CO3234 Pattern Recognition Assignment-1

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In [6]:
```
import idx2numpy
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import glob
import seaborn as sns


from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import confusion_matrix
```

Dataset

In [7]:
```
!ls
```

```
BankNote_Authentication.csv  q1.ipynb               t10k-labels.idx1-ubyte
pattern.ipynb                q2.ipynb               train-images.idx3-ubyte
pattern2.ipynb               t10k-images.idx3-ubyte  train-labels.idx1-ubyte
```

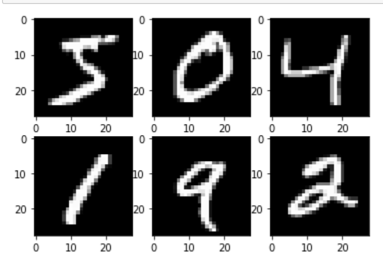
- Dataset downloaded from: http://yann.lecun.com/exdb/mnist/
- Importing Dataset and converting them into readable (numpy array) format

In [8]:
```
train_images = idx2numpy.convert_from_file('./train-images.idx3-ubyte')
train_labels = idx2numpy.convert_from_file('./train-labels.idx1-ubyte')

test_images = idx2numpy.convert_from_file('./t10k-images.idx3-ubyte')
test_labels = idx2numpy.convert_from_file('./t10k-labels.idx1-ubyte')
```

Data Exploration

Visualising data samples as grayscale images

In [9]:
```
for i in range(6):
    plt.subplot(2,3,i+1)
    plt.imshow(train_images[i], cmap='gray')
```

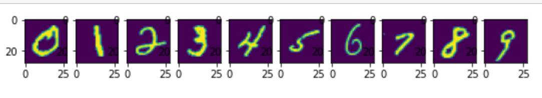


Data Exploration shows that the dataset contains images of digits 0-9

In [10]:
```
X = train_images
labels = np.unique(train_labels)
labels
```

Out[10]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype=uint8)
```

In [11]:
```
plt.figure(figsize= (9,9))

for i in labels:
    plt.subplot(1,10,i+1)
    img = np.array(X[train_labels == i][1:2]).reshape(28,28)
    plt.imshow(img)
```



Data Splitting and Model Training

In [12]:
```
X_train = train_images.reshape(60000, 28*28)
Y_train = train_labels

X_test = test_images.reshape(10000, 28*28)
Y_test = test_labels
```

I have used sklearn to build the gaussian bayes classifier model

In [13]:
```
nb_model = GaussianNB()
```

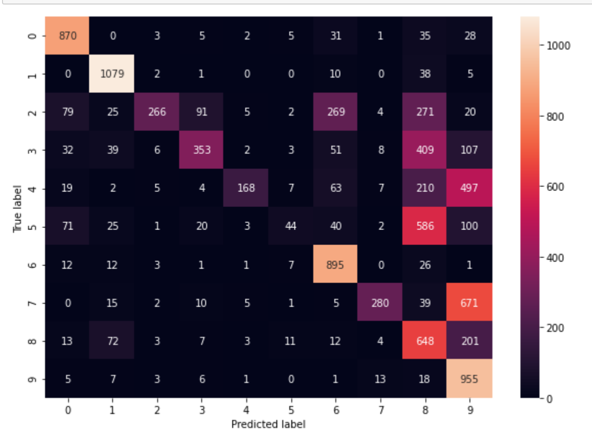
In [14]:
```
fit_nb = nb_model.fit(X_train, Y_train)
```

In [15]:
```
def draw_confusionmatrix(ytest, yhat):
    plt.figure(figsize=(10,7))
    cm = confusion_matrix(ytest, yhat)
    ax = sns.heatmap(cm, annot=True, fmt="d")
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

In [16]:
```
predictions = fit_nb.predict(X_test)
con_matrix = confusion_matrix(Y_test, predictions)
```

Confusion Matrix

In [17]:
```
draw_confusionmatrix(Y_test, predictions)
```



Q1. a) Design a classifier to distinguish between 0 and 1.

Filtering Dataset as per requirements

In [18]:
```
X_train = train_images.reshape(60000, 28*28)
Y_train = train_labels

X_test = test_images.reshape(10000, 28*28)
Y_test = test_labels


train_filter = np.where((Y_train == 0 ) | (Y_train == 1))
test_filter = np.where((Y_test == 0) | (Y_test == 1))
```

In [19]:
```
X_train, Y_train = X_train[train_filter], Y_train[train_filter]
X_test, Y_test = X_test[test_filter], Y_test[test_filter]
```

Now the training and testing dataset only contains data for digits 0 and 1

In [20]:
```
print(np.unique(Y_train))
print(np.unique(Y_test))
```

```
[0 1]
[0 1]
```

In [21]:
```
X_train.shape
```

Out[21]:
```
(12665, 784)
```

Building the model

In [22]:
```
nb_model01 = GaussianNB()
```

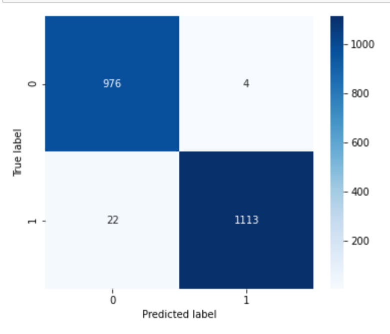
In [23]:
```
fit_nb01 = nb_model01.fit(X_train, Y_train)
```

In [24]:
```
predictions01 = fit_nb01.predict(X_test)



con_matrix01 = confusion_matrix(Y_test, predictions01)

print(con_matrix01)
```

```
[[ 976    4]
 [  22 1113]]
```

Confusion Matrix

In [25]:
```
def draw_confusionmatrix(ytest, yhat):
    plt.figure(figsize=(6,5))
    cm = confusion_matrix(ytest, yhat)
    ax = sns.heatmap(cm, annot=True, fmt="d", cmap = "Blues")
    plt.ylabel('True label')
    plt.xlabel('Predicted label')

draw_confusionmatrix(Y_test, predictions01)
```



In [26]:
```
def diag_sum(conmat):
    sum =0
    for i in range(len(conmat)):
        for j in range(len(conmat[0])):
            if i == j:
                sum += conmat[i,j]
    return sum
```

Q1. b) Compute classification accuracy using the predictions made by the model on testing dataset

In [27]:
```
accurate = diag_sum(con_matrix01)
total = np.sum(con_matrix01)
acc = accurate/total
print(f"accuracy = {accurate}/{total} = {acc*100}%")
```

```
accuracy = 2089/2115 = 98.77068557919621%
```

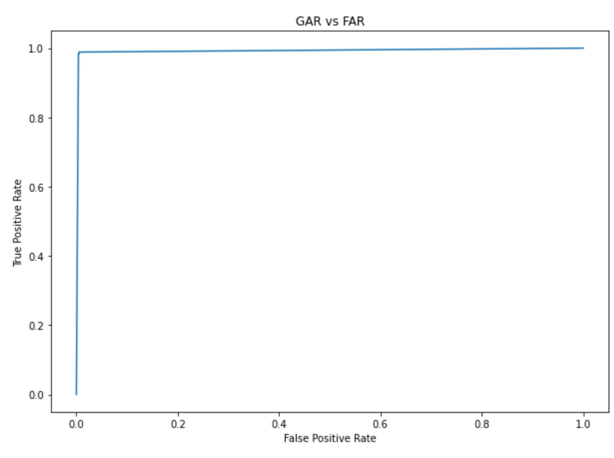
Q1. c) Plot the ROC curve

In [54]:
```
from sklearn.metrics import roc_curve, plot_roc_curve, roc_auc_score
from sklearn.preprocessing import LabelEncoder
```

In [29]:
```
probs = fit_nb01.predict_proba(X_test)
preds = probs[:,1]


fpr, tpr, threshold = roc_curve(Y_test, preds)
```

In [30]:
```
plt.figure(figsize=(10,7))
plt.plot(fpr,tpr)
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('GAR vs FAR')
```

Out[30]:
```
Text(0.5, 1.0, 'GAR vs FAR')
```



In [31]:
```
auc = roc_auc_score(Y_test, preds)
print(f"AUC: {auc*100}%")
```

```
AUC: 99.22030926908208%
```

Q1. d) Repeat the same for digits 3 and 8

Filtering Data

In [32]:
```
X_train = train_images.reshape(60000, 28*28)
Y_train = train_labels

X_test = test_images.reshape(10000, 28*28)
Y_test = test_labels

train_filter = np.where((Y_train == 3 ) | (Y_train == 8))
test_filter = np.where((Y_test == 3) | (Y_test == 8))
```

In [33]:
```
X_train, Y_train = X_train[train_filter], Y_train[train_filter]
X_test, Y_test = X_test[test_filter], Y_test[test_filter]
```

In [34]:
```
print(np.unique(Y_train))
print(np.unique(Y_test))
```

```
[3 8]
[3 8]
```

In [35]:
```
X_train.shape
```

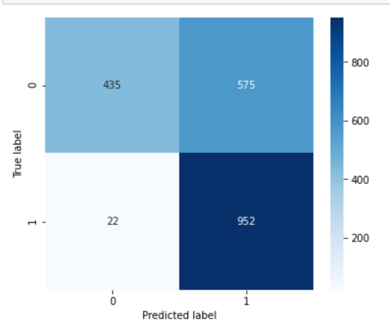
Out[35]:
```
(11982, 784)
```

In [36]:
```
nb_model38 = GaussianNB()
fit_nb38 = nb_model38.fit(X_train, Y_train)
```

In [37]:
```
predictions38 = fit_nb38.predict(X_test)
con_matrix38 = confusion_matrix(Y_test, predictions38)

print(Y_test)
print(con_matrix38)
```

```
[3 3 3 ... 3 8 3]
[[435 575]
 [ 22 952]]
```

In [38]:
```
def draw_confusionmatrix(ytest, yhat):
    plt.figure(figsize=(6,5))
    cm = confusion_matrix(ytest, yhat)
    ax = sns.heatmap(cm, annot=True, fmt="d", cmap = "Blues")
    plt.ylabel('True label')
    plt.xlabel('Predicted label')

draw_confusionmatrix(Y_test, predictions38)
```



Accuracy

In [46]:
```
accurate = diag_sum(con_matrix38)
total = np.sum(con_matrix38)
acc = accurate/total
print(f"accuracy = {accurate}/{total} = {acc*100}%")
```

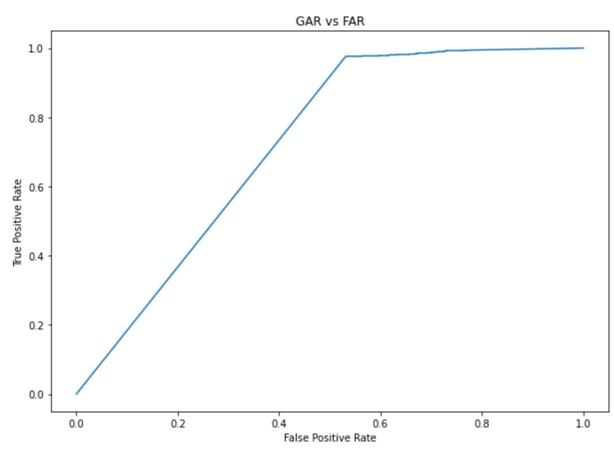
```
accuracy = 1387/1984 = 69.90927419354838%
```

In [56]:
```
probs = fit_nb38.predict_proba(X_test)
preds = probs[:,1]

label_encoder = LabelEncoder()
y = label_encoder.fit_transform(Y_test)

fpr, tpr, threshold = roc_curve(y, preds)
```

ROC Curve

In [57]:
```
plt.figure(figsize=(10,7))
plt.plot(fpr,tpr)
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('GAR vs FAR')
```

Out[57]:
```
Text(0.5, 1.0, 'GAR vs FAR')
```



In [58]:
```
auc = roc_auc_score(y, preds)
print(f"AUC: {auc*100}%")
```

```
AUC: 72.32261573179903%
```