Practical No. 03

Aim : To perform and analysis of Naive Bayes, Confusion matrix, K fold cross Validation

In [4]:

```
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#Section : B
#Subject : PE-II
```

In [6]:

```
#Finding the parameters of confusion matrix
```

In [8]:

```
import os
import pandas as pd
import numpy as np
```

In [10]:

```
os.getcwd()
```

Out[10]:

```
'C:\\Users\\USER'
```

In [18]:

```
os.chdir("C:\\Users\\USER\\Desktop")
```

In [22]:

```
data = pd.read_csv("heart.csv")
```

In [24]:

```
data.head()
```

Out[24]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	52	1	0	125	212	0	1	168	0	1.0	2	2	3	0
1	53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
2	70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
3	61	1	0	148	203	0	1	161	0	0.0	2	1	3	0
4	62	0	0	138	294	1	1	106	0	1.9	1	3	2	0

In [26]:

```
data.tail()
```

Out[26]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
1020	59	1	1	140	221	0	1	164	1	0.0	2	0	2	1
1021	60	1	0	125	258	0	0	141	1	2.8	1	1	3	0
1022	47	1	0	110	275	0	0	118	1	1.0	1	1	2	0
1023	50	0	0	110	254	0	0	159	0	0.0	2	0	2	1

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
1024	54	1	0	120	188	0	1	113	0	1.4	1	1	3	0

In [28]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1025 entries, 0 to 1024
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1025 non-null   int64  
 1   sex       1025 non-null   int64  
 2   cp        1025 non-null   int64  
 3   trestbps  1025 non-null   int64  
 4   chol      1025 non-null   int64  
 5   fbs       1025 non-null   int64  
 6   restecg   1025 non-null   int64  
 7   thalach   1025 non-null   int64  
 8   exang     1025 non-null   int64  
 9   oldpeak   1025 non-null   float64
 10  slope     1025 non-null   int64  
 11  ca        1025 non-null   int64  
 12  thal      1025 non-null   int64  
 13  target    1025 non-null   int64  
dtypes: float64(1), int64(13)
memory usage: 112.2 KB
```

In [30]:

```
data.describe()
```

Out[30]:

	age	sex	cp	trestbps	chol	fbs	restecg	
count	1025.000000	1025.000000	1025.000000	1025.000000	1025.00000	1025.000000	1025.000000	102
mean	54.434146	0.695610	0.942439	131.611707	246.00000	0.149268	0.529756	14
std	9.072290	0.460373	1.029641	17.516718	51.59251	0.356527	0.527878	2
min	29.000000	0.000000	0.000000	94.000000	126.00000	0.000000	0.000000	7
25%	48.000000	0.000000	0.000000	120.000000	211.00000	0.000000	0.000000	13
50%	56.000000	1.000000	1.000000	130.000000	240.00000	0.000000	1.000000	15
75%	61.000000	1.000000	2.000000	140.000000	275.00000	0.000000	1.000000	16
max	77.000000	1.000000	3.000000	200.000000	564.00000	1.000000	2.000000	20

In [32]:

```
data.size
```

Out[32]:

```
14350
```

In [34]:

```
data.shape
```

Out[34]:
(1025, 14)

In [36]:
```
data.ndim
```

Out[36]:
2

Data pre-processing, data-cleaning, mising value treatment

In [39]:
```
data.isna()
```

Out[39]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
0	False	False	False	False	False	False	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False	False	False	False	False	False	False
2	False	False	False	False	False	False	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...	...	...	...	...	...	...
1020	False	False	False	False	False	False	False	False	False	False	False	False	False
1021	False	False	False	False	False	False	False	False	False	False	False	False	False
1022	False	False	False	False	False	False	False	False	False	False	False	False	False
1023	False	False	False	False	False	False	False	False	False	False	False	False	False
1024	False	False	False	False	False	False	False	False	False	False	False	False	False

1025 rows × 14 columns

In [41]:
```
data.isna().any()
```

Out[41]:
```
age         False
sex         False
cp          False
trestbps    False
chol        False
fbs         False
restecg     False
thalach     False
exang       False
oldpeak     False
slope       False
ca          False
thal        False
target      False
dtype: bool
```

data.isna().sum()

Removing Duplicates

In [46]:
```
data_dup =data.duplicated().any()
```

In [48]:
```
data_dup
```

Out[48]:
True

In [50]:
```
data=data.drop_duplicates()
```

In [52]:
```
data_dup =data.duplicated().any()
```

In [54]:
```
data_dup
```

Out[54]:
False

Splitting dataset into training and testing

In [57]:
```
x = data.drop('target', axis = 1)
y = data['target']
```

In [59]:
```
from sklearn.model_selection import train_test_split, KFold, cross_val_score

x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2 ,random_state=42)
```

In [61]:
```
x_train
```

Out[61]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
163	48	1	0	124	274	0	0	166	0	0.5	1	0	3
291	58	1	0	128	259	0	0	130	1	3.0	1	2	3
280	45	0	1	130	234	0	0	175	0	0.6	1	0	2
85	44	1	1	120	220	0	1	170	0	0.0	2	0	2
239	62	0	0	150	244	0	1	154	1	1.4	1	0	2
...	...	...	...	...	...	...	...	...	...	...	...	...	...
267	67	1	0	120	237	0	1	71	0	1.0	1	0	2
77	63	1	0	140	187	0	0	144	1	4.0	2	2	3
125	60	0	3	150	240	0	1	171	0	0.9	2	0	2
522	67	0	2	152	277	0	1	172	0	0.0	2	1	2
119	42	1	1	120	295	0	1	162	0	0.0	2	0	2

241 rows × 13 columns

In [63]:

```
x_test
```

Out[63]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
245	44	1	1	130	219	0	0	188	0	0.0	2	0	2
349	62	0	2	130	263	0	1	97	0	1.2	1	1	3
135	58	0	0	170	225	1	0	146	1	2.8	1	2	1
389	63	1	3	145	233	1	0	150	0	2.3	0	0	1
66	53	1	2	130	197	1	0	152	0	1.2	0	0	2
...	...	...	...	...	...	...	...	...	...	...	...	...	...
402	70	1	1	156	245	0	0	143	0	0.0	2	0	2
123	65	0	2	140	417	1	0	157	0	0.8	2	1	2
739	52	1	0	128	255	0	1	161	1	0.0	2	1	3
274	66	1	0	160	228	0	0	138	0	2.3	2	0	1
256	35	0	0	138	183	0	1	182	0	1.4	2	0	2

61 rows × 13 columns

In [65]:

```
y_train
```

Out[65]:

```
163    0
291    0
280    1
85     1
239    0
      ..
267    0
77     0
125    1
522    1
119    1
Name: target, Length: 241, dtype: int64
```

In [67]:

```
y_test
```

Out[67]:

```
245    1
349    0
135    0
389    1
66     1
      ..
402    1
123    1
739    0
```

```
274    1
256    1
Name: target, Length: 61, dtype: int64
```

In [69]:

```
data.head()
```

Out[69]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	52	1	0	125	212	0	1	168	0	1.0	2	2	3	0
1	53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
2	70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
3	61	1	0	148	203	0	1	161	0	0.0	2	1	3	0
4	62	0	0	138	294	1	1	106	0	1.9	1	3	2	0

Naive Bayes

In [72]:

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

In [74]:

```
nb_classifier = GaussianNB()
nb_classifier.fit(x_train, y_train)
```

Out[74]:

GaussianNB

```
GaussianNB()
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook. On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [77]:

```
y_pred = nb_classifier.predict(x_test)
```

In [79]:

```
accuracy_score (y_test,y_pred)
```

Out[79]:

```
0.8524590163934426
```

Confusion Matrix

In [84]:

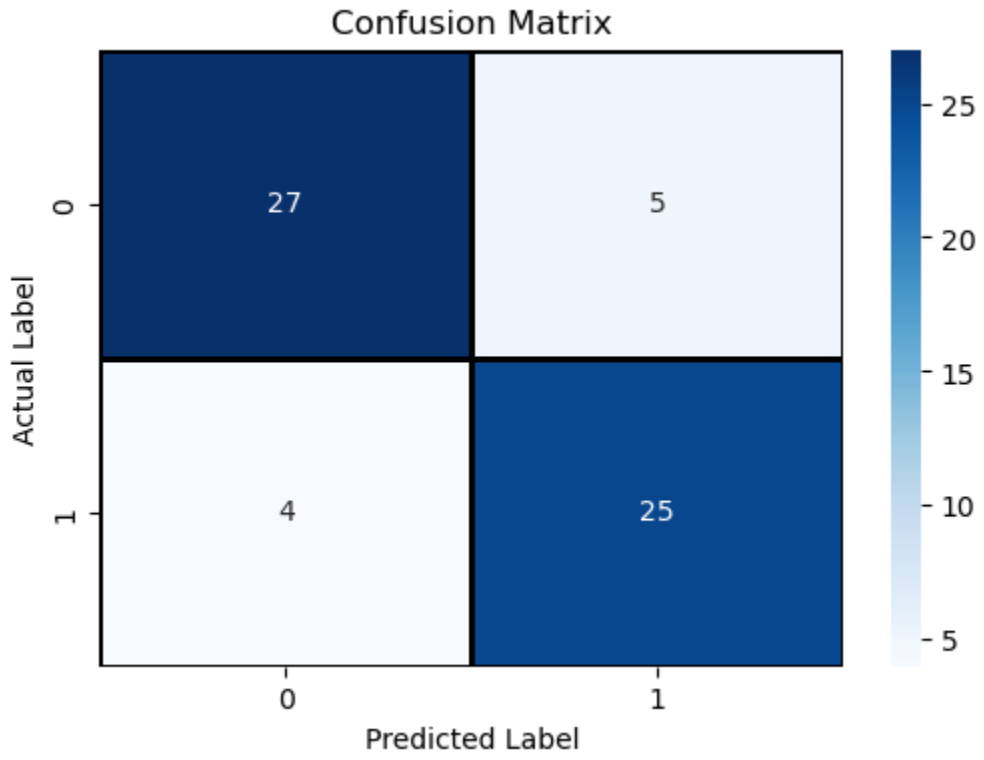
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(y_test, y_pred)
```

```
labels = np.unique(y_test)  # Get unique class labels
cm_df = pd.DataFrame(cm, index=labels, columns=labels)

# Plot confusion matrix using seaborn
plt.figure(figsize=(6, 4))
sns.heatmap(cm_df, annot=True, fmt='d', cmap='Blues', linewidths=1, linecolor='black')

plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
plt.title("Confusion Matrix")
plt.show()
```



In [86]:

```
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report, pre
```

In [88]:

```
conf_matrix = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:")
print(conf_matrix)

# Accuracy
accuracy = accuracy_score(y_test, y_pred)
print(f'Accuracy: {accuracy:.4f}')

# Precision
precision = precision_score(y_test, y_pred, average='weighted')
print(f'Precision: {precision:.4f}')

# Recall
recall = recall_score(y_test, y_pred, average='weighted')
print(f'Recall: {recall:.4f}')

# Error Rate
error_rate = 1 - accuracy
print(f'Error Rate: {error_rate:.4f}')
```

```
# Classification report
print("Classification Report:")
print(classification_report(y_test,y_pred))
```

```
Confusion Matrix:
[[27  5]
 [ 4 25]]
Accuracy: 0.8525
Precision: 0.8531
Recall: 0.8525
Error Rate: 0.1475
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.84      0.86        32
           1       0.83      0.86      0.85        29

    accuracy                           0.85        61
   macro avg       0.85      0.85      0.85        61
weighted avg       0.85      0.85      0.85        61
```

K Fold Cross Validation

In [91]:

```
from sklearn.model_selection import KFold, cross_val_score
```

In [93]:

```
k = 5
kf = KFold(n_splits=k, shuffle=True, random_state=42)

scores = cross_val_score(nb_classifier, x, y, cv=kf, scoring='accuracy')
```

In [95]:

```
print(f'Cross-validation scores: {scores}')
print(f'Mean accuracy: {scores.mean():.4f}')
```

```
Cross-validation scores: [0.85245902 0.81967213 0.83333333 0.76666667 0.83333333]
Mean accuracy: 0.8211
```