Machine Learning Assignment - Sardindu Meghana karlapalem

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```r
install.packages("psych", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("caret", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("FNN", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("class", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("dplyr", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("rlang",repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

```r
install.packages("ggplot2",repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/s0/bmcnbw5s19v51v5f0f1lcj_m0000gn/T//RtmpUfl6ul/downloaded_packages
```

###Project Background:

Liability customers - Majority - Depositors Asset customers - Small - Borrowers *Campaign of last year - conversion rate of 9.6% [Among the 5000 customers, only 480 (= 9.6%) accepted the personal loan that was offered to them in the earlier campaign.]* Goal : use k-NN to predict whether a new customer will accept a loan offer. * Data (rows): 5000 customers *Success class as 1 (loan acceptance)

####Packages used:

```
library(psych)  #for creating dummies
```

```
## Warning: package 'psych' was built under R version 4.1.2
```

```
library(caret)  #for data partition, normalize data
```

```
## Warning: package 'caret' was built under R version 4.1.2

## Loading required package: ggplot2

## Warning: package 'ggplot2' was built under R version 4.1.2

##
## Attaching package: 'ggplot2'

## The following objects are masked from 'package:psych':
##
##     %+%, alpha

## Loading required package: lattice
```

```
library(FNN)    #for Perfoming knn classification
```

```
## Warning: package 'FNN' was built under R version 4.1.2
```

```
library(class)
```

```
## Warning: package 'class' was built under R version 4.1.2

##
## Attaching package: 'class'

## The following objects are masked from 'package:FNN':
##
##     knn, knn.cv
```

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 4.1.2

##
## 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(rlang)
```

```
## Warning: package 'rlang' was built under R version 4.1.2
```

```
library(ggplot2)
```

###importing data

```
Data1 <- read.csv("~/Downloads/UniversalBank (1).csv", stringsAsFactors=TRUE)
```

```
#Eliminating variables [id & zip code] from the dataset
df=subset(Data1, select=-c(ID, ZIP.Code ))
```

```
#creating dummies
dummy_Education<- as.data.frame(dummy.code(df$Education))
names(dummy_Education) <- c("Education_1", "Education_2","Education_3") #renaming dummy variable
df_without_education <- subset(df, select=-c(Education))                #eliminating education variable

Data1 <- cbind(df_without_education, dummy_Education)              #main dataset
```

###Data partition

```
#Partitioning the data into Traning(60%) and Validation(40%)
set.seed(1234)
Train_Index     = createDataPartition(Data1$Age, p= 0.6 , list=FALSE)
Train_Data      = Data1[Train_Index,]  #3001 observations

Validation_Data = Data1[-Train_Index,] #1999 observations
```

###Generating test data

```
Test_Data <- data.frame(Age=40 , Experience=10, Income = 84, Family = 2, CCAvg = 2, Education_1 = 0, Edu
```

###Data Normalization

```
train.norm.df    <- Train_Data
valid.norm.df    <- Validation_Data
test.norm.df     <- Test_Data
maindata.norm.df <-Data1

head(maindata.norm.df)
```

```
##   Age Experience Income Family CCAvg Mortgage Personal.Loan Securities.Account
## 1  25          1     49      4   1.6        0             0                  1
## 2  45         19     34      3   1.5        0             0                  1
## 3  39         15     11      1   1.0        0             0                  0
## 4  35          9    100      1   2.7        0             0                  0
## 5  35          8     45      4   1.0        0             0                  0
## 6  37         13     29      4   0.4      155             0                  0
##   CD.Account Online CreditCard Education_1 Education_2 Education_3
## 1          0      0          0           1           0           0
## 2          0      0          0           1           0           0
## 3          0      0          0           1           0           0
## 4          0      0          0           0           0           1
## 5          0      0          1           0           0           1
## 6          0      1          0           0           0           1
```

```
# use preProcess() from the caret package to normalize .
norm.values <- preProcess(Train_Data[,-7], method=c("center", "scale"))

train.norm.df[,-7] <- predict(norm.values, Train_Data[,-7])  #Training Data
valid.norm.df [,-7]<- predict(norm.values, Validation_Data[,-7])#Validation Data
test.norm.df <- predict(norm.values, Test_Data)#Test Data
maindata.norm.df[,-7] <- predict(norm.values,Data1[,-7]) #Training + Validation data

head(maindata.norm.df)
```

```
##           Age Experience     Income     Family      CCAvg   Mortgage
## 1 -1.77136698 -1.6613124 -0.5177762  1.3933091 -0.1845814 -0.5438042
## 2 -0.03145296 -0.0978843 -0.8425723  0.5187388 -0.2419870 -0.5438042
## 3 -0.55342717 -0.4453128 -1.3405930 -1.2304018 -0.5290146 -0.5438042
## 4 -0.90140997 -0.9664555  0.5865306 -1.2304018  0.4468794 -0.5438042
## 5 -0.90140997 -1.0533126 -0.6043885  1.3933091 -0.5290146 -0.5438042
## 6 -0.72741857 -0.6190270 -0.9508377  1.3933091 -0.8734478  1.0035659
##   Personal.Loan Securities.Account CD.Account     Online CreditCard Education_1
## 1             0          2.9564494 -0.2533042 -1.2038741 -0.6538696   1.1696714
## 2             0          2.9564494 -0.2533042 -1.2038741 -0.6538696   1.1696714
## 3             0         -0.3381309 -0.2533042 -1.2038741 -0.6538696   1.1696714
## 4             0         -0.3381309 -0.2533042 -1.2038741 -0.6538696  -0.8546561
## 5             0         -0.3381309 -0.2533042 -1.2038741  1.5288474  -0.8546561
## 6             0         -0.3381309 -0.2533042  0.8303749 -0.6538696  -0.8546561
##   Education_2 Education_3
## 1  -0.6414311  -0.6331615
## 2  -0.6414311  -0.6331615
## 3  -0.6414311  -0.6331615
## 4  -0.6414311   1.5788497
## 5  -0.6414311   1.5788497
## 6  -0.6414311   1.5788497
```

###Perfoming k-NN classification , using k = 1

```r
set.seed(2000)
prediction <- knn(train = train.norm.df[,-7], test = valid.norm.df[,-7],
          cl = train.norm.df[,7], k = 1, prob=TRUE)
actual= valid.norm.df$Personal.Loan
prediction_prob = attr(prediction,"prob")
table(prediction,actual)
```

```
##             actual
## prediction    0    1
##          0 1770   68
##          1   25  136
```

```r
mean(prediction==actual)
```

```
## [1] 0.9534767
```

```r
NROW(train.norm.df)
```

```
## [1] 3001
```

```r
sqrt(3001)
```

```
## [1] 54.78138
```

```r
accuracy.df <- data.frame(k = seq(1, 60, 1), accuracy = rep(0, 60))

# compute knn for different k on validation.
for(i in 1:60) {
prediction <- knn(train = train.norm.df[,-7], test = valid.norm.df[-7],
          cl = train.norm.df[,7], k = i, prob=TRUE)

accuracy.df[i,2] <- mean(prediction==actual)
}
accuracy.df
```

```
##     k  accuracy
## 1   1 0.9534767
## 2   2 0.9484742
## 3   3 0.9544772
## 4   4 0.9529765
## 5   5 0.9524762
## 6   6 0.9479740
## 7   7 0.9489745
## 8   8 0.9459730
## 9   9 0.9454727
## 10 10 0.9469735
## 11 11 0.9439720
## 12 12 0.9434717
```

```
## 13 13 0.9424712
## 14 14 0.9409705
## 15 15 0.9409705
## 16 16 0.9404702
## 17 17 0.9399700
## 18 18 0.9399700
## 19 19 0.9404702
## 20 20 0.9379690
## 21 21 0.9379690
## 22 22 0.9354677
## 23 23 0.9364682
## 24 24 0.9344672
## 25 25 0.9349675
## 26 26 0.9329665
## 27 27 0.9354677
## 28 28 0.9344672
## 29 29 0.9339670
## 30 30 0.9314657
## 31 31 0.9314657
## 32 32 0.9314657
## 33 33 0.9319660
## 34 34 0.9304652
## 35 35 0.9304652
## 36 36 0.9299650
## 37 37 0.9284642
## 38 38 0.9284642
## 39 39 0.9284642
## 40 40 0.9274637
## 41 41 0.9269635
## 42 42 0.9254627
## 43 43 0.9254627
## 44 44 0.9249625
## 45 45 0.9249625
## 46 46 0.9239620
## 47 47 0.9244622
## 48 48 0.9249625
## 49 49 0.9244622
## 50 50 0.9224612
## 51 51 0.9244622
## 52 52 0.9234617
## 53 53 0.9234617
## 54 54 0.9239620
## 55 55 0.9224612
## 56 56 0.9219610
## 57 57 0.9229615
## 58 58 0.9224612
## 59 59 0.9214607
## 60 60 0.9214607
```

The value of k we choose is 1 as it is given in the question [i.e the choice of k that balances between overfitting and ignoring the predictor information]

####Validation data results using best k value [i.e: k = 1]

```
set.seed(1234)
prediction <- knn(train = train.norm.df[,-7], test = valid.norm.df[,-7],
          cl = train.norm.df[,7], k = 1, prob=TRUE)
actual= valid.norm.df$Personal.Loan
prediction_prob = attr(prediction,"prob")



#Answer 3: confusion matrix for the best k value =1
table(prediction,actual)
```

```
##           actual
## prediction    0    1
##          0 1770   68
##          1   25  136
```

```
#accuracy of the best k=1
mean(prediction==actual)
```

```
## [1] 0.9534767
```

```


prediction_test <- knn(train = maindata.norm.df[,-7], test = Test_Data,
          cl = maindata.norm.df[,7], k = 1, prob=TRUE)
head(prediction_test)
```

Classifying the customer using the best k [perfominng k-NN classification on test data]

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

k-NN model predicted that the new customer will accept a loan offer [loan accepted]

5)Repartition the data, this time into training, validation, and test sets (50% : 30% : 20%). Apply the k-NN method with the k chosen above. Compare the confusion matrix of the test set with that of the training and validation sets.

```
#Partitioning the data into Traning(50%) ,Validation(30%), Test(20%)
set.seed(1234)

Test_Index_1 = createDataPartition(Data1$Age, p= 0.2 , list=FALSE) #20% test data
Test_Data_1  = Data1 [Test_Index_1,]

Rem_DATA = Data1[-Test_Index_1,] #80% remaining data [training + validation]

Train_Index_1 = createDataPartition(Rem_DATA$Age, p= 0.5 , list=FALSE)
Train_Data_1 = Rem_DATA[Train_Index_1,] #Training data

Validation_Data_1 = Rem_DATA[-Train_Index_1,] #Validation data
```

```r
#Data Normalization


# Copy the original data
train.norm.df_1 <- Train_Data_1
valid.norm.df_1 <- Validation_Data_1
test.norm.df_1 <- Test_Data_1
rem_data.norm.df_1 <- Rem_DATA

# use preProcess() from the caret package to normalize Sales and Age.
norm.values_1 <- preProcess(Train_Data_1[-7], method=c("center", "scale"))

train.norm.df_1[-7] <- predict(norm.values_1, Train_Data_1[-7])  #Training Data
valid.norm.df_1[-7] <- predict(norm.values_1, Validation_Data_1[-7])#Validation Data
test.norm.df_1[-7] <- predict(norm.values_1, test.norm.df_1[-7]) #Test Data
test.norm.df_1[-7] <- predict(norm.values_1, Test_Data_1[-7])
rem_data.norm.df_1[-7] <- predict(norm.values_1,Rem_DATA[-7]) #Training + Validation data

head(test.norm.df_1)
```

```
##            Age   Experience     Income     Family        CCAvg   Mortgage
## 9  -0.90840439 -0.883582836  0.1435652  0.5333142 -0.780693325  0.4495336
## 28  0.05751618 -0.008054857  1.8189997 -1.2081200  0.234699617 -0.5532869
## 32 -0.46934959 -0.358266049 -0.9878972 -1.2081200  0.009056741 -0.5532869
## 40 -0.64497151 -0.620924443  0.1218063  1.4040313 -0.724282606  2.1948269
## 42 -0.99621536 -0.971135634 -0.3133715  0.5333142  0.178288898 -0.5532869
## 63 -0.29372767 -0.183160453 -1.1402094 -1.2081200 -0.555050449 -0.5532869
##    Personal.Loan Securities.Account CD.Account     Online CreditCard
## 9              0         -0.3360202 -0.2646808  0.8429167 -0.6350646
## 28             0         -0.3360202 -0.2646808  0.8429167  1.5738557
## 32             0         -0.3360202 -0.2646808  0.8429167 -0.6350646
## 40             0         -0.3360202 -0.2646808  0.8429167 -0.6350646
## 42             0         -0.3360202 -0.2646808 -1.1857637 -0.6350646
## 63             0         -0.3360202 -0.2646808 -1.1857637 -0.6350646
##    Education_1 Education_2 Education_3
## 9    -0.827392  -0.6607293    1.566207
## 28    1.208013  -0.6607293   -0.638166
## 32   -0.827392  -0.6607293    1.566207
## 40   -0.827392   1.5127224   -0.638166
## 42    1.208013  -0.6607293   -0.638166
## 63    1.208013  -0.6607293   -0.638166
```

```r
#Perfoming k-NN classification on Training Data, k = 1
set.seed(1234)
prediction_Q5 <- knn(train = train.norm.df_1[,-7], test = valid.norm.df_1[,-7],
          cl = train.norm.df_1[,7], k = 1, prob=TRUE)
actual= valid.norm.df_1$Personal.Loan
prediction_prob = attr(prediction_Q5,"prob")

table(prediction_Q5,actual)  #confusion matrix for the best k value =1
```

```
##                actual
## prediction_Q5    0    1
```

```
##             0 1795   69
##             1   16  119
```

```r
mean(prediction_Q5==actual)  #accuracy of the best k=1
```

```
## [1] 0.9574787
```

```r
set.seed(1234)
prediction_Q5 <- knn(train = rem_data.norm.df_1[,-7], test = test.norm.df_1[,-7],
          cl = rem_data.norm.df_1[,7], k = 1, prob=TRUE)
actual= test.norm.df_1$Personal.Loan
prediction_prob = attr(prediction_Q5,"prob")

table(prediction_Q5,actual)  #confusion matrix for the best k value =1
```

```
##              actual
## prediction_Q5   0   1
##             0 907  25
##             1  12  57
```

```r
mean(prediction_Q5==actual)  #accuracy of the best k=1
```

```
## [1] 0.963037
```

The model performed better in the test set, as it got enough data to learn from i.e 80% of the data, Whereas when we were working on training data it only learned from 50% of the data.