LAB 10 : Naive Bayes Classifier

1. Binary Classification using Naive Bayes Classifier

2. Sentiment Analysis using Naive Bayes

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
from jupyterthemes import jtplot
jtplot.style(theme='gruvboxd',context='notebook',grid=False,ticks=True)
```

Binary Classification using Naive Bayes Classifier

Useful References :

1. https://machinelearningmastery.com/naive-bayes-classifier-scratch-python/

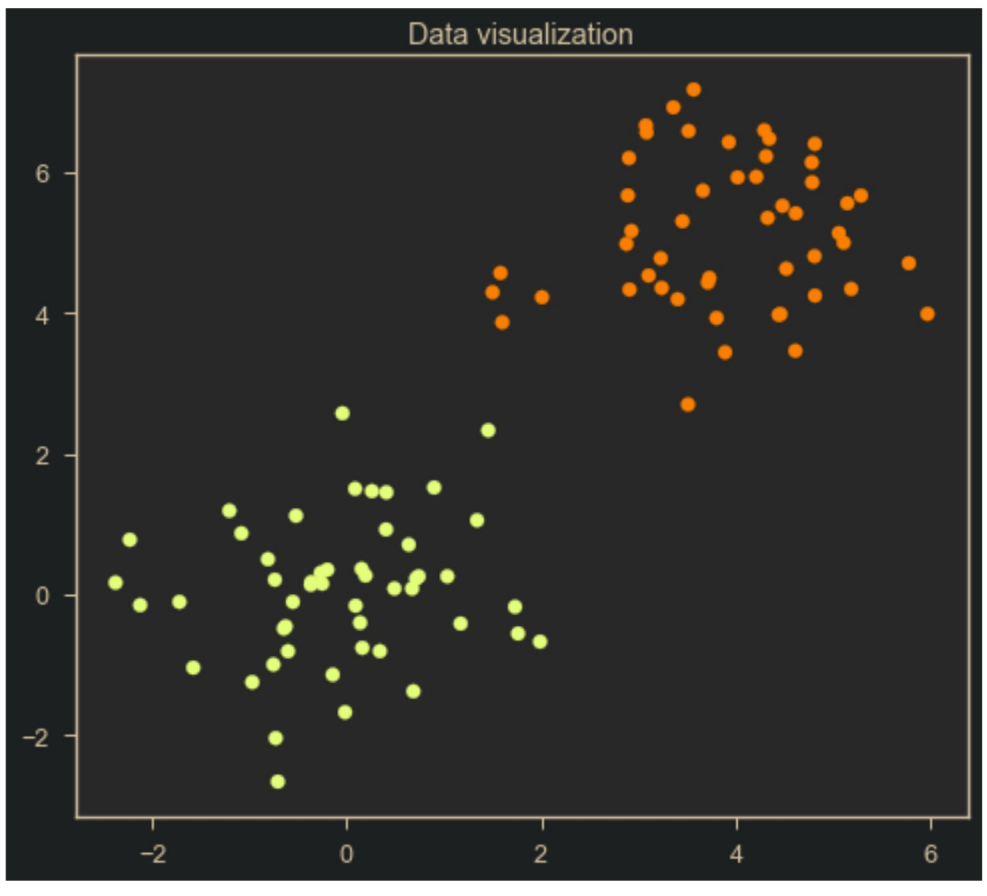
2. https://www.analyticsvidhya.com/blog/2021/01/a-guide-to-the-naive-bayes-algorithm/

3. https://towardsdatascience.com/implementing-naive-bayes-algorithm-from-scratch-python-c6880cfc9c41

Note : The goal of this experiment is to perform and understand Naive Bayes classification by applying it on the below dataset, you can either fill in the below functions to get the result or you can create a class of your own using the above references to perform classification

1. Generation of 2D training data

In [2]:
```
mean1=np.array([0,0])
mean2=np.array([4,5])
var=np.array([[1,0.1],[0.1,1]])
np.random.seed(0)
data1=np.random.multivariate_normal(mean1,var,50)
data2=np.random.multivariate_normal(mean2,var,50)
data=np.concatenate((data1,data2))
label=np.concatenate((np.zeros(data1.shape[0]),np.ones(data2.shape[0])))
# plots
plt.figure()
plt.scatter(data[:,0],data[:,1],c=label,cmap='Wistia')
plt.title('Data visualization');
```



1. Split the Dataset by Class Values (Create a Dictionary)

In [3]:
```
def class_dictionary(data,label):
    class_dict = {}

    ## Write your code here
    for i in np.unique(label):
        class_dict[i]=data[np.where(label==i)]; # storing variables corresponding to labels
    return class_dict
```

1. Calculate Mean, Std deviation and count for each column in a dataset

In [4]:
```
def get_variables(class_dict):
    var_dict = {}

    ## Write your code here
    # storing mean, std dev and number of elements of each class
    for keys in class_dict:
        var_dict[keys] =
[np.mean(class_dict[keys],axis=0),np.std(class_dict[keys],axis=0),class_dict[keys].shape[0]];
    return var_dict
```

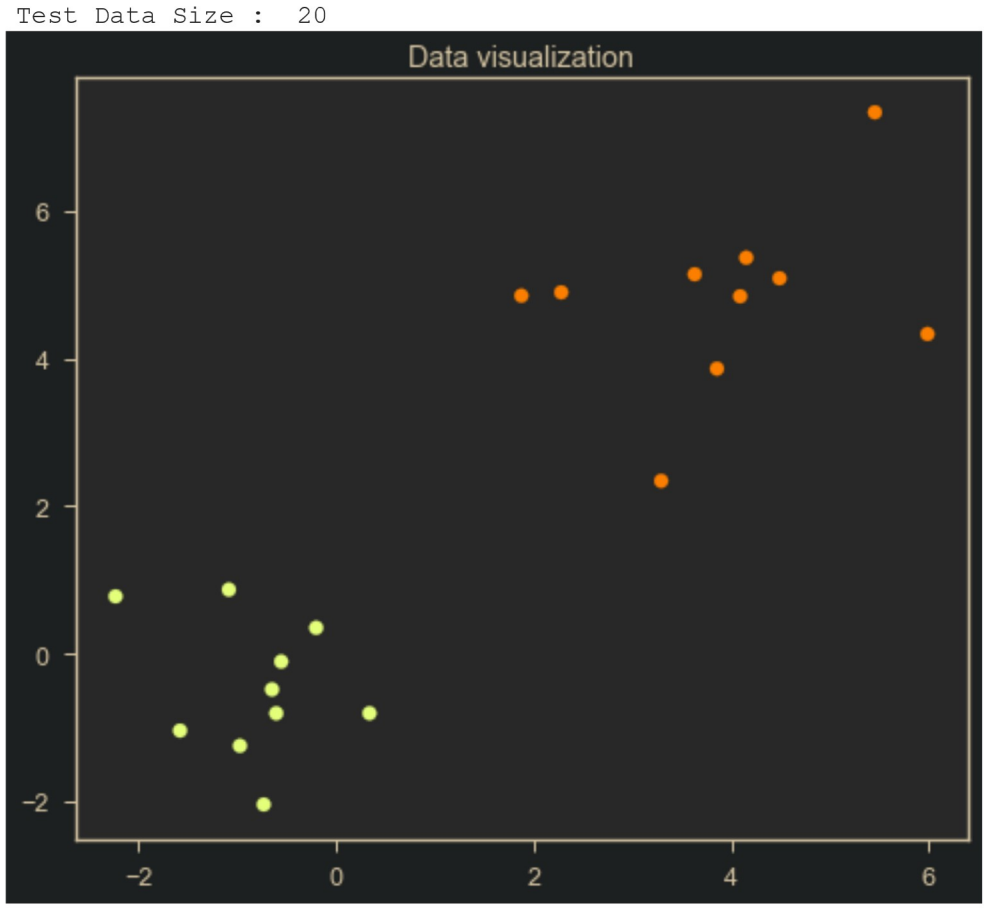
1. Calculate Class Probabilities

In [5]:
```
def calculate_probability(x,mean,stdev):
    exponent = np.exp(-((x-mean)**2 / (2 * stdev**2 )));
    return (1 / (np.sqrt(2 * np.pi) * stdev)) * exponent

def calculate_class_probabilities(summaries,row):
    probabilities = dict()
    total_pts=0;
    for keys in summaries:
        tmp=1;
        p = calculate_probability(row,summaries[keys][0],summaries[keys][1]);
        for i in range(p.shape[1]):
             tmp*=p[:,i]; # multiplying prob to get likelihood
        total_pts+=summaries[keys][2];
        probabilities[keys] = tmp;
    for keys in summaries:
        probabilities[keys] *= summaries[keys][2]/total_pts; # multiplying priori
    ## Write your code here to calculate the class probabilities
    '''
    You can use the above function (calculate_probability) to calculate probability of an individual
data point belonging to a particular class
    based on mean and std deviation of that class
    '''
    return probabilities
```

1. Test the model using some samples

In [6]:
```
## Test Data Generation
mean1=np.array([0,0])
mean2=np.array([4,5])
var=np.array([[1,0.1],[0.1,1]])
np.random.seed(0)
data1=np.random.multivariate_normal(mean1,var,10)
data2=np.random.multivariate_normal(mean2,var,10)
test_data=np.concatenate((data1,data2))
y_test=np.concatenate((np.zeros(data1.shape[0]),np.ones(data2.shape[0])))
print('Test Data Size : ',test_data.shape[0])
plt.figure()
plt.scatter(test_data[:,0],test_data[:,1],c=y_test,cmap='Wistia');
plt.title('Data visualization');
```

```
Test Data Size :  20
```



Testing for a sample point

In [7]:
```
class_dict = class_dictionary(data,label)
var_dict = get_variables(class_dict)
out = calculate_class_probabilities(var_dict,np.reshape(test_data[0,:],(1,-1)))
print('Class Probabilites for the first sample of test dataset : ')
print(out)
```

```
Class Probabilites for the first sample of test dataset :
{0.0: array([0.0141972]), 1.0: array([8.33297509e-16])}
```

As seen above the class probability for the 1st sample is given, we can observe that probability is higher for class 0 than 1 and hence imply that this datapoint belongs to class 0

Now Calculate the class probabilities for all the data points in the test dataset and calculate the accuracy by comparing the predicted labels with the true test labels

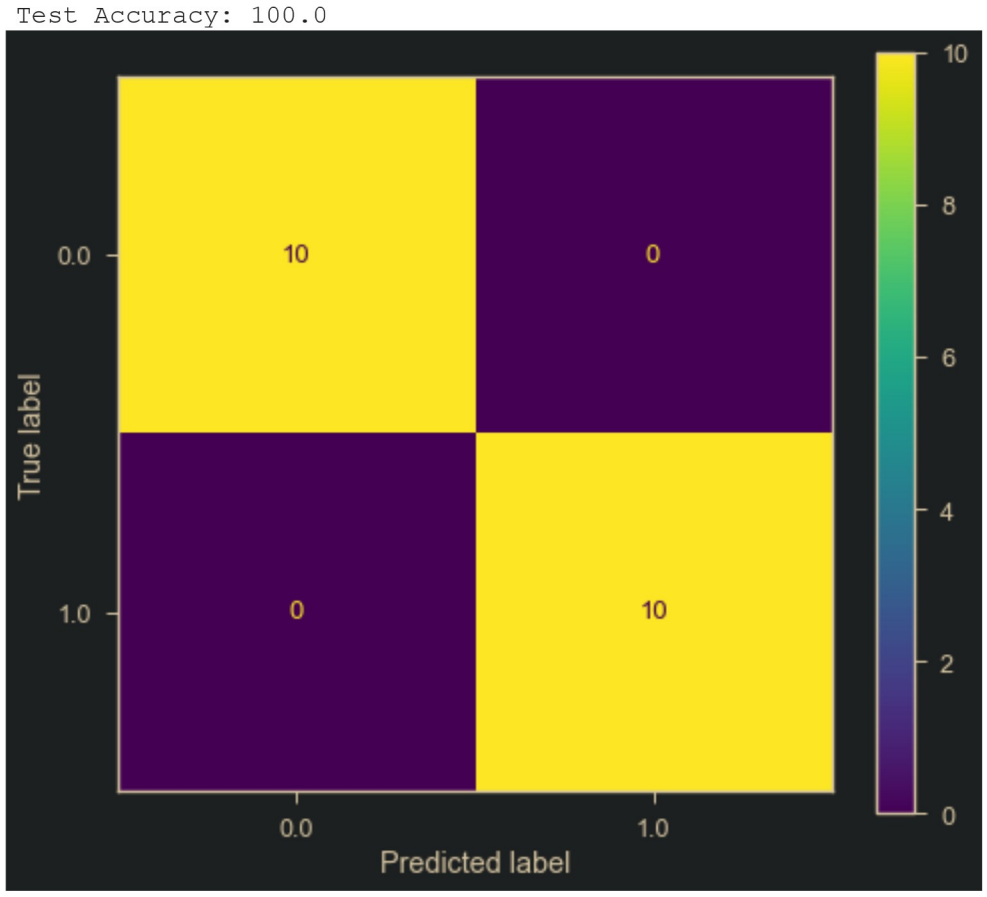
In [8]:
```
## Write your code here
p = calculate_class_probabilities(var_dict,test_data);
y_pred = p[1] > p[0];
acc = np.sum(y_pred == y_test)*100/len(y_pred);
print("Test Accuracy:",acc);
```

```
Test Accuracy: 100.0
```

1. Use the Sci-kit Learn library to perform Gaussian Naive Bayes classifier on the above dataset, also report the accuracy and confusion matrix for the same

In [9]:
```
## Write your code here
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score
from sklearn.metrics import plot_confusion_matrix

gnb = GaussianNB()
y_pred = gnb.fit(data, label).predict(test_data)
print("Test Accuracy:",accuracy_score(y_pred,y_test)*100)
#Plotting confusion matrix
plot_confusion_matrix(gnb,test_data,y_test);
```

```
Test Accuracy: 100.0
```



Sentiment Analysis using Naive Bayes Classifier

Go through the following article and implement the same

Keypoints :

1. The link to the dataset is given in the above article, download the same to perform sentiment analysis
2. Understanding how to deal with text data is very important since it requires a lot of preprocessing, you can go through this article if you are interested in learning more about it
3. Split the dataset into train-test and train the model
4. Report the accuracy metrics and try some sample prediction outside of those present in the dataset

Note : The goal of this experiment is to explore a practical use case of Naive bayes classifier as well as to understand how to deal with textual data, you can follow any other open source implemetations of sentiment analysis using naive bayes also

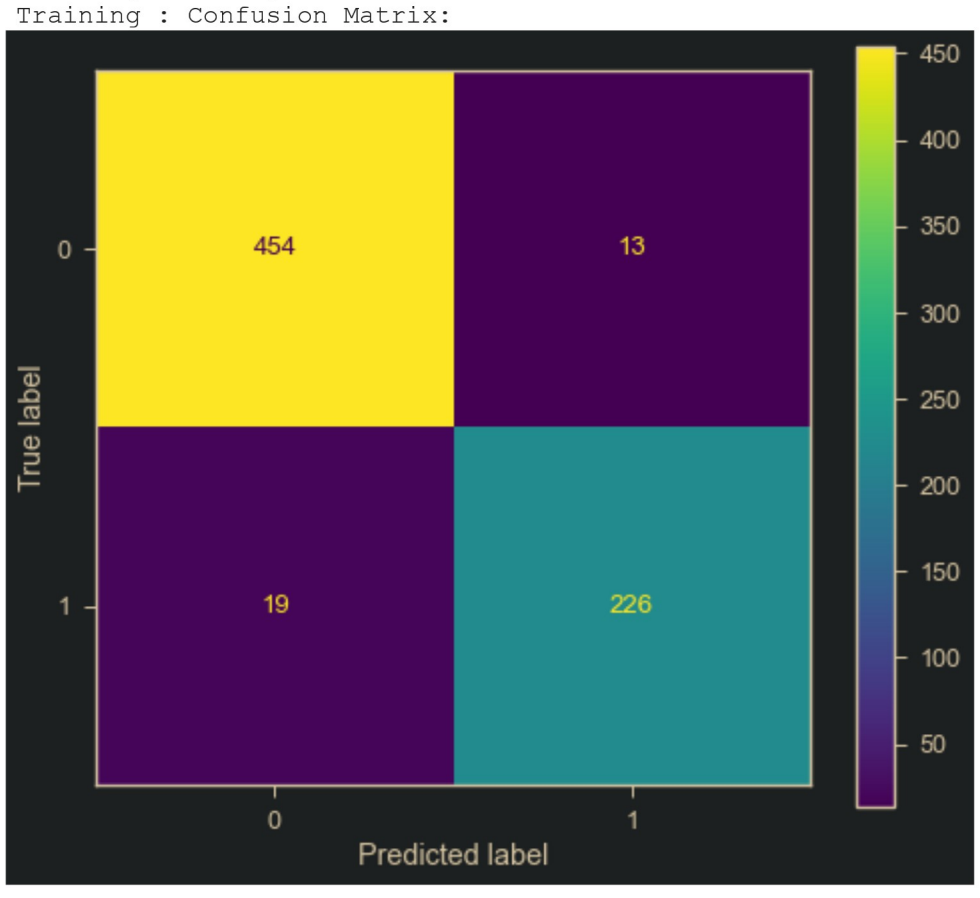
Other References :

1. https://towardsdatascience.com/sentiment-analysis-introduction-to-naive-bayes-algorithm-96831d77ac91
2. https://gist.github.com/CateGitau/6608912ca92733036c090676c61c13cd

In [10]:

```
## Write your code here
import pandas as pd
from sklearn.model_selection import train_test_split
import joblib
from sklearn.feature_extraction.text import CountVectorizer

data = pd.read_csv("C:/Users/R3M0/Documents/EE 413 Pattern Recognition and Machine Learning Laboratory/10/dataset.csv")

def preprocess_data(data):
    # Remove package name as it's not relevant
    data = data.drop('package_name', axis=1)
    # Convert text to lowercase
    data['review'] = data['review'].str.strip().str.lower()
    return data

data = preprocess_data(data);
# print(data.shape)
x = data['review'];
y = data['polarity'];
x, x_test, y, y_test = train_test_split(x,y, stratify=y, test_size=0.20, random_state=42);
vec = CountVectorizer(stop_words='english');
x = vec.fit_transform(x).toarray();
x_test = vec.transform(x_test).toarray();

from sklearn.naive_bayes import MultinomialNB

model = MultinomialNB();
model.fit(x, y);
print("Training Accuracy:",model.score(x, y)*100);
print("Training : Confusion Matrix:");
plot_confusion_matrix(model,x,y);
```

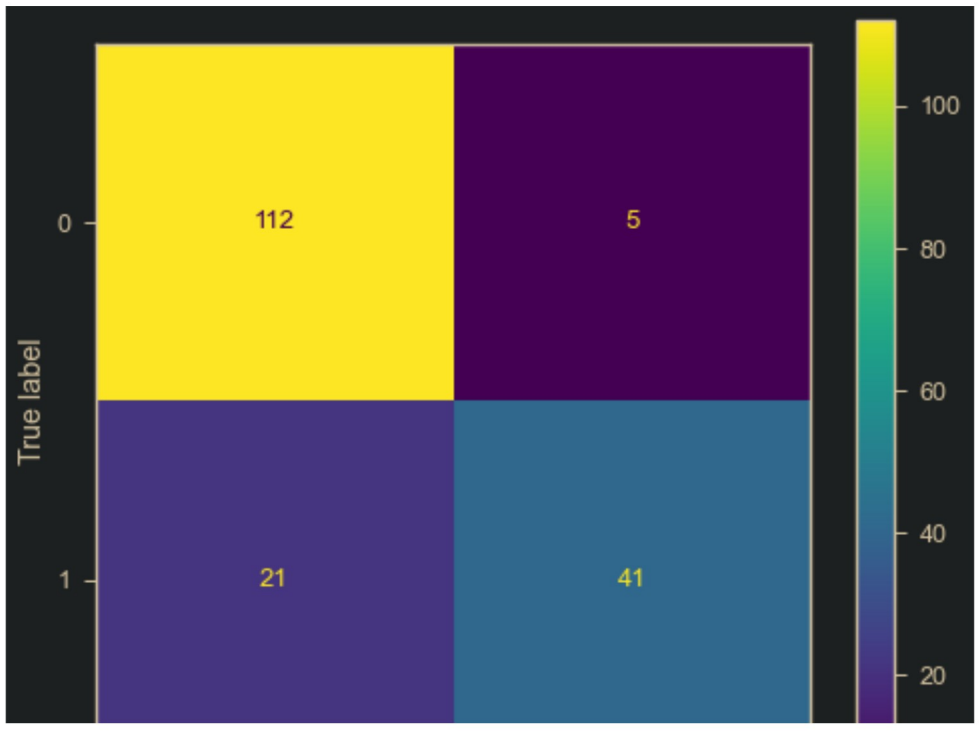
```
Training Accuracy: 95.50561797752809
Training : Confusion Matrix:
```



In [11]:

```
print("Testing Accuracy:",model.score(x_test, y_test)*100);
print("Test : Confusion Matrix:");
plot_confusion_matrix(model,x_test,y_test);
```

```
Testing Accuracy: 85.47486033519553
Test : Confusion Matrix:
```



In [ ]: