Yes
No
## 6 Female             0      No         No      8          Yes
Yes
##   InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport
## 1             DSL             No          Yes               No          No
## 2             DSL            Yes           No              Yes          No
## 3             DSL            Yes          Yes               No          No
## 4             DSL            Yes           No              Yes         Yes
## 5     Fiber optic             No           No               No          No
## 6     Fiber optic             No           No              Yes          No
##   StreamingTV StreamingMovies       Contract PaperlessBilling
## 1          No              No Month-to-month              Yes
## 2          No              No       One year               No
## 3          No              No Month-to-month              Yes
## 4          No              No       One year               No
## 5          No              No Month-to-month              Yes
## 6         Yes             Yes Month-to-month              Yes
##              PaymentMethod MonthlyCharges TotalCharges Churn
## 1          Electronic check          29.85        29.85    No
## 2              Mailed check          56.95      1889.50    No
## 3              Mailed check          53.85       108.15   Yes
## 4 Bank transfer (automatic)          42.30      1840.75    No
## 5          Electronic check          70.70       151.65   Yes
## 6          Electronic check          99.65       820.50   Yes
```

```
#missing value imputation
df$TotalCharges <- as.numeric(df$TotalCharges)
miss = which(is.na(df$TotalCharges) == TRUE)
df$TotalCharges[miss] <- median(df$TotalCharges, na.rm = TRUE)
str(df)
```

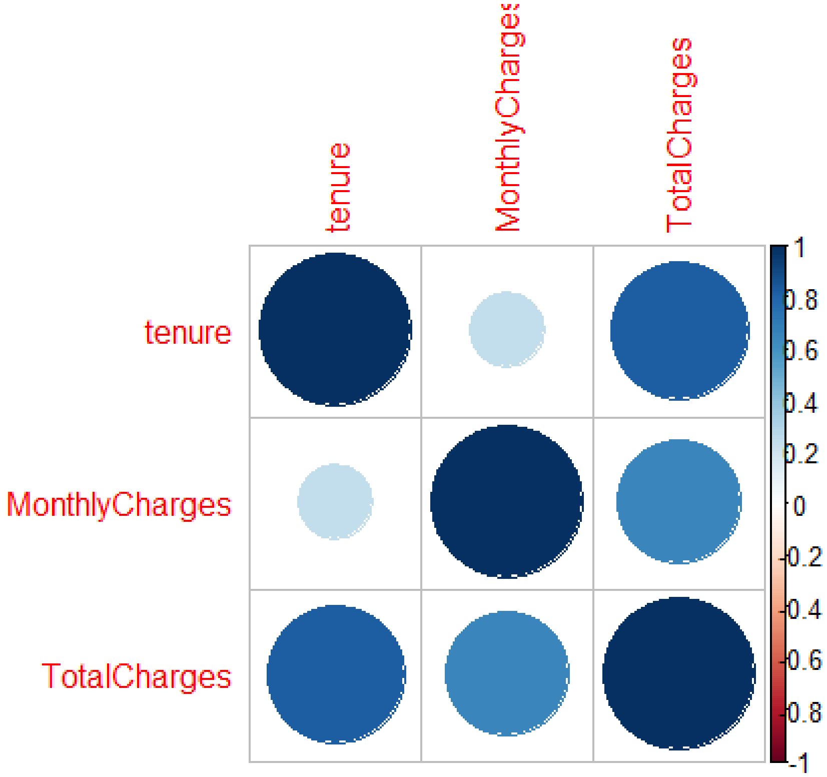
```
## 'data.frame':    7043 obs. of  20 variables:
##  $ gender          : chr  "Female" "Male" "Male" "Male" ...
##  $ SeniorCitizen   : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Partner         : chr  "Yes" "No" "No" "No" ...
##  $ Dependents      : chr  "No" "No" "No" "No" ...
##  $ tenure          : int  1 34 2 45 2 8 22 10 28 62 ...
##  $ PhoneService    : chr  "No" "Yes" "Yes" "No" ...
##  $ MultipleLines   : chr  "No phone service" "No" "No" "No phone service"
...
##  $ InternetService : chr  "DSL" "DSL" "DSL" "DSL" ...
##  $ OnlineSecurity  : chr  "No" "Yes" "Yes" "Yes" ...
##  $ OnlineBackup    : chr  "Yes" "No" "Yes" "No" ...
##  $ DeviceProtection: chr  "No" "Yes" "No" "Yes" ...
##  $ TechSupport     : chr  "No" "No" "No" "Yes" ...
##  $ StreamingTV     : chr  "No" "No" "No" "No" ...
##  $ StreamingMovies : chr  "No" "No" "No" "No" ...
##  $ Contract        : chr  "Month-to-month" "One year" "Month-to-month"
"One year" ...
##  $ PaperlessBilling: chr  "Yes" "No" "Yes" "No" ...
##  $ PaymentMethod   : chr  "Electronic check" "Mailed check" "Mailed check"
"Bank transfer (automatic)" ...
##  $ MonthlyCharges  : num  29.9 57 53.9 42.3 70.7 ...
##  $ TotalCharges    : num  29.9 1889.5 108.2 1840.8 151.7 ...
##  $ Churn           : chr  "No" "No" "Yes" "No" ...
```

```
#No Service to No
for(i in (which(colnames(df) == 'OnlineSecurity') : which(colnames(df) ==
'StreamingMovies'))){
  df[i] <- as.factor(ifelse(df[i] != 'Yes', 'No', 'Yes'))
}
df$InternetService <- as.factor(ifelse(df$InternetService != 'No', 'Yes',
'No'))
df$MultipleLines <- as.factor(ifelse(df$MultipleLines != 'Yes', 'No', 'Yes'))
df$SeniorCitizen <- as.factor(df$SeniorCitizen)

for(i in 1:ncol(df)){
  if(class(df[,i]) == 'character'){
    df[,i] <- as.factor(df[,i])
  }
}
str(df)
```

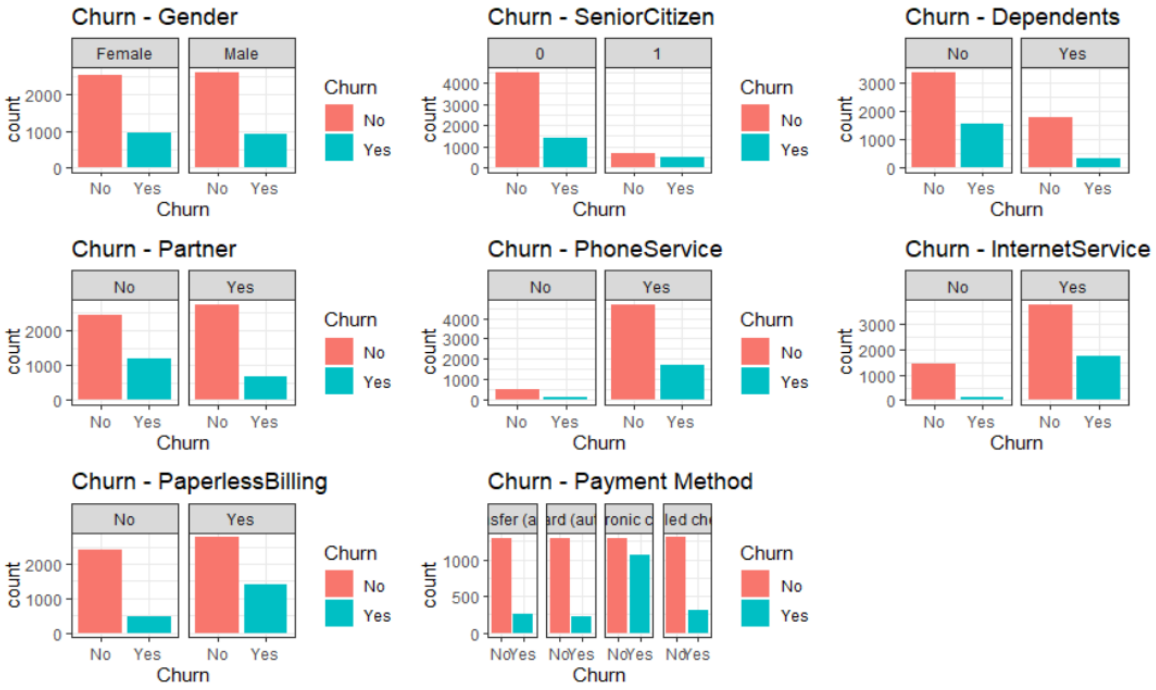
```
## 'data.frame':    7043 obs. of  20 variables:
##  $ gender          : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 1 2 1 1
2 ...
##  $ SeniorCitizen   : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Partner         : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 1 1 1 2 1
...
##  $ Dependents      : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 2 1 1 2
...
##  $ tenure          : int  1 34 2 45 2 8 22 10 28 62 ...
##  $ PhoneService    : Factor w/ 2 levels "No","Yes": 1 2 2 1 2 2 2 1 2 2
...
##  $ MultipleLines   : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 2 2 1 2 1
...
##  $ InternetService : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 2 2 2 2 2
...
##  $ OnlineSecurity  : Factor w/ 2 levels "No","Yes": 1 2 2 2 1 1 1 2 1 2
...
##  $ OnlineBackup    : Factor w/ 2 levels "No","Yes": 2 1 2 1 1 1 2 1 1 2
...
##  $ DeviceProtection: Factor w/ 2 levels "No","Yes": 1 2 1 2 1 2 1 1 2 1
...
##  $ TechSupport     : Factor w/ 2 levels "No","Yes": 1 1 1 2 1 1 1 1 2 1
...
##  $ StreamingTV     : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 2 2 1 2 1
...
##  $ StreamingMovies : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 2 1 1 2 1
...
##  $ Contract        : Factor w/ 3 levels "Month-to-month",..: 1 2 1 2 1 1 1
1 1 2 ...
##  $ PaperlessBilling: Factor w/ 2 levels "No","Yes": 2 1 2 1 2 2 2 1 2 1
```

```
...
##  $ PaymentMethod   : Factor w/ 4 levels "Bank transfer (automatic)",..: 3
4 4 1 3 3 2 4 3 1 ...
##  $ MonthlyCharges  : num  29.9 57 53.9 42.3 70.7 ...
##  $ TotalCharges    : num  29.9 1889.5 108.2 1840.8 151.7 ...
##  $ Churn           : Factor w/ 2 levels "No","Yes": 1 1 2 1 2 2 1 1 2 1
...
```

```
#Correlation between numeric variables
cr <-cor(df[,c(5,18,19)])
corrplot(cr, method="circle")
```



```
#EDA
p1 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~gender)+
geom_bar() +ggtitle("Churn - Gender") + theme_bw()
p2 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~SeniorCitizen)+
geom_bar() + ggtitle("Churn - SeniorCitizen") + theme_bw()
p3 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~Dependents)+
geom_bar() + ggtitle("Churn - Dependents") + theme_bw()
p4 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~Partner)+
geom_bar() + ggtitle("Churn - Partner") + theme_bw()
p5 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~PhoneService)+
geom_bar() + ggtitle("Churn - PhoneService")+ theme_bw()
p6 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~InternetService)+
geom_bar() + ggtitle("Churn - InternetService") + theme_bw()
p7 <- ggplot(df, aes(x = Churn, fill = Churn))
+facet_grid(~PaperlessBilling)+ geom_bar() + ggtitle("Churn -
PaperlessBilling") + theme_bw()
p8 <- ggplot(df, aes(x = Churn, fill = Churn)) +facet_grid(~PaymentMethod)+
geom_bar() + ggtitle("Churn - Payment Method") + theme_bw()
ggpubr::ggarrange(p1,p2,p3,p4,p5,p6,p7,p8, nrow = 3, ncol = 3)
```



```
#dummification
attach(df)
to_dummy <- data.frame(Contract,PaymentMethod)
dmy <- dummyVars(" ~ .", data = to_dummy)
df2 <- data.frame(predict(dmy, newdata = to_dummy))
df2 <- df2[, !(colnames(df2) %in% c("Contract.Month.to.month",
"PaymentMethod.Bank.transfer..automatic."))]
df <- df[,!(colnames(df) %in% c("Contract","PaymentMethod","TotalCharges"))]
df <- cbind(df, df2)
head(df)

##   gender SeniorCitizen Partner Dependents tenure PhoneService
MultipleLines
## 1 Female             0     Yes         No      1           No
No
## 2   Male             0      No         No     34          Yes
No
## 3   Male             0      No         No      2          Yes
No
## 4   Male             0      No         No     45           No
No
## 5 Female             0      No         No      2          Yes
No
## 6 Female             0      No         No      8          Yes
```

```
Yes
##   InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport
## 1             Yes             No          Yes               No          No
## 2             Yes            Yes           No              Yes          No
## 3             Yes            Yes          Yes               No          No
## 4             Yes            Yes           No              Yes         Yes
## 5             Yes             No           No               No          No
## 6             Yes             No           No              Yes          No
##   StreamingTV StreamingMovies PaperlessBilling MonthlyCharges Churn
## 1          No              No              Yes          29.85    No
## 2          No              No               No          56.95    No
## 3          No              No              Yes          53.85   Yes
## 4          No              No               No          42.30    No
## 5          No              No              Yes          70.70   Yes
## 6         Yes             Yes              Yes          99.65   Yes
##   Contract.One.year Contract.Two.year
PaymentMethod.Credit.card..automatic.
## 1                 0                 0
0
## 2                 1                 0
0
## 3                 0                 0
0
## 4                 1                 0
0
## 5                 0                 0
0
## 6                 0                 0
0
##   PaymentMethod.Electronic.check PaymentMethod.Mailed.check
## 1                              1                          0
## 2                              0                          1
## 3                              0                          1
## 4                              0                          0
## 5                              1                          0
## 6                              1                          0
```

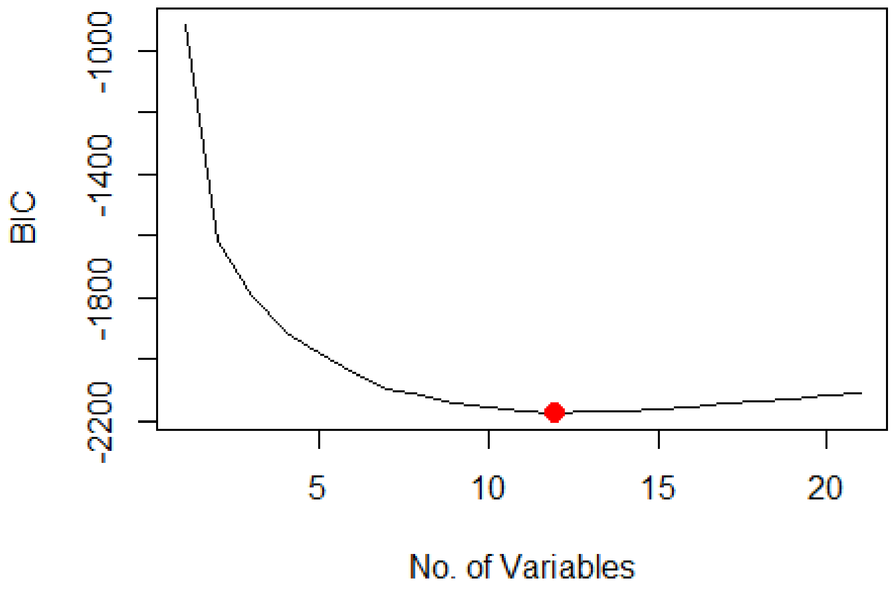
```
attach(df)
```

```
## The following objects are masked from df (pos = 3):
##
##     Churn, Dependents, DeviceProtection, gender, InternetService,
##     MonthlyCharges, MultipleLines, OnlineBackup, OnlineSecurity,
##     PaperlessBilling, Partner, PhoneService, SeniorCitizen,
##     StreamingMovies, StreamingTV, TechSupport, tenure
```

```
dim(df)
```

```
## [1] 7043   22
```

```
#Feature Selection

regfit.full=regsubsets(Churn~.,data=df,nvmax=21)
reg.summary=summary(regfit.full)
names(reg.summary)

## [1] "which"  "rsq"    "rss"    "adjr2"  "cp"     "bic"    "outmat" "obj"

which.min(reg.summary$bic)

## [1] 12

plot(reg.summary$bic,xlab="No. of
Variables",ylab=expression(paste("BIC")),type="l")
points(12,reg.summary$bic[12],col="red",cex=2,pch=20)
```



```
names(coef(regfit.full,12))[-1]

##  [1] "SeniorCitizen1"                 "tenure"
##  [3] "PhoneServiceYes"                "OnlineSecurityYes"
##  [5] "OnlineBackupYes"                "DeviceProtectionYes"
##  [7] "TechSupportYes"                 "PaperlessBillingYes"
##  [9] "MonthlyCharges"                 "Contract.One.year"
## [11] "Contract.Two.year"              "PaymentMethod.Electronic.check"

#Final Dataset
data=df[,-c(1,3,4,7,8,13,14,20,22)]
dim(data)
```

```
## [1] 7043   13
```

```
#train-test split:

index1=sample(1:nrow(data),floor(0.7*nrow(data)))
train=data[index1,]
remaining=data[-index1,]
index2=sample(1:nrow(remaining),floor(2/3*nrow(remaining)))
crossval=remaining[index2,]
test=remaining[-index2,]
actual_churn=crossval$Churn

#logistic regression
logistic.fit=glm(Churn~.,data=train,family="binomial")
logistic.predict=rep("No",nrow(crossval))
predicted_prob=predict(logistic.fit,newdata=crossval,type="response")
logistic.predict[predicted_prob>0.5]="Yes"
table(logistic.predict,actual_churn)
```

```
##                  actual_churn
## logistic.predict  No Yes
##              No  938 169
##              Yes 100 201
```

```
mean(logistic.predict==actual_churn)
```

```
## [1] 0.8089489
```

```
#lda fit
lda.fit=lda(Churn~.,data=train)
lda.predict=predict(lda.fit,crossval)$class
table(lda.predict,actual_churn)
```

```
##             actual_churn
## lda.predict  No Yes
##         No  930 169
##         Yes 108 201
```

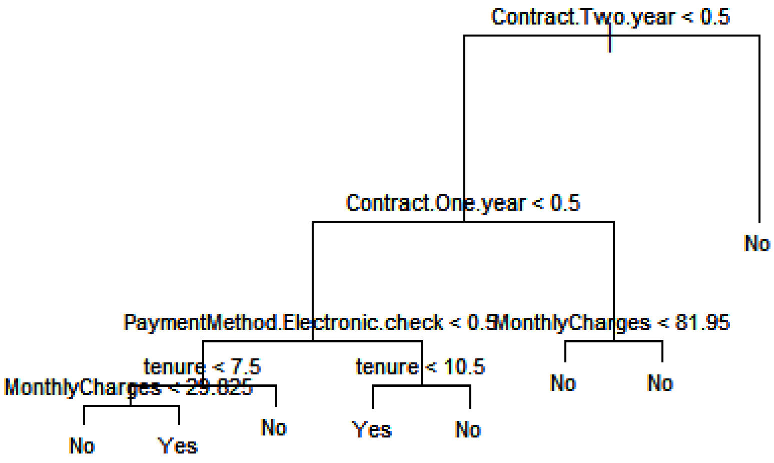
```
mean(lda.predict==actual_churn)
```

```
## [1] 0.803267
```

```
#Classification Tree

tree.fit=tree(Churn~.,train,method="class")
summary(tree.fit)
```

```
## 
## Classification tree:
## tree(formula = Churn ~ ., data = train, method = "class")
## Variables actually used in tree construction:
## [1] "Contract.Two.year"              "Contract.One.year"
## [3] "PaymentMethod.Electronic.check" "tenure"
## [5] "MonthlyCharges"
## Number of terminal nodes:  8
## Residual mean deviance:  0.8856 = 4359 / 4922
## Misclassification error rate: 0.2152 = 1061 / 4930
```

```
plot(tree.fit)
text(tree.fit,pretty=0,cex=0.7)
text(tree.fit,pretty=0,cex=0.7)
```



```
tree.predict=predict(tree.fit,crossval,type="class")
table(predicted_churn=tree.predict,actual_churn)
```

```
##                 actual_churn
## predicted_churn  No Yes
##             No  920 226
##             Yes 118 144
```

```
mean(tree.predict==actual_churn)
```

```
## [1] 0.7556818
```

```
#Random Forest

rf.fit=randomForest(Churn~.,data=train,ntree=200,mtry=4)
rf.predict=predict(rf.fit,crossval)
table(predicted_churn=rf.predict,actual_churn)
```

```
##                 actual_churn
## predicted_churn  No Yes
##             No  917 178
##             Yes 121 192
```

```
mean(rf.predict==actual_churn)
```

```
## [1] 0.787642
```

```
misclassification_rate_logistic=(mean(logistic.predict!=actual_churn))*100
misclassification_rate_lda=(mean(lda.predict!=actual_churn))*100
misclassification_rate_tree=(mean(tree.predict!=actual_churn))*100
misclassification_rate_forest=(mean(rf.predict!=actual_churn))*100
paste("Misclassification Error Rate for Logistic Regression
is",misclassification_rate_logistic,"%")
```

```
## [1] "Misclassification Error Rate for Logistic Regression is
19.1051136363636 %"
```

```
paste("Misclassification Error Rate for Linear Discriminant Analysis is
is",misclassification_rate_lda,"%")
```

```
## [1] "Misclassification Error Rate for Linear Discriminant Analysis is is
19.6732954545455 %"
```

```
paste("Misclassification Error Rate for Decision Tree
is",misclassification_rate_tree,"%")
```

```
## [1] "Misclassification Error Rate for Decision Tree is 24.4318181818182 %"
```

```
paste("Misclassification Error Rate for Random Forest
is",misclassification_rate_forest,"%")
```

```
## [1] "Misclassification Error Rate for Random Forest is 21.2357954545455 %"
```

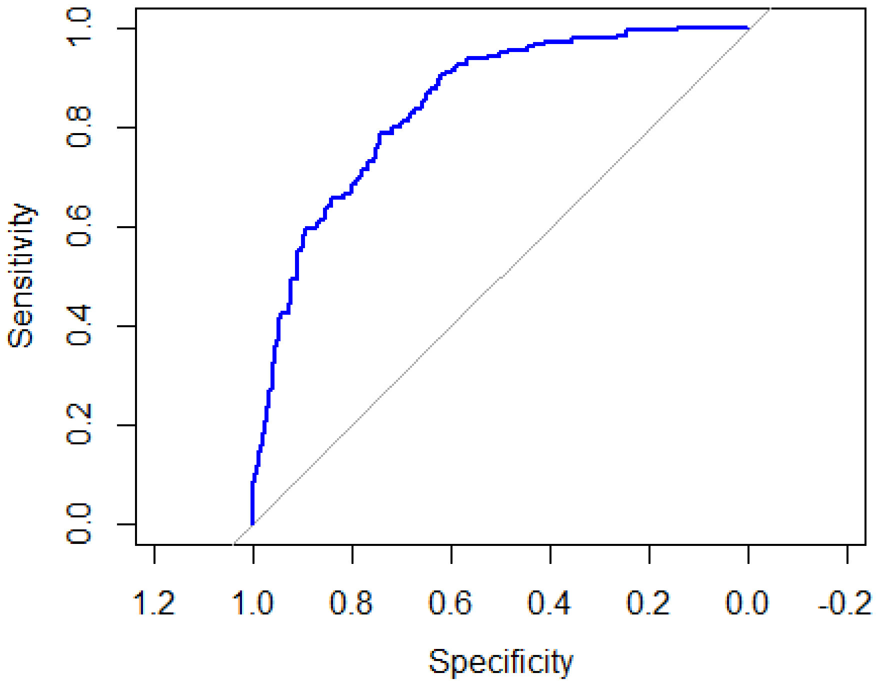
```
#Choice is Logistic Regression
#Fit on test dataset
predicted_prob=predict(logistic.fit,newdata=test,type="response")
logistic.predict.test=rep("No",nrow(test))
logistic.predict.test[predicted_prob>0.5]="Yes"
actual.churn.test=test$Churn
table(logistic.predict.test,actual.churn.test)
```

```
##                       actual.churn.test
## logistic.predict.test  No Yes
##                    No  474  72
##                    Yes  56 103
```

```
misclassification.final=mean(logistic.predict.test!=actual.churn.test)*100
paste("Misclassification Error Rate for final model
is",misclassification.final,"%")
```

```
## [1] "Misclassification Error Rate for final model is 18.1560283687943 %"
```

```
#Assessing final model accuracy via ROC curve
ROC=roc(actual.churn.test,predicted_prob)

## Setting levels: control = No, case = Yes

## Setting direction: controls < cases

plot(ROC,col="blue")
```



```
auc(ROC)

## Area under the curve: 0.8427
```