Gaussian Bayes Classifier(non Naive)

```
#Importing the libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sn
from scipy.stats import multivariate_normal as mvn
```

```
#importing the training data
data=pd.read_csv('/content/drive/MyDrive/Classroom/Artificial Mariachi Intelligence/Aldo Cao
data.head(5)
```

	Unnamed: 0	index	labels	0	1	2	3	4	5	6	...	774	775	776	777	778	779
0	0	0	5	0	0	0	0	0	0	0	...	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
2	2	2	4	0	0	0	0	0	0	0	...	0	0	0	0	0	0
3	3	3	1	0	0	0	0	0	0	0	...	0	0	0	0	0	0
4	4	4	9	0	0	0	0	0	0	0	...	0	0	0	0	0	0

```
#Observing the data shape
data.shape
```

```
(60000, 787)
```

```
#Dropping unnecessary columns
data = data.drop(['Unnamed: 0','index'], 1)
data
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:2: FutureWarning: In a futu
```

	labels	0	1	2	3	4	5	6	7	8	...	774	775	776	777	778	779	780	78
0	5	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
2	4	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
3	1	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
4	9	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
59995	8	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	
59996	3	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	

```
#Converting the data into an array and Selecting the columns for the X and y variables
X = data.to_numpy()
y = X[:,0]
X = X[:,1:]/255
```

60000 rows × 785 columns

```
#Verifiyin the shape of the data
X.shape
```

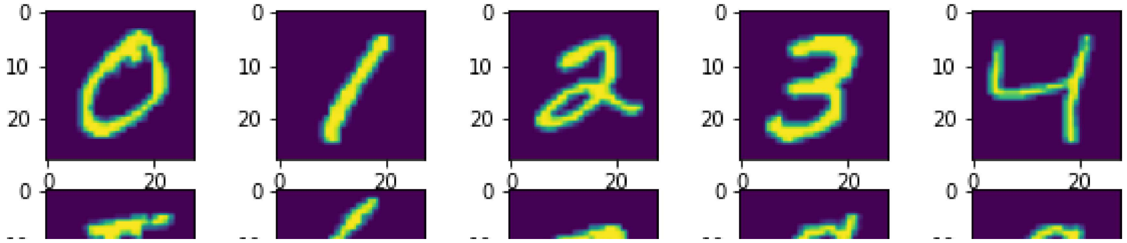
```
(60000, 784)
```

```
y.shape
```

```
(60000,)
```

```
##Adjusting the sahe of the data into a square matrix of matrices
X_sqrt = np.reshape(X, (60000,28,28))
```

```
#Plotting some examples of the visulization of the data
plt.figure(figsize=(10,3))
for i in range(10):
  index= np.where(y==i)
  index=index[0][0]
  plt.subplot(2,5,i+1)
  plt.imshow(X_sqrt[index])
```



```
##Defining the algorithm
class GaussBayes():

  def fit(self, X, y, epsilon=1e-3):

    self.likelihoods = dict()
    self.priors=dict()
    self.K=set(y.astype(int))

    for k in self.K:

      X_k=X[y==k,:]
      N_k, D= X_k.shape
      mu_k = X_k.mean(axis=0)

      self.likelihoods[k]= {'mean':X_k.mean(axis=0), 'cov':(1/(N_k-1))*np.matmul((X_k-mu_k).T
      self.priors[k]=len(X_k)/len(X)
  def predict(self,X):

    N,D=X.shape
    P_hat = np.zeros((N, len(self.K)))

    for k, l in self.likelihoods.items():
      P_hat[:,k]=mvn.logpdf(X,l['mean'],l['cov'])+np.log(self.priors[k])

    return P_hat.argmax(axis=1)



#Fitting and predicting the data
gbayes=GaussBayes()
gbayes.fit(X,y)
y_hat=gbayes.predict(X)


#Defining the accuracy
def accuracy(y,y_hat):
  return np.mean(y==y_hat)


#Getting the accuracy
accuracy(y,y_hat)
```

```
     0.9306333333333333
```

```
#Obteining the Data frame of the prediction and the actual values
results = pd.DataFrame({'Actual': y, 'prediction': y_hat})
results.head(10)
```

	Actual	prediction
0	5	5
1	0	0
2	4	4
3	1	1
4	9	9
5	2	2
6	1	1
7	3	3
8	1	1
9	4	4

```
confusion_matrix1=[]
for i in range(0,10):
  b=[]
  for j in range(0,10):
    x=results[(results['Actual']==j)&(results['prediction']==i)].shape[0]
    b.append(x)
  confusion_matrix1.append(b)
plt.figure(figsize=(10,5))
matrix=pd.DataFrame(confusion_matrix1)
sn.heatmap(matrix, cmap="BrBG",annot=True)
plt.show
```

```
<function matplotlib.pyplot.show>
```

Testing

```
#Importing the testing data
data=pd.read_csv('/content/drive/MyDrive/Classroom/Artificial Mariachi Intelligence/Aldo Cao
```

```
#Observing the data
data.head(5)
```

	Unnamed: 0	index	labels	0	1	2	3	4	5	6	...	774	775	776	777	778	779
0	0	0	7	0	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	0
2	2	2	1	0	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	0
4	4	4	4	0	0	0	0	0	0	0	...	0	0	0	0	0	0

```
t=data.drop(['Unnamed: 0','index'], 1)
X_test = t.to_numpy()
y_test = X_test[:,0]
X_test = X_test[:,1:]/255
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:1: FutureWarning: In a futu
  """Entry point for launching an IPython kernel.
```

```
#Getting the shape of the data
X_test.shape
```

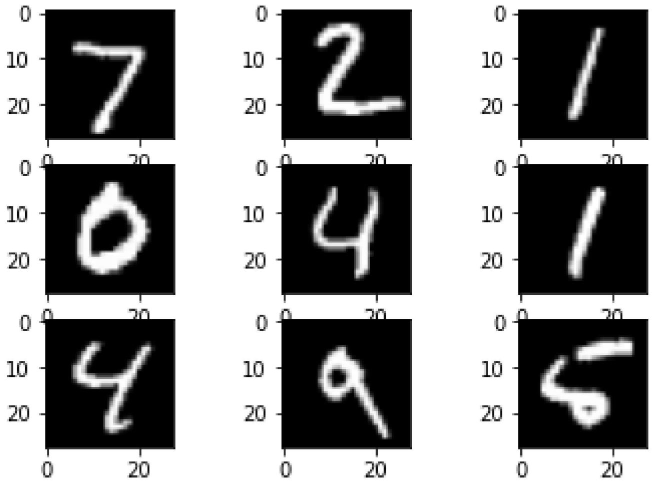
```
(10000, 784)
```

```
y_test.shape
```

```
(10000,)
```

```
#Reshaping the data
X_sqrt_test = np.reshape(X_test, (10000,28,28))
```

```
#Showing some examples
for i in range(9):
  plt.subplot(330 + 1 + i)
  plt.imshow(X_sqrt_test[i], cmap=plt.get_cmap('gray'))
```



```
#Fitting and predciting the test data
gbayes_test=GaussBayes()
gbayes_test.fit(X_test,y_test)
y_hat_test=gbayes_test.predict(X_test)
```

```
#Getting the accuracy
accuracy(y_test,y_hat_test)
```

```
     0.9948
```

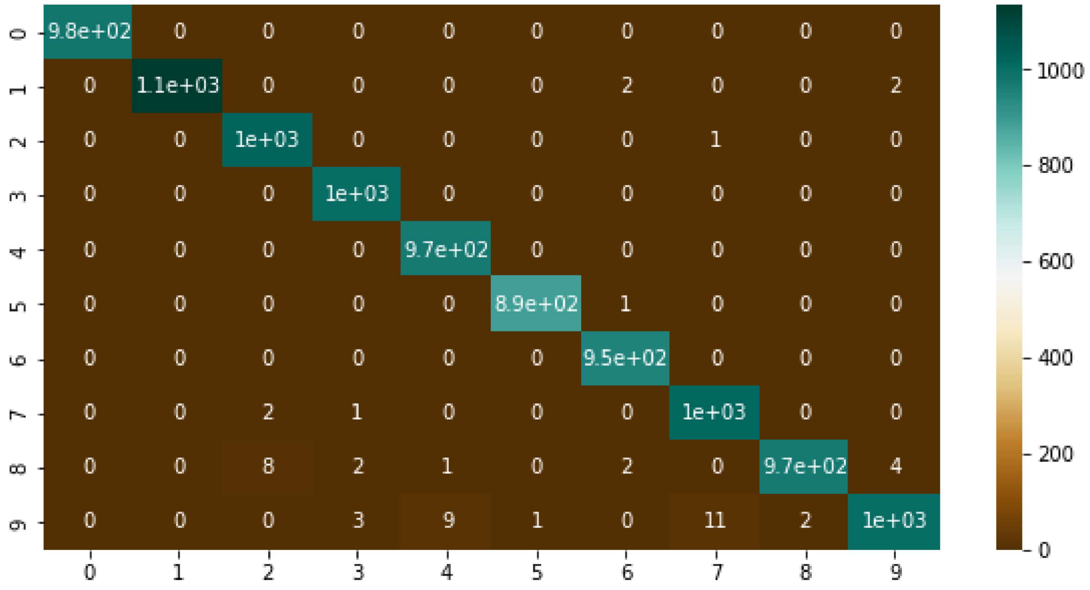
```
#CrEating a data frame for the results
results = pd.DataFrame({'Actual': y_test, 'Predict': y_hat_test})
results.head(10)
```

	Actual	Predict
0	7	7
1	2	2

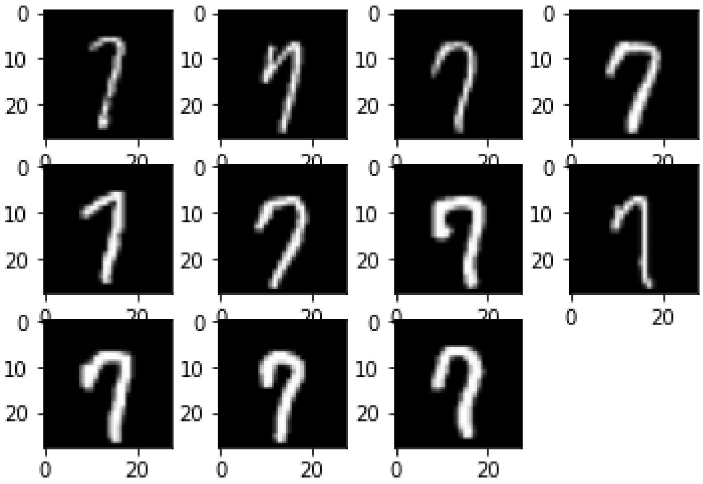
```
##Creation of the Confusion matrix
confusion_matrix=[]
for i in range(0,10):
  b=[]
  for j in range(0,10):
    x=results[(results['y']==j)&(results['y_pred']==i)].shape[0]
    b.append(x)
  confusion_matrix.append(b)
```

```
#Heatmap of the confusion matrix
plt.figure(figsize=(10,5))
matrix=pd.DataFrame(confusion_matrix)
sn.heatmap(matrix,·cmap="BrBG",annot=True)
plt.show
```

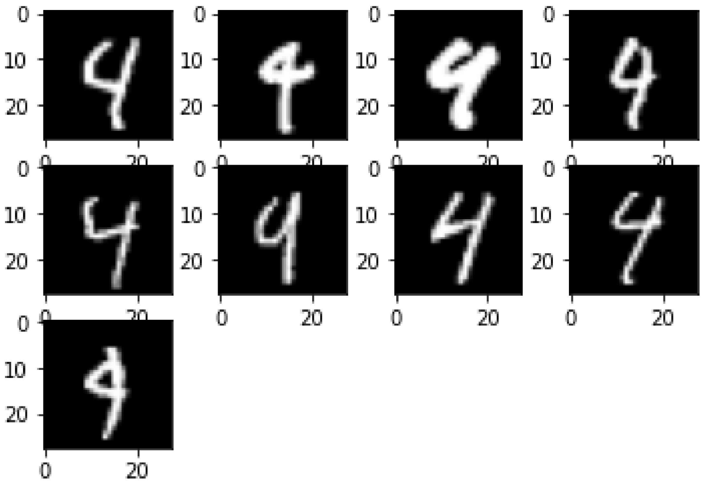
```
<function matplotlib.pyplot.show>
```



```
#Analyzing what happen ith the 9 confused with the 4 and 7
index=[]
for idx in results[(results['y']==7)&(results['y_pred']==9)].index:
        index.append(idx)
    for i in range(len(index)):
        plt.subplot(3,4,i+1)
        plt.imshow(X_sqrt_test[index[i]], cmap=plt.get_cmap('gray'))
```



```
index=[]
for idx in results[(results['y']==4)&(results['y_pred']==9)].index:
    index.append(idx)
for i in range(len(index)):
    plt.subplot(3,4,i+1)
    plt.imshow(X_sqrt_test[index[i]], cmap=plt.get_cmap('gray'))
```



Naive - Bayes

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