

Assignment 2

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1. Inserting Data and Libraries

Reading the UniversalBank csv file and inserting approproate libraries

```
library(class)
library(caret)

## Loading required package: lattice

## Loading required package: ggplot2

library(ISLR)
library(dummies)

## dummies-1.5.6 provided by Decision Patterns

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

library(tidyr)
library(ggplot2)

UBank_data <- read.csv("UniversalBank.csv")
```

2. Data Cleaning and Splitting

Removing the ID and Zipcode columns from the Bank_data dataset

Converting Education column into factor and creating a dummy database of Bank_data

Moving personal.loan column to the first column position

```
library(caret)
library(class)
library(ISLR)
library(tidyr)
library(dummies)
library(dplyr)
library(ggplot2)

UBank_data$Education = as.factor(UBank_data$Education)
UBank_data$Personal.Loan = as.factor(UBank_data$Personal.Loan)
UBank_data_d = dummy.data.frame(select(UBank_data, -c(ZIP.Code, ID)))

## Warning in model.matrix.default(~x - 1, model.frame(~x - 1), contrasts = FALSE):
## non-list contrasts argument ignored

## Warning in model.matrix.default(~x - 1, model.frame(~x - 1), contrasts = FALSE):
## non-list contrasts argument ignored

n <- which(colnames(UBank_data_d)=="Personal.Loan")
Personal.Loan <- UBank_data_d$Personal.Loan
UBank_data_d <- cbind(Personal.Loan, UBank_data_d[, -n])
UBank_data_d <- UBank_data_d[,-11]

head(UBank_data_d)

##   Personal.Loan Age Experience Income Family CCAvg Education1 Education2
## 1            0    25          1     49      4    1.6         1         0
## 2            0    45          19     34      3    1.5         1         0
## 3            0    39          15     11      1    1.0         1         0
## 4            0    35           9    100      1    2.7         0         1
## 5            0    35           8     45      4    1.0         0         1
## 6            0    37          13     29      4    0.4         0         1
##   Education3 Mortgage Securities.Account CD.Account Online CreditCard
## 1            0          0             1          0        0         0
## 2            0          0             1          0        0         0
## 3            0          0             0          0        0         0
## 4            0          0             0          0        0         0
## 5            0          0             0          0        0         1
## 6            0        155             0          0        1         0
```

3. Data Partition

Partitioning the UniversalBank dataset into Training and validation sets

```
set.seed(123)
Index_Train <- createDataPartition(UBank_data_d$Personal.Loan, p=0.6, list = FALSE)
# 60% of data is taken as Training Data
```

```
Train <- UBank_data_d[Index_Train,]
Validation <- UBank_data_d[-Index_Train,]
# Rest of the data is taken as Validation Data
```

```
summary(Train)
```

```
## Personal.Loan      Age      Experience      Income
## Min.   :0.00000   Min.   :23.00   Min.   :-3.00   Min.   : 8.0
## 1st Qu.:0.00000   1st Qu.:36.00   1st Qu.:10.00   1st Qu.: 39.0
## Median :0.00000   Median :46.00   Median :20.00   Median : 64.0
## Mean   :0.09267   Mean   :45.43   Mean   :20.21   Mean   : 73.4
## 3rd Qu.:0.00000   3rd Qu.:55.00   3rd Qu.:30.00   3rd Qu.: 95.0
## Max.   :1.00000   Max.   :67.00   Max.   :43.00   Max.   :224.0
## Family          CCAvg      Education1      Education2
## Min.   :1.000   Min.   : 0.000   Min.   :0.000   Min.   :0.000
## 1st Qu.:1.000   1st Qu.: 0.700   1st Qu.:0.000   1st Qu.:0.000
## Median :2.000   Median : 1.500   Median :0.000   Median :0.000
## Mean   :2.399   Mean   : 1.924   Mean   :0.424   Mean   :0.285
## 3rd Qu.:4.000   3rd Qu.: 2.600   3rd Qu.:1.000   3rd Qu.:1.000
## Max.   :4.000   Max.   :10.000  Max.   :1.000   Max.   :1.000
## Education3      Mortgage     Securities.Account  CD.Account
## Min.   :0.000   Min.   : 0.00   Min.   :0.000   Min.   :0.000
## 1st Qu.:0.000   1st Qu.: 0.00   1st Qu.:0.000   1st Qu.:0.000
## Median :0.000   Median : 0.00   Median :0.000   Median :0.000
## Mean   :0.291   Mean   : 55.29  Mean   :0.103   Mean   :0.059
## 3rd Qu.:1.000   3rd Qu.: 98.00  3rd Qu.:0.000   3rd Qu.:0.000
## Max.   :1.000   Max.   :635.00  Max.   :1.000   Max.   :1.000
## Online          CreditCard
## Min.   :0.0000   Min.   :0.0000
## 1st Qu.:0.0000   1st Qu.:0.0000
## Median :1.0000   Median :0.0000
## Mean   :0.5997   Mean   :0.2943
## 3rd Qu.:1.0000   3rd Qu.:1.0000
## Max.   :1.0000   Max.   :1.0000
```

```
summary(Validation)
```

```
## Personal.Loan      Age      Experience      Income
## Min.   :0.000   Min.   :23.0   Min.   :-3.00   Min.   : 8.00
## 1st Qu.:0.000   1st Qu.:35.0   1st Qu.:10.00   1st Qu.: 39.00
## Median :0.000   Median :45.0   Median :20.00   Median : 63.00
```

```

##  Mean   :0.101   Mean   :45.2    Mean   :19.95   Mean   : 74.34
##  3rd Qu.:0.000   3rd Qu.:55.0    3rd Qu.:30.00   3rd Qu.:100.00
##  Max.   :1.000   Max.   :67.0    Max.   :43.00   Max.   :204.00
## Family          CCAvg       Education1      Education2
##  Min.   :1.000   Min.   : 0.000   Min.   :0.000   Min.   :0.000
##  1st Qu.:1.000   1st Qu.: 0.700   1st Qu.:0.000   1st Qu.:0.000
##  Median :2.000   Median : 1.600   Median :0.000   Median :0.000
##  Mean   :2.393   Mean   : 1.959   Mean   :0.412   Mean   :0.274
##  3rd Qu.:3.000   3rd Qu.: 2.500   3rd Qu.:1.000   3rd Qu.:1.000
##  Max.   :4.000   Max.   :10.000   Max.   :1.000   Max.   :1.000
## Education3        Mortgage     Securities.Account  CD.Account
##  Min.   :0.000   Min.   : 0.00   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.000   1st Qu.: 0.00   1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.000   Median : 0.00   Median :0.0000   Median :0.0000
##  Mean   :0.314   Mean   : 58.32  Mean   :0.1065  Mean   :0.0625
##  3rd Qu.:1.000   3rd Qu.:103.00 3rd Qu.:0.0000  3rd Qu.:0.0000
##  Max.   :1.000   Max.   :601.00  Max.   :1.0000  Max.   :1.0000
## Online           CreditCard
##  Min.   :0.0000  Min.   :0.0000
##  1st Qu.:0.0000 1st Qu.:0.0000
##  Median :1.0000  Median :0.0000
##  Mean   :0.5925  Mean   :0.2935
##  3rd Qu.:1.0000 3rd Qu.:1.0000
##  Max.   :1.0000  Max.   :1.0000

```

4. Q1. Classifying customer using given constraints

Creating Test data from Q1 in Assignment

Normalizing the Training Data

Applying KNN Model with k=1

```

# copying data

Train_norm <- Train
Validation_norm <- Validation
UBD_norm <- UBank_data_d

#Creating test data from the question

Test1 <- data.frame(Age = 40, Experience = 10, Income = 84, Family = 2, CCAvg = 2, Education1 = 0, Education2 = 0)

#Normalizing the data

Test_norm1 <- Test1

norm_values <- preprocess(Train, method = c("center", "scale"))
Train_norm <- predict(norm_values, Train)
Validation_norm <- predict(norm_values, Validation)

```

```

UBD_norm <- predict(norm_values, UBank_data_d)

#combine normalized values of train and validation and then preprocess and normalize test data#####
summary(Train_norm)

## Personal.Loan          Age           Experience        Income
## Min.   :-0.3195    Min.   :-1.96925   Min.   :-2.03259   Min.   :-1.4286
## 1st Qu.:-0.3195    1st Qu.:-0.82784   1st Qu.:-0.89392   1st Qu.:-0.7514
## Median :-0.3195    Median : 0.05016   Median :-0.01801   Median :-0.2053
## Mean   : 0.0000    Mean   : 0.00000   Mean   : 0.00000   Mean   : 0.0000
## 3rd Qu.:-0.3195    3rd Qu.: 0.84037   3rd Qu.: 0.85789   3rd Qu.: 0.4720
## Max.   : 3.1286    Max.   : 1.89398   Max.   : 1.99656   Max.   : 3.2901
## Family            CCAvg          Education1       Education2
## Min.   :-1.2142    Min.   :-1.1157    Min.   :-0.8578    Min.   :-0.6312
## 1st Qu.:-1.2142    1st Qu.:-0.7098    1st Qu.:-0.8578    1st Qu.:-0.6312
## Median :-0.3463    Median :-0.2459    Median :-0.8578    Median :-0.6312
## Mean   : 0.0000    Mean   : 0.00000   Mean   : 0.00000   Mean   : 0.0000
## 3rd Qu.: 1.3895    3rd Qu.: 0.3921    3rd Qu.: 1.1653    3rd Qu.: 1.5836
## Max.   : 1.3895    Max.   : 4.6835    Max.   : 1.1653    Max.   : 1.5836
## Education3         Mortgage        Securities.Account CD.Account
## Min.   :-0.6405    Min.   :-0.5477    Min.   :-0.3388    Min.   :-0.2504
## 1st Qu.:-0.6405    1st Qu.:-0.5477    1st Qu.:-0.3388    1st Qu.:-0.2504
## Median :-0.6405    Median :-0.5477    Median :-0.3388    Median :-0.2504
## Mean   : 0.0000    Mean   : 0.00000   Mean   : 0.00000   Mean   : 0.0000
## 3rd Qu.: 1.5606    3rd Qu.: 0.4231    3rd Qu.:-0.3388   3rd Qu.:-0.2504
## Max.   : 1.5606    Max.   : 5.7429    Max.   : 2.9506    Max.   : 3.9930
## Online             CreditCard
## Min.   :-1.2237    Min.   :-0.6457
## 1st Qu.:-1.2237    1st Qu.:-0.6457
## Median : 0.8169    Median :-0.6457
## Mean   : 0.0000    Mean   : 0.0000
## 3rd Qu.: 0.8169    3rd Qu.: 1.5481
## Max.   : 0.8169    Max.   : 1.5481

var(Train_norm)

##          Personal.Loan          Age           Experience        Income
## Personal.Loan 1.00000000 -0.021822200 -0.021166260 0.488102867
## Age           -0.02182220  1.000000000 0.994046117 -0.058886301
## Experience    -0.02116626  0.994046117  1.000000000 -0.049627190
## Income         0.48810287 -0.058886301 -0.049627190  1.000000000
## Family         0.05096949 -0.047518269 -0.052070243 -0.158593072
## CCAvg          0.34988271 -0.064959563 -0.063361729 0.649073730
## Education1    -0.15555490 -0.014705142  0.010836619 0.228897878
## Education2    0.09363791 -0.025452176 -0.025283471 -0.124462179
## Education3    0.07618321  0.041293806  0.013336986 -0.125345941
## Mortgage       0.14814232 -0.007099632 -0.003875213 0.201359111
## Securities.Account 0.02407606  0.002844950  0.003405624 0.009194703
## CD.Account     0.34931209 -0.001475115  0.002056915 0.198656079
## Online          0.02884123  0.013192870  0.012993003 0.020872689
## CreditCard     0.02314386  0.013069757  0.014634477 0.028104163

```

```

##          Family      CCAvg Education1 Education2
## Personal.Loan 0.050969493 0.3498827085 -0.155554896 0.093637912
## Age           -0.047518269 -0.0649595631 -0.014705142 -0.025452176
## Experience   -0.052070243 -0.0633617290  0.010836619 -0.025283471
## Income         -0.158593072  0.6490737302  0.228897878 -0.124462179
## Family        1.000000000 -0.1046245559 -0.118580297  0.124257664
## CCAvg         -0.104624556  1.000000000  0.158046007 -0.085770034
## Education1   -0.118580297  0.158046007  1.000000000 -0.541677873
## Education2   0.124257664 -0.0857700337 -0.541677873  1.000000000
## Education3   0.005524861 -0.0867127350 -0.549661177 -0.404476027
## Mortgage     -0.020468810  0.1156690366  0.031288479 -0.016957841
## Securities.Account 0.009242326  0.0037544277  0.002183559  0.033852865
## CD.Account    -0.008133090  0.1560439055 -0.028763610  0.029944231
## Online        -0.009921811 -0.0006108599 -0.023094425  0.032078283
## CreditCard   -0.012264272  0.0098128271  0.009779915 -0.005922037
##          Education3 Mortgage Securities.Account CD.Account
## Personal.Loan 0.076183212  0.148142317  0.024076056  0.349312088
## Age           0.041293806 -0.007099632  0.002844950 -0.001475115
## Experience   0.013336986 -0.003875213  0.003405624  0.002056915
## Income         -0.125345941  0.201359111  0.009194703  0.198656079
## Family        0.005524861 -0.020468810  0.009242326 -0.008133090
## CCAvg         -0.086712735  0.115669037  0.003754428  0.156043906
## Education1   -0.549661177  0.031288479  0.002183559 -0.028763610
## Education2   -0.404476027 -0.016957841  0.033852865  0.029944231
## Education3   1.000000000 -0.017188557  -0.036019196  0.001535448
## Mortgage     -0.017188557  1.000000000  -0.011946442  0.098948506
## Securities.Account -0.036019196 -0.011946442  1.000000000  0.287483990
## CD.Account    0.001535448  0.098948506  0.287483990  1.000000000
## Online        -0.006753417  0.010952781  -0.002902940  0.169943664
## CreditCard   -0.004755028  0.005400099  -0.031158792  0.285277874
##          Online CreditCard
## Personal.Loan 0.0288412325  0.023143864
## Age           0.0131928696  0.013069757
## Experience   0.0129930031  0.014634477
## Income         0.0208726892  0.028104163
## Family         -0.0099218106 -0.012264272
## CCAvg         -0.0006108599  0.009812827
## Education1   -0.0230944254  0.009779915
## Education2   0.0320782833 -0.005922037
## Education3   -0.0067534166 -0.004755028
## Mortgage     0.0109527811  0.005400099
## Securities.Account -0.0029029400 -0.031158792
## CD.Account    0.1699436636  0.285277874
## Online        1.00000000000  0.003723470
## CreditCard   0.0037234702  1.000000000

```

```
summary(Validation_norm)
```

	Personal.Loan	Age	Experience	Income
## Min.	-0.31953	Min. :-1.96925	Min. :-2.03259	Min. :-1.42861
## 1st Qu.	-0.31953	1st Qu.:-0.91565	1st Qu.:-0.89392	1st Qu.:-0.75140
## Median	-0.31953	Median :-0.03764	Median :-0.01801	Median :-0.22710
## Mean	0.02873	Mean :-0.01981	Mean :-0.02213	Mean : 0.02067
## 3rd Qu.	-0.31953	3rd Qu.: 0.84037	3rd Qu.: 0.85789	3rd Qu.: 0.58119

```

## Max. : 3.12859  Max. : 1.89398  Max. : 1.99656  Max. : 2.85314
## Family          CCAvg           Education1      Education2
## Min. :-1.214194  Min. :-1.11573  Min. :-0.85783  Min. :-0.63124
## 1st Qu.:-1.214194 1st Qu.:-0.70979 1st Qu.:-0.85783 1st Qu.:-0.63124
## Median :-0.346293 Median :-0.18786 Median :-0.85783 Median :-0.63124
## Mean  :-0.005641 Mean  : 0.02029 Mean  :-0.02428 Mean  :-0.02436
## 3rd Qu.: 0.521609 3rd Qu.: 0.33407 3rd Qu.: 1.16535 3rd Qu.: 1.58365
## Max. : 1.389511  Max. : 4.68347  Max. : 1.16535  Max. : 1.58365
## Education3       Mortgage        Securities.Account CD.Account
## Min. :-0.64055  Min. :-0.54769  Min. :-0.33881  Min. :-0.25036
## 1st Qu.:-0.64055 1st Qu.:-0.54769 1st Qu.:-0.33881 1st Qu.:-0.25036
## Median :-0.64055 Median :-0.54769 Median :-0.33881 Median :-0.25036
## Mean  : 0.05063  Mean  : 0.03003 Mean  : 0.01151 Mean  : 0.01485
## 3rd Qu.: 1.56065 3rd Qu.: 0.47267 3rd Qu.:-0.33881 3rd Qu.:-0.25036
## Max. : 1.56065  Max. : 5.40606  Max. : 2.95057  Max. : 3.99297
## Online            CreditCard
## Min. :-1.22369  Min. :-0.645725
## 1st Qu.:-1.22369 1st Qu.:-0.645725
## Median : 0.81693 Median :-0.645725
## Mean  :-0.01462 Mean  :-0.001828
## 3rd Qu.: 0.81693 3rd Qu.: 1.548131
## Max. : 0.81693  Max. : 1.548131

```

```
var(Validation_norm)
```

	Personal.Loan	Age	Experience	Income
## Personal.Loan	1.08009777	0.0133266557	0.0132191744	0.551059837
## Age	0.01332666	1.0327551325	1.0220182700	-0.051302177
## Experience	0.01321917	1.0220182700	1.0226757778	-0.042924214
## Income	0.55105984	-0.0513021773	-0.0429242139	1.028521084
## Family	0.07891768	-0.0451479570	-0.0534726737	-0.156530305
## CCAvg	0.41939848	-0.0349824725	-0.0321607240	0.672463699
## Education1	-0.14386434	-0.0480099895	-0.0238708722	0.204299406
## Education2	0.04069611	-0.0028449500	-0.0078847351	-0.134250919
## Education3	0.11607841	0.0550617028	0.0338072229	-0.088854867
## Mortgage	0.14097190	-0.0207909520	-0.0205702104	0.221586939
## Securities.Account	0.01978492	-0.0052356992	-0.0080697325	-0.020556280
## CD.Account	0.28820198	0.0228544894	0.0234039913	0.133332209
## Online	-0.02705050	0.0145597473	0.0152625195	0.004632481
## CreditCard	-0.02757569	-0.0003045919	0.0005372617	-0.048136139
	Family	CCAvg	Education1	Education2
## Personal.Loan	0.07891768	0.419398479	-0.14386434	0.040696112
## Age	-0.04514796	-0.034982473	-0.04800999	-0.002844950
## Experience	-0.05347267	-0.032160724	-0.02387087	-0.007884735
## Income	-0.15653031	0.672463699	0.20429941	-0.134250919
## Family	0.98080706	-0.118834966	-0.11719581	0.158583078
## CCAvg	-0.11883497	1.068246059	0.16041345	-0.098969863
## Education1	-0.11719581	0.160413452	0.99210723	-0.506116587
## Education2	0.15858308	-0.098969863	-0.50611659	0.976357112
## Education3	-0.03009458	-0.076170293	-0.57641529	-0.419669648
## Mortgage	-0.02050409	0.106779382	0.06127397	-0.053882485
## Securities.Account	0.03627116	0.032690069	0.01412891	-0.037765542
## CD.Account	0.04778511	0.115558998	0.00644197	-0.029385032
## Online	0.04065499	-0.008067683	0.04291686	0.002961914

```

## CreditCard      0.04724647 -0.031647341  0.02255025 -0.021483322
##                 Education3      Mortgage Securities.Account  CD.Account
## Personal.Loan  0.116078410  0.140971903     0.019784921  0.28820198
## Age            0.055061703 -0.020790952     -0.005235699  0.02285449
## Experience    0.033807223 -0.020570210     -0.008069733  0.02340399
## Income         -0.088854867  0.221586939     -0.020556280  0.13333221
## Family          -0.030094584 -0.020504095     0.036271159  0.04778511
## CCAvg           -0.076170293  0.106779382     0.032690069  0.11555900
## Education1    -0.576415293  0.061273973     0.014128914  0.00644197
## Education2    -0.419669648 -0.053882485     -0.037765542 -0.02938503
## Education3     1.044207846 -0.013116159     0.022159882  0.02219451
## Mortgage        -0.013116159  1.038206516     0.003999834  0.07880069
## Securities.Account  0.022159882  0.003999834  1.030117842  0.37486936
## CD.Account       0.022194512  0.078800690     0.374869362  1.05555793
## Online           -0.049636676 -0.031290949     0.036256424  0.19032293
## CreditCard      -0.003183968 -0.026281792     0.008969063  0.27621566
##                 Online      CreditCard
## Personal.Loan  -0.027050497 -0.0275756944
## Age             0.014559747 -0.0003045919
## Experience     0.015262519  0.0005372617
## Income          0.004632481 -0.0481361390
## Family          0.040654991  0.0472464673
## CCAvg           -0.008067683 -0.0316473407
## Education1    0.042916862  0.0225502527
## Education2    0.002961914 -0.0214833220
## Education3     -0.049636676 -0.0031839680
## Mortgage        -0.031290949 -0.0262817921
## Securities.Account  0.036256424  0.0089690627
## CD.Account       0.190322928  0.2762156637
## Online           1.005904426  0.0049325668
## CreditCard      0.004932567  0.9985127901

```

```

# Applying KNN Model on test data

Q1_KNN <- knn(train = Train_norm[,-10], test = Test1, cl = Train[,1], k=1, prob = 0.5)
Q1.attributes<- attributes(Q1_KNN)
row.names(Train_norm)[attr(Q1_KNN, "Q1_KNN.index")]

```

```
## character(0)
```

```
Q1.attributes[1]
```

```
## $levels
## [1] "0" "1"
```

```
Q1.attributes[3]
```

```
## $prob
## [1] 1
```

5. Training the KNN Model

Combining training and validation datasets and renormalizing data

Expanding search grid to appropriate K value to gain highest possible accuracy

```
set.seed(123)
Search_grid <- expand.grid(k=c(2,3,5,7,14))
Model <- train(Personal.Loan~Income+Mortgage, data =UBD_norm, method = "knn", tuneGrid=Search_grid, pre=
```



```
## Warning in train.default(x, y, weights = w, ...): You are trying to do
## regression and your outcome only has two possible values Are you trying to do
## classification? If so, use a 2 level factor as your outcome column.
```



```
head(Model)
```



```
## $method
## [1] "knn"
##
## $modelInfo
## $modelInfo$label
## [1] "k-Nearest Neighbors"
##
## $modelInfo$library
## NULL
##
## $modelInfo$loop
## NULL
##
## $modelInfo$type
## [1] "Classification" "Regression"
##
## $modelInfo$parameters
##   parameter    class      label
## 1           k numeric #Neighbors
##
## $modelInfo$grid
## function(x, y, len = NULL, search = "grid"){
##   if(search == "grid") {
##     out <- data.frame(k = (5:((2 * len)+4))[(5:((2 * len)+4))%%2 > 0])
##   } else {
##     by_val <- if(is.factor(y)) length(levels(y)) else 1
##     out <- data.frame(k = sample(seq(1, floor(nrow(x)/3), by = by_val), size = len))
##   }
## }
##
## $modelInfo$fit
## function(x, y, wts, param, lev, last, classProbs, ...) {
##   if(is.factor(y))
```

```

##           {
##             knn3(as.matrix(x), y, k = param$k, ...)
##           } else {
##             knnreg(as.matrix(x), y, k = param$k, ...)
##           }
##         }
## <bytecode: 0x00000000216a4a48>
##
## $modelInfo$predict
## function(modelFit, newdata, submodels = NULL) {
##   if(modelFit$problemType == "Classification")
##   {
##     out <- predict(modelFit, newdata, type = "class")
##   } else {
##     out <- predict(modelFit, newdata)
##   }
##   out
## }
## <bytecode: 0x0000000020ff7678>
##
## $modelInfo$predictors
## function(x, ...) colnames(x$learn$X)
##
## $modelInfo$tags
## [1] "Prototype Models"
##
## $modelInfo$prob
## function(modelFit, newdata, submodels = NULL)
##   predict(modelFit, newdata, type = "prob")
##
## $modelInfo$levels
## function(x) levels(x$learn$y)
##
## $modelInfo$sort
## function(x) x[order(-x[,1]),]
##
##
## $modelType
## [1] "Regression"
##
## $results
##   k      RMSE    Rsquared      MAE      RMSESD  RsquaredSD      MAESD
## 1  2 0.9776761 0.1832878 0.4094909 0.02788705 0.02042435 0.01639182
## 2  3 0.9573072 0.1961045 0.4103678 0.02761934 0.02132426 0.01654075
## 3  5 0.9319872 0.2144342 0.4126807 0.02757722 0.02326601 0.01576960
## 4  7 0.9139502 0.2302150 0.4121928 0.02407857 0.02375640 0.01511472
## 5 14 0.8831811 0.2614493 0.4100736 0.02058955 0.02211097 0.01283333
##
## $pred
## NULL
##
## $bestTune
##   k
## 5 14

```

7. Q3. Creating Confusion Matrix

```
Train_Predictors <- Train_norm
Test_Predictors <- Validation

Train_labels <- Train_norm[,1]
Test_labels <- Validation_norm[,1]

Predicted_Test_labels <- knn(Train_Predictors, Test_Predictors, cl=Train_labels, k=1, prob = TRUE)
library(gmodels)
CrossTable(x=Test_labels, y=Predicted_Test_labels, prop.chisq = FALSE)

## 
## 
##     Cell Contents
## |-----|
## |           N |
## |           N / Row Total |
## |           N / Col Total |
## |           N / Table Total |
## |-----|
## 
## 
## Total Observations in Table:  2000
## 
## 
##          | Predicted_Test_labels
## Test_labels | -0.319525808959514 | 3.12859443161078 |      Row Total |
## -----|-----|-----|-----|
## -0.319525808959514 |           363 |           1435 |           1798 |
## |           0.202 |           0.798 |           0.899 |
## |           0.771 |           0.939 |           |
## |           0.181 |           0.718 |           |
## -----|-----|-----|-----|
## 3.12859443161078 |           108 |            94 |           202 |
## |           0.535 |           0.465 |           0.101 |
## |           0.229 |           0.061 |           |
## |           0.054 |           0.047 |           |
## -----|-----|-----|-----|
## Column Total |           471 |           1529 |           2000 |
## |           0.235 |           0.764 |           |
## -----|-----|-----|-----|
## 
```

8. Q4. Classifying customer using best K

```
Q4_KNN <- knn(Train_norm[,2:14], Test1, cl = Train[,1], k=3, prob = TRUE)
head(Q4_KNN)

## [1] 1
```

```
## Levels: 0 1
```

9. Q5. Repartitioning data into 5:3:2

```
set.seed(123)
Index_Train2 <- createDataPartition(UBank_data_d$Personal.Loan, p=0.5, list = FALSE)
# 50% of data is taken as Training Data

Train2 <- UBank_data_d[Index_Train2,]
Validation.test <- UBank_data_d[-Index_Train2,]
# Rest of the data is taken as Validation and Test Data
Index_Validation <- createDataPartition(Validation.test$Personal.Loan, p=0.6, list = FALSE)
# 30% of total or 60% of remaining data is taken as Validation Data
Validation2 <- Validation.test[Index_Validation,]
Test2 <- Validation.test[-Index_Validation,]

knn12 <- knn(train=Train2, test=Train2, cl=Train2[,1], k=3 ,prob=TRUE)
head(knn12)

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

10. Normalizing the data

```
Train_norm2 <- Train2
Validation_norm2 <- Validation2
Test_norm2 <- Test2

norm_values2 <- preProcess(Train2, method = c("center", "scale"))
Train_norm2 <- predict(norm_values2, Train2)
Validation_norm2 <- predict(norm_values2, Validation2)

summary(Train_norm2)
```

```
## Personal.Loan          Age          Experience          Income
## Min.   :-0.3175   Min.   :-1.96620   Min.   :-2.028011  Min.   :-1.4337
## 1st Qu.:-0.3175   1st Qu.:-0.91026   1st Qu.:-0.887141  1st Qu.:-0.7553
## Median :-0.3175   Median : 0.05769   Median :-0.009548  Median :-0.2081
## Mean    : 0.0000   Mean   : 0.00000   Mean   : 0.000000  Mean   : 0.0000
## 3rd Qu.:-0.3175   3rd Qu.: 0.84965   3rd Qu.: 0.868044  3rd Qu.: 0.5360
## Max.    : 3.1485   Max.   : 1.90559   Max.   : 2.008915  Max.   : 3.2937
##       Family          CCAvg          Education1          Education2
## Min.   :-1.2072   Min.   :-1.1117   Min.   :-0.8627   Min.   :-0.6235
## 1st Qu.:-1.2072   1st Qu.:-0.7101   1st Qu.:-0.8627   1st Qu.:-0.6235
## Median :-0.3442   Median :-0.2510   Median :-0.8627   Median :-0.6235
## Mean    : 0.0000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000
## 3rd Qu.: 1.3818   3rd Qu.: 0.3801   3rd Qu.: 1.1587   3rd Qu.: 1.6032
## Max.    : 1.3818   Max.   : 4.6261   Max.   : 1.1587   Max.   : 1.6032
##       Education3         Mortgage        Securities.Account      CD.Account
```

```

## Min.   :-0.6439   Min.   :-0.5478   Min.   :-0.3443   Min.   :-0.2472
## 1st Qu.:-0.6439   1st Qu.:-0.5478   1st Qu.:-0.3443   1st Qu.:-0.2472
## Median :-0.6439   Median :-0.5478   Median :-0.3443   Median :-0.2472
## Mean    : 0.0000   Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000
## 3rd Qu.: 1.5523   3rd Qu.: 0.4302   3rd Qu.: -0.3443  3rd Qu.: -0.2472
## Max.    : 1.5523   Max.   : 5.7888   Max.   : 2.9035   Max.   : 4.0441
##          Online      CreditCard
## Min.   :-1.2255   Min.   :-0.6508
## 1st Qu.:-1.2255   1st Qu.:-0.6508
## Median : 0.8157   Median :-0.6508
## Mean    : 0.0000   Mean   : 0.0000
## 3rd Qu.: 0.8157   3rd Qu.: 1.5360
## Max.    : 0.8157   Max.   : 1.5360

var(Train_norm2)

##          Personal.Loan      Age      Experience      Income
## Personal.Loan      1.00000000 -0.039892527 -0.0394261891  0.48831047
## Age                 -0.03989253  1.000000000  0.9938753927 -0.07315732
## Experience        -0.03942619  0.993875393  1.0000000000 -0.06362619
## Income              0.48831047 -0.073157322 -0.0636261874  1.00000000
## Family              0.05466992 -0.052886503 -0.0566271658 -0.15774567
## CCAvg               0.34286680 -0.080084888 -0.0787215841  0.64293801
## Education1         -0.15345851 -0.028931723 -0.0032007434  0.23409981
## Education2         0.09845703 -0.002123290 -0.0007944896 -0.13699741
## Education3         0.06962520  0.033528932  0.0042612661 -0.11923015
## Mortgage            0.12344822 -0.009330027 -0.0062713370  0.18868170
## Securities.Account 0.02128853  0.007288790  0.0081171364  0.02023177
## CD.Account           0.33811664 -0.025475234 -0.0218012286  0.20688577
## Online              0.01559431  0.016175686  0.0169663649  0.02293378
## CreditCard          0.02077448  0.007297123  0.0086818520  0.02257521
##          Family      CCAvg      Education1      Education2
## Personal.Loan      0.054669919 0.3428668037 -0.153458509  0.0984570322
## Age                 -0.052886503 -0.0800848877 -0.028931723 -0.0021232903
## Experience        -0.056627166 -0.0787215841 -0.003200743 -0.0007944896
## Income              -0.157745671 0.6429380113  0.234099807 -0.1369974100
## Family              1.000000000 -0.1073080770 -0.108562019  0.1121474674
## CCAvg               -0.107308077 1.0000000000  0.157720930 -0.0873376377
## Education1         -0.108562019 0.1577209302  1.0000000000 -0.5381110149
## Education2         0.112147467 -0.0873376377 -0.538111015  1.0000000000
## Education3         0.007341507 -0.0852235891 -0.555767091 -0.4016488058
## Mortgage            -0.025484237 0.0882360290  0.024209999 -0.0107674476
## Securities.Account 0.020545392 -0.0019484187  0.010240351  0.0312548048
## CD.Account           -0.016934369 0.1440580262 -0.022420461  0.0293661537
## Online              -0.018749386 0.0001651959 -0.009290158  0.0267725326
## CreditCard          -0.023944582 0.0016695385  0.002583906 -0.0025720532
##          Education3      Mortgage      Securities.Account      CD.Account
## Personal.Loan      0.0696252018 0.123448217  0.021288532  0.338116639
## Age                 0.0335289318 -0.009330027  0.007288790 -0.025475234
## Experience        0.0042612661 -0.006271337  0.008117136 -0.021801229
## Income              -0.1192301463 0.188681704  0.020231773  0.206885769
## Family              0.0073415073 -0.025484237  0.020545392 -0.016934369
## CCAvg               -0.0852235891 0.088236029  -0.001948419  0.144058026
## Education1         -0.5557670911 0.024209999  0.010240351 -0.022420461

```

```

## Education2      -0.4016488058 -0.010767448      0.031254805  0.029366154
## Education3      1.0000000000 -0.015684406      -0.041953316 -0.004604107
## Mortgage        -0.0156844062  1.0000000000      -0.011679779  0.086936391
## Securities.Account -0.0419533156 -0.011679779      1.0000000000  0.271806163
## CD.Account       -0.0046041067  0.086936391      0.271806163  1.0000000000
## Online           -0.0163122324  0.004979324      -0.013545219  0.166639952
## CreditCard       -0.0002705974  0.010598666      -0.045086060  0.278424713
##                         Online     CreditCard
## Personal.Loan    0.0155943070  0.0207744812
## Age               0.0161756863  0.0072971226
## Experience        0.0169663649  0.0086818520
## Income            0.0229337773  0.0225752126
## Family            -0.0187493856 -0.0239445818
## CCAvg             0.0001651959  0.0016695385
## Education1       -0.0092901578  0.0025839062
## Education2       0.0267725326 -0.0025720532
## Education3       -0.0163122324 -0.0002705974
## Mortgage          0.0049793241  0.0105986657
## Securities.Account -0.0135452189 -0.0450860601
## CD.Account         0.1666399517  0.2784247125
## Online            1.0000000000  0.0041124343
## CreditCard        0.0041124343  1.0000000000

```

```
summary(Validation_norm2)
```

	Personal.Loan	Age	Experience	Income
## Min.	-0.31748	Min. : -1.966201	Min. : -1.940252	Min. : -1.43373
## 1st Qu.	-0.31748	1st Qu. : -0.910258	1st Qu. : -0.887141	1st Qu. : -0.75526
## Median	-0.31748	Median : -0.030306	Median : -0.009548	Median : -0.22999
## Mean	: 0.01294	Mean : 0.005479	Mean : 0.008589	Mean : 0.00752
## 3rd Qu.	-0.31748	3rd Qu. : 0.849647	3rd Qu. : 0.868044	3rd Qu. : 0.54150
## Max.	: 3.14850	Max. : 1.905589	Max. : 1.833396	Max. : 2.87786
## Family		CCAvg	Education1	Education2
## Min.	-1.20717	Min. : -1.1117	Min. : -0.862725	Min. : -0.62348
## 1st Qu.	-1.20717	1st Qu. : -0.7101	1st Qu. : -0.862725	1st Qu. : -0.62348
## Median	-0.34416	Median : -0.2510	Median : -0.862725	Median : -0.62348
## Mean	: -0.02946	Mean : -0.0057	Mean : -0.009703	Mean : -0.02078
## 3rd Qu.	: 0.51884	3rd Qu. : 0.3227	3rd Qu. : 1.158655	3rd Qu. : 1.60325
## Max.	: 1.38184	Max. : 4.0524	Max. : 1.158655	Max. : 1.60325
## Education3		Mortgage	Securities.Account	CD.Account
## Min.	-0.64394	Min. : -0.54777	Min. : -0.34427	Min. : -0.2472
## 1st Qu.	-0.64394	1st Qu. : -0.54777	1st Qu. : -0.34427	1st Qu. : -0.2472
## Median	-0.64394	Median : -0.54777	Median : -0.34427	Median : -0.2472
## Mean	: 0.03104	Mean : 0.04763	Mean : -0.00433	Mean : 0.0246
## 3rd Qu.	: 1.55231	3rd Qu. : 0.48006	3rd Qu. : -0.34427	3rd Qu. : -0.2472
## Max.	: 1.55231	Max. : 5.44953	Max. : 2.90355	Max. : 4.0441
## Online		CreditCard		
## Min.	-1.22552	Min. : -0.650785		
## 1st Qu.	-1.22552	1st Qu. : -0.650785		
## Median	: 0.81565	Median : -0.650785		
## Mean	: -0.02803	Mean : 0.009622		
## 3rd Qu.	: 0.81565	3rd Qu. : 1.535992		
## Max.	: 0.81565	Max. : 1.535992		

```
var(Validation_norm2)
```

	Personal.Loan	Age	Experience	Income
## Personal.Loan	1.0367562006	0.034760883	0.033977749	0.524482873
## Age	0.0347608835	1.034390729	1.020937362	-0.021521017
## Experience	0.0339777489	1.020937362	1.018204680	-0.016387163
## Income	0.5244828729	-0.021521017	-0.016387163	1.022101427
## Family	0.0735369006	-0.082295131	-0.091855996	-0.142636126
## CCAvg	0.4090315990	-0.009366446	-0.007441807	0.644671543
## Education1	-0.1465059112	-0.038495762	-0.015126481	0.194247333
## Education2	0.0581522428	-0.037267710	-0.042877732	-0.104391821
## Education3	0.1018242731	0.078583805	0.058726012	-0.108089239
## Mortgage	0.1884327805	-0.006476600	-0.005513505	0.235021855
## Securities.Account	0.0002453135	-0.015795157	-0.019099334	-0.034320896
## CD.Account	0.2673380394	0.008657233	0.010392644	0.137092495
## Online	0.0099426249	-0.011606783	-0.013009669	0.007398131
## CreditCard	-0.0211655142	0.014862622	0.015667732	-0.037290749
	Family	CCAvg	Education1	Education2
## Personal.Loan	0.07353690	0.409031599	-0.146505911	0.058152243
## Age	-0.08229513	-0.009366446	-0.038495762	-0.037267710
## Experience	-0.09185600	-0.007441807	-0.015126481	-0.042877732
## Income	-0.14263613	0.644671543	0.194247333	-0.104391821
## Family	0.96165678	-0.108245622	-0.105707510	0.147356325
## CCAvg	-0.10824562	1.006053439	0.143798447	-0.078782727
## Education1	-0.10570751	0.143798447	0.997299429	-0.514461096
## Education2	0.14735633	-0.078782727	-0.514461096	0.979458824
## Education3	-0.03048693	-0.078534451	-0.576159121	-0.407084716
## Mortgage	-0.01098045	0.122849332	0.035517010	-0.066948308
## Securities.Account	0.01448616	0.035852491	-0.005492059	-0.007211108
## CD.Account	0.02558667	0.130553167	-0.006307495	-0.030045444
## Online	0.01303622	-0.020178598	-0.023010842	0.038851554
## CreditCard	0.05892716	-0.018939831	0.002459329	-0.008484843
	Education3	Mortgage	Securities.Account	CD.Account
## Personal.Loan	0.101824273	0.188432781	0.0002453135	0.267338039
## Age	0.078583805	-0.006476600	-0.0157951568	0.008657233
## Experience	0.058726012	-0.005513505	-0.0190993344	0.010392644
## Income	-0.108089239	0.235021855	-0.0343208962	0.137092495
## Family	-0.030486929	-0.010980453	0.0144861591	0.025586673
## CCAvg	-0.078534451	0.122849332	0.0358524914	0.130553167
## Education1	-0.576159121	0.035517010	-0.0054920586	-0.006307495
## Education2	-0.407084716	-0.066948308	-0.0072111081	-0.030045444
## Education3	1.027517723	0.027442322	0.0130796085	0.036487407
## Mortgage	0.027442322	1.103049365	-0.0050065488	0.107889682
## Securities.Account	0.013079609	-0.005006549	0.9891579289	0.363135926
## CD.Account	0.036487407	0.107889682	0.3631359263	1.093139341
## Online	-0.013318229	-0.062805436	0.0525985088	0.200232474
## CreditCard	0.005696622	-0.026417305	0.0169904348	0.289909068
	Online	CreditCard		
## Personal.Loan	0.009942625	-0.021165514		
## Age	-0.011606783	0.014862622		
## Experience	-0.013009669	0.015667732		
## Income	0.007398131	-0.037290749		
## Family	0.013036220	0.058927161		

```

## CCAvg          -0.020178598 -0.018939831
## Education1    -0.023010842  0.002459329
## Education2     0.038851554 -0.008484843
## Education3    -0.013318229  0.005696622
## Mortgage       -0.062805436 -0.026417305
## Securities.Account  0.052598509  0.016990435
## CD.Account      0.200232474  0.289909068
## Online          1.010977649  0.009647790
## CreditCard      0.009647790  1.008697186

```

11. Combining Train2 and Validation2 datasets to renormalize

Re-normalizing the combined data

```

ForTest_norm2 <- rbind.data.frame(Train_norm2, Validation_norm2, deparse.level = 1, make.row.names = T,
norm_values3 <- preProcess(ForTest_norm2, method = c("center", "scale"))
Test_norm2 <- predict(norm_values3, ForTest_norm2)

head(Test_norm2)

##   Personal.Loan      Age Experience      Income   Family   CCAvg
## 1    -0.3201721 -1.78103674 -1.6746848 -0.53706088  1.4030355 -0.1913336
## 2    -0.3201721 -0.03215752 -0.1001986 -0.86404190  0.5337446 -0.2486542
## 5    -0.3201721 -0.90659713 -1.0623846 -0.62425581  1.4030355 -0.5352576
## 7    -0.3201721  0.66739417  0.5995731 -0.03568998 -0.3355463 -0.2486542
## 11   -0.3201721  1.71672171  1.6492306  0.68366827  1.4030355  0.2672319
## 13   -0.3201721  0.23017437  0.2496873  0.87985688 -0.3355463  1.0697213
##   Education1 Education2 Education3 Mortgage Securities.Account CD.Account
## 1     1.1630146 -0.6181217 -0.6522349 -0.5549367           2.9114521 -0.2520536
## 2     1.1630146 -0.6181217 -0.6522349 -0.5549367           2.9114521 -0.2520536
## 5    -0.8596195  1.6173999 -0.6522349 -0.5549367          -0.3433854 -0.2520536
## 7    -0.8596195  1.6173999 -0.6522349 -0.5549367          -0.3433854 -0.2520536
## 11   -0.8596195 -0.6181217  1.5328067 -0.5549367          -0.3433854 -0.2520536
## 13   -0.8596195 -0.6181217  1.5328067 -0.5549367           2.9114521 -0.2520536
##   Online CreditCard
## 1    -1.2125565 -0.6534032
## 2    -1.2125565 -0.6534032
## 5    -1.2125565  1.5300661
## 7     0.8244977 -0.6534032
## 11   -1.2125565 -0.6534032
## 13   -1.2125565 -0.6534032

var(Test_norm2)

##   Personal.Loan      Age Experience      Income
## Personal.Loan  1.000000000 -0.011728834 -0.011756844  0.4964071722
## Age          -0.011728834  1.000000000  0.994222365 -0.0532232125
## Experience   -0.011756844  0.994222365  1.000000000 -0.0455544621
## Income        0.496407172 -0.053223212 -0.045554462  1.0000000000

```

```

## Family          0.061671383 -0.063997298 -0.070156107 -0.1525902184
## CCAvg          0.364727538 -0.053174403 -0.051771655  0.6401950805
## Education1    -0.149923480 -0.032338292 -0.007669307  0.2183448689
## Education2    0.083028718 -0.015287234 -0.016621659 -0.1247693027
## Education3    0.080807736  0.049876931  0.024531442 -0.1139249768
## Mortgage       0.144149945 -0.007991582 -0.005759501  0.2013840413
## Securities.Account 0.013321026 -0.001365822 -0.002093179 -0.0002292213
## CD.Account     0.304234410 -0.012350625 -0.009483211  0.1769401938
## Online          0.013270140  0.005674230  0.005639355  0.0169526801
## CreditCard     0.005035806  0.010064745  0.011263492  0.0001453466
##               Family      CCAvg   Education1   Education2
## Personal.Loan  0.061671383  0.364727538 -0.149923480  0.083028718
## Age            -0.063997298 -0.053174403 -0.032338292 -0.015287234
## Experience    -0.070156107 -0.051771655 -0.007669307 -0.016621659
## Income          -0.152590218  0.640195080  0.218344869 -0.124769303
## Family          1.000000000 -0.108267865 -0.108247803  0.126874064
## CCAvg          -0.108267865  1.000000000  0.152415975 -0.084327778
## Education1    -0.108247803  0.152415975  1.000000000 -0.531482345
## Education2    0.126874064 -0.084327778 -0.531482345  1.000000000
## Education3    -0.007069571 -0.082230640 -0.560814034 -0.403261378
## Mortgage       -0.020130712  0.099112783  0.027815575 -0.031574008
## Securities.Account 0.018472115  0.012241324  0.004362557  0.016952465
## CD.Account     -0.001149917  0.136432425 -0.016162317  0.006877721
## Online          -0.006671358 -0.007400654 -0.014347086  0.031490543
## CreditCard     0.007099607 -0.006053718  0.002512432 -0.004846405
##               Education3   Mortgage  Securities.Account  CD.Account
## Personal.Loan  0.0808077360  0.1441499446  0.0133210257  0.304234410
## Age            0.0498769309 -0.0079915820  -0.0013658217 -0.012350625
## Experience    0.0245314415 -0.0057595014  -0.0020931789 -0.009483211
## Income          -0.1139249768  0.2013840413  -0.0002292213  0.176940194
## Family          -0.0070695714 -0.0201307121  0.0184721153 -0.001149917
## CCAvg          -0.0822306397  0.0991127826  0.0122413238  0.136432425
## Education1    -0.5608140336  0.0278155745  0.0043625568 -0.016162317
## Education2    -0.4032613783 -0.0315740084  0.0169524654  0.006877721
## Education3    1.0000000000  0.0008120123  -0.0212825122  0.010737656
## Mortgage       0.0008120123  1.0000000000  -0.0090689856  0.091665279
## Securities.Account -0.0212825122 -0.0090689856  1.0000000000  0.301408689
## CD.Account     0.0107376558  0.0916652791  0.3014086888  1.000000000
## Online          -0.0152803732 -0.0203103990  0.0112817558  0.175636853
## CreditCard     0.0020228010 -0.0031070805  -0.0218296666  0.277500011
##               Online   CreditCard
## Personal.Loan  0.013270140  0.0050358058
## Age            0.005674230  0.0100647454
## Experience    0.005639355  0.0112634917
## Income          0.016952680  0.0001453466
## Family          -0.006671358  0.0070996073
## CCAvg          -0.007400654 -0.0060537178
## Education1    -0.014347086  0.0025124324
## Education2    0.031490543 -0.0048464054
## Education3    -0.015280373  0.0020228010
## Mortgage       -0.020310399 -0.0031070805
## Securities.Account 0.011281756 -0.0218296666
## CD.Account     0.175636853  0.2775000115
## Online          1.0000000000  0.0061014669

```

```
## CreditCard          0.006101467  1.00000000000
```

12. Applying KNN Method with the best K

```
Q5_KNN <- knn(Train_norm2, Validation_norm2, cl = Train2[,1], k=3, prob = TRUE)
head(Q5_KNN)
```

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

row.names(Train_norm2)[attr(Q5_KNN, "Q5_KNN.index")]

## character(0)
```

13. Creating Confusion Matrix 2

```
Train_Predictors <- Train_norm2
Test_Predictors <- Validation_norm2

Train_labels2 <- Train_norm2[,1]
Test_labels2 <- Validation_norm2[,1]

Predicted_Test_labels2 <- knn(Train_Predictors, Test_Predictors, cl=Train_labels2, k=1, prob = TRUE)
library(gmodels)
CrossTable(x=Test_labels2, y=Predicted_Test_labels2, prop.chisq = FALSE)
```

```
##
##      Cell Contents
## |-----|
## |           N |
## |           N / Row Total |
## |           N / Col Total |
## |           N / Table Total |
## |-----|
## 
## 
## Total Observations in Table:  1500
## 
## 
##             | Predicted_Test_labels2
## Test_labels2 | -0.317484332194368 | 3.14850182713279 |       Row Total |
## -----|-----|-----|-----|
## -0.317484332194368 |           1357 |            0 |        1357 |
## |           1.000 |            0.000 |        0.905 |
## |           1.000 |            0.000 |        0.905 |
## |           0.905 |            0.000 |        0.905 |
## -----|-----|-----|-----|
```

```

##      3.14850182713279 |          0 |        143 |        143 |
##                      | 0.000 | 1.000 | 0.095 |
##                      | 0.000 | 1.000 | |
##                      | 0.000 | 0.095 | |
## -----
##      Column Total | 1357 | 143 | 1500 |
##                      | 0.905 | 0.095 | |
## -----
##
```

```

class_prob<-attr(Predicted_Test_labels, 'prob')
head(class_prob)

## [1] 1 1 1 1 1 1

```

14. Creating Confusion Matrix 3

```

Train_Predictors <- ForTest_norm2
Test_Predictors <- Test_norm2

Train_labels3 <-ForTest_norm2[,1]
Test_labels3 <-Test_norm2[,1]

Predicted_Test_labels3 <- knn(Train_Predictors, Test_Predictors, cl=Train_labels3, k=1, prob = TRUE)
library(gmodels)
CrossTable(x=Test_labels3, y=Predicted_Test_labels3, prop.chisq = FALSE)

##
```

```

##      Cell Contents
##      |-----|
##      |           N |
##      |           N / Row Total |
##      |           N / Col Total |
##      |           N / Table Total |
##      |-----|
##
```

```

##      Total Observations in Table:  4000
##
```

```

##      | Predicted_Test_labels3
##      Test_labels3 | -0.317484332194368 | 3.14850182713279 | Row Total |
##      |-----|-----|-----|
##      -0.320172138788574 | 3628 | 0 | 3628 |
##      | 1.000 | 0.000 | 0.907 |
##      | 1.000 | 0.000 | |
##      | 0.907 | 0.000 | |
##      |-----|-----|-----|
##      3.12253903098104 | 0 | 372 | 372 |

```

```
##          |      0.000 |      1.000 |      0.093 |
##          |      0.000 |      1.000 |      |
##          |      0.000 |      0.093 |      |
## -----|-----|-----|-----|-----|
##    Column Total |      3628 |      372 |      4000 |
##          |      0.907 |      0.093 |      |
## -----|-----|-----|-----|
##  
  
class_prob<-attr(Predicted_Test_labels3, 'prob')  
head(class_prob)  
  
## [1] 1 1 1 1 1 1
```