Assignment 2- Sai Gautham

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```
#Question 1
#Installing all the packages required and importing the data by using the
#read.csv function
library('caret')
```

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

```
## Warning in register(): Can't find generic 'scale_type' in package ggplot2 to
## register S3 method.
```

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

```
library('ISLR')
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('class')

Bank <- read.csv("C:/Users/gauth/Downloads/UniversalBank.csv", sep = ',' )


#Keeping ID and ZIp as NULL as they are not required for the data.
Bank$ID <- NULL
Bank$ZIP.Code <- NULL
summary(Bank)
```

```
##       Age           Experience       Income           Family
##  Min.   :23.00   Min.   :-3.0   Min.   :  8.00   Min.   :1.000
```

```
##  1st Qu.:35.00   1st Qu.:10.0   1st Qu.: 39.00   1st Qu.:1.000
##  Median :45.00   Median :20.0   Median : 64.00   Median :2.000
##  Mean   :45.34   Mean   :20.1   Mean   : 73.77   Mean   :2.396
##  3rd Qu.:55.00   3rd Qu.:30.0   3rd Qu.: 98.00   3rd Qu.:3.000
##  Max.   :67.00   Max.   :43.0   Max.   :224.00   Max.   :4.000
##      CCAvg          Education        Mortgage     Personal.Loan
##  Min.   : 0.000   Min.   :1.000   Min.   :  0.0   Min.   :0.000
##  1st Qu.: 0.700   1st Qu.:1.000   1st Qu.:  0.0   1st Qu.:0.000
##  Median : 1.500   Median :2.000   Median :  0.0   Median :0.000
##  Mean   : 1.938   Mean   :1.881   Mean   : 56.5   Mean   :0.096
##  3rd Qu.: 2.500   3rd Qu.:3.000   3rd Qu.:101.0   3rd Qu.:0.000
##  Max.   :10.000   Max.   :3.000   Max.   :635.0   Max.   :1.000
##  Securities.Account   CD.Account         Online         CreditCard
##  Min.   :0.0000     Min.   :0.0000   Min.   :0.0000   Min.   :0.000
##  1st Qu.:0.0000     1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.000
##  Median :0.0000     Median :0.0000   Median :1.0000   Median :0.000
##  Mean   :0.1044     Mean   :0.0604   Mean   :0.5968   Mean   :0.294
##  3rd Qu.:0.0000     3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:1.000
##  Max.   :1.0000     Max.   :1.0000   Max.   :1.0000   Max.   :1.000
```

```
#Converting the Personal loan which is a categorical variable to a factor,
#which classify a yes or no response.
Bank$Personal.Loan =  as.factor(Bank$Personal.Loan)

#Normalizing the data by making a normalization model first and then using
#the min max method.

Model_normalized <- preProcess(Bank[, -8],method = c("center", "scale"))
Bank_normalized <- predict(Model_normalized,Bank)
summary(Bank_normalized)
```

```
##       Age              Experience            Income            Family
##  Min.   :-1.94871   Min.   :-2.014710   Min.   :-1.4288   Min.   :-1.2167
##  1st Qu.:-0.90188   1st Qu.:-0.881116   1st Qu.:-0.7554   1st Qu.:-1.2167
##  Median :-0.02952   Median :-0.009121   Median :-0.2123   Median :-0.3454
##  Mean   : 0.00000   Mean   : 0.000000   Mean   : 0.0000   Mean   : 0.0000
##  3rd Qu.: 0.84284   3rd Qu.: 0.862874   3rd Qu.: 0.5263   3rd Qu.: 0.5259
##  Max.   : 1.88967   Max.   : 1.996468   Max.   : 3.2634   Max.   : 1.3973
##      CCAvg            Education          Mortgage       Personal.Loan
##  Min.   :-1.1089   Min.   :-1.0490   Min.   :-0.5555   0:4520
##  1st Qu.:-0.7083   1st Qu.:-1.0490   1st Qu.:-0.5555   1: 480
##  Median :-0.2506   Median : 0.1417   Median :-0.5555
##  Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000
##  3rd Qu.: 0.3216   3rd Qu.: 1.3324   3rd Qu.: 0.4375
##  Max.   : 4.6131   Max.   : 1.3324   Max.   : 5.6875
##  Securities.Account   CD.Account          Online          CreditCard
##  Min.   :-0.3414    Min.   :-0.2535   Min.   :-1.2165   Min.   :-0.6452
##  1st Qu.:-0.3414    1st Qu.:-0.2535   1st Qu.:-1.2165   1st Qu.:-0.6452
##  Median :-0.3414    Median :-0.2535   Median : 0.8219   Median :-0.6452
##  Mean   : 0.0000    Mean   : 0.0000   Mean   : 0.0000   Mean   : 0.0000
##  3rd Qu.:-0.3414    3rd Qu.:-0.2535   3rd Qu.: 0.8219   3rd Qu.: 1.5495
##  Max.   : 2.9286    Max.   : 3.9438   Max.   : 0.8219   Max.   : 1.5495
```

```r
#Partition data into testing and training sets
Train_index <- createDataPartition(Bank$Personal.Loan, p = 0.6, list = FALSE)
train.df = Bank_normalized[Train_index,]
validation.df = Bank_normalized[-Train_index,]

#Prediction
To_Predict = data.frame(Age = 40, Experience = 10, Income = 84, Family = 2,
                        CCAvg = 2, Education = 1, Mortgage = 0, Securities.Account =
                          0, CD.Account = 0, Online = 1, CreditCard = 1)
print(To_Predict)
```

```
##   Age Experience Income Family CCAvg Education Mortgage Securities.Account
## 1  40         10     84      2     2         1        0                   0
##   CD.Account Online CreditCard
## 1          0      1          1
```

```r
To_Predict_Normalized <- predict(Model_normalized,To_Predict)

Prediction <- knn(train= train.df[,1:7,9:12],
                  test = To_Predict_Normalized[,1:7,9:12],
                  cl= train.df$Personal.Loan,
                  k=1)
print(Prediction)
```

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

```r
#Question 2
#Finding the best value of K which balances between overfitting and underfitting.
set.seed(123)
Bankcontrol <- trainControl(method= "repeatedcv", number = 3, repeats = 2)
searchGrid = expand.grid(k=1:10)

knn.model = train(Personal.Loan~., data = train.df, method = 'knn', tuneGrid = searchGrid,trControl = Ba

knn.model
```

```
## k-Nearest Neighbors
##
## 3000 samples
##   11 predictor
##    2 classes: '0', '1'
##
## No pre-processing
## Resampling: Cross-Validated (3 fold, repeated 2 times)
## Summary of sample sizes: 2000, 2000, 2000, 2000, 2000, 2000, ...
## Resampling results across tuning parameters:
##
##   k   Accuracy   Kappa
##    1  0.9495000  0.6769037
##    2  0.9438333  0.6382284
##    3  0.9531667  0.6764764
```

```
##    4  0.9498333  0.6507156
##    5  0.9503333  0.6445841
##    6  0.9503333  0.6460186
##    7  0.9475000  0.6163708
##    8  0.9473333  0.6175083
##    9  0.9455000  0.5978015
##   10  0.9430000  0.5724066
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was k = 3.
```

```
#The best value of k is 3 which balances between the data overfitting and underfitting.


#Question 3
#The confusion matrix is shown below.
predictions <- predict(knn.model,validation.df)

confusionMatrix(predictions,validation.df$Personal.Loan)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    0    1
##          0 1793   66
##          1   15  126
##
##                Accuracy : 0.9595
##                  95% CI : (0.9499, 0.9677)
##     No Information Rate : 0.904
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.7352
##
##  Mcnemar's Test P-Value : 2.767e-08
##
##             Sensitivity : 0.9917
##             Specificity : 0.6562
##          Pos Pred Value : 0.9645
##          Neg Pred Value : 0.8936
##              Prevalence : 0.9040
##          Detection Rate : 0.8965
##    Detection Prevalence : 0.9295
##       Balanced Accuracy : 0.8240
##
##        'Positive' Class : 0
##
```

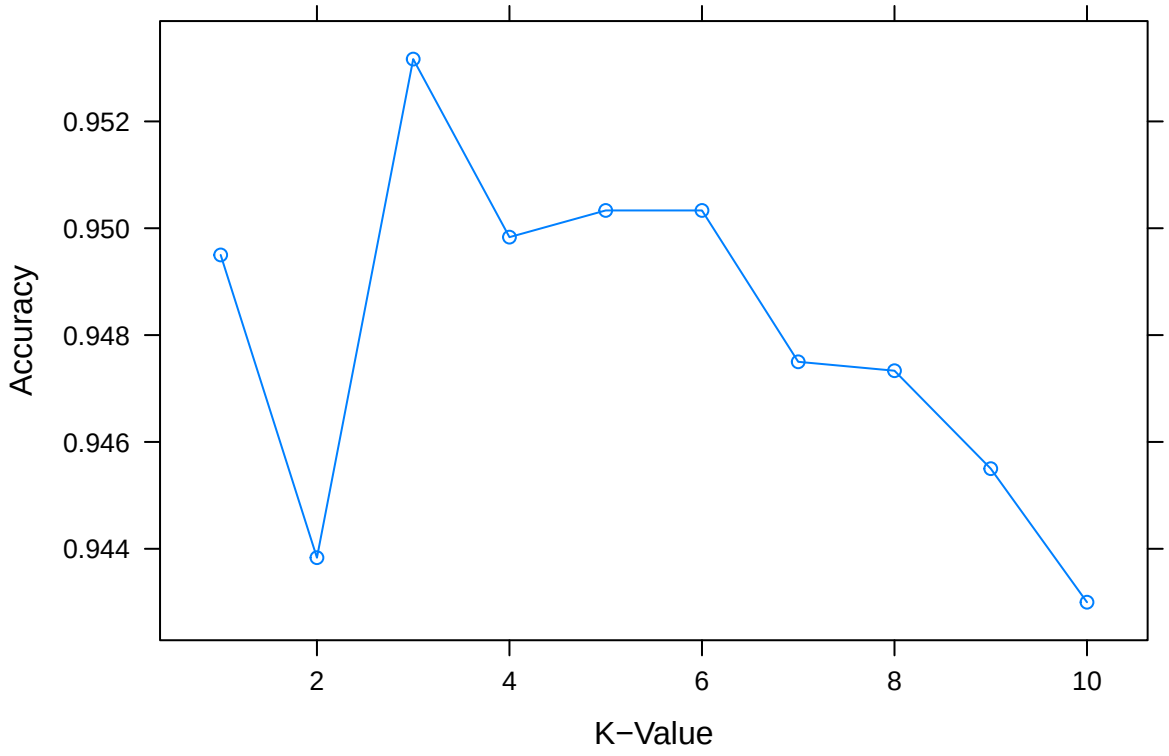
```
#The matrix has a 95.1% accuracy.

#Question 4
#Classyifing the customer using the best K.
To_Predict_Normalized = data.frame(Age = 40, Experience = 10, Income = 84, Family = 2,
```

```
                                    CCAvg = 2, Education = 1, Mortgage = 0,
                                    Securities.Account =0, CD.Account = 0, Online = 1,
                                    CreditCard = 1)
To_Predict_Normalized = predict(Model_normalized, To_Predict)
predict(knn.model, To_Predict_Normalized)
```

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

```
#There is also a plot which clearly shoes the best value of K (3), which has the highest accuracy.
plot(knn.model, type = "b", xlab = "K-Value", ylab = "Accuracy")
```




```
#Question 5
#Dividing the data set into training, testing and validation sets.
train_size = 0.5
Train_index = createDataPartition(Bank$Personal.Loan, p = 0.5, list = FALSE)
train.df = Bank_normalized[Train_index,]


test_size = 0.2
Test_index = createDataPartition(Bank$Personal.Loan, p = 0.2, list = FALSE)
Test.df = Bank_normalized[Test_index,]
```

```
valid_size = 0.3
Validation_index = createDataPartition(Bank$Personal.Loan, p = 0.3, list = FALSE)
validation.df = Bank_normalized[Validation_index,]



Testknn <- knn(train = train.df[,-8], test = Test.df[,-8], cl = train.df[,8], k =3)
Validationknn <- knn(train = train.df[,-8], test = validation.df[,-8], cl = train.df[,8], k =3)
Trainknn <- knn(train = train.df[,-8], test = train.df[,-8], cl = train.df[,8], k =3)

confusionMatrix(Testknn, Test.df[,8])
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 900  28
##          1   4  68
##
##                Accuracy : 0.968
##                  95% CI : (0.9551, 0.978)
##     No Information Rate : 0.904
##     P-Value [Acc > NIR] : 3.349e-15
##
##                   Kappa : 0.7924
##
##  Mcnemar's Test P-Value : 4.785e-05
##
##             Sensitivity : 0.9956
##             Specificity : 0.7083
##          Pos Pred Value : 0.9698
##          Neg Pred Value : 0.9444
##              Prevalence : 0.9040
##          Detection Rate : 0.9000
##    Detection Prevalence : 0.9280
##       Balanced Accuracy : 0.8520
##
##        'Positive' Class : 0
##
```

```
confusionMatrix(Trainknn, train.df[,8])
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    0    1
##          0 2255   58
##          1    5  182
##
##                Accuracy : 0.9748
##                  95% CI : (0.9679, 0.9806)
##     No Information Rate : 0.904
##     P-Value [Acc > NIR] : < 2.2e-16
```

```
##
##                  Kappa : 0.8389
##
##  Mcnemar's Test P-Value : 5.701e-11
##
##             Sensitivity : 0.9978
##             Specificity : 0.7583
##          Pos Pred Value : 0.9749
##          Neg Pred Value : 0.9733
##              Prevalence : 0.9040
##          Detection Rate : 0.9020
##    Detection Prevalence : 0.9252
##       Balanced Accuracy : 0.8781
##
##        'Positive' Class : 0
##
```

```
confusionMatrix(Validationknn, validation.df[,8])
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    0    1
##          0 1349   30
##          1    7  114
##
##                Accuracy : 0.9753
##                  95% CI : (0.9662, 0.9826)
##     No Information Rate : 0.904
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.847
##
##  Mcnemar's Test P-Value : 0.0002983
##
##             Sensitivity : 0.9948
##             Specificity : 0.7917
##          Pos Pred Value : 0.9782
##          Neg Pred Value : 0.9421
##              Prevalence : 0.9040
##          Detection Rate : 0.8993
##    Detection Prevalence : 0.9193
##       Balanced Accuracy : 0.8933
##
##        'Positive' Class : 0
##
```

```
# From the above matrices, we determined the values of Test, Training and
# Validation sets which are 96.3%,97.32% and 96.73% respectively.
# It can be said that if the Training data has a higher accuracy than the other
#sets , it would be called overfitting. Since, there is not much difference
#between the Training, Test and validation set's accuracies, we can conclude
#that we have determined the best value of k
```