Lab 5 : Diabetes Classification using Logistic Regression

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Step-1.[Understand Data]

In [1]:

```
import pandas as pd
df=pd.read_csv(r"diabetes.csv")
```

In [2]:

```
df.head()
```

Out[2]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunctio
0	6	148	72	35	0	33.6	0.62
1	1	85	66	29	0	26.6	0.35
2	8	183	64	0	0	23.3	0.67
3	1	89	66	23	94	28.1	0.16
4	0	137	40	35	168	43.1	2.28

In [3]:

```
df.shape
```

Out[3]:

```
(768, 9)
```

In [4]:

```
type(df)
```

Out[4]:

```
pandas.core.frame.DataFrame
```

In [5]:

```
df.columns
```

Out[5]:

```
Index(['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insuli
n',
       'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
      dtype='object')
```

In [6]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
Pregnancies                 768 non-null int64
Glucose                     768 non-null int64
BloodPressure               768 non-null int64
SkinThickness               768 non-null int64
Insulin                     768 non-null int64
BMI                         768 non-null float64
DiabetesPedigreeFunction    768 non-null float64
Age                         768 non-null int64
Outcome                     768 non-null int64
dtypes: float64(2), int64(7)
memory usage: 54.1 KB
```

In [7]:

```
df.count()
```

Out[7]:

```
Pregnancies                 768
Glucose                     768
BloodPressure               768
SkinThickness               768
Insulin                     768
BMI                         768
DiabetesPedigreeFunction    768
Age                         768
Outcome                     768
dtype: int64
```

Step-2 : [Build Logistic Regression model]

In [8]:

```
X=df.drop('Outcome',axis=1)
```

In [9]:

```
X.head()
```

Out[9]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunctio
0	6	148	72	35	0	33.6	0.62
1	1	85	66	29	0	26.6	0.35
2	8	183	64	0	0	23.3	0.67
3	1	89	66	23	94	28.1	0.16
4	0	137	40	35	168	43.1	2.28

In [10]:

```
y=df['Outcome'].values
```

In [11]:

```
y
```

Out[11]:

```
array([1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 0, 0,
       1, 1, 1, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0,
       1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 1, 0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1,
       1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1,
       0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1,
       1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 1,
       1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0,
       1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 0, 1, 0, 0,
       1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 1, 0,
       0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0,
       1, 1, 0, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 0,
       0, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
       0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 0, 0, 1, 0,
       0, 1, 0, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 1,
       0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0,
       1, 0, 0, 1, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
       1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
       0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0,
       0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1,
       0, 1, 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1,
       0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0,
       0, 0, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0,
       0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0,
       1, 1, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0],
      dtype=int64)
```

In [12]:

```
from sklearn.model_selection import StratifiedShuffleSplit

sss=StratifiedShuffleSplit(n_splits=4,test_size=0.25,random_state=42)
```

In [13]:

```
sss.get_n_splits(X,y)
```

Out[13]:

```
4
```

In [14]:

```
from sklearn.model_selection import train_test_split

X_train,X_test,y_train,y_test=train_test_split(X,y,stratify=y,test_size=.25,random_state=42
```

In [15]:

```
from sklearn.linear_model import LogisticRegression

LOR=LogisticRegression(penalty='l2',C=10.0)
LOR=LOR.fit(X_train,y_train)
```

In [16]:

```
y_pred=LOR.predict(X_test)
y_pred
```

Out[16]:

```
array([0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0,
       0, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0,
       1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 1, 0, 0, 1,
       0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 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, 1, 1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 1, 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, 1, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1,
       0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0], dtype=int64)
```

Step-3 : [Predict on a new sample]

In [18]:

```
new=LOR.predict([[6,200,90,10,25,23.3,.672,42]])
if new==0:
    print("Non-diabetic patient",new)
else:
    print("Diabetic patient",new)
```

```
Diabetic patient [1]
```

Step-3 : [Compute Classification Metrics]

In [21]:

```
def accuracy(actual,pred):
    return sum(actual==pred)/float(actual.shape[0])
```

In [22]:

```
accuracy_score=accuracy(y_test,y_pred)
accuracy_score
```

Out[22]:

```
0.734375
```

Precision

In [23]:

```
from sklearn.metrics import precision_score
print(precision_score(y_test,y_pred))
```

```
0.6481481481481481
```

Recall

In [24]:

```
from sklearn.metrics import recall_score
print(recall_score(y_test,y_pred))
```

```
0.5223880597014925
```

AUC Scores

In [25]:

```
from sklearn.metrics import roc_auc_score
print(roc_auc_score(y_test,y_pred))
```

```
0.6851940298507463
```

Step-4 : [Understand Correlation]

In [26]:

```
from sklearn.metrics import confusion_matrix
cfm=confusion_matrix(y_test,y_pred)
cfm
```

Out[26]:

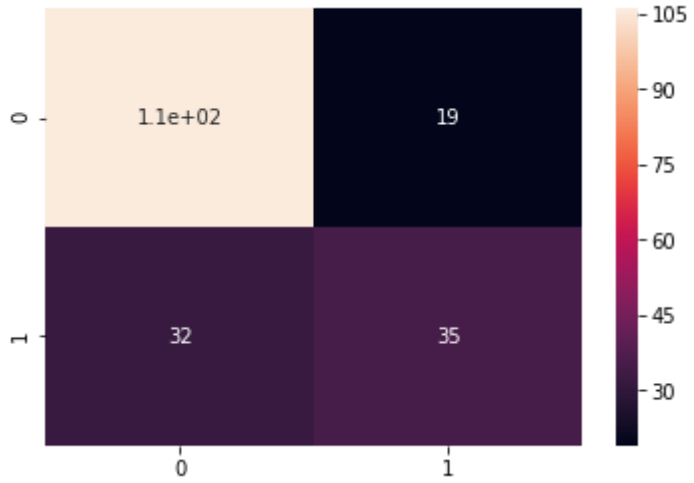
```
array([[106,  19],
       [ 32,  35]], dtype=int64)
```

In [31]:

```
import seaborn as sns
sns.heatmap(cfm, annot=True)
sns
```

Out[31]:

```
<module 'seaborn' from 'C:\\Program Files (x86)\\Microsoft Visual Studio\\Sh
ared\\Anaconda3_64\\lib\\site-packages\\seaborn\\__init__.py'>
```



Step-5 : [Normalization using MinMaxScaler and rebuild LOR]

In [32]:

```
#Normalizing using MinMaxScaler

from sklearn.preprocessing import MinMaxScaler
mm=MinMaxScaler()
mm_X_train=mm.fit_transform(X_train)
mm_X_train
```

Out[32]:

```
array([[0.05882353, 0.6080402 , 0.63934426, ..., 0.58122206, 0.07884187,
        0.11666667],
       [0.70588235, 0.44221106, 0.60655738, ..., 0.52608048, 0.13095768,
        0.45      ],
       [0.05882353, 0.54271357, 0.49180328, ..., 0.5290611 , 0.14743875,
        0.05      ],
       ...,
       [0.05882353, 0.48743719, 0.57377049, ..., 0.56780924, 0.0596882 ,
        0.15      ],
       [0.52941176, 0.7839196 , 0.70491803, ..., 0.51117735, 0.4922049 ,
        0.35      ],
       [0.23529412, 0.72361809, 0.47540984, ..., 0.43964232, 0.09042316,
        0.26666667]])
```

In [33]:

```
mm_X_test=mm.transform(X_test)
mm_X_test
```

Out[33]:

```
array([[0.76470588, 0.52261307, 0.59016393, ..., 0.46497765, 0.16971047,
        0.28333333],
       [0.23529412, 0.63819095, 0.72131148, ..., 0.51415797, 0.22895323,
        0.11666667],
       [0.11764706, 0.47236181, 0.62295082, ..., 0.4709389 , 0.25167038,
        0.03333333],
       ...,
       [0.        , 0.53266332, 0.57377049, ..., 0.58718331, 0.23207127,
        0.01666667],
       [0.29411765, 0.62311558, 0.60655738, ..., 0.50670641, 0.06057906,
        0.28333333],
       [0.17647059, 0.64321608, 0.59016393, ..., 0.4828614 , 0.20712695,
        0.1       ]])
```

In [34]:

```
#ReBuild LOR Model

mm_lor=LogisticRegression()
mm_lor=mm_lor.fit(mm_X_train,y_train)
```

In [35]:

```
mm_y_pred=mm_lor.predict(mm_X_test)
mm_y_pred
```

Out[35]:

```
array([0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0,
       0, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0,
       1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 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, 1, 1, 0, 0, 0, 0, 1, 1, 1, 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, 1, 0, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1,
       0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0], dtype=int64)
```

Accuracy

In [38]:

```
def accuracy(actual,pred):
    return sum(actual==pred)/float(actual.shape[0])
```

In [39]:

```
accuracy_score=accuracy(y_test,mm_y_pred)
accuracy_score
```

Out[39]:

```
0.7395833333333334
```

Precision

In [40]:

```
print(precision_score(y_test,mm_y_pred))
```

```
0.6888888888888889
```

Recall

In [41]:

```
print(recall_score(y_test,mm_y_pred))
```

```
0.4626865671641791
```

AUC scores

In [42]:

```
mm_auc=print(roc_auc_score(y_test,mm_y_pred))
mm_auc
```

```
0.6753432835820895
```

Step-6 : [Normalization using StandardScaler and rebuild LOR]

In [43]:

```
from sklearn.preprocessing import StandardScaler
ss=StandardScaler()
ss_X_train=ss.fit_transform(X_train)
ss_X_train
```

Out[43]:

```
array([[-0.85547074,  0.00732864,  0.47259835, ...,  0.88301955,
        -0.65845729, -0.46648591],
       [ 2.46780492, -1.03224482,  0.2585074 , ...,  0.41193433,
        -0.30699915,  1.21865604],
       [-0.85547074, -0.4022003 , -0.49081095, ...,  0.43739839,
        -0.19585426, -0.8035143 ],
       ...,
       [-0.85547074, -0.74872478,  0.04441644, ...,  0.76843126,
        -0.78762567, -0.29797171],
       [ 1.56145701,  1.10990656,  0.90078026, ...,  0.28461399,
         2.12917653,  0.71311346],
       [ 0.05087717,  0.73187984, -0.59785643, ..., -0.3265236 ,
        -0.58035548,  0.29182797]])
```

In [44]:

```
ss_X_test=ss.transform(X_test)
ss_X_test
```

Out[44]:

```
array([[ 2.76992089, -0.5282092 ,  0.15146192, ..., -0.11007904,
        -0.04565848,  0.37608507],
       [ 0.05087717,  0.196342  ,  1.00782574, ...,  0.31007806,
         0.35386232, -0.46648591],
       [-0.55335477, -0.84323146,  0.36555287, ..., -0.0591509 ,
         0.50706202, -0.8877714 ],
       ...,
       [-1.15758671, -0.46520475,  0.04441644, ...,  0.93394769,
         0.37488973, -0.97202849],
       [ 0.35299314,  0.10183532,  0.2585074 , ...,  0.24641789,
        -0.78161784,  0.37608507],
       [-0.2512388 ,  0.22784423,  0.15146192, ...,  0.04270536,
         0.20667045, -0.55074301]])
```

In [45]:

```
#Rebuild LOR

ss_lor=LogisticRegression()
ss_lor.fit(ss_X_train,y_train)
ss_y_pred=ss_lor.predict(ss_X_test)
```

Accuracy

In [47]:

```
def accuracy(actual,pred):
    return sum(actual==pred)/float(actual.shape[0])
```

In [48]:

```
ss_accuracy_score=accuracy(y_test,ss_y_pred)
ss_accuracy_score
```

Out[48]:

```
0.7291666666666666
```

Precision

In [49]:

```
print(precision_score(y_test,ss_y_pred))
```

```
0.6363636363636364
```

Recall

In [50]:

```
print(recall_score(y_test,ss_y_pred))
```

```
0.5223880597014925
```

AUC scores

In [51]:

```
auc_ss=print(roc_auc_score(y_test,ss_y_pred))
auc_ss
```

```
0.6811940298507462
```

Step-7 : [Plot ROC Curve]

In [53]:

```
pred_prob1=mm_lor.predict_proba(mm_X_test)
```

In [54]:

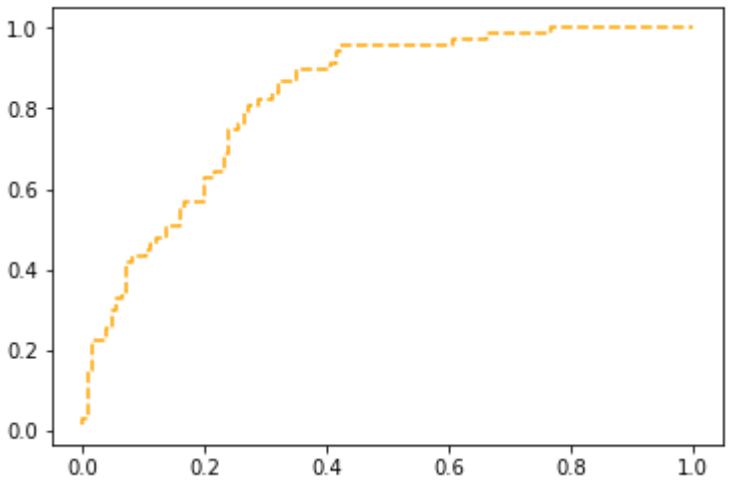
```
from sklearn.metrics import roc_curve

fpr1, tpr1, thresh1 = roc_curve(y_test, pred_prob1[:,1], pos_label=1)
```

In [60]:

```
import matplotlib.pyplot as plt

plt.plot(fpr1,tpr1,linestyle='--',color='orange',label='MinMaxScaler values')
plt.show()
```



Step-8 : [Comparison with KNN classifier]

In [61]:

```
from sklearn.neighbors import KNeighborsClassifier
knn=KNeighborsClassifier(n_neighbors=4)
knn=knn.fit(X_train,y_train)
```

In [62]:

```
knn_y_pred=knn.predict(X_test)
```

In [63]:

```
from sklearn.preprocessing import MinMaxScaler
m=MinMaxScaler()
m_X_train=m.fit_transform(X_train)
m_X_train
```

Out[63]:

```
array([[0.05882353, 0.6080402 , 0.63934426, ..., 0.58122206, 0.07884187,
        0.11666667],
       [0.70588235, 0.44221106, 0.60655738, ..., 0.52608048, 0.13095768,
        0.45      ],
       [0.05882353, 0.54271357, 0.49180328, ..., 0.5290611 , 0.14743875,
        0.05      ],
       ...,
       [0.05882353, 0.48743719, 0.57377049, ..., 0.56780924, 0.0596882 ,
        0.15      ],
       [0.52941176, 0.7839196 , 0.70491803, ..., 0.51117735, 0.4922049 ,
        0.35      ],
       [0.23529412, 0.72361809, 0.47540984, ..., 0.43964232, 0.09042316,
        0.26666667]])
```

In [64]:

```
m_X_test=m.transform(X_test)
m_X_test
```

Out[64]:

```
array([[0.76470588, 0.52261307, 0.59016393, ..., 0.46497765, 0.16971047,
        0.28333333],
       [0.23529412, 0.63819095, 0.72131148, ..., 0.51415797, 0.22895323,
        0.11666667],
       [0.11764706, 0.47236181, 0.62295082, ..., 0.4709389 , 0.25167038,
        0.03333333],
       ...,
       [0.        , 0.53266332, 0.57377049, ..., 0.58718331, 0.23207127,
        0.01666667],
       [0.29411765, 0.62311558, 0.60655738, ..., 0.50670641, 0.06057906,
        0.28333333],
       [0.17647059, 0.64321608, 0.59016393, ..., 0.4828614 , 0.20712695,
        0.1       ]])
```

In [65]:

```
m_knn=KNeighborsClassifier()
m_knn=m_knn.fit(m_X_train,y_train)
```

In [66]:

```
m_y_pred=m_knn.predict(m_X_test)
m_y_pred
```

Out[66]:

```
array([0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 1,
       1, 0, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1,
       0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0,
       0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0,
       0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1,
       1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0,
       0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1,
       0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0], dtype=int64)
```

Accuracy

In [67]:

```
def accuracy(actual,pred):
    return sum(actual==pred)/float(actual.shape[0])
```

In [68]:

```
ss_accuracy_score=accuracy(y_test,ss_y_pred)
ss_accuracy_score
```

Out[68]:

```
0.7291666666666666
```

Precision

In [69]:

```
print(precision_score(y_test,ss_y_pred))
```

```
0.6363636363636364
```

Recall

In [70]:

```
print(recall_score(y_test,ss_y_pred))
```

```
0.5223880597014925
```

AUC Scores

In [71]:

```
knn_auc=print(roc_auc_score(y_test,m_y_pred))
knn_auc
```

```
0.6646567164179105
```

Step-9 : [Update ROC Curve]

In [72]:

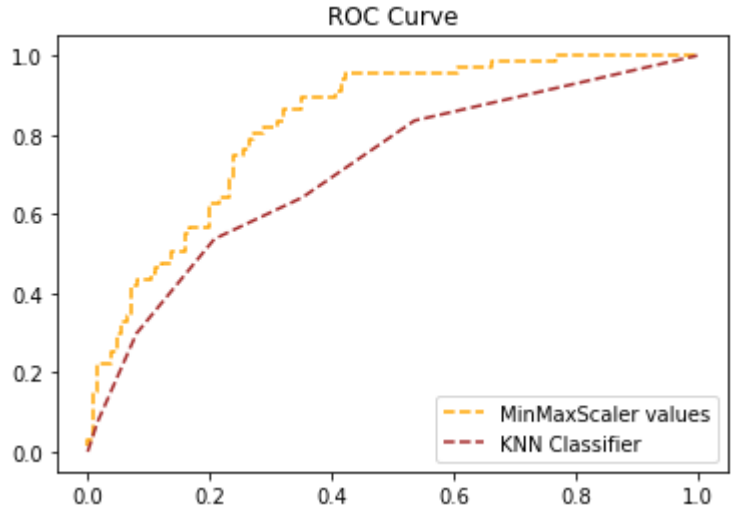
```
pred_prob2=m_knn.predict_proba(m_X_test)
```

In [73]:

```
from sklearn.metrics import roc_curve
fpr2,tpr2,thresh2=roc_curve(y_test,pred_prob2[:,1],pos_label=1)
```

In [74]:

```
import matplotlib.pyplot as plt
plt.plot(fpr1,tpr1,linestyle='--',color='orange',label='MinMaxScaler values')
plt.plot(fpr2,tpr2,linestyle='--',color='brown',label='KNN Classifier')
plt.title('ROC Curve')
plt.legend(loc='best')
plt.savefig('ROC',dpi=300)
plt.show()
```



Step-10 : [Regularization]

In [76]:

```
from sklearn.linear_model import LogisticRegressionCV
model1=LogisticRegressionCV(Cs=10,cv=4,penalty='l1',solver='liblinear')
model2=LogisticRegressionCV(Cs=10,cv=4,penalty='l2')
```

In [77]:

```
model1.fit(mm_X_train,y_train)
model2.fit(mm_X_train,y_train)
```

Out[77]:

```
LogisticRegressionCV(Cs=10, class_weight=None, cv=4, dual=False,
           fit_intercept=True, intercept_scaling=1.0, max_iter=100,
           multi_class='ovr', n_jobs=1, penalty='l2', random_state=None,
           refit=True, scoring=None, solver='lbfgs', tol=0.0001, verbose=0)
```

In [78]:

```
rg_y_pred1 = model1.predict(mm_X_test)
rg_y_pred2 = model2.predict(mm_X_test)
```

AUC SCORE OF L1

In [79]:

```
from sklearn.metrics import roc_auc_score
l1_auc = roc_auc_score(y_test, rg_y_pred1)
l1_auc = (' LOR L1 MINMAX AUC', l1_auc)
l1_auc
```

Out[79]:

```
(' LOR L1 MINMAX AUC', 0.6811940298507462)
```

AUC SCORE OF L2

In [80]:

```
from sklearn.metrics import roc_auc_score
l2_auc = roc_auc_score(y_test, rg_y_pred2)
l2_auc = (' LOR L2 MINMAX AUC', l2_auc)
l2_auc
```

Out[80]:

```
(' LOR L2 MINMAX AUC', 0.6851940298507463)
```

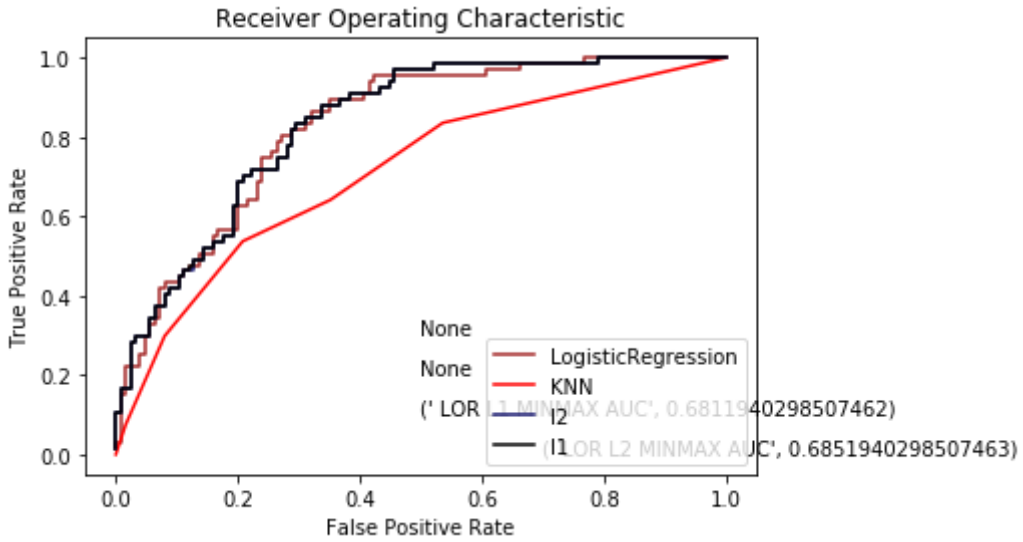
STEP 12 : UPDATE ROC CURVE

In [81]:

```
pred_prb7 = model1.predict_proba(mm_X_test)
pred_prb8 = model2.predict_proba(mm_X_test)
fpr,tbr,threshold = roc_curve(y_test, pred_prob1[:,1],pos_label=1)
fpr1,tbr1,threshold1 = roc_curve(y_test, pred_prob2[:,1],pos_label=1)
fpr2,tbr2,threshold2= roc_curve(y_test, pred_prb7[:,1],pos_label=1)
fpr3,tbr3,threshold3 = roc_curve(y_test, pred_prb8[:,1],pos_label=1)
```

In [82]:

```
plt.plot(fpr, tbr, linestyle='-', color='brown', label='LogisticRegression')
plt.plot(fpr1, tbr1, linestyle='-', color='red', label='KNN')
plt.plot(fpr3, tbr3, linestyle='-', color='midnightblue', label='l2')
plt.plot(fpr2, tbr2, linestyle='-', color='black', label='l1')
plt.annotate(xy=[0.5,0.3],s= auc_ss)
plt.annotate(xy=[0.5,0.2],s= knn_auc)
plt.annotate(xy=[0.5,0.1],s= l1_auc)
plt.annotate(xy=[0.7,0],s= l2_auc)
plt.title('Receiver Operating Characteristic')
plt.legend(loc = 'best')
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



In [ ]: