```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from keras.utils import np_utils
from scipy.stats import multivariate_normal as mvn

#Import .py file of general algorithms
from google.colab import files
files.upload()
from general import KNNClassifier as knn
from general import accuracy
from general import confusionMatrix
from general import GaussBayes as gb
from general import GaussNB as ngb
```

Elegir archivos Ninguno archivo selec. Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving general.py to general.py
```

Work with the data

Import the data, and create the train and test sets. Normalize and visualize your data

```
train_data = pd.read_csv('/content/drive/MyDrive/Enhance It/Training Projects/MNIST Bayes and
train_data
```

```
test_data = pd.read_csv('/content/drive/MyDrive/Enhance It/Training Projects/MNIST Bayes and
test_data
```

	Unnamed: 0	index	labels	0	1	2	3	4	5	6	...	774	775	776	777	778	77
0	0	0	7	0	0	0	0	0	0	0	...	0	0	0	0	0	(
1	1	1	2	0	0	0	0	0	0	0	...	0	0	0	0	0	(
2	2	2	1	0	0	0	0	0	0	0	...	0	0	0	0	0	(
3	3	3	0	0	0	0	0	0	0	0	...	0	0	0	0	0	(
4	4	4	4	0	0	0	0	0	0	0	...	0	0	0	0	0	(
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..
9995	9995	9995	2	0	0	0	0	0	0	0	...	0	0	0	0	0	(
9996	9996	9996	3	0	0	0	0	0	0	0	...	0	0	0	0	0	(
9997	9997	9997	4	0	0	0	0	0	0	0	...	0	0	0	0	0	(
9998	9998	9998	5	0	0	0	0	0	0	0	...	0	0	0	0	0	(
9999	9999	9999	6	0	0	0	0	0	0	0	...	0	0	0	0	0	(

10000 rows × 787 columns

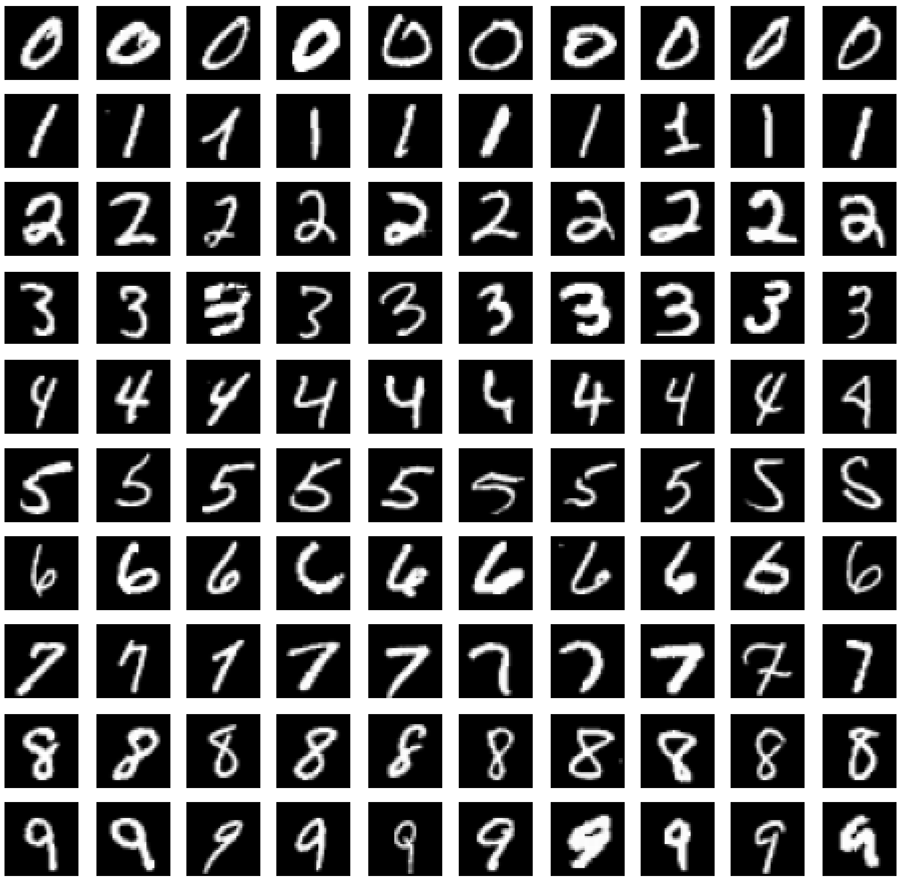
```
X_train = train_data.to_numpy()
X_test = test_data.to_numpy()
x_train = X_train[:,3:].astype('float32')
x_test = X_test[:,3:].astype('float32')
y_train = X_train[:,2]
y_test = X_test[:,2]

print(f"Train set: {x_train.shape},{y_train.shape}")
print(f"Train set: {x_test.shape},{y_test.shape}")
```

```
Train set: (60000, 784),(60000,)
Train set: (10000, 784),(10000,)
```

```
#Normalize the data
x_train /= 255
x_test /= 255
```

```
#Visualize 10 random training data from every single number
x_vis = X_train[:,3:].reshape(len(x_train),28,28)

plt.figure(figsize=(8,8))
for i in range(10):
```

```
    index = np.where(y_train == i)
    index = index[0][np.random.randint(index[0].shape[0], size=10)]
    for j in range(10):
      plt.subplot(10,10,i*10+j+1)
      plt.imshow(x_vis[index[j]], cmap='gray')
      plt.axis('off')
  plt.show()
```



Use of Naive Bayes

```
mnist_naive = ngb()
epsilons = np.linspace(1e-3,1e-1)
naive_accuracies = np.zeros(len(epsilons))


for i in range(len(epsilons)):
  print(f'Checking epsilon {i+1} out of {len(epsilons)}...')
  mnist_naive.fit(x_train,y_train,epsilon=epsilons[i])
  y_hat_naive = mnist_naive.predict(x_train)
  naive_accuracies[i] = accuracy(y_train,y_hat_naive)
#print(train_acc_naive)
```

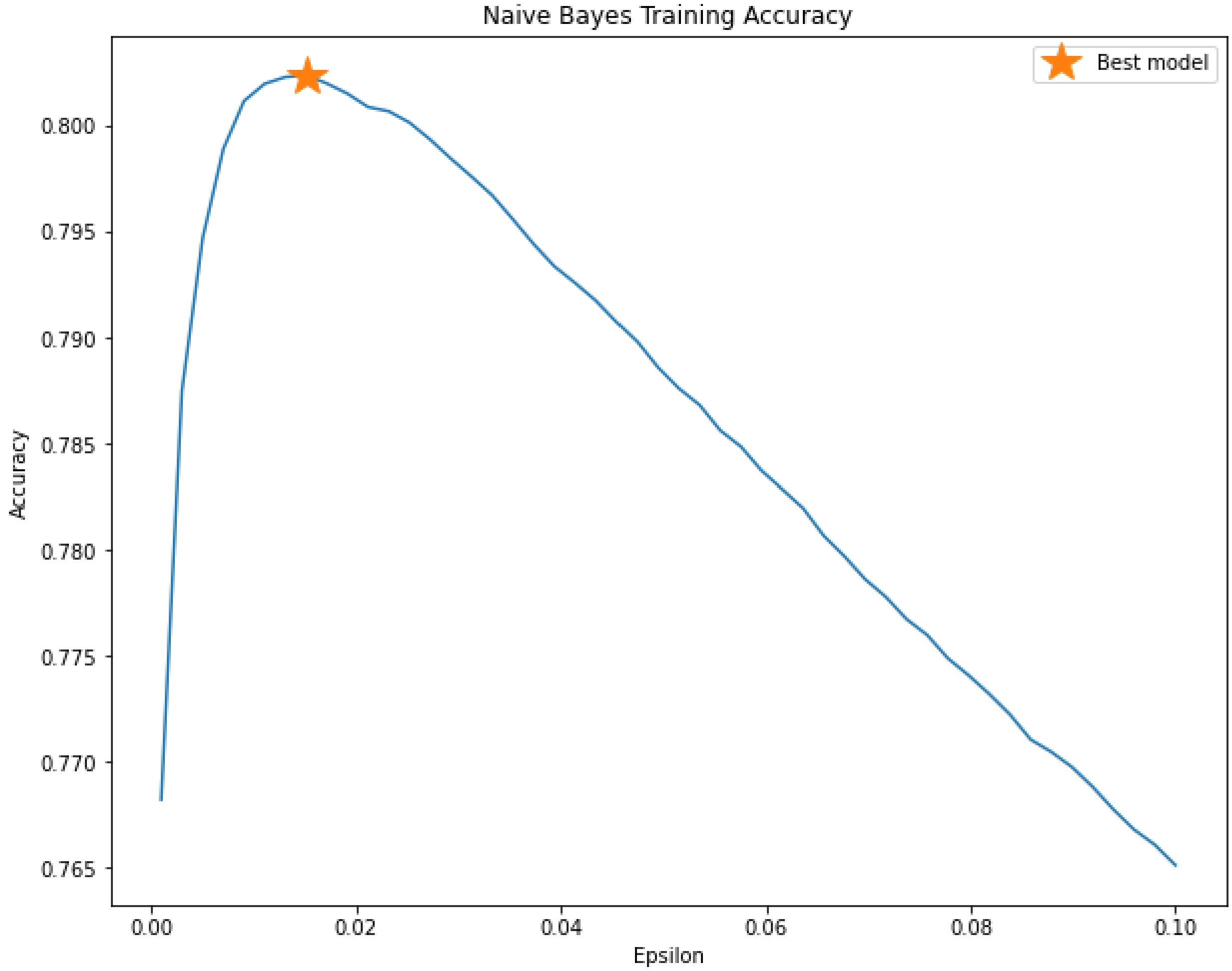
```
    Checking epsilon 1 out of 50...
    Checking epsilon 2 out of 50...
    Checking epsilon 3 out of 50...
```

```
Checking epsilon 4 out of 50...
Checking epsilon 5 out of 50...
Checking epsilon 6 out of 50...
Checking epsilon 7 out of 50...
Checking epsilon 8 out of 50...
Checking epsilon 9 out of 50...
Checking epsilon 10 out of 50...
Checking epsilon 11 out of 50...
Checking epsilon 12 out of 50...
Checking epsilon 13 out of 50...
Checking epsilon 14 out of 50...
Checking epsilon 15 out of 50...
Checking epsilon 16 out of 50...
Checking epsilon 17 out of 50...
Checking epsilon 18 out of 50...
Checking epsilon 19 out of 50...
Checking epsilon 20 out of 50...
Checking epsilon 21 out of 50...
Checking epsilon 22 out of 50...
Checking epsilon 23 out of 50...
Checking epsilon 24 out of 50...
Checking epsilon 25 out of 50...
Checking epsilon 26 out of 50...
Checking epsilon 27 out of 50...
Checking epsilon 28 out of 50...
Checking epsilon 29 out of 50...
Checking epsilon 30 out of 50...
Checking epsilon 31 out of 50...
Checking epsilon 32 out of 50...
Checking epsilon 33 out of 50...
Checking epsilon 34 out of 50...
Checking epsilon 35 out of 50...
Checking epsilon 36 out of 50...
Checking epsilon 37 out of 50...
Checking epsilon 38 out of 50...
Checking epsilon 39 out of 50...
Checking epsilon 40 out of 50...
Checking epsilon 41 out of 50...
Checking epsilon 42 out of 50...
Checking epsilon 43 out of 50...
Checking epsilon 44 out of 50...
Checking epsilon 45 out of 50...
Checking epsilon 46 out of 50...
Checking epsilon 47 out of 50...
Checking epsilon 48 out of 50...
Checking epsilon 49 out of 50...
Checking epsilon 50 out of 50...
```

```
max_acc = max(naive_accuracies)
best_e = epsilons[np.where(naive_accuracies == max_acc)]
print(best_e, max_acc)

plt.figure(figsize=(10,8))
plt.plot(epsilons,naive_accuracies)
```

```
plt.plot(best_e,max_acc,'*',markersize=20,label='Best model')
plt.legend()
plt.xlabel('Epsilon')
plt.ylabel('Accuracy')
plt.title('Naive Bayes Training Accuracy')
```

```
[0.01514286] 0.8024
Text(0.5, 1.0, 'Naive Bayes Training Accuracy')
```

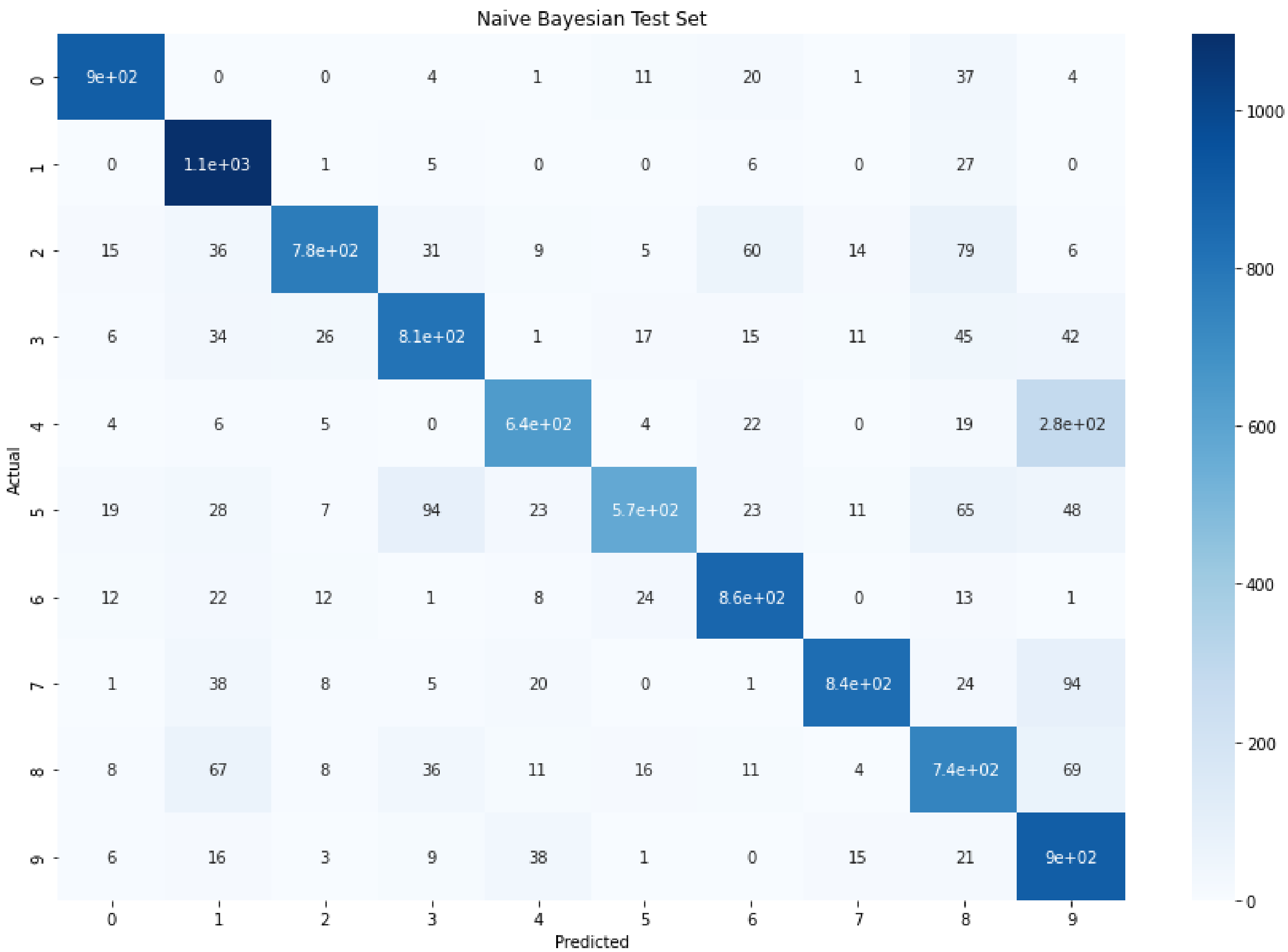



```
#Check the model with the test set
mnist_naive.fit(x_train,y_train,epsilon=best_e)
test_naive = mnist_naive.predict(x_test)
naive_test_acc = accuracy(y_test,test_naive)

print(f"Training accuracy: {max_acc}     Test accuracy: {naive_test_acc}")
```

```
Training accuracy: 0.8024     Test accuracy: 0.8148
```

```
#Get the confusion matrix
naive_conf = confusionMatrix(y_test,test_naive)

plt.figure(figsize=(15,10))
conf_plt = sns.heatmap(naive_conf, annot=True, cmap='Blues')
conf_plt.set_title('Naive Bayesian Test Set')
```

```
conf_plt.set_xlabel('Predicted')
conf_plt.set_ylabel('Actual')
conf_plt.xaxis.set_ticklabels(['0','1', '2','3','4','5','6','7','8','9'])
conf_plt.yaxis.set_ticklabels(['0','1', '2','3','4','5','6','7','8','9'])
plt.show()
```



Use of Non-naive Bayes

```
mnist_gauss = gb()
bayes_accuracies = np.zeros(len(epsilons))


for i in range(len(epsilons)):
  print(f'Checking epsilon {i+1} out of {len(epsilons)}...')
  mnist_gauss.fit(x_train,y_train,epsilon=epsilons[i])
  y_hat_gauss = mnist_gauss.predict(x_train)
```

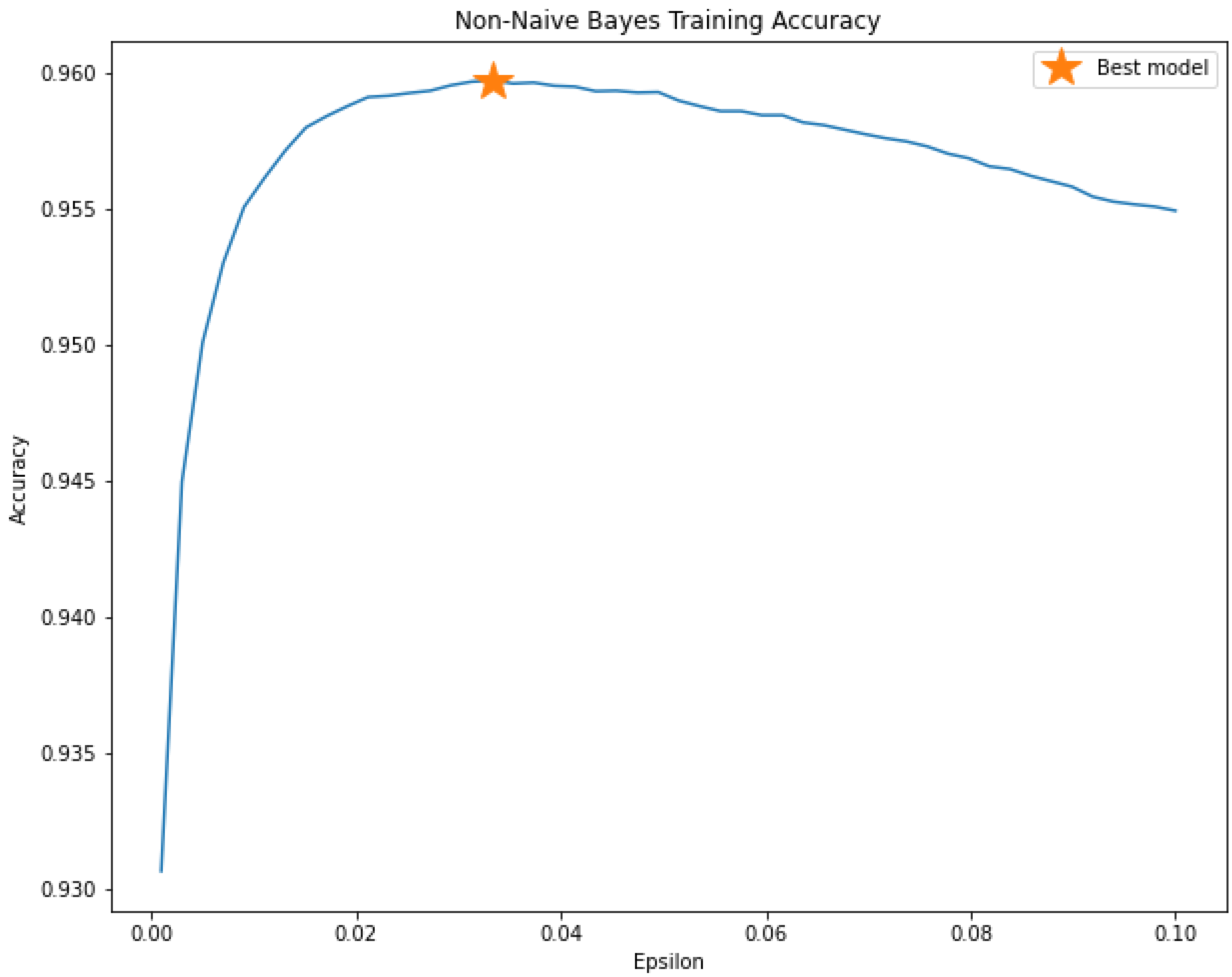
```
    bayes_accuracies[i] = accuracy(y_train,y_hat_gauss)
#print(train_acc_gauss)
```

```
Checking epsilon 1 out of 50...
Checking epsilon 2 out of 50...
Checking epsilon 3 out of 50...
Checking epsilon 4 out of 50...
Checking epsilon 5 out of 50...
Checking epsilon 6 out of 50...
Checking epsilon 7 out of 50...
Checking epsilon 8 out of 50...
Checking epsilon 9 out of 50...
Checking epsilon 10 out of 50...
Checking epsilon 11 out of 50...
Checking epsilon 12 out of 50...
Checking epsilon 13 out of 50...
Checking epsilon 14 out of 50...
Checking epsilon 15 out of 50...
Checking epsilon 16 out of 50...
Checking epsilon 17 out of 50...
Checking epsilon 18 out of 50...
Checking epsilon 19 out of 50...
Checking epsilon 20 out of 50...
Checking epsilon 21 out of 50...
Checking epsilon 22 out of 50...
Checking epsilon 23 out of 50...
Checking epsilon 24 out of 50...
Checking epsilon 25 out of 50...
Checking epsilon 26 out of 50...
Checking epsilon 27 out of 50...
Checking epsilon 28 out of 50...
Checking epsilon 29 out of 50...
Checking epsilon 30 out of 50...
Checking epsilon 31 out of 50...
Checking epsilon 32 out of 50...
Checking epsilon 33 out of 50...
Checking epsilon 34 out of 50...
Checking epsilon 35 out of 50...
Checking epsilon 36 out of 50...
Checking epsilon 37 out of 50...
Checking epsilon 38 out of 50...
Checking epsilon 39 out of 50...
Checking epsilon 40 out of 50...
Checking epsilon 41 out of 50...
Checking epsilon 42 out of 50...
Checking epsilon 43 out of 50...
Checking epsilon 44 out of 50...
Checking epsilon 45 out of 50...
Checking epsilon 46 out of 50...
Checking epsilon 47 out of 50...
Checking epsilon 48 out of 50...
Checking epsilon 49 out of 50...
Checking epsilon 50 out of 50...
```

```
max_acc = max(bayes_accuracies)
best_e = epsilons[np.where(bayes_accuracies == max_acc)]
```

```
print(best_e, max_acc)

plt.figure(figsize=(10,8))
plt.plot(epsilons,bayes_accuracies)
plt.plot(best_e,max_acc,'*',markersize=20,label='Best model')
plt.legend()
plt.xlabel('Epsilon')
plt.ylabel('Accuracy')
plt.title('Non-Naive Bayes Training Accuracy')
```

```
[0.03332653] 0.9597333333333333
Text(0.5, 1.0, 'Non-Naive Bayes Training Accuracy')
```

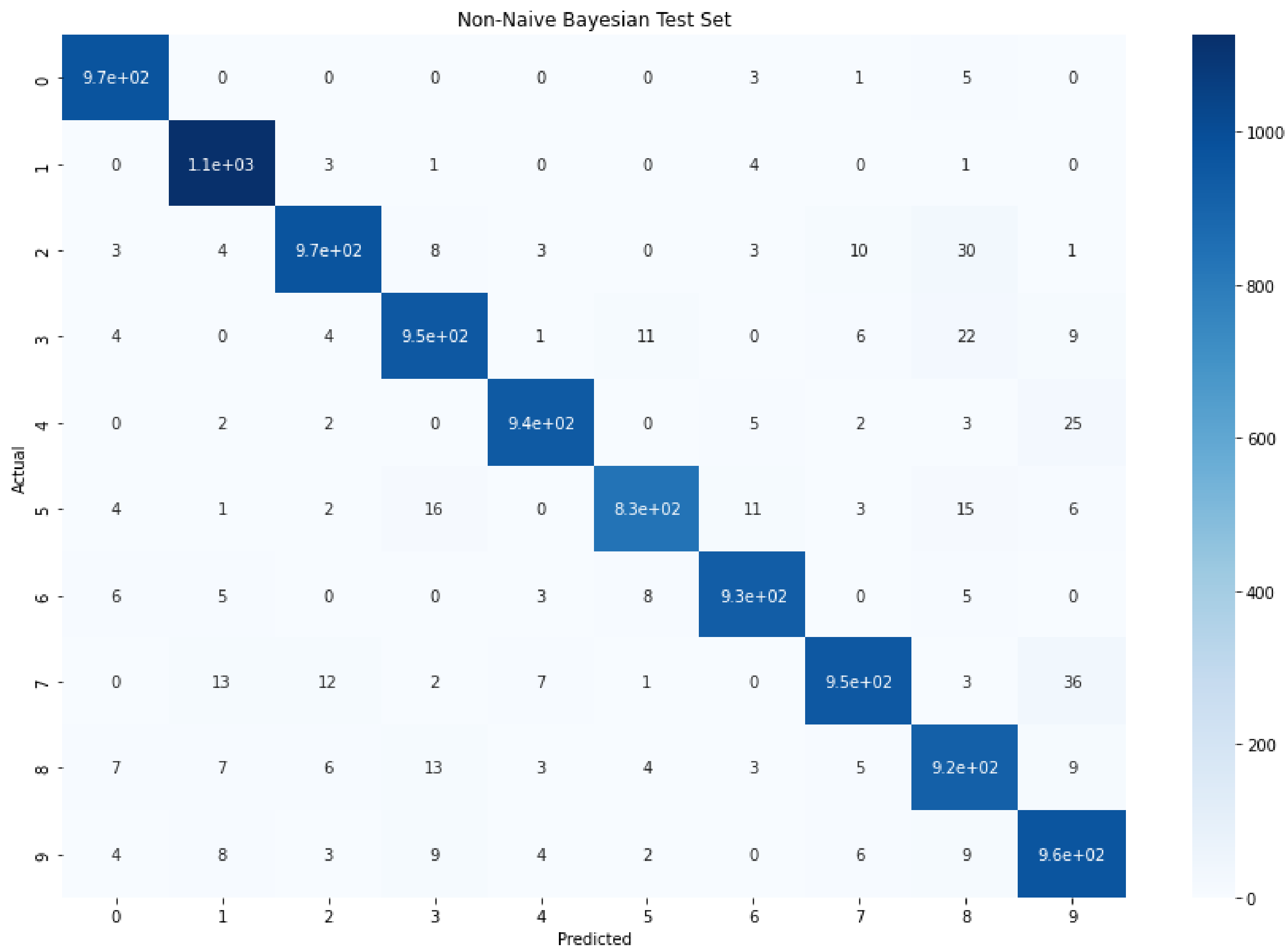



```
#Check the model with the test set
mnist_gauss.fit(x_train,y_train,epsilon=best_e)
test_bayes = mnist_gauss.predict(x_test)
gauss_test_acc = accuracy(y_test,test_bayes)

print(f"Training accuracy: {max_acc}     Test accuracy: {gauss_test_acc}")
```

```
Training accuracy: 0.9597333333333333     Test accuracy: 0.9563
```

```
#Create the confusion matrix
```

```
bayes_conf = confusionMatrix(y_test,test_bayes)

plt.figure(figsize=(15,10))
conf_plt = sns.heatmap(bayes_conf, annot=True, cmap='Blues')
conf_plt.set_title('Non-Naive Bayesian Test Set')
conf_plt.set_xlabel('Predicted')
conf_plt.set_ylabel('Actual')
conf_plt.xaxis.set_ticklabels(['0','1', '2','3','4','5','6','7','8','9'])
conf_plt.yaxis.set_ticklabels(['0','1', '2','3','4','5','6','7','8','9'])
plt.show()
```



Use of KNN

Cannot implement due to high dimensionality

```
#Reshape the data for x
```

```
x_train = x_train.reshape(len(x_train),28,28)
x_train.shape
```

```
(60000, 28, 28)
```

```
with tf.device('/device:GPU:0'):
  mnist_knn = knn()
  mnist_knn.fit(x_train,y_train)

  neighbors = [x for x in range(2,11)]
  knn_acc = np.zeros(len(neighbors))

  for i in range(len(neighbors)):
    print(f"Checking {i+1} out of {len(neighbors)+1}...")
    y_hat = mnist_knn.predict(x_train, neighbors[i])
    knn_acc[i] = accuracy(y_train,y_hat)
```

```
Checking 1 out of 10...
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-31-eb89569fa6e3> in <module>()
      8   for i in range(len(neighbors)):
      9     print(f"Checking {i+1} out of {len(neighbors)+1}...")
---> 10     y_hat = mnist_knn.predict(x_train, neighbors[i])
     11     knn_acc[i] = accuracy(y_train,y_hat)

/content/general.py in predict(self, x, k, epsilon)
     54
     55     for i in range(N):
---> 56       dist_sqr = np.sum((self.x - x[i])**2, axis=1) #Get the squared distance of
     57       idxt = np.argsort(dist_sqr)[:k] #Get the indexes of the K nearest neighbor
     58       gamma_k = 1 / (np.sqrt(dist_sqr[idxt]+epsilon)) #Get the weights

KeyboardInterrupt:
```

SEARCH STACK OVERFLOW

```
max_acc = max(knn_acc)
best_k = neighbors[np.where(knn_acc == max_acc)]

plt.figure(figsize=(10,8))
plt.plot(neighbors,knn_acc)
plt.plot(best_k,max_acc,'*',markersize=20,label='Best model')
plt.legend()
plt.xlabel('K neighbors')
plt.ylabel('Accuracy')
plt.title('KNN Training Accuracy')
```

```
#Determine the best number of neighbors for the classification
plt.figure(figsize=(10,6))
```

```
plt.plot(neighbors,accuracies)
plt.xlabel('Neighbors')
plt.ylabel('Train accuracy')
```