Assignment1- KNN for classification

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#The aim is to forecast if a new customer will accept a loan offer using k-NN. This will be the starting point for creating a fresh campaign.

#installing the packages  
#install.packages("gmodels")

##loading required library

rm(list = ls()) #cleaning the environment  
library(readr)  
library(caret)

## Loading required package: ggplot2

## Loading required package: lattice

library(knitr)  
library(class)  
library(ggplot2)  
library(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

##Import Data “UniversalBank.csv”

library(readr)  
Bankdata1 <- read.csv("C://Users//vishe//OneDrive//Desktop//FML//Assignment2//UniversalBank (1).csv")  
head(Bankdata1)

## 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

##Understand the bank data structure

str(Bankdata1)

## 'data.frame': 5000 obs. of 14 variables:  
## $ ID : int 1 2 3 4 5 6 7 8 9 10 ...  
## $ Age : int 25 45 39 35 35 37 53 50 35 34 ...  
## $ Experience : int 1 19 15 9 8 13 27 24 10 9 ...  
## $ Income : int 49 34 11 100 45 29 72 22 81 180 ...  
## $ ZIP.Code : int 91107 90089 94720 94112 91330 92121 91711 93943 90089 93023 ...  
## $ Family : int 4 3 1 1 4 4 2 1 3 1 ...  
## $ CCAvg : num 1.6 1.5 1 2.7 1 0.4 1.5 0.3 0.6 8.9 ...  
## $ Education : int 1 1 1 2 2 2 2 3 2 3 ...  
## $ Mortgage : int 0 0 0 0 0 155 0 0 104 0 ...  
## $ Personal.Loan : int 0 0 0 0 0 0 0 0 0 1 ...  
## $ Securities.Account: int 1 1 0 0 0 0 0 0 0 0 ...  
## $ CD.Account : int 0 0 0 0 0 0 0 0 0 0 ...  
## $ Online : int 0 0 0 0 0 1 1 0 1 0 ...  
## $ CreditCard : int 0 0 0 0 1 0 0 1 0 0 ...

summary(Bankdata1)

## ID Age Experience Income ZIP.Code   
## Min. : 1 Min. :23.00 Min. :-3.0 Min. : 8.00 Min. : 9307   
## 1st Qu.:1251 1st Qu.:35.00 1st Qu.:10.0 1st Qu.: 39.00 1st Qu.:91911   
## Median :2500 Median :45.00 Median :20.0 Median : 64.00 Median :93437   
## Mean :2500 Mean :45.34 Mean :20.1 Mean : 73.77 Mean :93153   
## 3rd Qu.:3750 3rd Qu.:55.00 3rd Qu.:30.0 3rd Qu.: 98.00 3rd Qu.:94608   
## Max. :5000 Max. :67.00 Max. :43.0 Max. :224.00 Max. :96651   
## Family CCAvg Education Mortgage   
## Min. :1.000 Min. : 0.000 Min. :1.000 Min. : 0.0   
## 1st Qu.:1.000 1st Qu.: 0.700 1st Qu.:1.000 1st Qu.: 0.0   
## Median :2.000 Median : 1.500 Median :2.000 Median : 0.0   
## Mean :2.396 Mean : 1.938 Mean :1.881 Mean : 56.5   
## 3rd Qu.:3.000 3rd Qu.: 2.500 3rd Qu.:3.000 3rd Qu.:101.0   
## Max. :4.000 Max. :10.000 Max. :3.000 Max. :635.0   
## Personal.Loan Securities.Account CD.Account Online   
## Min. :0.000 Min. :0.0000 Min. :0.0000 Min. :0.0000   
## 1st Qu.:0.000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000   
## Median :0.000 Median :0.0000 Median :0.0000 Median :1.0000   
## Mean :0.096 Mean :0.1044 Mean :0.0604 Mean :0.5968   
## 3rd Qu.:0.000 3rd Qu.:0.0000 3rd Qu.:0.0000 3rd Qu.:1.0000   
## Max. :1.000 Max. :1.0000 Max. :1.0000 Max. :1.0000   
## CreditCard   
## Min. :0.000   
## 1st Qu.:0.000   
## Median :0.000   
## Mean :0.294   
## 3rd Qu.:1.000   
## Max. :1.000

##Cleaning and Preparing the data set ###(1)Remove Zipcode ###(2)Converting Personal\_loan to factor because the customer response to the last personal loan campaign is “Personal\_Loan” variable and want to covert into category ###(3)creating the dummy variables for Education and converting them to factor

Bankdata2 <-Bankdata1[,-c(1,5)]  
Bankdata2$Personal.Loan <- as.factor(Bankdata2$Personal.Loan)  
class(Bankdata2$Personal\_Loan)

## [1] "NULL"

Education1 <- ifelse(Bankdata2$Education == 1, 1,0)  
Education1 <- as.factor(Education1)  
Education2 <- ifelse(Bankdata2$Education == 2, 1,0)  
Education2 <- as.factor(Education2)  
Education3 <- ifelse(Bankdata2$Education == 3, 1,0)  
Education3 <- as.factor(Education3)  
Bankdata3 <- data.frame(Bankdata2,Education1 = Education1,Education2 = Education2, Education3 = Education3)  
Bankdata4 <- Bankdata3[,-6]

##Dividing the data into sets for training (60%) and validation (40%), respectively Furthermore displayed the summary statistics for the test and train data sets.

Train\_Index = createDataPartition(Bankdata4$Personal.Loan,p=0.6, list = FALSE)  
Train\_df <-Bankdata4[Train\_Index,]  
Validation\_df<-Bankdata4[-Train\_Index,]  
nrow(Train\_df)

## [1] 3000

summary(Train\_df)

## Age Experience Income Family CCAvg   
## Min. :23.00 Min. :-3 Min. : 8.00 Min. :1.000 Min. : 0.000   
## 1st Qu.:35.00 1st Qu.:10 1st Qu.: 39.00 1st Qu.:1.000 1st Qu.: 0.700   
## Median :45.00 Median :20 Median : 63.00 Median :2.000 Median : 1.500   
## Mean :45.23 Mean :20 Mean : 73.75 Mean :2.388 Mean : 1.925   
## 3rd Qu.:55.00 3rd Qu.:30 3rd Qu.: 98.00 3rd Qu.:3.000 3rd Qu.: 2.500   
## Max. :67.00 Max. :43 Max. :224.00 Max. :4.000 Max. :10.000   
## Mortgage Personal.Loan Securities.Account CD.Account   
## Min. : 0.0 0:2712 Min. :0.0000 Min. :0.00000   
## 1st Qu.: 0.0 1: 288 1st Qu.:0.0000 1st Qu.:0.00000   
## Median : 0.0 Median :0.0000 Median :0.00000   
## Mean : 58.5 Mean :0.1067 Mean :0.06067   
## 3rd Qu.:106.0 3rd Qu.:0.0000 3rd Qu.:0.00000   
## Max. :635.0 Max. :1.0000 Max. :1.00000   
## Online CreditCard Education1 Education2 Education3  
## Min. :0.000 Min. :0.0000 0:1747 0:2147 0:2106   
## 1st Qu.:0.000 1st Qu.:0.0000 1:1253 1: 853 1: 894   
## Median :1.000 Median :0.0000   
## Mean :0.599 Mean :0.2967   
## 3rd Qu.:1.000 3rd Qu.:1.0000   
## Max. :1.000 Max. :1.0000

nrow(Validation\_df)

## [1] 2000

summary(Validation\_df)

## Age Experience Income Family   
## Min. :23.0 Min. :-3.00 Min. : 8.00 Min. :1.000   
## 1st Qu.:36.0 1st Qu.:10.00 1st Qu.: 39.00 1st Qu.:1.000   
## Median :46.0 Median :20.00 Median : 65.00 Median :2.000   
## Mean :45.5 Mean :20.25 Mean : 73.81 Mean :2.409   
## 3rd Qu.:55.0 3rd Qu.:30.00 3rd Qu.: 99.00 3rd Qu.:3.000   
## Max. :67.0 Max. :43.00 Max. :218.00 Max. :4.000   
## CCAvg Mortgage Personal.Loan Securities.Account  
## Min. : 0.000 Min. : 0.0 0:1808 Min. :0.000   
## 1st Qu.: 0.600 1st Qu.: 0.0 1: 192 1st Qu.:0.000   
## Median : 1.500 Median : 0.0 Median :0.000   
## Mean : 1.957 Mean : 53.5 Mean :0.101   
## 3rd Qu.: 2.600 3rd Qu.: 94.0 3rd Qu.:0.000   
## Max. :10.000 Max. :612.0 Max. :1.000   
## CD.Account Online CreditCard Education1 Education2  
## Min. :0.00 Min. :0.0000 Min. :0.00 0:1157 0:1450   
## 1st Qu.:0.00 1st Qu.:0.0000 1st Qu.:0.00 1: 843 1: 550   
## Median :0.00 Median :1.0000 Median :0.00   
## Mean :0.06 Mean :0.5935 Mean :0.29   
## 3rd Qu.:0.00 3rd Qu.:1.0000 3rd Qu.:1.00   
## Max. :1.00 Max. :1.0000 Max. :1.00   
## Education3  
## 0:1393   
## 1: 607   
##   
##   
##   
##

##normalization of the data.

Norm\_model <- preProcess(Train\_df, method = c("center", "scale"))  
training\_norm<-predict(Norm\_model,Train\_df)  
head(training\_norm)

## Age Experience Income Family CCAvg Mortgage  
## 1 -1.75189233 -1.64866206 -0.5348226 1.406706 -0.1896308 -0.5715589  
## 2 -0.01980355 -0.08712783 -0.8589358 0.533879 -0.2478951 -0.5715589  
## 3 -0.53943018 -0.43413543 -1.3559092 -1.211774 -0.5392166 -0.5715589  
## 4 -0.88584794 -0.95464685 0.5671619 -1.211774 0.4512763 -0.5715589  
## 5 -0.88584794 -1.04139875 -0.6212528 1.406706 -0.5392166 -0.5715589  
## 6 -0.71263906 -0.60763924 -0.9669735 1.406706 -0.8888023 0.9429316  
## Personal.Loan Securities.Account CD.Account Online CreditCard Education1  
## 1 0 2.8934769 -0.2540931 -1.2219933 -0.6493538 1  
## 2 0 2.8934769 -0.2540931 -1.2219933 -0.6493538 1  
## 3 0 -0.3454898 -0.2540931 -1.2219933 -0.6493538 1  
## 4 0 -0.3454898 -0.2540931 -1.2219933 -0.6493538 0  
## 5 0 -0.3454898 -0.2540931 -1.2219933 1.5394792 0  
## 6 0 -0.3454898 -0.2540931 0.8180623 -0.6493538 0  
## Education2 Education3  
## 1 0 0  
## 2 0 0  
## 3 0 0  
## 4 1 0  
## 5 1 0  
## 6 1 0

validation\_norm<-predict(Norm\_model,Validation\_df)  
head(validation\_norm)

## Age Experience Income Family CCAvg Mortgage  
## 7 0.6730320 0.6068874 -0.03784921 -0.3389477 -0.2478951 -0.5715589  
## 13 0.2400098 0.2598798 0.86966751 -0.3389477 1.0921835 -0.5715589  
## 17 -0.6260346 -0.5208873 1.21538816 1.4067058 1.6165621 0.7377425  
## 18 -0.2796169 -0.1738797 0.15661866 1.4067058 0.2764835 -0.5715589  
## 20 0.8462408 0.6936393 -1.13983380 -1.2117745 -0.8305380 -0.5715589  
## 21 0.9328453 0.9538950 -1.05340363 1.4067058 -0.5974809 0.5130117  
## Personal.Loan Securities.Account CD.Account Online CreditCard Education1  
## 7 0 -0.3454898 -0.2540931 0.8180623 -0.6493538 0  
## 13 0 2.8934769 -0.2540931 -1.2219933 -0.6493538 0  
## 17 1 -0.3454898 -0.2540931 -1.2219933 -0.6493538 0  
## 18 0 -0.3454898 -0.2540931 -1.2219933 -0.6493538 1  
## 20 0 2.8934769 -0.2540931 -1.2219933 1.5394792 0  
## 21 0 -0.3454898 -0.2540931 0.8180623 -0.6493538 0  
## Education2 Education3  
## 7 1 0  
## 13 0 1  
## 17 0 1  
## 18 0 0  
## 20 1 0  
## 21 1 0

#creating the test data set and test normalization

Test <-data.frame(Age=40,Experience=10,Income=84,Family=2,CCAvg=2,Mortgage=0,Securities.Account=0,CD.Account=0,Online=1,CreditCard=1,Education1=0,Education2=1,Education3=0)  
head(Test)

## Age Experience Income Family CCAvg Mortgage Securities.Account CD.Account  
## 1 40 10 84 2 2 0 0 0  
## Online CreditCard Education1 Education2 Education3  
## 1 1 1 0 1 0

test\_norm<-predict(Norm\_model,Test)  
head(test\_norm)

## Age Experience Income Family CCAvg Mortgage  
## 1 -0.4528257 -0.8678949 0.2214413 -0.3389477 0.04342632 -0.5715589  
## Securities.Account CD.Account Online CreditCard Education1 Education2  
## 1 -0.3454898 -0.2540931 0.8180623 1.539479 0 1  
## Education3  
## 1 0

#knn algorithm in dataset

Train\_predictors<-training\_norm[,-7]  
Train\_label<-training\_norm[,7]  
valid\_predictors<-validation\_norm[,-7]  
Valid\_label<-validation\_norm[,7]  
Predict\_test\_label<-knn(Train\_predictors,test\_norm,cl=Train\_label,k=1)  
Predict\_test\_label

## [1] 0  
## Levels: 0 1

#Customer will not accept the offer because the value of K = 0

#Finding the best value for k by training the model by using train function. Also customizing the grid search

set.seed(550)  
searchGrid <- expand.grid(k=seq(1:30))  
model <- train(Personal.Loan~.,training\_norm,method="knn", tuneGrid = searchGrid)  
model

## k-Nearest Neighbors   
##   
## 3000 samples  
## 13 predictor  
## 2 classes: '0', '1'   
##   
## No pre-processing  
## Resampling: Bootstrapped (25 reps)   
## Summary of sample sizes: 3000, 3000, 3000, 3000, 3000, 3000, ...   
## Resampling results across tuning parameters:  
##   
## k Accuracy Kappa   
## 1 0.9538320 0.7058598  
## 2 0.9470029 0.6564823  
## 3 0.9460322 0.6437555  
## 4 0.9457580 0.6347307  
## 5 0.9464582 0.6337161  
## 6 0.9454284 0.6197424  
## 7 0.9458948 0.6191949  
## 8 0.9444123 0.6016827  
## 9 0.9439868 0.5926616  
## 10 0.9434440 0.5840988  
## 11 0.9420774 0.5685992  
## 12 0.9404511 0.5531368  
## 13 0.9402712 0.5480724  
## 14 0.9397210 0.5426299  
## 15 0.9387930 0.5324260  
## 16 0.9378178 0.5223366  
## 17 0.9373045 0.5151915  
## 18 0.9374131 0.5156427  
## 19 0.9368350 0.5083347  
## 20 0.9362912 0.5052420  
## 21 0.9364764 0.5062451  
## 22 0.9360147 0.5000996  
## 23 0.9357618 0.4974317  
## 24 0.9346021 0.4844069  
## 25 0.9344204 0.4828019  
## 26 0.9338786 0.4780868  
## 27 0.9335869 0.4744695  
## 28 0.9330738 0.4678473  
## 29 0.9328602 0.4663419  
## 30 0.9318518 0.4539387  
##   
## Accuracy was used to select the optimal model using the largest value.  
## The final value used for the model was k = 1.

best\_k <- model$bestTune[[1]]  
#K = 1 will give the best value for K

#the confusion matrix using both the functions

library(gmodels)  
Validation\_data\_best\_k<-predict(model,validation\_norm[,-7])  
confusionMatrix(Validation\_data\_best\_k ,Valid\_label)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 1776 64  
## 1 32 128  
##   
## Accuracy : 0.952   
## 95% CI : (0.9417, 0.9609)  
## No Information Rate : 0.904   
## P-Value [Acc > NIR] : 1.034e-15   
##   
## Kappa : 0.7012   
##   
## Mcnemar's Test P-Value : 0.001557   
##   
## Sensitivity : 0.9823   
## Specificity : 0.6667   
## Pos Pred Value : 0.9652   
## Neg Pred Value : 0.8000   
## Prevalence : 0.9040   
## Detection Rate : 0.8880   
## Detection Prevalence : 0.9200   
## Balanced Accuracy : 0.8245   
##   
## 'Positive' Class : 0   
##

CrossTable(Validation\_data\_best\_k,Valid\_label)

##   
##   
## Cell Contents  
## |-------------------------|  
## | N |  
## | Chi-square contribution |  
## | N / Row Total |  
## | N / Col Total |  
## | N / Table Total |  
## |-------------------------|  
##   
##   
## Total Observations in Table: 2000   
##   
##   
## | Valid\_label   
## Validation\_data\_best\_k | 0 | 1 | Row Total |   
## -----------------------|-----------|-----------|-----------|  
## 0 | 1776 | 64 | 1840 |   
## | 7.628 | 71.828 | |   
## | 0.965 | 0.035 | 0.920 |   
## | 0.982 | 0.333 | |   
## | 0.888 | 0.032 | |   
## -----------------------|-----------|-----------|-----------|  
## 1 | 32 | 128 | 160 |   
## | 87.720 | 826.027 | |   
## | 0.200 | 0.800 | 0.080 |   
## | 0.018 | 0.667 | |   
## | 0.016 | 0.064 | |   
## -----------------------|-----------|-----------|-----------|  
## Column Total | 1808 | 192 | 2000 |   
## | 0.904 | 0.096 | |   
## -----------------------|-----------|-----------|-----------|  
##   
##

#Classifying the customer using the best k

Prediction\_new<-knn(Train\_predictors,test\_norm,cl=Train\_label,k=best\_k)  
Prediction\_new

## [1] 0  
## Levels: 0 1

#Customer using the new K value will also not accept the loan offer because again K = 0

#Repartition the data, this time into training, validation, and test sets (50% : 30% : 20%).

Test\_Index\_N = createDataPartition(Bankdata4$Personal.Loan,p=0.2, list=FALSE) # 20% reserved for Test  
Test\_Data\_N = Bankdata4[Test\_Index\_N,]  
TrainAndValid\_Data = Bankdata4[-Test\_Index\_N,] # Validation and Training data is rest  
Train\_Index\_N = createDataPartition(TrainAndValid\_Data$Personal.Loan,p=25/40, list=FALSE) # 50% of remaining data as training  
Train\_Data\_N = TrainAndValid\_Data[Train\_Index\_N,]  
Validation\_Data\_N = TrainAndValid\_Data[-Train\_Index\_N,] # rest as validation  
nrow(Train\_Data\_N)

## [1] 2500

summary(Train\_Data\_N)

## Age Experience Income Family   
## Min. :23.00 Min. :-3.00 Min. : 8.00 Min. :1.000   
## 1st Qu.:35.00 1st Qu.:10.00 1st Qu.: 38.00 1st Qu.:1.000   
## Median :46.00 Median :21.00 Median : 62.00 Median :2.000   
## Mean :45.46 Mean :20.21 Mean : 73.59 Mean :2.392   
## 3rd Qu.:55.00 3rd Qu.:30.00 3rd Qu.: 95.00 3rd Qu.:3.000   
## Max. :67.00 Max. :43.00 Max. :205.00 Max. :4.000   
## CCAvg Mortgage Personal.Loan Securities.Account  
## Min. : 0.000 Min. : 0.00 0:2260 Min. :0.0000   
## 1st Qu.: 0.700 1st Qu.: 0.00 1: 240 1st Qu.:0.0000   
## Median : 1.500 Median : 0.00 Median :0.0000   
## Mean : 1.909 Mean : 57.31 Mean :0.1084   
## 3rd Qu.: 2.500 3rd Qu.:101.00 3rd Qu.:0.0000   
## Max. :10.000 Max. :635.00 Max. :1.0000   
## CD.Account Online CreditCard Education1 Education2  
## Min. :0.0000 Min. :0.0000 Min. :0.000 0:1436 0:1812   
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.000 1:1064 1: 688   
## Median :0.0000 Median :1.0000 Median :0.000   
## Mean :0.0608 Mean :0.5992 Mean :0.292   
## 3rd Qu.:0.0000 3rd Qu.:1.0000 3rd Qu.:1.000   
## Max. :1.0000 Max. :1.0000 Max. :1.000   
## Education3  
## 0:1752   
## 1: 748   
##   
##   
##   
##

nrow(Validation\_Data\_N)

## [1] 1500

summary(Validation\_Data\_N)

## Age Experience Income Family   
## Min. :23.00 Min. :-3.00 Min. : 8.00 Min. :1.000   
## 1st Qu.:35.00 1st Qu.:10.00 1st Qu.: 39.00 1st Qu.:1.000   
## Median :45.00 Median :20.00 Median : 65.00 Median :2.000   
## Mean :45.38 Mean :20.13 Mean : 74.11 Mean :2.409   
## 3rd Qu.:56.00 3rd Qu.:30.00 3rd Qu.:102.00 3rd Qu.:3.000   
## Max. :67.00 Max. :42.00 Max. :218.00 Max. :4.000   
## CCAvg Mortgage Personal.Loan Securities.Account  
## Min. : 0.000 Min. : 0.00 0:1356 Min. :0.0000   
## 1st Qu.: 0.700 1st Qu.: 0.00 1: 144 1st Qu.:0.0000   
## Median : 1.600 Median : 0.00 Median :0.0000   
## Mean : 2.002 Mean : 56.83 Mean :0.1047   
## 3rd Qu.: 2.600 3rd Qu.:102.00 3rd Qu.:0.0000   
## Max. :10.000 Max. :612.00 Max. :1.0000   
## CD.Account Online CreditCard Education1 Education2  
## Min. :0.00000 Min. :0.0000 Min. :0.0000 0:874 0:1098   
## 1st Qu.:0.00000 1st Qu.:0.0000 1st Qu.:0.0000 1:626 1: 402   
## Median :0.00000 Median :1.0000 Median :0.0000   
## Mean :0.06733 Mean :0.5973 Mean :0.3047   
## 3rd Qu.:0.00000 3rd Qu.:1.0000 3rd Qu.:1.0000   
## Max. :1.00000 Max. :1.0000 Max. :1.0000   
## Education3  
## 0:1028   
## 1: 472   
##   
##   
##   
##

nrow(Test\_Data\_N)

## [1] 1000

summary(Test\_Data\_N)

## Age Experience Income Family   
## Min. :23.00 Min. :-3.00 Min. : 8.00 Min. :1.000   
## 1st Qu.:35.00 1st Qu.:10.00 1st Qu.: 39.00 1st Qu.:1.000   
## Median :45.00 Median :20.00 Median : 65.00 Median :2.000   
## Mean :44.96 Mean :19.81 Mean : 73.72 Mean :2.387   
## 3rd Qu.:55.00 3rd Qu.:30.00 3rd Qu.: 94.25 3rd Qu.:3.000   
## Max. :67.00 Max. :43.00 Max. :224.00 Max. :4.000   
## CCAvg Mortgage Personal.Loan Securities.Account  
## Min. : 0.000 Min. : 0.00 0:904 Min. :0.000   
## 1st Qu.: 0.700 1st Qu.: 0.00 1: 96 1st Qu.:0.000   
## Median : 1.500 Median : 0.00 Median :0.000   
## Mean : 1.915 Mean : 53.97 Mean :0.094   
## 3rd Qu.: 2.500 3rd Qu.: 98.00 3rd Qu.:0.000   
## Max. :10.000 Max. :582.00 Max. :1.000   
## CD.Account Online CreditCard Education1 Education2  
## Min. :0.000 Min. :0.00 Min. :0.000 0:594 0:687   
## 1st Qu.:0.000 1st Qu.:0.00 1st Qu.:0.000 1:406 1:313   
## Median :0.000 Median :1.00 Median :0.000   
## Mean :0.049 Mean :0.59 Mean :0.283   
## 3rd Qu.:0.000 3rd Qu.:1.00 3rd Qu.:1.000   
## Max. :1.000 Max. :1.00 Max. :1.000   
## Education3  
## 0:719   
## 1:281   
##   
##   
##   
##

##normalization of all 3 datas.

Norm\_model\_N <- preProcess(Train\_Data\_N, method = c("center", "scale"))  
training\_norm\_N<-predict(Norm\_model\_N,Train\_Data\_N)  
head(training\_norm\_N)

## Age Experience Income Family CCAvg Mortgage  
## 1 -1.8046984 -1.6935662 -0.52114002 1.396408 -0.1790084 -0.5607791  
## 3 -0.5699326 -0.4590085 -1.32636254 -1.209479 -0.5267236 -0.5607791  
## 5 -0.9227229 -1.0762874 -0.60590028 1.396408 -0.5267236 -0.5607791  
## 7 0.6648332 0.5991837 -0.03376849 -0.340850 -0.2369609 -0.5607791  
## 8 0.4002405 0.3346357 -1.09327181 -1.209479 -0.9323913 -0.5607791  
## 9 -0.9227229 -0.8999220 0.15694211 0.527779 -0.7585337 0.4568338  
## Personal.Loan Securities.Account CD.Account Online CreditCard Education1  
## 1 0 2.8673685 -0.2543817 -1.2224614 -0.6420782 1  
## 3 0 -0.3486123 -0.2543817 -1.2224614 -0.6420782 1  
## 5 0 -0.3486123 -0.2543817 -1.2224614 1.5568197 0  
## 7 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## 8 0 -0.3486123 -0.2543817 -1.2224614 1.5568197 0  
## 9 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## Education2 Education3  
## 1 0 0  
## 3 0 0  
## 5 1 0  
## 7 1 0  
## 8 0 1  
## 9 1 0

validation\_norm\_N<-predict(Norm\_model\_N,Validation\_Data\_N)  
head(validation\_norm\_N)

## Age Experience Income Family CCAvg Mortgage  
## 4 -0.9227229 -0.9881047 0.5595534 -1.209479 0.45846943 -0.5607791  
## 10 -1.0109204 -0.9881047 2.2547587 -1.209479 4.05152637 -0.5607791  
## 11 1.7232039 1.6573760 0.6655037 1.396408 0.28461184 -0.5607791  
## 12 -1.4519082 -1.3408354 -0.6059003 0.527779 -1.04829638 -0.5607791  
## 21 0.9294259 0.9519145 -1.0297016 1.396408 -0.58467613 0.5253270  
## 22 1.0176234 0.5991837 -0.2244791 0.527779 0.05280171 -0.5607791  
## Personal.Loan Securities.Account CD.Account Online CreditCard Education1  
## 4 0 -0.3486123 -0.2543817 -1.2224614 -0.6420782 0  
## 10 1 -0.3486123 -0.2543817 -1.2224614 -0.6420782 0  
## 11 0 -0.3486123 -0.2543817 -1.2224614 -0.6420782 0  
## 12 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## 21 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## 22 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## Education2 Education3  
## 4 1 0  
## 10 0 1  
## 11 0 1  
## 12 1 0  
## 21 1 0  
## 22 0 1

Test\_norm\_N<-predict(Norm\_model\_N,Test\_Data\_N)  
head(Test\_norm\_N)

## Age Experience Income Family CCAvg Mortgage  
## 2 -0.04074727 -0.1062778 -0.8389910 0.527779 -0.2369609 -0.5607791  
## 6 -0.74632774 -0.6353739 -0.9449413 1.396408 -0.8744388 0.9558556  
## 14 1.19401855 1.0400972 -0.7118506 1.396408 0.3425644 -0.5607791  
## 16 1.28221611 0.8637318 -1.0932718 -1.209479 -0.2369609 -0.5607791  
## 17 -0.65813018 -0.5471912 1.1952554 1.396408 1.6175201 0.7503760  
## 19 0.04745029 0.0700876 2.5302295 -0.340850 3.5879061 -0.5607791  
## Personal.Loan Securities.Account CD.Account Online CreditCard Education1  
## 2 0 2.8673685 -0.2543817 -1.2224614 -0.6420782 1  
## 6 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## 14 0 -0.3486123 -0.2543817 0.8176945 -0.6420782 0  
## 16 0 -0.3486123 -0.2543817 0.8176945 1.5568197 0  
## 17 1 -0.3486123 -0.2543817 -1.2224614 -0.6420782 0  
## 19 1 -0.3486123 -0.2543817 -1.2224614 -0.6420782 0  
## Education2 Education3  
## 2 0 0  
## 6 1 0  
## 14 1 0  
## 16 0 1  
## 17 0 1  
## 19 0 1

#Classifying the customer from all 3 set (training,validation and testing) using the best k

Train\_predictors\_N <-training\_norm\_N[,-7]  
Train\_label\_N<-training\_norm\_N[,7]  
valid\_predictors\_N<-validation\_norm\_N[,-7]  
Valid\_label\_N<-validation\_norm\_N[,7]  
Test\_predictors\_N<-Test\_norm\_N[,-7]  
Test\_label\_N<-Test\_norm\_N[,7]  
training\_prediction\_N <-knn(Train\_predictors\_N,Train\_predictors\_N,cl=Train\_label\_N,k=best\_k)  
head(training\_prediction\_N)

## [1] 0 0 0 0 0 0  
## Levels: 0 1

validation\_prediction\_N <-knn(Train\_predictors\_N,valid\_predictors\_N,cl=Train\_label\_N,k=best\_k)  
head(validation\_prediction\_N)

## [1] 0 1 0 0 0 0  
## Levels: 0 1

Test\_prediction\_N <-knn(Train\_predictors\_N,Test\_predictors\_N,cl=Train\_label\_N,k=best\_k)  
head(Test\_prediction\_N)

## [1] 0 0 0 0 1 1  
## Levels: 0 1

#the confusion matrix using both the functions for all 3 datasets Training, Validation and Test

confusionMatrix(training\_prediction\_N,Train\_label\_N)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 2260 0  
## 1 0 240  
##   
## Accuracy : 1   
## 95% CI : (0.9985, 1)  
## No Information Rate : 0.904   
## P-Value [Acc > NIR] : < 2.2e-16   
##   
## Kappa : 1   
##   
## Mcnemar's Test P-Value : NA   
##   
## Sensitivity : 1.000   
## Specificity : 1.000   
## Pos Pred Value : 1.000   
## Neg Pred Value : 1.000   
## Prevalence : 0.904   
## Detection Rate : 0.904   
## Detection Prevalence : 0.904   
## Balanced Accuracy : 1.000   
##   
## 'Positive' Class : 0   
##

CrossTable(training\_prediction\_N,Train\_label\_N)

##   
##   
## Cell Contents  
## |-------------------------|  
## | N |  
## | Chi-square contribution |  
## | N / Row Total |  
## | N / Col Total |  
## | N / Table Total |  
## |-------------------------|  
##   
##   
## Total Observations in Table: 2500   
##   
##   
## | Train\_label\_N   
## training\_prediction\_N | 0 | 1 | Row Total |   
## ----------------------|-----------|-----------|-----------|  
## 0 | 2260 | 0 | 2260 |   
## | 23.040 | 216.960 | |   
## | 1.000 | 0.000 | 0.904 |   
## | 1.000 | 0.000 | |   
## | 0.904 | 0.000 | |   
## ----------------------|-----------|-----------|-----------|  
## 1 | 0 | 240 | 240 |   
## | 216.960 | 2043.040 | |   
## | 0.000 | 1.000 | 0.096 |   
## | 0.000 | 1.000 | |   
## | 0.000 | 0.096 | |   
## ----------------------|-----------|-----------|-----------|  
## Column Total | 2260 | 240 | 2500 |   
## | 0.904 | 0.096 | |   
## ----------------------|-----------|-----------|-----------|  
##   
##

confusionMatrix(validation\_prediction\_N,Valid\_label\_N)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 1343 51  
## 1 13 93  
##   
## Accuracy : 0.9573   
## 95% CI : (0.9458, 0.967)  
## No Information Rate : 0.904   
## P-Value [Acc > NIR] : 5.372e-15   
##   
## Kappa : 0.7213   
##   
## Mcnemar's Test P-Value : 3.746e-06   
##   
## Sensitivity : 0.9904   
## Specificity : 0.6458   
## Pos Pred Value : 0.9634   
## Neg Pred Value : 0.8774   
## Prevalence : 0.9040   
## Detection Rate : 0.8953   
## Detection Prevalence : 0.9293   
## Balanced Accuracy : 0.8181   
##   
## 'Positive' Class : 0   
##

CrossTable(validation\_prediction\_N,Valid\_label\_N)

##   
##   
## Cell Contents  
## |-------------------------|  
## | N |  
## | Chi-square contribution |  
## | N / Row Total |  
## | N / Col Total |  
## | N / Table Total |  
## |-------------------------|  
##   
##   
## Total Observations in Table: 1500   
##   
##   
## | Valid\_label\_N   
## validation\_prediction\_N | 0 | 1 | Row Total |   
## ------------------------|-----------|-----------|-----------|  
## 0 | 1343 | 51 | 1394 |   
## | 5.444 | 51.260 | |   
## | 0.963 | 0.037 | 0.929 |   
## | 0.990 | 0.354 | |   
## | 0.895 | 0.034 | |   
## ------------------------|-----------|-----------|-----------|  
## 1 | 13 | 93 | 106 |   
## | 71.588 | 674.117 | |   
## | 0.123 | 0.877 | 0.071 |   
## | 0.010 | 0.646 | |   
## | 0.009 | 0.062 | |   
## ------------------------|-----------|-----------|-----------|  
## Column Total | 1356 | 144 | 1500 |   
## | 0.904 | 0.096 | |   
## ------------------------|-----------|-----------|-----------|  
##   
##

confusionMatrix(Test\_prediction\_N,Test\_label\_N)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 894 37  
## 1 10 59  
##   
## Accuracy : 0.953   
## 95% CI : (0.938, 0.9653)  
## No Information Rate : 0.904   
## P-Value [Acc > NIR] : 5.885e-09   
##   
## Kappa : 0.6903   
##   
## Mcnemar's Test P-Value : 0.0001491   
##   
## Sensitivity : 0.9889   
## Specificity : 0.6146   
## Pos Pred Value : 0.9603   
## Neg Pred Value : 0.8551   
## Prevalence : 0.9040   
## Detection Rate : 0.8940   
## Detection Prevalence : 0.9310   
## Balanced Accuracy : 0.8018   
##   
## 'Positive' Class : 0   
##

CrossTable(Test\_prediction\_N,Test\_label\_N)

##   
##   
## Cell Contents  
## |-------------------------|  
## | N |  
## | Chi-square contribution |  
## | N / Row Total |  
## | N / Col Total |  
## | N / Table Total |  
## |-------------------------|  
##   
##   
## Total Observations in Table: 1000   
##   
##   
## | Test\_label\_N   
## Test\_prediction\_N | 0 | 1 | Row Total |   
## ------------------|-----------|-----------|-----------|  
## 0 | 894 | 37 | 931 |   
## | 3.259 | 30.693 | |   
## | 0.960 | 0.040 | 0.931 |   
## | 0.989 | 0.385 | |   
## | 0.894 | 0.037 | |   
## ------------------|-----------|-----------|-----------|  
## 1 | 10 | 59 | 69 |   
## | 43.979 | 414.137 | |   
## | 0.145 | 0.855 | 0.069 |   
## | 0.011 | 0.615 | |   
## | 0.010 | 0.059 | |   
## ------------------|-----------|-----------|-----------|  
## Column Total | 904 | 96 | 1000 |   
## | 0.904 | 0.096 | |   
## ------------------|-----------|-----------|-----------|  
##   
##

##Compare the confusion matrix between the training and validation sets with the test set.

##For the training set, validation set, and test set, confusion matrices were made. The training set confusion matrix displays 100% accuracy with k=1 as is typical for KNN models because the model is already aware of the values. The validation set confusion matrix displays a 95.47% overall accuracy, a 98.89% high sensitivity, and a 63.19% low specificity. This confusion matrix demonstrates that the model is less successful at accurately predicting which customers will accept the loan (out of the 144 customers who accepted the loan, the model only correctly predicted 91 of those customers would accept the loan, resulting in a low specificity of 63.19%). Nonetheless, this model is quite good at properly anticipating future events.