```
import math
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

Candace Edwards
ICS 635: Machine Learning
Homework 1
Part 1: Q1- Q3
Part 2: Q4 in [C.Edwards_Homework 1 Question 4.ipynb]

QUESTION 1

Model Classes: For each situation below, would you use Regression, Classification, or Clustering models?

- Predicting the inches of rainfall tomorrow given the inches of rainfall over the past week (0.2 points) **Linear Regression**
- Predicting the type of skin cancer from an image of the skin (0.2 points) **Classification**
- Determining the best grouping students into grade buckets of A+, A, A-, B+, B, B-, C+, C, C-, and F (0.2 points) **Clustering**
- Forecasting the number of COVID-19 cases in 1 month given prior history (0.2 points) **Linear Regression**
- Face ID on a smartphone (0.2 points)**Classification**

QUESTION 2: ROC Curve

Code/Work

```
def calc_y_hat(x,x2):
  '''
  Given logistic regression model
  Y_hat = 1/1+e^-(3x-4x2+3)
  '''

  y_hat = 1/(1 + math.exp(-((3*x)-(4*x2)+3)))

  return y_hat
```

```
#test
print(calc_y_hat(0,0)) #Expected: 0.952574...
```

```
    0.9525741268224334
```

```
def thresh(p,y_hat):
  '''
  Classifies y_hat given threshold p
  '''
  if y_hat>p:
    return 1
  return 0
```

```
#test
print(thresh(0.4,0.9)) #1
print(thresh(0.4,0.2)) #0
```

```
    1
    0
```

```
x1 = np.array([0, 0, 0, 1, 1, 1, 2, 2, 2, -1])
x2 = np.array([0, 1, 2, 0, 1, 2, 0, 1, 2, 0])
y = np.array([1,1,0,1,1,0,1,1,0,0])
y_hat = np.full(10,-1)
```

```
print(x1.shape)
print(x2.shape)
print(y.shape)
print(y_hat.shape)
```

```
(10,)
(10,)
(10,)
(10,)
```

```
data = {'x1':x1, 'x2':x2, 'y':y ,'y_hat': y_hat}
data
```

```
{'x1': array([ 0,  0,  0,  1,  1,  1,  2,  2,  2, -1]),
 'x2': array([0, 1, 2, 0, 1, 2, 0, 1, 2, 0]),
 'y': array([1, 1, 0, 1, 1, 0, 1, 1, 0, 0]),
 'y_hat': array([-1, -1, -1, -1, -1, -1, -1, -1, -1, -1])}
```

```
df = pd.DataFrame(data)
df
```

	x1	x2	y	y_hat
0	0	0	1	-1
1	0	1	1	-1
2	0	2	0	-1
3	1	0	1	-1
4	1	1	1	-1
5	1	2	0	-1
6	2	0	1	-1
7	2	1	1	-1
8	2	2	0	-1
9	-1	0	0	-1

```
df['y_hat'] = df.apply(lambda x: calc_y_hat(x['x1'],x['x2']), axis=1)
df
```

	x1	x2	y	y_hat
0	0	0	1	0.952574
1	0	1	1	0.268941
2	0	2	0	0.006693
3	1	0	1	0.997527
4	1	1	1	0.880797
5	1	2	0	0.119203
6	2	0	1	0.999877
7	2	1	1	0.993307
8	2	2	0	0.731059
9	-1	0	0	0.500000

```
#threshold calcs 0, 0.2, 0.4, 0.6, 0.8, 1
df['0'] = df.apply(lambda x: thresh(0,x['y_hat']), axis = 1)
df
```

	x1	x2	y	y_hat	0
0	0	0	1	0.952574	1
1	0	1	1	0.268941	1
2	0	2	0	0.006693	1
3	1	0	1	0.997527	1
4	1	1	1	0.880797	1
5	1	2	0	0.119203	1
6	2	0	1	0.999877	1

```
df['0.2'] = df.apply(lambda x: thresh(0.2,x['y_hat']), axis = 1)
df['0.4'] = df.apply(lambda x: thresh(0.4,x['y_hat']), axis = 1)
df['0.6'] = df.apply(lambda x: thresh(0.6,x['y_hat']), axis = 1)
df['0.8'] = df.apply(lambda x: thresh(0.8,x['y_hat']), axis = 1)
df['1'] = df.apply(lambda x: thresh(1,x['y_hat']), axis = 1)

df
```

	x1	x2	y	y_hat	0	0.2	0.4	0.6	0.8	1
0	0	0	1	0.952574	1	1	1	1	1	0
1	0	1	1	0.268941	1	1	0	0	0	0
2	0	2	0	0.006693	1	0	0	0	0	0
3	1	0	1	0.997527	1	1	1	1	1	0
4	1	1	1	0.880797	1	1	1	1	1	0
5	1	2	0	0.119203	1	0	0	0	0	0
6	2	0	1	0.999877	1	1	1	1	1	0
7	2	1	1	0.993307	1	1	1	1	1	0
8	2	2	0	0.731059	1	1	1	1	0	0
9	-1	0	0	0.500000	1	1	1	0	0	0

```
def cmatrix(actual,predicted):
  '''
  confusion matrix
  '''
  true_pos,false_neg,false_pos,true_neg = [0]*4

  for p,a in zip(predicted,actual):

    #print((p,a))
    if (p,a) == (1,1):
      true_pos += 1
      continue

    if (p,a) == (1,0):
      false_pos += 1
      continue

    if (p,a) == (0,1):
      false_neg += 1
      continue

    if (p,a) == (0,0):
      true_neg += 1
      continue

    else:
      print('should_not_reach')
  return {'TP':true_pos, 'FN': false_neg, 'FP': false_pos, 'TN':true_neg}


print(cmatrix(df['y'],df['0'])) #Expected TP:6 FN:0 FP:4 FN:0
```

```
{'TP': 6, 'FN': 0, 'FP': 4, 'TN': 0}
```

```
m_0 = cmatrix(df['y'],df['0'])
m_2 = cmatrix(df['y'],df['0.2'])
m_4 = cmatrix(df['y'],df['0.4'])
m_6 = cmatrix(df['y'],df['0.6'])
m_8 = cmatrix(df['y'],df['0.8'])
m_1 = cmatrix(df['y'],df['1'])
```

```
m_6
```

```
{'TP': 5, 'FN': 1, 'FP': 1, 'TN': 3}
```

```
 #calculate y-axis: true positive rate   x-axis: false positive rate
```

```
def roc(m):
  '''
  tpr = true positive / true positive + false negative
  fpr = false positive/false postive + true negative
  '''
  tpr = m['TP']/(m['TP'] + m['FN'])
  fpr = m['FP']/(m['FP'] + m['TN'])

  return {'tp_rate': tpr, 'fp_rate':fpr}
```

```
print(roc(m_6)) #Expected {tp_rate: 0.833... , fp_rate: 0.25}
```

```
{'tp_rate': 0.8333333333333334, 'fp_rate': 0.25}
```

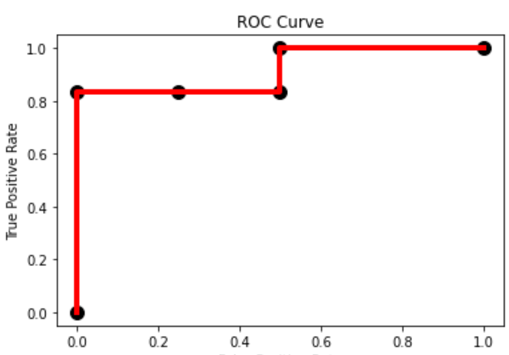
```
print(roc(m_0))
print(roc(m_2))
print(roc(m_4))
print(roc(m_6))
print(roc(m_8))
print(roc(m_1))
```

```
{'tp_rate': 1.0, 'fp_rate': 1.0}
{'tp_rate': 1.0, 'fp_rate': 0.5}
{'tp_rate': 0.8333333333333334, 'fp_rate': 0.5}
{'tp_rate': 0.8333333333333334, 'fp_rate': 0.25}
{'tp_rate': 0.8333333333333334, 'fp_rate': 0.0}
{'tp_rate': 0.0, 'fp_rate': 0.0}
```

ROC Curve

```
x = np.array([roc(m_0)['fp_rate'], roc(m_2)['fp_rate'], roc(m_4)['fp_rate'], roc(m_6)['fp_rate'],roc(m_8)['fp_rate'],roc(m_1)['fp_rate']])
y = np.array([roc(m_0)['tp_rate'], roc(m_2)['tp_rate'], roc(m_4)['tp_rate'], roc(m_6)['tp_rate'],roc(m_8)['tp_rate'],roc(m_1)['tp_rate']])

plt.plot(x, y, 'o', markersize = 10, color = 'black')
plt.plot(x,y, linewidth = 4, color = 'red')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.show()
```



AUROC:

The AUROC score evaluates the efficiency of model on a scale from 0 to 1; where 1 indicated a perfect classifier.

QUESTION 3: Evaluation Metrics

```
def new_thresh(y_hat):
  '''
  New decision threshold
  p >= 0.5
  '''
  if y_hat>=0.5:
    return 1
  return 0
```

```
df['0.5'] = df.apply(lambda x: new_thresh(x['y_hat']), axis = 1)
df
```

	x1	x2	y	y_hat	0	0.2	0.4	0.6	0.8	1	0.5
0	0	0	1	0.952574	1	1	1	1	1	0	1
1	0	1	1	0.268941	1	1	0	0	0	0	0
2	0	2	0	0.006693	1	0	0	0	0	0	0
3	1	0	1	0.997527	1	1	1	1	1	0	1
4	1	1	1	0.880797	1	1	1	1	1	0	1
5	1	2	0	0.119203	1	0	0	0	0	0	0
6	2	0	1	0.999877	1	1	1	1	1	0	1
7	2	1	1	0.993307	1	1	1	1	1	0	1
8	2	2	0	0.731059	1	1	1	1	0	0	1
9	-1	0	0	0.500000	1	1	1	0	0	0	1

```
conf_matrix = cmatrix(df['y'],df['0.5'])
conf_matrix
```

```
{'TP': 5, 'FN': 1, 'FP': 2, 'TN': 2}
```

```
accuracy = (conf_matrix['TP']+conf_matrix['TN'])/(conf_matrix['TP']+conf_matrix['FN']+conf_matrix['FP']+conf_matrix['TN'])
precision = (conf_matrix['TP'])/(conf_matrix['TP']+conf_matrix['FP'])
recall = (conf_matrix['TP'])/(conf_matrix['TP']+conf_matrix['FN']) #sensativity
specificity= (conf_matrix['TN'])/(conf_matrix['TN']+conf_matrix['FP'])
```

```
print(f"Accuracy: {accuracy *100}")
print(f"Precision: {precision *100}")
print(f"Recall: {recall *100}")
print(f"Specificity: {specificity *100}")
```

```
Accuracy: 70.0
Precision: 71.42857142857143
Recall: 83.33333333333334
Specificity: 50.0
```

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