```
> library(caret)
> library(ISLR)
> library(FNN)
> library(gmodels)
> library(dummies)
> #UniversalBank<-read.csv("C:/Users/suman/Documents/Machine Learning/class_w
ork_probs/UniversalBank.csv")
> UniversalBank <- read_csv("C:/Users/Ghirghir/Desktop/Mashine Learning/Assig
nment/UniversalBank.csv")
Parsed with column specification:
cols(
  ID = col_double(),
  Age = col_double(),
  Experience = col_double(),
  Income = col_double(),
  ZIPCode = col_double(),
  Family = col_double(),
  CCAvg = col_double(),
  Education = col_double(),
  Mortgage = col_double(),
  PersonalLoan = col_double(),
  SecuritiesAccount = col_double(),
  CDAccount = col_double(),
  Online = col_double(),
  CreditCard = col_double()
)
>
> Elham<-UniversalBank[,c(-1,-5)]
> str(Elham)
Classes ‘tbl_df’, ‘tbl’ and 'data.frame':     5000 obs. of  12 variables:
 $ Age               : num  25 45 39 35 35 37 53 50 35 34 ...
 $ Experience        : num  1 19 15 9 8 13 27 24 10 9 ...
 $ Income            : num  49 34 11 100 45 29 72 22 81 180 ...
 $ Family            : num  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         : num  1 1 1 2 2 2 2 3 2 3 ...
 $ Mortgage          : num  0 0 0 0 0 155 0 0 104 0 ...
 $ PersonalLoan      : num  0 0 0 0 0 0 0 0 0 1 ...
 $ SecuritiesAccount: num  1 1 0 0 0 0 0 0 0 0 ...
 $ CDAccount         : num  0 0 0 0 0 0 0 0 0 0 ...
 $ Online            : num  0 0 0 0 0 1 1 0 1 0 ...
 $ CreditCard        : num  0 0 0 0 1 0 0 1 0 0 ...
```

```
> # Assignment 1
>
> # Dummies
>
> dummy_model <- dummyVars(~Education,data=Elham)
> head(predict(dummy_model,Elham))
  Education
1         1
2         1
3         1
4         2
5         2
6         2
```

```
> # Normalization:
> norm_model<-preProcess(UniversalBank, method = c('range'))
> UniversalBank_normalized<-predict(norm_model,UniversalBank)
> UniversalBank_Predictors<-UniversalBank_normalized[,-10]
> UniversalBank_labels<-UniversalBank_normalized[,10]
>
>
> set.seed(123)
> Train = createDataPartition(UniversalBank_normalized$PersonalLoan,p=0.6, li
st=FALSE)
> Train_Data = UniversalBank_normalized[Train,]
> Val_Data = UniversalBank_normalized[-Train,]
> dim(Train_Data)

[1] 3000   14


> summary(Train_Data)
       ID                Age           Experience         Income          ZIPCo
de            Family
 Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :
0.9239   Min.   :0.0000
 1st Qu.:0.2514   1st Qu.:0.2955   1st Qu.:0.2826   1st Qu.:0.1435   1st Qu.:
0.9461   1st Qu.:0.0000
 Median :0.5020   Median :0.5227   Median :0.5000   Median :0.2593   Median :
0.9646   Median :0.3333
 Mean   :0.5019   Mean   :0.5097   Mean   :0.5045   Mean   :0.3028   Mean   :
0.9603   Mean   :0.4663
 3rd Qu.:0.7542   3rd Qu.:0.7273   3rd Qu.:0.7174   3rd Qu.:0.4028   3rd Qu.:
0.9766   3rd Qu.:1.0000
 Max.   :0.9998   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :
1.0000   Max.   :1.0000
     CCAvg          Education        Mortgage        PersonalLoan     Securi
tiesAccount
 Min.   :0.0000   Min.   :0.0000   Min.   :0.00000   Min.   :0.00000   Min.
:0.000
 1st Qu.:0.0700   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu
.:0.000
 Median :0.1500   Median :0.5000   Median :0.00000   Median :0.00000   Median
:0.000
 Mean   :0.1924   Mean   :0.4335   Mean   :0.08707   Mean   :0.09267   Mean
:0.103
 3rd Qu.:0.2600   3rd Qu.:1.0000   3rd Qu.:0.15433   3rd Qu.:0.00000   3rd Qu
.:0.000
 Max.   :1.0000   Max.   :1.0000   Max.   :1.00000   Max.   :1.00000   Max.
:1.000
   CDAccount         Online         CreditCard
 Min.   :0.000   Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.000   1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.000   Median :1.0000   Median :0.0000
 Mean   :0.059   Mean   :0.5997   Mean   :0.2943
 3rd Qu.:0.000   3rd Qu.:1.0000   3rd Qu.:1.0000
 Max.   :1.000   Max.   :1.0000   Max.   :1.0000


> summary(Val_Data)
       ID                  Age           Experience         Income          ZI
PCode
 Min.   :0.0004001   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.
:0.0000
 1st Qu.:0.2481496   1st Qu.:0.2727   1st Qu.:0.2826   1st Qu.:0.1435   1st Q
u.:0.9457
```

```
 Median :0.4971994   Median :0.5000   Median :0.5000   Median :0.2546   Media
n :0.9595
 Mean   :0.4971293   Mean   :0.5046   Mean   :0.4990   Mean   :0.3071   Mean
:0.9594
 3rd Qu.:0.7441488   3rd Qu.:0.7273   3rd Qu.:0.7174   3rd Qu.:0.4259   3rd Q
u.:0.9766
 Max.   :1.0000000   Max.   :1.0000   Max.   :1.0000   Max.   :0.9074   Max.
:1.0000
     Family           CCAvg          Education        Mortgage         Persona
lLoan   SecuritiesAccount
 Min.   :0.0000   Min.   :0.0000   Min.   :0.000   Min.   :0.00000   Min.   :
0.000   Min.   :0.0000
 1st Qu.:0.0000   1st Qu.:0.0700   1st Qu.:0.000   1st Qu.:0.00000   1st Qu.:
0.000   1st Qu.:0.0000
 Median :0.3333   Median :0.1600   Median :0.500   Median :0.00000   Median :
0.000   Median :0.0000
 Mean   :0.4642   Mean   :0.1959   Mean   :0.451   Mean   :0.09184   Mean   :
0.101   Mean   :0.1065
 3rd Qu.:0.6667   3rd Qu.:0.2500   3rd Qu.:1.000   3rd Qu.:0.16220   3rd Qu.:
0.000   3rd Qu.:0.0000
 Max.   :1.0000   Max.   :1.0000   Max.   :1.000   Max.   :0.94646   Max.   :
1.000   Max.   :1.0000
   CDAccount          Online         CreditCard
 Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
 1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000
 Median :0.0000   Median :1.0000   Median :0.0000
 Mean   :0.0625   Mean   :0.5925   Mean   :0.2935
 3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:1.0000
 Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
```

```
> Train_Predictors<-Train_Data[,-10]
> Val_Predictors<-Val_Data[,-10]
>
> Train_labels <-Train_Data[,10]
> Val_labels  <-Val_Data[,10]
>
> Train_labels=as.factor(Train_labels$PersonalLoan)
> Val_labels=as.factor(Val_labels$PersonalLoan)
> UniversalBank_labels<-as.factor(UniversalBank_labels$PersonalLoan)
```

```
> #Knn method, k=1
```

```
> knn.pred <- knn(Train_Predictors,Val_Predictors,cl=Train_labels,k=1,prob =
TRUE)
```

```
> knn.pred
```

```
 [3,] 0.33851682
    [4,] 0.23566218
    [5,] 0.28679266
    [6,] 0.51364739
    [7,] 0.04840709
    [8,] 0.26539642
    [9,] 0.21782071
   [10,] 0.17068906
   [11,] 0.41029404
```

```
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[30,] 0.17702644
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```

```
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  [999,] 0.24195585
 [1000,] 0.25233951
  [ reached getOption("max.print") -- omitted 1000 rows ]
 Levels: 0 1

 >
> Q1 <- c(40, 10, 84, 2, 2, 0, 1, 0, 0, 0, 0, 1, 1)
> knn.pred1 <- knn(Train_Predictors, Q1, cl=Train_labels, k=1, prob = TRUE)
> knn.pred1

[1] 0
attr(,"prob")
[1] 1
attr(,"nn.index")
     [,1]
[1,] 2679
attr(,"nn.dist")
         [,1]
[1,] 92.24023
Levels: 0



> #Assignment 2
>
> accuracy.df <- data.frame(k = seq(1, 14, 1), accuracy = rep(0, 14))
>
> for(i in 1:14) {
+   knn <- knn(Train_Predictors, Val_Predictors, cl = Train_labels, k = i)
+   accuracy.df[i, 2] <- confusionMatrix(knn, Val_labels)$overall[1]
+ }
> accuracy.df
    k accuracy
1   1   0.9535
2   2   0.9440
3   3   0.9550
```

```
4   4   0.9385
5   5   0.9425
6   6   0.9375
7   7   0.9410
8   8   0.9335
9   9   0.9360
10 10   0.9280
11 11   0.9310
12 12   0.9265
13 13   0.9295
14 14   0.9250
>
> which.max( (accuracy.df$accuracy) )
[1] 3



> # Assignment 3
>
> knn.pred3 <- knn(Train_Predictors,Val_Predictors,cl=Train_labels,k=3,prob =
TRUE)
> confusionMatrix(knn.pred3,Val_labels)


Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 1794   86
         1    4  116

               Accuracy : 0.955
                 95% CI : (0.945, 0.9637)
    No Information Rate : 0.899
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 0.6977

 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.9978
            Specificity : 0.5743
         Pos Pred Value : 0.9543
         Neg Pred Value : 0.9667
             Prevalence : 0.8990
         Detection Rate : 0.8970
   Detection Prevalence : 0.9400
      Balanced Accuracy : 0.7860

       'Positive' Class : 0



> # Assignment 4
>
> knn.pred4 <- knn(Train_Predictors, Q1, cl=Train_labels, k=3, prob = TRUE)
> knn.pred4
[1] 0
attr(,"prob")
[1] 1
attr(,"nn.index")
     [,1] [,2] [,3]
```

```
[1,] 2679 2618 3000
attr(,"nn.dist")
         [,1]     [,2]     [,3]
[1,] 92.24023 92.24131 92.24802
Levels: 0


>
> knn.pred4 <- knn(Val_Predictors, Q1, cl=Val_labels, k=3, prob = TRUE)
> knn.pred4



[1] 0
attr(,"prob")
[1] 1
attr(,"nn.index")
     [,1] [,2] [,3]
[1,] 1973 1908 1905
attr(,"nn.dist")
         [,1]    [,2]     [,3]
[1,] 92.24308 92.2469 92.24862
Levels: 0




> # Assignment 5
>
>
> set.seed(123)
> Elham_Partition = createDataPartition(UniversalBank_normalized$PersonalLoan
,p=0.5, list=FALSE)
> Training_Data = UniversalBank_normalized[Elham_Partition,]  #50% of total d
ata assigned to Test data
> Test_Valid_Data = UniversalBank_normalized[-Elham_Partition,]
>
> Test_Index = createDataPartition(Test_Valid_Data$PersonalLoan, p=0.6, list=
FALSE)
> Validation_Data = Test_Valid_Data[Test_Index,]     # i partioned 60% test_v
alid_data to test and train to achieve 50:30:20 ratio
> Test_Data = Test_Valid_Data[-Test_Index,]
>
>
> Training_Predictors<-Training_Data[,-10]
> Test_Predictors<-Test_Data[,-10]
> Validation_Predictors<-Validation_Data[,-10]
>
>
> Training_labels <-Training_Data[,10]
> Test_labels <-Test_Data[,10]
> Validation_labels <-Validation_Data[,10]

> Training_labels=as.factor(Training_labels$PersonalLoan)
> Test_labels<-as.factor(Test_labels$PersonalLoan)
> Validation_labels=as.factor(Validation_labels$PersonalLoan)
```

```
> knn.pred5 <- knn(Training_Predictors, Test_Predictors , cl=Training_labels,
k=3, prob = TRUE)
> knn.pred5


   [1] 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0
  [50] 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 1 0 0 0 0 0 0
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0 0 0 0 0 1 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [197] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [246] 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 0 1 0 0 0 0 1
 [295] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 0 0 0
 [344] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [393] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [442] 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0
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Confusion Matrix and Statistics

          Reference
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               Accuracy : 0.94
                 95% CI : (0.9234, 0.9539)
    No Information Rate : 0.892
    P-Value [Acc > NIR] : 9.117e-08

                  Kappa : 0.605

 Mcnemar's Test P-Value : 4.577e-11
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            Sensitivity : 0.9955
            Specificity : 0.4815
         Pos Pred Value : 0.9407
         Neg Pred Value : 0.9286
             Prevalence : 0.8920
         Detection Rate : 0.8880
   Detection Prevalence : 0.9440
      Balanced Accuracy : 0.7385

       'Positive' Class : 0
```

```
> knn.pred6 <- knn(Validation_Predictors, Test_Predictors, cl=Validation_labe
ls, k=3, prob = TRUE)
> knn.pred6

   [1] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0
  [50] 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0
  [99] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [148] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [197] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [246] 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 1 0 0 0 0 1
 [295] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [344] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [393] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [442] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 0
 [491] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [540] 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [589] 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [638] 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0
 [687] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [736] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1
 [785] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0
 [834] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [883] 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [932] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 [981] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
attr(,"prob")
```

```
   [1] 1.0000000 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
  [10] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
  [19] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
0.6666667 1.0000000
  [28] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
0.6666667 0.6666667
  [37] 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
  [46] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 0.6666667
0.6666667 1.0000000
  [55] 0.6666667 1.0000000 1.0000000 1.0000000 0.6666667 1.0000000 1.0000000
1.0000000 1.0000000
  [64] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 0.6666667
1.0000000 1.0000000
  [73] 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
  [82] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 0.6666667
  [91] 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 0.6666667
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 0.6666667
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
 [262] 1.0000000 1.0000000 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
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1.0000000 1.0000000
 [280] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 0.6666667
0.6666667 1.0000000
```

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1.0000000 1.0000000
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1.0000000 1.0000000
 [307] 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 0.6666667
1.0000000 0.6666667
 [316] 1.0000000 0.6666667 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
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1.0000000 0.6666667
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1.0000000 1.0000000
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1.0000000 1.0000000
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0.6666667 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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0.6666667 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 0.6666667
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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0.6666667 1.0000000
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1.0000000 1.0000000

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1.0000000 1.0000000
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1.0000000 1.0000000
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0.6666667 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 0.6666667
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1.0000000 1.0000000
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0.6666667 0.6666667
 [829] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
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1.0000000 0.6666667
 [847] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 0.6666667 0.6666667
1.0000000 1.0000000
 [856] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 0.6666667

```
 [865] 0.6666667 1.0000000 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
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1.0000000 1.0000000
 [973] 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
0.6666667 1.0000000
 [982] 1.0000000 1.0000000 0.6666667 1.0000000 0.6666667 1.0000000 1.0000000
1.0000000 1.0000000
 [991] 1.0000000 0.6666667 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
1.0000000 1.0000000
[1000] 0.6666667
attr(,"nn.index")
      [,1] [,2] [,3]
 [1,]   28  298  557
 [2,]  362  228  277
 [3,]  641  321  203
 [4,]  313    3  244
 [5,]   38  245  258
 [6,]   85  129  291
 [7,]  334  132  350
 [8,]  347  587  797
 [9,]  102  117    3
[10,]    3    2  421
[11,]  394  253  255
[12,]   63  337   49
[13,]  548  103  285
[14,]  466   82   37
[15,]  192  237    7
[16,]  206  128  415
[17,]   37  254   82
[18,]  262  502  401
[19,]   61  531   51
[20,]  183   33  293
[21,]  500   38  361
[22,]  192  396    7
[23,]  295  225  192
[24,]  107  191  331
[25,]  243  446  501
[26,]  391  134   83
[27,]  316   64 1297
[28,]  409  371  115
[29,]  349  371  409
[30,]  525  418  270
[31,]   63  441  337
```

```
[32,]  443   21  762
[33,]  206  415   61
[34,]  127  518  225
[35,]  721  134  416
[36,]  165  372  114
[37,]  126   21  286
[38,]  292  329  317
[39,]   62  446  239
[40,]  385   54  336
[41,]  115  280  306
[42,]   83  599  233
[43,]  459  243  496
[44,]   75  289  466
[45,]   24  182   39
[46,]  247   41  447
[47,]  151  260  464
[48,]  940  111  272
[49,]   82  450   37
[50,]  180  200  479
[51,]  499  140  312
[52,]  347   20  527
[53,]  412  300  296
[54,]  209  223  123
[55,]  721  134  416
[56,]   90   33  452
[57,]  135  159   16
[58,]  437  113   65
[59,]  326  182  154
[60,]  247   41  447
[61,]  479  180  200
[62,]  247   41  447
[63,]  421  537   57
[64,]   80  242  629
[65,]   29  224  346
[66,]  459  524  243
[67,]  229  303  147
[68,]  603  315  368
[69,]  403   73  336
[70,]  494  271   70
[71,]  201  161  164
[72,]  354   51  704
[73,]  391  134   83
[74,]   19  153  346
[75,]  372  165  147
[76,]  224   29  100
[77,]  166  365  220
[78,]  363   48  420
[79,]  193    5    9
[80,]  378   68  343
[81,]  618  556    8
[82,]  270  318   85
[83,]   63  242   49
[84,]  416  233  399
[85,]   70  178   99
[86,]  280  306  409
[87,]  148  175  309
[88,]  131 1126  476
[89,]  396  519  121
[90,]  587  712  527
[91,]  130  129  291
[92,]  594  142  322
[93,]   89   65  234
[94,]  135   16  159
[95,]  426  478  670
```

```
 [96,]   19  153   36
 [97,]   25  465  116
 [98,]   19   36  153
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[101,]  103  722  534
[102,]  357  425  536
[103,]  372  165  196
[104,]  260  464  391
[105,]  113  575  612
[106,]   41  247  447
[107,]  200  180   41
[108,]  489  187  115
[109,]  204  252  168
[110,]  479  200  180
[111,]  332  476  573
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[116,]  318  270  130
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[121,]  147  136  503
[122,]  242   80  628
[123,]  160  272  111
[124,]  230  232  109
[125,]  469  141   97
[126,]    3  107  102
[127,]  569  691  718
[128,]  210  109  244
[129,]  260  464  517
[130,]  169  261  494
[131,]  149   66  406
[132,]  445  537  421
[133,]  270  453  634
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[137,]  440  710  516
[138,]  150  171  213
[139,]  712  797  211
[140,]  452  110   33
[141,]  299  348  484
[142,]   72  526  298
[143,]  354  553  896
[144,]  176  512  174
[145,]  161  442  173
[146,]    3  313  421
[147,]  371  409  450
[148,]  181  202  215
[149,]   33  491  110
[150,]  376  287  478
[151,]  194  606  706
[152,]  420   55  554
[153,]  199  469  577
[154,]  331  310  152
[155,]  217  163  387
[156,]  266  159  135
[157,]  795   22  132
[158,]  180  200  479
[159,]  187  395  619
```

```
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[161,]  404  150  696
[162,]  466  289   75
[163,]  342  386  597
[164,]  318  270  129
[165,]  466   75  289
[166,]  264  152  645
[167,]  406   66  402
[168,]  176  512  174
[169,]  153   36  667
[170,]  507  387  444
[171,]  658  489  409
[172,]  185  725 1073
[173,]  245  258  335
[174,]  201  389   96
[175,]  361   38  245
[176,]  372  165  303
[177,]  731  385   54
[178,]  268  328  191
[179,]   80  629  242
[180,]  237  539   51
[181,]  716  204  252
[182,]  227  518  127
[183,]  164  442  101
[184,]  229  311  303
[185,]  618  556  862
[186,]  356  106   75
[187,]   49  508   47
[188,]  362  464  260
[189,]  621  167  586
[190,]  236  757  894
[191,]  131 1040 1327
[192,]  256  397  348
[193,]  109  232  428
[194,]  344  212  246
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[196,]  182   77   65
[197,]   76  679  658
[198,]  245  335  485
[199,]  128  415  206
[200,]  437  433  154
[201,]   24  226  664
[202,]  460  349  557
[203,]  385  731   54
[204,]  199  283  469
[205,]  396  400  192
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[207,]  176  357  512
[208,]  593  382  642
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[210,]  176  512  580
[211,]  749   19  214
[212,]  493  149  406
[213,]  332  573  476
[214,]  421  445  537
[215,]  377  254   82
[216,]  424  509  224
[217,]  313  421  796
[218,]  511  470  759
[219,]  618  556  294
[220,]   53  122  149
[221,]  460  899  164
[222,]  879  169  178
[223,]  582  477   98
```

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[226,]  173   77  326
[227,]  375  683   74
[228,]  572  516  440
[229,]  174  176  512
[230,]  461  330  514
[231,]  548  285   50
[232,]  420  413  498
[233,]  816  538  456
[234,]  623  843  867
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 [316,] 0.13582965 0.23495122 0.2503672
 [317,] 0.44091081 0.53470655 0.5406197
 [318,] 0.40550796 0.47969186 0.6798060
 [319,] 0.18253430 0.33985729 0.3488748
 [320,] 0.08755257 0.17097802 0.1718344
 [321,] 0.19242904 0.22729285 0.2384437
 [322,] 0.05795974 0.11606781 0.1292860
 [323,] 0.45034009 0.50229596 0.5817527
 [324,] 0.18936358 0.40144271 0.4216529
 [325,] 0.28583741 0.50512380 0.5063870
 [326,] 0.23567656 0.28731933 0.3869430
 [327,] 0.18903923 0.28497541 0.3742905
 [328,] 0.18835814 0.24680145 0.3287025
 [329,] 0.19921951 0.20635331 0.2635208
 [330,] 0.17007288 0.20357749 0.2505152
 [331,] 0.19898385 0.39820036 0.4033711
 [332,] 0.20573858 0.22840123 0.2635263
 [333,] 0.26192966 0.26878987 0.2886973
 [ reached getOption("max.print") -- omitted 667 rows ]
Levels: 0 1
```

```
> confusionMatrix(knn.pred6,Test_labels)
Confusion Matrix and Statistics

          Reference
Prediction   0   1
         0 890  60
         1   2  48

               Accuracy : 0.938
                 95% CI : (0.9212, 0.9521)
    No Information Rate : 0.892
    P-Value [Acc > NIR] : 3.24e-07

                  Kappa : 0.5788

 Mcnemar's Test P-Value : 4.52e-13

            Sensitivity : 0.9978
            Specificity : 0.4444
         Pos Pred Value : 0.9368
         Neg Pred Value : 0.9600
             Prevalence : 0.8920
         Detection Rate : 0.8900
   Detection Prevalence : 0.9500
      Balanced Accuracy : 0.7211

       'Positive' Class : 0



> #        0.959 for knn.pred5 i.e., for Training set
> #        0.951 for knn.pred6 i.e., for Validation set
>
> # The Training set has more data compared to validation set. hence, Accurac
y has improved because the data feed to the model.
```