FML Assignment 3

Pavan Kumar Mekala

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Importing the dataset UniversalBank(1).csv file into Rstudio and checked it by using head and tail funcitons and converting Online, Personal.Loan, CreditCard into factor value by using as.factor() function

```
UniversalBank<-read.csv("UniversalBank (1).csv")
head(UniversalBank)
```

```
##   ID Age Experience Income ZIP.Code Family CCAvg Education Mortgage
## 1  1  25          1     49    91107      4   1.6         1        0
## 2  2  45         19     34    90089      3   1.5         1        0
## 3  3  39         15     11    94720      1   1.0         1        0
## 4  4  35          9    100    94112      1   2.7         2        0
## 5  5  35          8     45    91330      4   1.0         2        0
## 6  6  37         13     29    92121      4   0.4         2      155
##   Personal.Loan Securities.Account CD.Account Online CreditCard
## 1             0                  1          0      0          0
## 2             0                  1          0      0          0
## 3             0                  0          0      0          0
## 4             0                  0          0      0          0
## 5             0                  0          0      0          1
## 6             0                  0          0      1          0
```

```
tail(UniversalBank)
```

```
##        ID Age Experience Income ZIP.Code Family CCAvg Education Mortgage
## 4995 4995  64         40     75    94588      3   2.0         3        0
## 4996 4996  29          3     40    92697      1   1.9         3        0
## 4997 4997  30          4     15    92037      4   0.4         1       85
## 4998 4998  63         39     24    93023      2   0.3         3        0
## 4999 4999  65         40     49    90034      3   0.5         2        0
## 5000 5000  28          4     83    92612      3   0.8         1        0
##      Personal.Loan Securities.Account CD.Account Online CreditCard
## 4995             0                  0          0      1          0
## 4996             0                  0          0      1          0
## 4997             0                  0          0      1          0
## 4998             0                  0          0      0          0
## 4999             0                  0          0      1          0
## 5000             0                  0          0      1          1
```

```
UniversalBank$Personal.Loan <- as.factor(UniversalBank$Personal.Loan)
UniversalBank$Online <- as.factor(UniversalBank$Online)
UniversalBank$CreditCard <- as.factor(UniversalBank$CreditCard)
UniversalBank <-UniversalBank[,c("Personal.Loan","Online","CreditCard")]
head(UniversalBank)
```

```
##   Personal.Loan Online CreditCard
## 1             0      0          0
## 2             0      0          0
## 3             0      0          0
## 4             0      0          0
## 5             0      0          1
## 6             0      1          0
```

Loading Packages

```
library(ISLR)
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```
library(knitr)
```

Partitioning the data into training (60%) and validation (40%) sets and adding set.seed(123) for reproducibility and checked them by using dim function

```
set.seed(123)
Training_Index <- createDataPartition(UniversalBank$Personal.Loan, p=0.6 , list = FALSE)
Training <- UniversalBank[Training_Index,]
Validation <- UniversalBank[-Training_Index,]
dim(Training)
```

```
## [1] 3000    3
```

```
dim(Validation)
```

```
## [1] 2000    3
```

##A. Creating a Pivot table for the training data and checked them by using print() and dim() function

```
P_Table<-ftable(Training$Online,Training$CreditCard,Training$Personal.Loan, row.vars = c(3,2),dnn=c('On
P_Table
```

```
##                           Online    0    1
## Personal.loan CreditCard
## 0             0                  791 1144
##               1                  310  467
## 1             0                   79  125
##               1                   33   51
```

##B. Probability of loan acceptance (Loan = 1) conditional on having a bank credit card (CC = 1) and checked it by using print() function

```
P_Loan_Acceptance <- P_Table[4,2] / (P_Table[2,2]+P_Table[4,2])
print(P_Loan_Acceptance)
```

```
## [1] 0.0984556
```

##C. Creating two seperate pivot tables for the training data by using ftable() function and checked them by using print() function

```
P_table_online <- ftable(Training$Online, Training$Personal.Loan, row.vars = c(2))
P_table_cc <- ftable(Training$CreditCard, Training$Personal.Loan, row.vars = c(2))
print(P_table_online)
```

```
##       0    1
##
## 0  1101 1611
## 1   112  176
```

```
print(P_table_cc)
```

```
##       0    1
##
## 0  1935  777
## 1   204   84
```

##D. Computing the following quantities [P(A | B) means "the probability of A given B"] under different conditions; ## 1. P(CC = 1 | Loan = 1) ## 2. P(Online = 1 | Loan = 1) ## 3. P(Loan = 1)(the proportion on loan acceptors) ## 4. P(CC = 1 | Loan = 0) ## 5. P(Online = 1 | Loan = 0) ## 6. P(Loan = 0) and checked it by using print() function

```
P_CC_Loan <- P_table_cc[2,2] / (P_table_cc[2,1]+P_table_cc[2,2])
print(P_CC_Loan)
```

```
## [1] 0.2916667
```

```
P_Online_Loan <- P_table_online[2,2] / (P_table_online[2,1] + P_table_online[2,2])
print(P_Online_Loan)
```

```
## [1] 0.6111111
```

```r
P_Loan <- sum(Training$Personal.Loan == 1) / nrow(Training)
print(P_Loan)
```

```
## [1] 0.096
```

```r
P_CC_Not_Loan <- P_table_cc[1,2]/(P_table_cc[1,1]+P_table_cc[1,2])
print(P_CC_Not_Loan)
```

```
## [1] 0.2865044
```

```r
P_Online_Not_Loan <- P_table_online[1,2] / (P_table_online[1,1]+P_table_online[1,2])
print(P_Online_Not_Loan)
```

```
## [1] 0.5940265
```

```r
P_Not_Loan <- sum(Training$Personal.Loan == 0) / nrow(Training)
print(P_Not_Loan)
```

```
## [1] 0.904
```

##E. Naive Bayes Probability P(Loan = 1 | CC = 1, Online = 1)

```r
P_Loan_CC_Online <- (P_CC_Loan * P_Online_Loan * P_Loan) / ((P_CC_Loan * P_Online_Loan * P_Loan) + (P_C
print(P_Loan_CC_Online)
```

```
## [1] 0.1000861
```

##F. Comparing the values obtained from Pivot tables in B

```r
P_Loan_CC_Online - P_Loan_Acceptance
```

```
## [1] 0.001630457
```

```r
print("We persume conditional independence in Naive Bayes")
```

```
## [1] "We persume conditional independence in Naive Bayes"
```

```r
print("We can see there is an increase of 0.001630457")
```

```
## [1] "We can see there is an increase of 0.001630457"
```

##G. Comparing Numbers with D

```r
library(e1071)
Probability_Loan <- naiveBayes(Personal.Loan ~ ., data = Training)
loan_probabilities <- c(Probability_Loan$apriori[1] / sum(Probability_Loan$apriori), Probability_Loan$ap
Probability_Loan$tables
```

```
## $Online
##    Online
## Y           0         1
##   0 0.4059735 0.5940265
##   1 0.3888889 0.6111111
##
## $CreditCard
##    CreditCard
## Y           0         1
##   0 0.7134956 0.2865044
##   1 0.7083333 0.2916667
```

```
print("As we can see the individual probabilities are matching with D, so the Naive Bayes probability is
```

```
## [1] "As we can see the individual probabilities are matching with D, so the Naive Bayes probability i
```

ROC and plotting

```
library(pROC)
```

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

##
## Attaching package: 'pROC'

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

```
Predict_Probability<-predict(Probability_Loan, newdata = Validation, type = "raw")
roc(Validation$Personal.Loan, Predict_Probability[, 2])
```

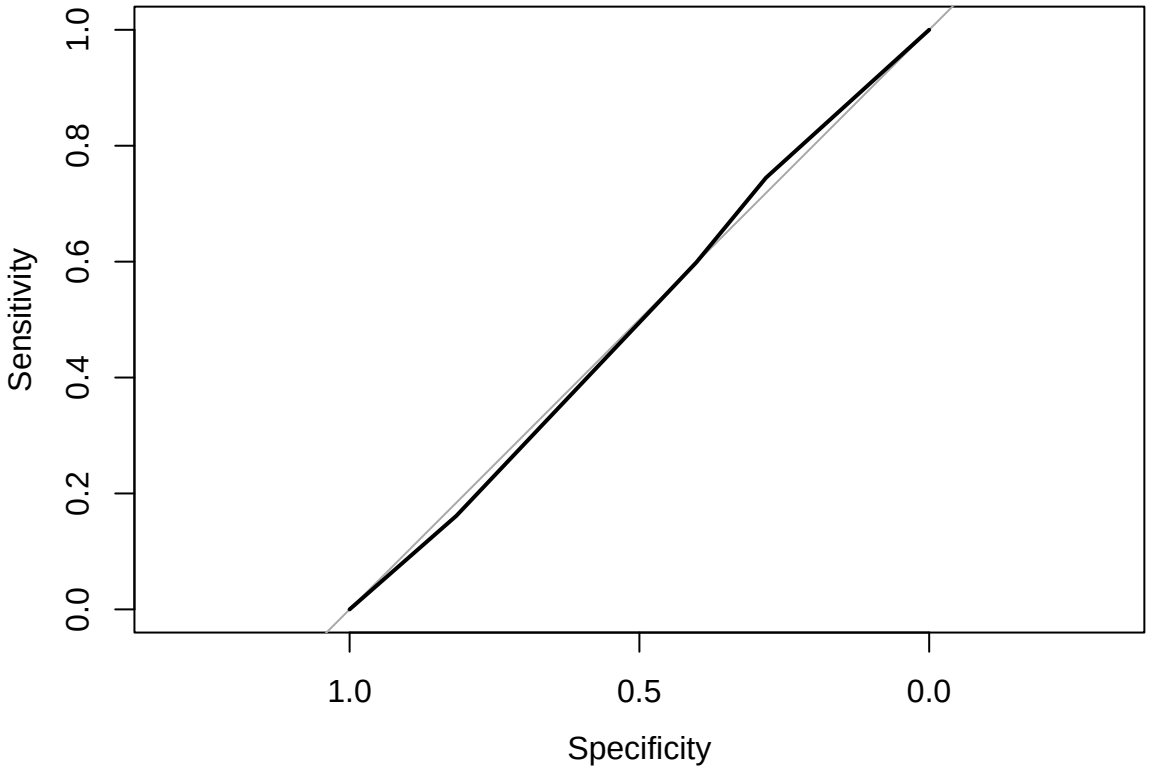
```
## Setting levels: control = 0, case = 1

## Setting direction: controls < cases

##
## Call:
## roc.default(response = Validation$Personal.Loan, predictor = Predict_Probability[,     2])
##
## Data: Predict_Probability[, 2] in 1808 controls (Validation$Personal.Loan 0) < 192 cases (Validation$
## Area under the curve: 0.4986
```

```
plot.roc(Validation$Personal.Loan, Predict_Probability[,2])
```

```
## Setting levels: control = 0, case = 1
## Setting direction: controls < cases
```


Sensitivity
0.0
0.2
0.4
0.6
0.8
1.0
1.0
0.5
0.0
Specificity