This Notebook gives some example of Performance metric for Classification and Regression Task. </br>

- **Classificiation**
  - **A. Highly Imbalanced Data (Positive points >>>>> Negative Points)**
  - **B. Highly Imbalanced Data (Negative points >>>>> Positive Points)**
  - **C. Almost Balanced Data (Used custom Metric to Penalized False Negative Rate)**
- **Regression Case**

In [2]:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [3]:

```
cd drive/MyDrive/Applied_AI/Performance\ Matrix
```

```
/content/drive/MyDrive/Applied_AI/Performance Matrix
```

In [4]:

```
import numpy as np
import pandas as pd
from tqdm import tqdm
# other than these two you should not import any other packages
```

A. Compute performance metrics for the given data **5_a.csv**
Note 1: in this data you can see number of positive points >> number of negatives points
Note 2: use pandas or numpy to read the data from **5_a.csv**
Note 3: you need to derive the class labels from given score

$$y^{pred} = [0 \text{ if y\_score} < 0.5 \text{ else } 1]$$

1. Compute Confusion Matrix
2. Compute F1 Score
3. Compute AUC Score, you need to compute different thresholds and for each threshold compute tpr,fpr and then use numpy.trapz(tpr_array, fpr_array) https://stackoverflow.com/q/53603376/4084039, https://stackoverflow.com/a/39678975/4084039 Note: it should be numpy.trapz(tpr_array, fpr_array) not numpy.trapz(fpr_array, tpr_array)
4. Compute Accuracy Score

In [5]:

```
"""
Class to get confusion matrix from true and predicted labels .
This is only for Binary Classfication Problem.
This is very basic class defination. Validation is not performed.
"""
class ConfusionMatrix(object):
```

```
  def __init__(self, data) :

    self.data = data
    self.tp = None
    self.tn  = None
    self.fp = None
    self.fn = None
    self.recall = None
    self.precision = None
    self.tpr = None
    self.fpr = None
    self.accuracy = None


  def getTruePositive(self) :
    self.tp  =  np.count_nonzero(np.logical_and(self.data["pred_y"] ==  1 ,  self.data["y
"] == 1))
    return self.tp


  def getTrueNegative(self):
    self.tn =   np.count_nonzero(np.logical_and(self.data["pred_y"] ==  0 ,  self.data["y
"] == 0))
    return self.tn

  def getFalsePositive(self):
    self.fp =  np.count_nonzero(np.logical_and(self.data["pred_y"] ==  1 ,  self.data["y"
] == 0))
    return self.fp


  def getFalseNegative(self):
    self.fn =  np.count_nonzero(np.logical_and(self.data["pred_y"] ==  0 ,  self.data["y"
] == 1))
    return self.fn

  def getRecall(self) :
    if self.tp is None or self.fn is None :
      self.getTruePositive()
      self.getFalseNegative()
    self.recall = self.tp / (self.tp + self.fn)
    self.tpr = self.recall
    return self.recall

  def getPrecision(self) :
    if self.tp is None or self.fp is None :
      self.getTruePositive()
      self.getFalsePositive()
    self.precision = self.tp / (self.tp + self.fp)
    return self.precision

  def getTruePositiveRate(self) :
    return self.getRecall()

  def getFalsePositiveRate(self):
    if self.fp is None or self.tn is None:
      self.getFalsePositive()
      self.getTrueNegative()
    self.tpr = self.fp / (self.fp + self.tn)
    return self.tpr

  def getAccuracy(self) :
    if self.tp  is None or self.tn is None:
      self.getTruePositive()
      self.getTrueNegative()
    return (self.tp + self.tn) / self.data["y"].count()
```

Case 1 **</br> Performance matrix on highly imbalanced data </br>**

10000 positive points </br>

100 negative points </br>

In [5]:

```
```

In [6]:

```
data1 =  pd.read_csv("5_a.csv")
print(data1.columns)
data1["y"].value_counts()
# data is highly imbalanced
# positive points to negative point ratio is 100 : 1
```

```
Index(['y', 'proba'], dtype='object')
```

Out[6]:

```
1.0    10000
0.0      100
Name: y, dtype: int64
```

In [7]:

```
# f1 score
# f1 score is harmonic mean of precision and recall

def getF1Score(precison, recall) :
  return 2 /( (1/precison ) + (1/recall))
```

In [8]:

```
# let's predict y based on probability score given in the data
# if proba > 0.5 :
#   y_pred = 1
# else :
#   y_predd = 0
data1["pred_y"] = np.where(data1["proba"] < 0.5, 0, 1 )
```

In [9]:

```
# Confusion Matrix
cm   = ConfusionMatrix(data1)
tp = cm.getTruePositive()
fp = cm.getFalsePositive()
tn = cm.getTrueNegative()
fn  = cm.getFalseNegative()
print("true positive : {}, false positive : {} , true Negative : {}, false Negative : {}"
.format(tp, fp, tn, fn))
```

```
true positive : 10000, false positive : 100 , true Negative : 0, false Negative : 0
```

In [11]:

```
# f1 score
recall = cm.getRecall()

precision = cm.getPrecision()
f1Score = getF1Score(precision, recall)
print("Recall : {}, Precision : {}, F1score : {} ".format(recall, precision, f1Score))
```

```
Recall : 1.0, Precision : 0.9900990099009901, F1score : 0.9950248756218907
```

In [ ]:

```
```

In [12]:

```
# Accuracy score
accuracy = cm.getAccuracy()
```

```
print("accuracy : {} ".format(accuracy))
```

```
accuracy : 0.9900990099009901
```

In [13]:

```
# 4) AUC and ROC curve
class ROC(object) :
  def __init__(self, data, thresholdList) :
    self.data  = data
    self.thresholdList = thresholdList
    self.fprList = []
    self.tprList = []


  def getROCData(self ) :

    for tau in tqdm(self.thresholdList) :
      self.data["pred_y"] = np.where(self.data["proba"] < tau, 0, 1 )
      confusion = ConfusionMatrix(self.data)
      tpr = confusion.getTruePositiveRate()
      fpr = confusion.getFalsePositiveRate()
      self.fprList.append(fpr)
      self.tprList.append(tpr)

    return

  def gettprList(self):
    return sorted(self.tprList)

  def getfprList(self):
    return sorted(self.fprList)

  def getAUCValue(self) :
    if len(self.tprList ) == 0 or len(self.fprList) == 0 :
      self.getROCData()
    return np.trapz(sorted(self.tprList), sorted(self.fprList))
```

In [14]:

```
# 4) Computer AUC curve

#  for auc we need to get threshold so we will sort based on prob value
# then for each sorted prob vale will be used as threshold to predict based on threshold a
nd
# then we will plot all tpr and fpr calculated based on this threshold and calculate the a
re under ROC curve

sorted_data1 = data1.sort_values(by=['proba'])
```

In [ ]:

```
thresholdList = np.unique(sorted_data1["proba"]).tolist()
len(thresholdList)
```

In [ ]:

```
#Auc value
roc = ROC(sorted_data1, thresholdList)
print("AUC {} ".format( roc.getAUCValue()))
```

In [ ]:

```
# plot roc curve
import matplotlib.pyplot as plt
plt.plot(roc.tprList, roc.fprList)
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
```

In [ ]:

Compute performance metrics for the given Y and Y_score without sklearn

B. Compute performance metrics for the given data **5_b.csv**
Note 1: in this data you can see number of positive points << number of negatives points
Note 2: use pandas or numpy to read the data from **5_b.csv**
Note 3: you need to derive the class labels from given score

y^{pred}
$= [0 \text{ if y\_score} < 0.5 \text{ else } 1]$

1. Compute Confusion Matrix
2. Compute F1 Score
3. Compute AUC Score, you need to compute different thresholds and for each threshold compute tpr,fpr and then use numpy.trapz(tpr_array, fpr_array) https://stackoverflow.com/q/53603376/4084039, https://stackoverflow.com/a/39678975/4084039
4. Compute Accuracy Score

Case 2 </br>

positive points << number of negatives points </br> Performance matrix on highly imbalanced data </br>

10000 Negative points </br>

100 positive points </br>

In [15]:

```
# write your code here
data2 =  pd.read_csv("5_b.csv")
print(data1.columns)
data2["y"].value_counts()
# data is highly imbalanced
# positive points to negative point ratio is 100 : 1
```

```
Index(['y', 'proba', 'pred_y'], dtype='object')
```

Out[15]:

```
0.0    10000
1.0      100
Name: y, dtype: int64
```

In [16]:

```
# let's predict y based on probability score given in the data
# if proba > 0.5 :
#   y_pred = 1
# else :
#   y_predd = 0
data2["pred_y"] = np.where(data2["proba"] < 0.5, 0, 1 )
```

In [17]:

```
# 1) confusion Matrix

cm   = ConfusionMatrix(data2)
tp = cm.getTruePositive()
fp = cm.getFalsePositive()
tn = cm.getTrueNegative()
fn  = cm.getFalseNegative()
fpr = cm.getFalsePositiveRate()
tpr = cm.getTruePositiveRate()
print("true positive : {}, false positive : {} , true Negative : {}, false Negative : {}"
.format(tp, fp, tn, fn))
```

```
true positive : 55, false positive : 239 , true Negative : 9761, false Negative : 45
```

In [18]:

```
# f1 score

recall = cm.getRecall()
precision = cm.getPrecision()
f1ScoreData2 = getF1Score(precision, recall)
f1ScoreData2
print("Recall : {}, Precision : {}, F1score : {} ".format(recall, precision, f1ScoreData2
))
```

```
Recall : 0.55, Precision : 0.1870748299319728, F1score : 0.27918781725888325
```

In [19]:

```
#Auc Curve
# 4) Computer AUC curve

#  for auc we need to get threshold so we will sort based on prob value
# then for each sorted prob vale will be used as threshold to predict based on threshold a
nd
# then we will plot all tpr and fpr calculated based on this threshold and calculate the a
re under ROC curve

sorted_data2 = data2.sort_values(by=['proba'])

# get Threshold values
thresholdList2 = np.unique(sorted_data2["proba"]).tolist()
len(thresholdList2)

#Auc value
roc2 = ROC(sorted_data2, thresholdList2)
```

In [23]:

```
# AUC

print("AUC {}".format(roc2.getAUCValue()))
```

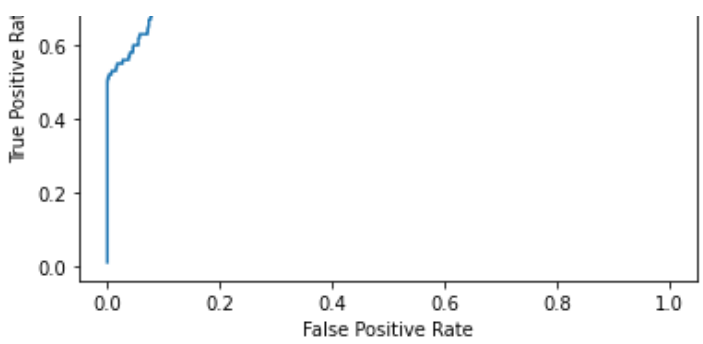
```
AUC 0.9377570000000001
```

In [24]:

```
# plot roc curve
import matplotlib.pyplot as plt
plt.plot( (roc2.fprList), (roc2.tprList))
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
```

Out[24]:

```
Text(0, 0.5, 'True Positive Rate')
```



In [22]:

```
# 4) Accuracy score

accuracy2 = cm.getAccuracy()
accuracy2
```

Out[22]:

```
0.9718811881188119
```

C. Compute the best threshold (similarly to ROC curve computation) of probability which gives lowest values of metric A for the given data 5_c.csv

you will be predicting label of a data points like this: $y^{pred} = [0 \text{ if y\_score} < \text{threshold else } 1]$

$$A = 500 \times \text{number of false negative} + 100 \times \text{numebr of false positive}$$

Note 1: in this data you can see number of negative points > number of positive points

Note 2: use pandas or numpy to read the data from 5_c.csv

Case 3 </br>

Fairly Balanced Data : </br>

1805 Negative points

1047 positive points

We want to penalized more False Negative, because in this case buissness objective is to get lowest false negative numbers. for example this matrix is critical in medical or clinical research. You don't want to miss any potential patient. </br>

We will use custom metric which is defined as below : </br>

$$A = 500 \times \text{number of false negative} + 100 \times \text{numebr of false positive}$$ </br>

we will select threshold such that this metrix is minimized.

In [25]:

```
# write your code

 data3 = pd.read_csv("5_c.csv")
 data3["y"].value_counts()
```

Out[25]:

```
0    1805
1    1047
```

```
Name: y, dtype: int64
```

In [26]:

```
# we need to get threshold so we will sort based on prob value
# then for each sorted prob vale will be used as threshold to predict based on threshold a
nd
# then we will plot all tpr and fpr calculated based on this threshold and calculate the a
re under ROC curve

sorted_data3 = data3.sort_values(by=['prob'])

# get Threshold values
thresholdList3 = np.unique(sorted_data3["prob"]).tolist()
len(thresholdList3)
```

Out[26]:

```
2791
```

In [27]:

```
# 4) AUC and ROC curve
class CustomMatrix(object) :
  def __init__(self, data, thresholdList) :
    self.data  = data
    self.thresholdList = thresholdList
    self.fprList = []
    self.tprList = []
    self.customMatrixValues = []


  def calculateMatrixValue(self ) :

    for tau in tqdm(self.thresholdList) :
      self.data["pred_y"] = np.where(self.data["prob"] < tau, 0, 1 )
      confusion = ConfusionMatrix(self.data)
      fp = confusion.getFalsePositive()
      fn = confusion.getFalseNegative()
      matricValue = (500 * fn ) + (100 * fp)
      self.customMatrixValues.append((tau, matricValue))


    return self.customMatrixValues
```

In [28]:

```
newmatric = CustomMatrix(data3, thresholdList3)
customMatrixValues = newmatric.calculateMatrixValue()
```

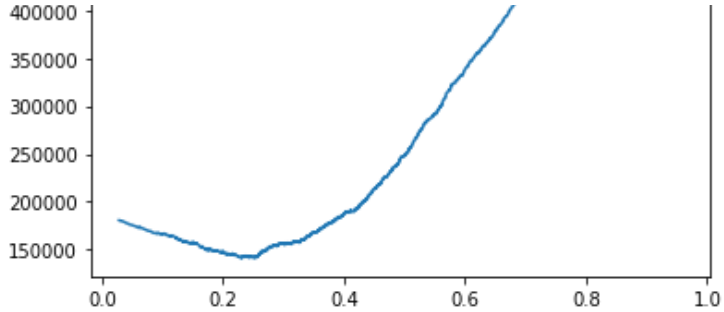
```
100%|██████████| 2791/2791 [00:05<00:00, 484.96it/s]
```

In [29]:

```
# create new data frame from list of tuple and set threshold as index
# get minimum matrix value threshold use idxmin method

newdf = pd.DataFrame(customMatrixValues, columns=['threshold', 'matrix']).set_index('thre
shold')

minThreshold = newdf[["matrix"]].idxmin()

plt.plot(*zip(*customMatrixValues))
```

Out[29]:

```
[<matplotlib.lines.Line2D at 0x7f2c6bccc2b0>]
```



In [30]:

```
print("Minimum Threshold Value : {}".format(minThreshold))
```

```
Minimum Threshold Value : matrix    0.230039
dtype: float64
```

D. Compute performance metrics(for regression) for the given data **5_d.csv**
Note 2: use pandas or numpy to read the data from **5_d.csv**
Note 1: **5_d.csv** will having two columns Y and predicted_Y both are real valued features

1. Compute Mean Square Error
2. Compute MAPE: https://www.youtube.com/watch?v=ly6ztgIkUxk
3. Compute R^2 error: https://en.wikipedia.org/wiki/Coefficient_of_determination#Definitions

Confusion Matrix is not a metric for regression problem.

We will use Mean Square Error, Mean Absolute Percentage Error for Regression Problem

In [31]:

```
data4 = pd.read_csv("5_d.csv")
meanError = np.mean(data4["y"])
data4["error"] = data4["y"] - data4["pred"]
data4["meanError"] = data4["y"] - meanError
# 1) Mean Squared Error
MSE = np.mean(np.square(data4["error"]))
print( "Mean Squared Error", MSE)
SST = np.mean(np.square(data4["meanError"]))
print("Sum of Squared Total : ",SST)
# R^2
R2 = 1 - (MSE/SST)
print( "R^2 value ",R2)

#MAPE
sumOfActualValue = np.sum(data4["y"])
sumOfErrors = np.sum(abs(data4["error"]))
MAPE = sumOfErrors/ (sumOfActualValue)
print('MAPE Value :', MAPE)
```

```
Mean Squared Error 177.16569974554707
Sum of Squared Total :  4059.54885518869
R^2 value  0.9563582786990964
MAPE Value : 0.1291202994009687
```