Homework-2

PART-1 Identity System Evaluation

(a) For each of the systems, plot the genuine and impostor score distributions.

In [1]:
```
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd
```

In [2]:
```
sys1 = np.loadtxt('simMatrix1.txt', delimiter=' ')
sys2 = np.loadtxt('simMatrix2.txt', delimiter=' ')
```

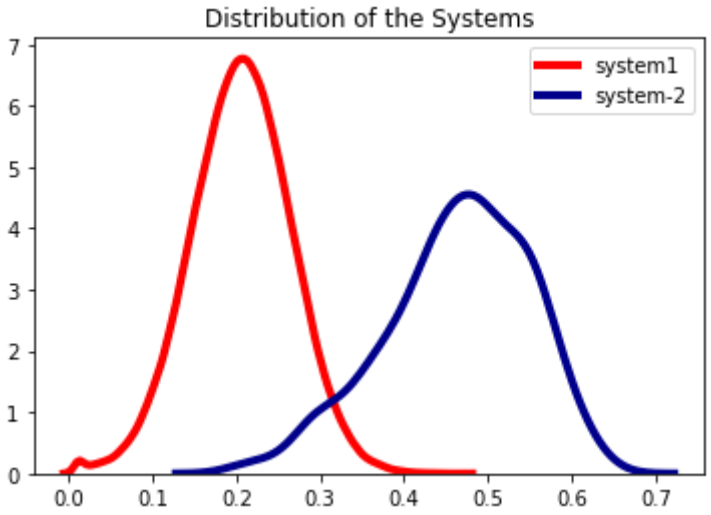
In [3]:
```
genuine_sys1 = sys1.diagonal()
genuine_sys2 = sys2.diagonal()
```

In [4]:
```
non_diag = np.ones(shape=sys1.shape, dtype = bool)^np.identity(len(sys1
)).astype(bool)
imposter_sys1 = sys1[non_diag==True]
```

In [5]:
```
non_diag = np.ones(shape=sys2.shape, dtype = bool)^np.identity(len(sys2
)).astype(bool)
imposter_sys2 = sys2[non_diag==True]
```

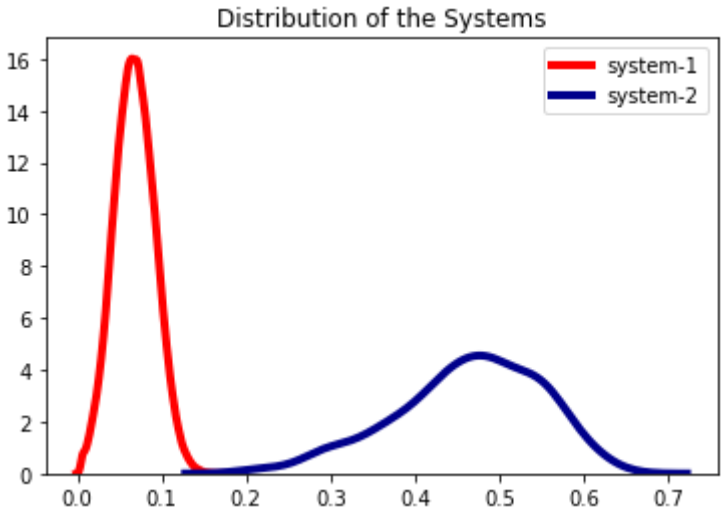
In [6]:
```
# Density Plot
s1 = sns.distplot(imposter_sys1, hist=False,
                  bins=int(180/5), color = 'red',
                  hist_kws={'edgecolor':'black'},
                  kde_kws={'linewidth': 4}, label = 'system1')

s2 = sns.distplot(genuine_sys1, hist=False,
                  bins=int(180/5), color = 'darkblue',
                  hist_kws={'edgecolor':'black'},
                  kde_kws={'linewidth': 4}, label='system-2')
plt.title('Distribution of the Systems')
```

Out[6]:
```
Text(0.5, 1.0, 'Distribution of the Systems')
```



In [7]:
```
# Density Plot and Histogram of all arrival delays
s1 = sns.distplot(imposter_sys2, hist=False,
             bins=int(180/5), color = 'red',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4}, label='system-1')

s2 = sns.distplot(genuine_sys1, hist=False,
             bins=int(180/5), color = 'darkblue',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 4}, label='system-2')
plt.title('Distribution of the Systems')
```

Out[7]:
```
Text(0.5, 1.0, 'Distribution of the Systems')
```



Cumulative Match Characteristic Curve

(b) For each of the systems, plot the Cumulative Match Characteristic curves.

(c) For each of the systems, calculate the d' (decidability index).

In [8]:
```
ordered_sys1 = np.zeros((466,466))
for i in range(0,len(sys1)):
    row = sys1[i]
    sort_row = np.sort(row)[::-1]
    ordered_sys1[i] = sort_row
```

In [9]:
```
ordered_sys2 = np.zeros((466,466))
for i in range(0,len(sys2)):
    row = sys2[i]
    sort_row = np.sort(row)[::-1]
    ordered_sys2[i] = sort_row
```

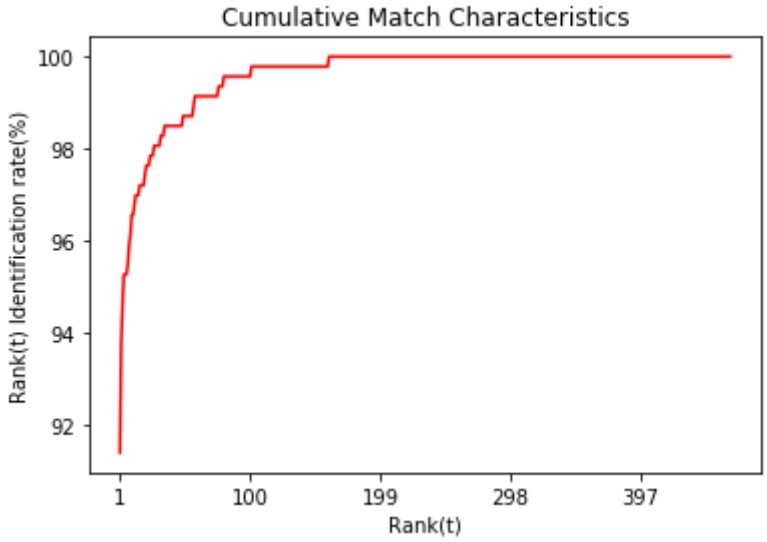
System1

In [10]:
```
rank_prob1 = []
for t in range(1,len(genuine_sys1)):
    prob = 0
    for r in range(0,len(ordered_sys1)):
        row = ordered_sys1[r]
        topt = row[0:t]
        if(np.isin(genuine_sys1[r],topt)):
            prob+=1
    prob = prob/466*100
    rank_prob1.append(prob)
```

In [11]:
```
t1 = np.arange(1,466)
```

In [12]:
```
plt.plot(t1,rank_prob1,'r')
plt.xlabel('Rank(t)')
plt.ylabel('Rank(t) Identification rate(%)')
plt.xticks(np.arange(1, 466, step=99))
plt.title('Cumulative Match Characteristics')
```

Out[12]:
```
Text(0.5, 1.0, 'Cumulative Match Characteristics')
```



Decidability Index

In [13]:
```
mean_genuine = np.mean(genuine_sys1)
mean_imposter = np.mean(imposter_sys1)
std_genuine = np.std(genuine_sys1)
std_imposter = np.std(imposter_sys1)
d1 = np.sqrt(2)*np.absolute(mean_genuine-mean_imposter)/np.sqrt(std_genu
ine**2+std_imposter**2)
print("Decidability Index =",d1)
```

```
Decidability Index = 3.516470545146112
```

(d) For each system, what is the lowest rank at which the system achieves performance greaterthan 70%?

System1 achieves performance greater than 70% from rank 1

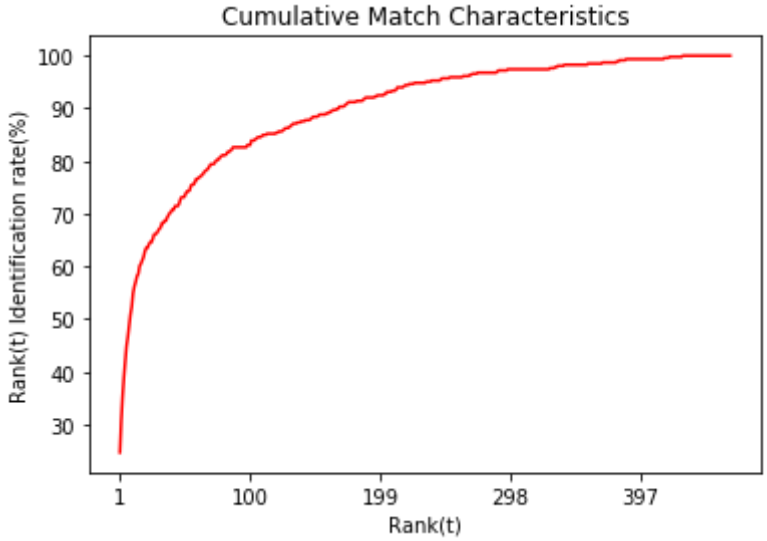
System2

In [14]:
```
rank_prob2 = []
for t in range(1,len(genuine_sys2)):
    prob = 0
    for r in range(0,len(ordered_sys2)):
        row = ordered_sys2[r]
        topt = row[0:t]
        if(np.isin(genuine_sys2[r],topt)):
            prob+=1
    prob = prob/466*100
    rank_prob2.append(prob)
```

In [15]:
```
t2 = np.arange(1,466)
```

In [16]:
```
plt.plot(t2,rank_prob2,'r')
plt.xlabel('Rank(t)')
plt.ylabel('Rank(t) Identification rate(%)')
plt.xticks(np.arange(1, 466, step=99))
plt.title('Cumulative Match Characteristics')
```

Out[16]: Text(0.5, 1.0, 'Cumulative Match Characteristics')



Decidability Index

In [17]:
```
mean_genuine = np.mean(genuine_sys2)
mean_imposter = np.mean(imposter_sys2)
std_genuine = np.std(genuine_sys2)
std_imposter = np.std(imposter_sys2)
d2 = np.sqrt(2)*np.absolute(mean_genuine-mean_imposter)/np.sqrt(std_genu
ine**2+std_imposter**2)
print("Decidability Index =",d2)
```

```
Decidability Index = 1.7116813276236182
```

(d) For each system, what is the lowest rank at which the system achieves performance greaterthan 70%?

System1 achieves performance greater than 70% from rank 40

PART-2 Verification System Evaluation

ROC Curve

(e) For each of the systems, plot the Receiver Operating Curve (FAR vs. FRR)

(f) For each of the systems, calculate the Equal Error Rate. At what operating point is this rate achieved for each system?

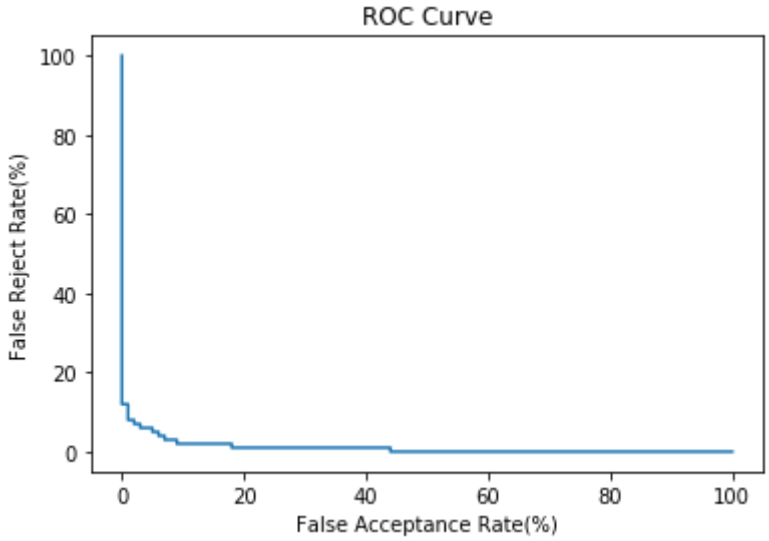
(g) For each of the systems, determine what the FRR is when the FAR = 1%, FAR = 5%, FAR = 10%, and FAR = 20%. Present results in tabular format.

System1

In [18]:
```
FAR=[]
FRR=[]
thresh = []
t=0
while(t<=1):
    thresh.append(t)
    far=len(imposter_sys1[imposter_sys1>t])/len(imposter_sys1)
    FAR.append(far)
    frr=len(genuine_sys1[genuine_sys1<t])/len(genuine_sys1)
    FRR.append(frr)
    t+=0.0001

FAR=np.round(np.array(FAR)*100)
FRR=np.round(np.array(FRR)*100)
```

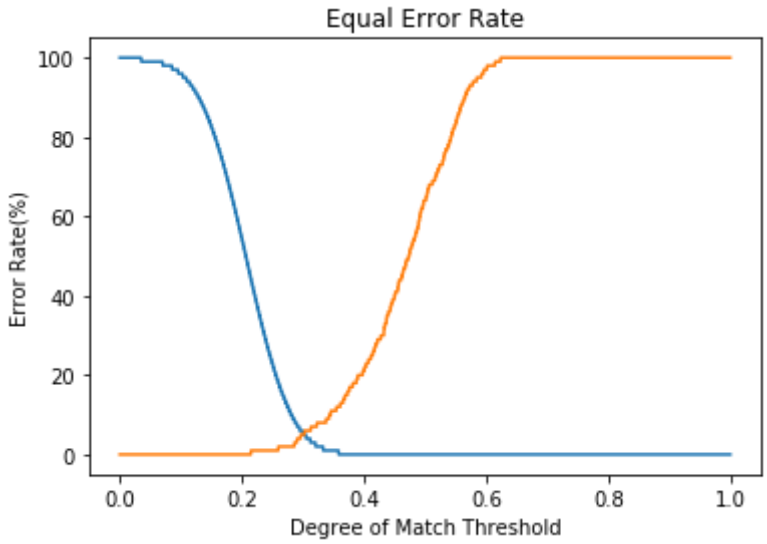
In [19]:
```
plt.plot(FAR,FRR)
plt.xlabel('False Acceptance Rate(%)')
plt.ylabel('False Reject Rate(%)')
plt.title('ROC Curve')
```

Out[19]: Text(0.5, 1.0, 'ROC Curve')



Equal Error Rate

In [20]:
```
p1 = plt.plot(thresh,FAR)
p2 = plt.plot(thresh,FRR)
plt.xlabel('Degree of Match Threshold')
plt.ylabel('Error Rate(%)')
plt.title("Equal Error Rate")
plt.show()
```



In [21]:
```
eer = FRR[np.argmin(np.absolute(FAR-FRR))]
print('Equal Error Rate',eer)
op_point = thresh[np.argmin(np.absolute(FAR-FRR))]
print('Operating Point',op_point)
```

```
Equal Error Rate 5.0
Operating Point 0.29919999999998337
```

Equal Error rate for system 1 is at 5%. The Operating Point or match threshold is 0.29

In [22]:
```
frr1 = np.min(FRR[np.where(FAR==1)])
frr5 = np.min(FRR[np.where(FAR==5)])
frr10 = np.min(FRR[np.where(FAR==10)])
frr20 = np.min(FRR[np.where(FAR==20)])
```

In [23]:
```
data = [['1%', frr1], ['5%', frr5], ['10%', frr10], ['20%', frr20]]
df = pd.DataFrame(data, columns = ['FRR', 'FAR'])
df
```

Out[23]:

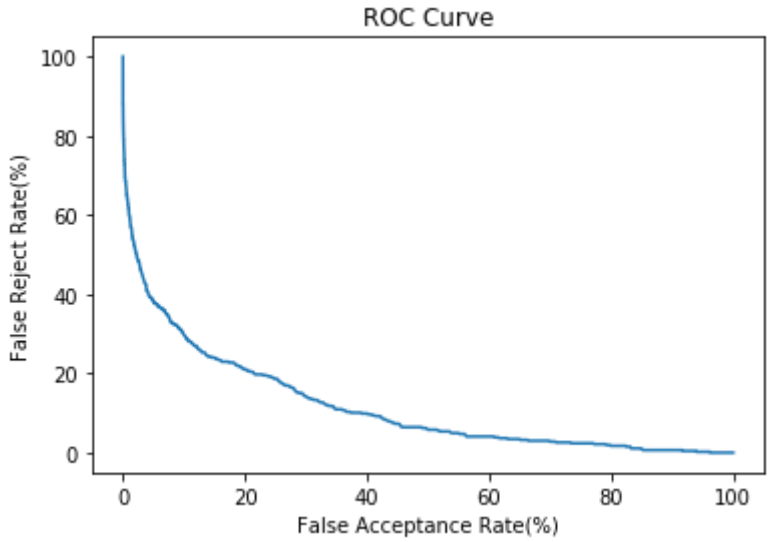
	FRR	FAR
0	1%	8.0
1	5%	5.0
2	10%	2.0
3	20%	1.0

Svstem2

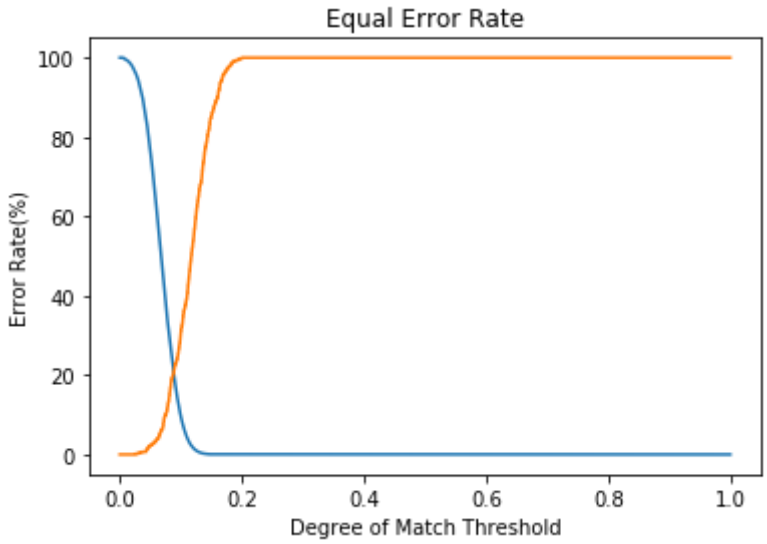
In [24]:
```
FAR=[]
FRR=[]
thresh = []
t=0
while(t<=1):
    thresh.append(t)
    far=len(imposter_sys2[imposter_sys2>t])/len(imposter_sys2)
    FAR.append(far)
    frr=len(genuine_sys2[genuine_sys2<t])/len(genuine_sys2)
    FRR.append(frr)
    t+=0.0001

FAR=np.round(np.array(FAR)*100,2)
FRR=np.round(np.array(FRR)*100,2)
```

In [25]:
```
plt.plot(FAR,FRR)
plt.xlabel('False Acceptance Rate(%)')
plt.ylabel('False Reject Rate(%)')
plt.title('ROC Curve')
```

Out[25]:
```
Text(0.5, 1.0, 'ROC Curve')
```



In [26]:
```
p1 = plt.plot(thresh,FAR)
p2 = plt.plot(thresh,FRR)
plt.xlabel('Degree of Match Threshold')
plt.ylabel('Error Rate(%)')
plt.title("Equal Error Rate")
plt.show()
```



In [27]:
```
eer = FRR[np.argmin(np.absolute(FAR-FRR))]
print('Equal Error Rate',eer)
op_point = thresh[np.argmin(np.absolute(FAR-FRR))]
print('Operating Point',op_point)
```

```
Equal Error Rate 20.6
Operating Point 0.0880000000000015
```

Equal Error rate for system 2 is at 20.6%. The Operating Point or match threshold is 0.088

In [28]:
```
frr1 = np.min(FRR[np.where(np.absolute(FAR-1)<=0.02)])
frr5 = np.min(FRR[np.where(np.absolute(FAR-5)<=0.02)])
frr10 = np.min(FRR[np.where(np.absolute(FAR-10)<=0.02)])
frr20 = np.min(FRR[np.where(np.absolute(FAR-20)<=0.05)])
```

In [29]:
```
data = [['1%', frr1], ['5%', frr5], ['10%', frr10], ['20%', frr20]]
df = pd.DataFrame(data, columns = ['FRR', 'FAR'])
df
```

Out[29]:

	FRR	FAR
0	1%	60.30
1	5%	38.20
2	10%	29.83
3	20%	21.03

System 1 performs better than System2. This can be verified by the fact that System1 has a lower equal error rate than System2. Also, the decidability index of system 1 is more than system 2.

References: [1] https://towardsdatascience.com/histograms-and-density-plots-in-python-f6bda88f5ac0 (https://towardsdatascience.com/histograms-and-density-plots-in-python-f6bda88f5ac0)

In [ ]: