21BCE8974 - Assignment-4(22nd september)

September 27, 2023

1 Assignment-4(22 september)

1.1 E.Tarun Ganesh - 21BCE8974

2 Data preprocessing on Employees-Attrition.csv

[1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

[2]:
```
data=pd.read_csv("Employee-Attrition.csv")
```

[3]:
```
data.head()
```

[3]:
```
   Age Attrition     BusinessTravel  DailyRate              Department  \
0   41       Yes      Travel_Rarely       1102                   Sales
1   49        No  Travel_Frequently        279  Research & Development
2   37       Yes      Travel_Rarely       1373  Research & Development
3   33        No  Travel_Frequently       1392  Research & Development
4   27        No      Travel_Rarely        591  Research & Development

   DistanceFromHome  Education EducationField  EmployeeCount  EmployeeNumber  \
0                 1          2  Life Sciences              1               1
1                 8          1  Life Sciences              1               2
2                 2          2          Other              1               4
3                 3          4  Life Sciences              1               5
4                 2          1        Medical              1               7

   …  RelationshipSatisfaction StandardHours  StockOptionLevel  \
0  …                         1            80                 0
1  …                         4            80                 1
2  …                         2            80                 0
3  …                         3            80                 0
4  …                         4            80                 1

   TotalWorkingYears  TrainingTimesLastYear WorkLifeBalance  YearsAtCompany  \
```

```
0                  8                       0               1                6
1                 10                       3               3               10
2                  7                       3               3                0
3                  8                       3               3                8
4                  6                       3               3                2

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                  4                        0                     5
1                  7                        1                     7
2                  0                        0                     0
3                  7                        3                     0
4                  2                        2                     2

[5 rows x 35 columns]
```

[4]:
```python
data.tail()
```

[4]:
```
      Age Attrition     BusinessTravel  DailyRate              Department  \
1465   36        No  Travel_Frequently        884  Research & Development
1466   39        No      Travel_Rarely        613  Research & Development
1467   27        No      Travel_Rarely        155  Research & Development
1468   49        No  Travel_Frequently       1023                   Sales
1469   34        No      Travel_Rarely        628  Research & Development

      DistanceFromHome  Education EducationField  EmployeeCount  \
1465                23          2        Medical              1
1466                 6          1        Medical              1
1467                 4          3  Life Sciences              1
1468                 2          3        Medical              1
1469                 8          3        Medical              1

      EmployeeNumber  …  RelationshipSatisfaction StandardHours  \
1465            2061  …                         3            80
1466            2062  …                         1            80
1467            2064  …                         2            80
1468            2065  …                         4            80
1469            2068  …                         1            80

      StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
1465                 1                 17                      3
1466                 1                  9                      5
1467                 1                  6                      0
1468                 0                 17                      3
1469                 0                  6                      3

     WorkLifeBalance  YearsAtCompany YearsInCurrentRole  \
1465               3               5                  2
```

```
1466                3                7                 7
1467                3                6                 2
1468                2                9                 6
1469                4                4                 3

      YearsSinceLastPromotion  YearsWithCurrManager
1465                        0                     3
1466                        1                     7
1467                        0                     3
1468                        0                     8
1469                        1                     2

[5 rows x 35 columns]
```

[5]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 35 columns):
 #   Column                    Non-Null Count  Dtype 
---  ------                    --------------  ----- 
 0   Age                       1470 non-null   int64 
 1   Attrition                 1470 non-null   object
 2   BusinessTravel            1470 non-null   object
 3   DailyRate                 1470 non-null   int64 
 4   Department                1470 non-null   object
 5   DistanceFromHome          1470 non-null   int64 
 6   Education                 1470 non-null   int64 
 7   EducationField            1470 non-null   object
 8   EmployeeCount             1470 non-null   int64 
 9   EmployeeNumber            1470 non-null   int64 
 10  EnvironmentSatisfaction   1470 non-null   int64 
 11  Gender                    1470 non-null   object
 12  HourlyRate                1470 non-null   int64 
 13  JobInvolvement            1470 non-null   int64 
 14  JobLevel                  1470 non-null   int64 
 15  JobRole                   1470 non-null   object
 16  JobSatisfaction           1470 non-null   int64 
 17  MaritalStatus             1470 non-null   object
 18  MonthlyIncome             1470 non-null   int64 
 19  MonthlyRate               1470 non-null   int64 
 20  NumCompaniesWorked        1470 non-null   int64 
 21  Over18                    1470 non-null   object
 22  OverTime                  1470 non-null   object
 23  PercentSalaryHike         1470 non-null   int64 
 24  PerformanceRating         1470 non-null   int64 
 25  RelationshipSatisfaction  1470 non-null   int64 
 26  StandardHours             1470 non-null   int64 
```

```
 27  StockOptionLevel          1470 non-null   int64
 28  TotalWorkingYears         1470 non-null   int64
 29  TrainingTimesLastYear     1470 non-null   int64
 30  WorkLifeBalance           1470 non-null   int64
 31  YearsAtCompany            1470 non-null   int64
 32  YearsInCurrentRole        1470 non-null   int64
 33  YearsSinceLastPromotion   1470 non-null   int64
 34  YearsWithCurrManager      1470 non-null   int64
dtypes: int64(26), object(9)
memory usage: 402.1+ KB
```

[6]:

```
data.describe()
```

[6]:

```
               Age    DailyRate  DistanceFromHome    Education  EmployeeCount  \
count  1470.000000  1470.000000       1470.000000  1470.000000         1470.0
mean     36.923810   802.485714          9.192517     2.912925            1.0
std       9.135373   403.509100          8.106864     1.024165            0.0
min      18.000000   102.000000          1.000000     1.000000            1.0
25%      30.000000   465.000000          2.000000     2.000000            1.0
50%      36.000000   802.000000          7.000000     3.000000            1.0
75%      43.000000  1157.000000         14.000000     4.000000            1.0
max      60.000000  1499.000000         29.000000     5.000000            1.0

       EmployeeNumber  EnvironmentSatisfaction   HourlyRate  JobInvolvement  \
count     1470.000000              1470.000000  1470.000000     1470.000000
mean      1024.865306                 2.721769    65.891156        2.729932
std        602.024335                 1.093082    20.329428        0.711561
min          1.000000                 1.000000    30.000000        1.000000
25%        491.250000                 2.000000    48.000000        2.000000
50%       1020.500000                 3.000000    66.000000        3.000000
75%       1555.750000                 4.000000    83.750000        3.000000
max       2068.000000                 4.000000   100.000000        4.000000

          JobLevel  …  RelationshipSatisfaction  StandardHours  \
count  1470.000000  …               1470.000000         1470.0
mean      2.063946  …                  2.712245           80.0
std       1.106940  …                  1.081209            0.0
min       1.000000  …                  1.000000           80.0
25%       1.000000  …                  2.000000           80.0
50%       2.000000  …                  3.000000           80.0
75%       3.000000  …                  4.000000           80.0
max       5.000000  …                  4.000000           80.0

       StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
count       1470.000000        1470.000000            1470.000000
mean           0.793878          11.279592               2.799320
std            0.852077           7.780782               1.289271
```

```
min              0.000000           0.000000                0.000000
25%              0.000000           6.000000                2.000000
50%              1.000000          10.000000                3.000000
75%              1.000000          15.000000                3.000000
max              3.000000          40.000000                6.000000

       WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
count      1470.000000     1470.000000         1470.000000
mean          2.761224        7.008163            4.229252
std           0.706476        6.126525            3.623137
min           1.000000        0.000000            0.000000
25%           2.000000        3.000000            2.000000
50%           3.000000        5.000000            3.000000
75%           3.000000        9.000000            7.000000
max           4.000000       40.000000           18.000000

       YearsSinceLastPromotion  YearsWithCurrManager
count              1470.000000           1470.000000
mean                  2.187755              4.123129
std                   3.222430              3.568136
min                   0.000000              0.000000
25%                   0.000000              2.000000
50%                   1.000000              3.000000
75%                   3.000000              7.000000
max                  15.000000             17.000000

[8 rows x 26 columns]
```

2.1 Handling Null Values

[7]:
```
data.isnull().any()
```

[7]:
```
Age                         False
Attrition                   False
BusinessTravel              False
DailyRate                   False
Department                  False
DistanceFromHome            False
Education                   False
EducationField              False
EmployeeCount               False
EmployeeNumber              False
EnvironmentSatisfaction     False
Gender                      False
HourlyRate                  False
JobInvolvement              False
JobLevel                    False
```

```
JobRole                     False
JobSatisfaction             False
MaritalStatus               False
MonthlyIncome               False
MonthlyRate                 False
NumCompaniesWorked          False
Over18                      False
OverTime                    False
PercentSalaryHike           False
PerformanceRating           False
RelationshipSatisfaction    False
StandardHours               False
StockOptionLevel            False
TotalWorkingYears           False
TrainingTimesLastYear       False
WorkLifeBalance             False
YearsAtCompany              False
YearsInCurrentRole          False
YearsSinceLastPromotion     False
YearsWithCurrManager        False
dtype: bool
```

[8]:
```
data.isnull().sum()
```

[8]:
```
Age                         0
Attrition                   0
BusinessTravel              0
DailyRate                   0
Department                  0
DistanceFromHome            0
Education                   0
EducationField              0
EmployeeCount               0
EmployeeNumber              0
EnvironmentSatisfaction     0
Gender                      0
HourlyRate                  0
JobInvolvement              0
JobLevel                    0
JobRole                     0
JobSatisfaction             0
MaritalStatus               0
MonthlyIncome               0
MonthlyRate                 0
NumCompaniesWorked          0
Over18                      0
OverTime                    0
```

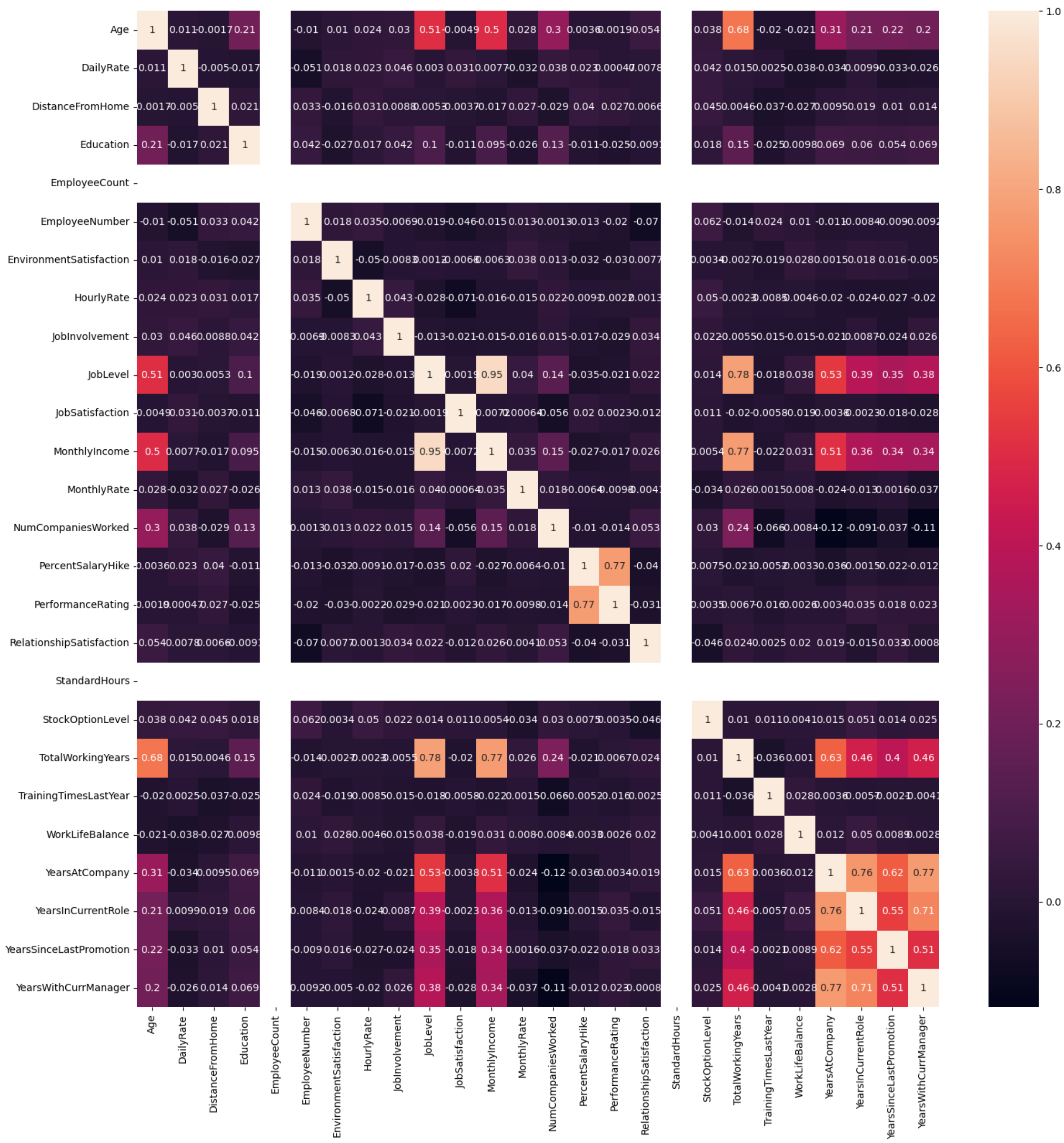
```
PercentSalaryHike           0
PerformanceRating           0
RelationshipSatisfaction    0
StandardHours               0
StockOptionLevel            0
TotalWorkingYears           0
TrainingTimesLastYear       0
WorkLifeBalance             0
YearsAtCompany              0
YearsInCurrentRole          0
YearsSinceLastPromotion     0
YearsWithCurrManager        0
dtype: int64
```

[9]:
```
cor=data.corr()
```

```
C:\Users\MSI\AppData\Local\Temp\ipykernel_9064\1426905697.py:1: FutureWarning:
The default value of numeric_only in DataFrame.corr is deprecated. In a future
version, it will default to False. Select only valid columns or specify the
value of numeric_only to silence this warning.
  cor=data.corr()
```

[10]:
```
fig=plt.figure(figsize=(18,18))
sns.heatmap(cor,annot=True)
```

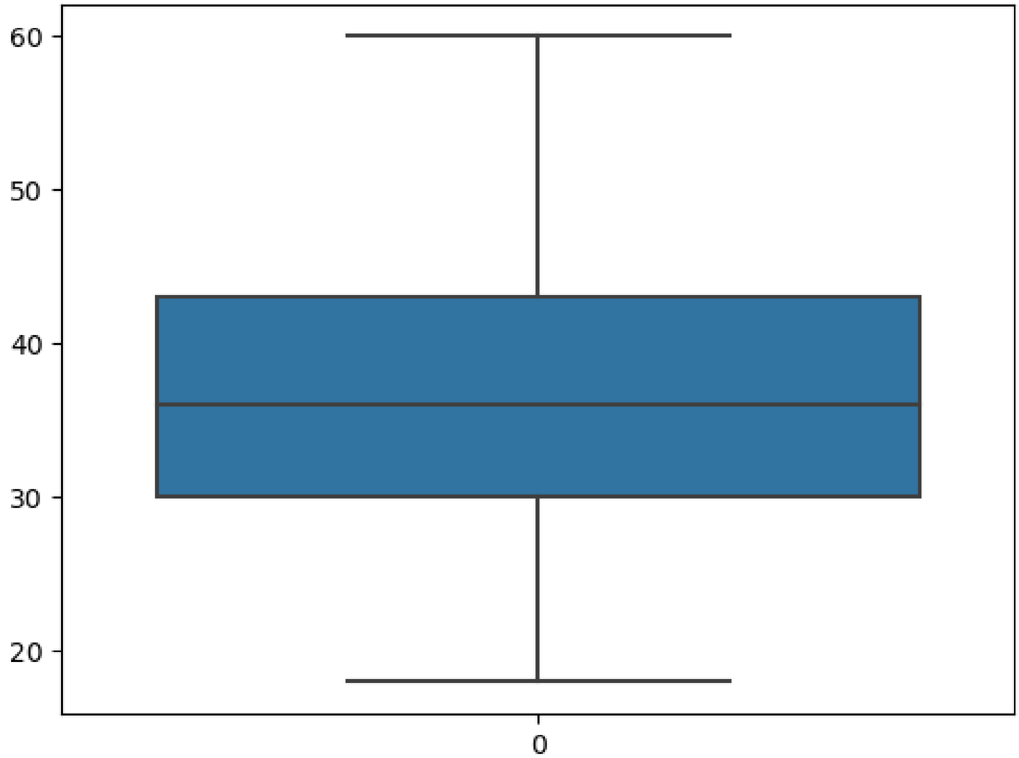
[10]:
```
<Axes: >
```



2.2 Outliers

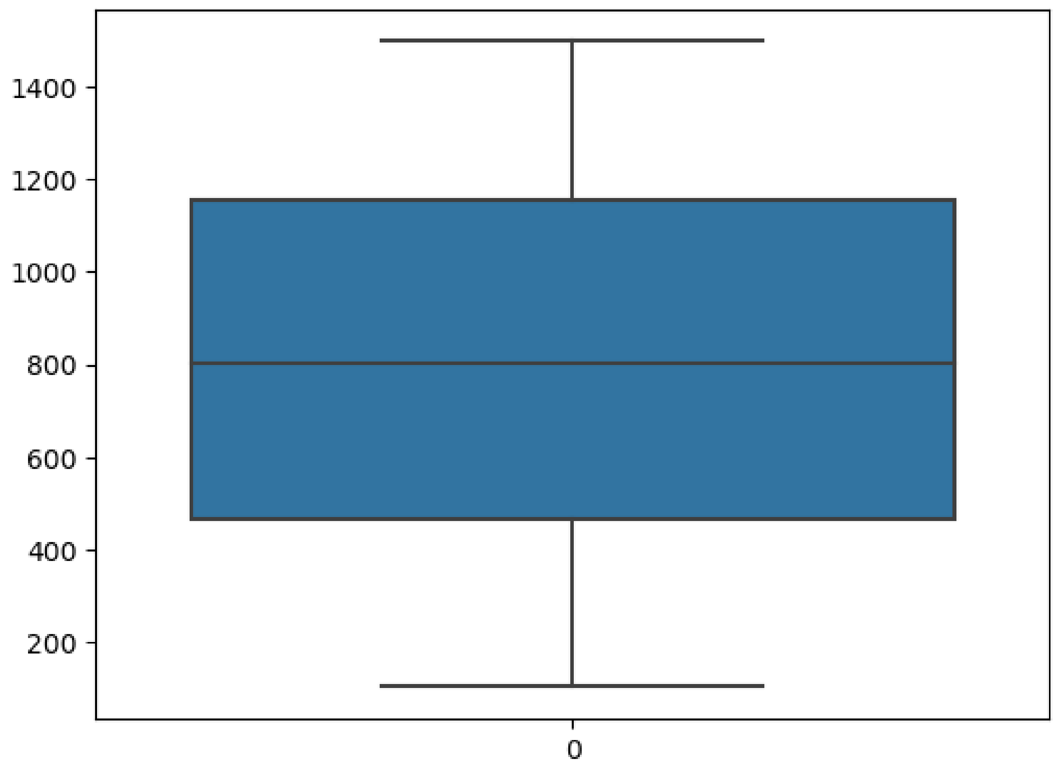
[11]:
```
sns.boxplot(data["Age"])
```

[11]: <Axes: >



[12]:
```
sns.boxplot(data["DailyRate"])
```

[12]: <Axes: >



[13]:
```
data.describe()
```

[13]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount \
count	1470.000000	1470.000000	1470.000000	1470.000000	1470.0
mean	36.923810	802.485714	9.192517	2.912925	1.0
std	9.135373	403.509100	8.106864	1.024165	0.0
min	18.000000	102.000000	1.000000	1.000000	1.0
25%	30.000000	465.000000	2.000000	2.000000	1.0
50%	36.000000	802.000000	7.000000	3.000000	1.0
75%	43.000000	1157.000000	14.000000	4.000000	1.0
max	60.000000	1499.000000	29.000000	5.000000	1.0

	EmployeeNumber	EnvironmentSatisfaction	HourlyRate	JobInvolvement \
count	1470.000000	1470.000000	1470.000000	1470.000000
mean	1024.865306	2.721769	65.891156	2.729932
std	602.024335	1.093082	20.329428	0.711561
min	1.000000	1.000000	30.000000	1.000000
25%	491.250000	2.000000	48.000000	2.000000
50%	1020.500000	3.000000	66.000000	3.000000
75%	1555.750000	4.000000	83.750000	3.000000
max	2068.000000	4.000000	100.000000	4.000000

```
       JobLevel  …  RelationshipSatisfaction  StandardHours  \
count  1470.000000  …               1470.000000         1470.0
mean      2.063946  …                  2.712245           80.0
std       1.106940  …                  1.081209            0.0
min       1.000000  …                  1.000000           80.0
25%       1.000000  …                  2.000000           80.0
50%       2.000000  …                  3.000000           80.0
75%       3.000000  …                  4.000000           80.0
max       5.000000  …                  4.000000           80.0

       StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
count       1470.000000        1470.000000            1470.000000
mean           0.793878          11.279592               2.799320
std            0.852077           7.780782               1.289271
min            0.000000           0.000000               0.000000
25%            0.000000           6.000000               2.000000
50%            1.000000          10.000000               3.000000
75%            1.000000          15.000000               3.000000
max            3.000000          40.000000               6.000000

       WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
count      1470.000000     1470.000000         1470.000000
mean          2.761224        7.008163            4.229252
std           0.706476        6.126525            3.623137
min           1.000000        0.000000            0.000000
25%           2.000000        3.000000            2.000000
50%           3.000000        5.000000            3.000000
75%           3.000000        9.000000            7.000000
max           4.000000       40.000000           18.000000

       YearsSinceLastPromotion  YearsWithCurrManager
count              1470.000000           1470.000000
mean                  2.187755              4.123129
std                   3.222430              3.568136
min                   0.000000              0.000000
25%                   0.000000              2.000000
50%                   1.000000              3.000000
75%                   3.000000              7.000000
max                  15.000000             17.000000

[8 rows x 26 columns]
```

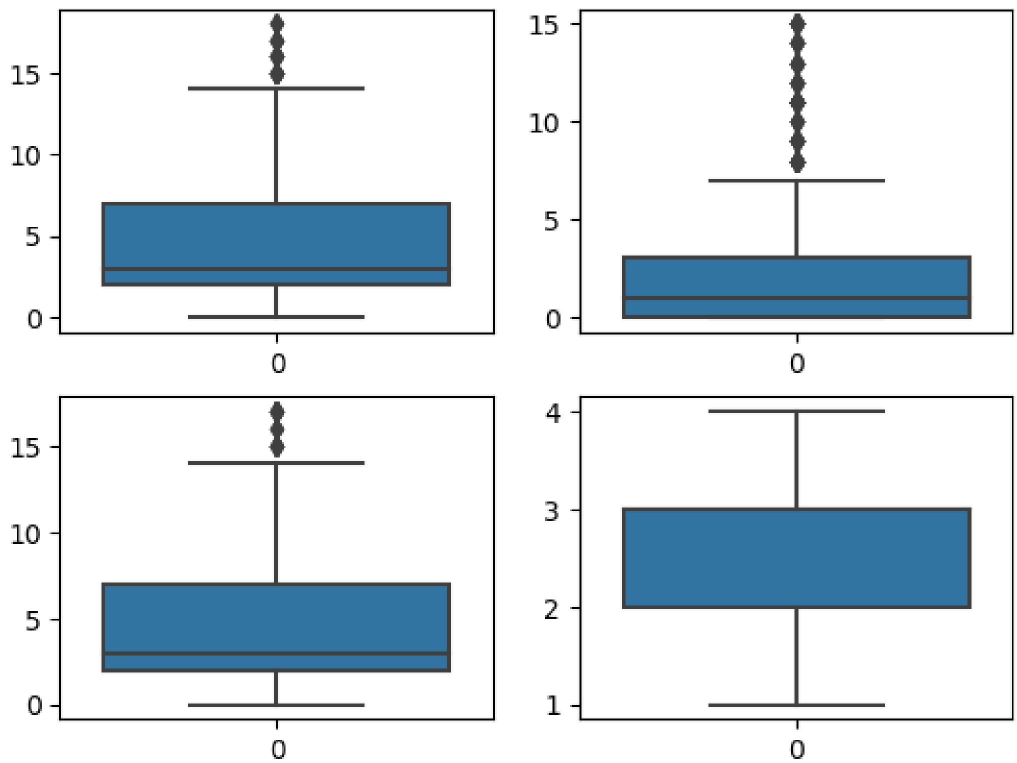
[14]:
```
data.head()
```

[14]:
```
   Age Attrition     BusinessTravel  DailyRate              Department  \
0   41       Yes      Travel_Rarely       1102                   Sales
1   49        No  Travel_Frequently        279  Research & Development
```

```
2   37        Yes       Travel_Rarely       1373  Research & Development
3   33         No   Travel_Frequently       1392  Research & Development
4   27         No       Travel_Rarely        591  Research & Development

   DistanceFromHome  Education EducationField  EmployeeCount  EmployeeNumber  \
0                 1          2  Life Sciences              1               1
1                 8          1  Life Sciences              1               2
2                 2          2          Other              1               4
3                 3          4  Life Sciences              1               5
4                 2          1        Medical              1               7

   …  RelationshipSatisfaction StandardHours  StockOptionLevel  \
0  …                         1            80                 0
1  …                         4            80                 1
2  …                         2            80                 0
3  …                         3            80                 0
4  …                         4            80                 1

   TotalWorkingYears  TrainingTimesLastYear WorkLifeBalance  YearsAtCompany  \
0                  8                      0               1               6
1                 10                      3               3              10
2                  7                      3               3               0
3                  8                      3               3               8
4                  6                      3               3               2

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                  4                        0                     5
1                  7                        1                     7
2                  0                        0                     0
3                  7                        3                     0
4                  2                        2                     2

[5 rows x 35 columns]
```

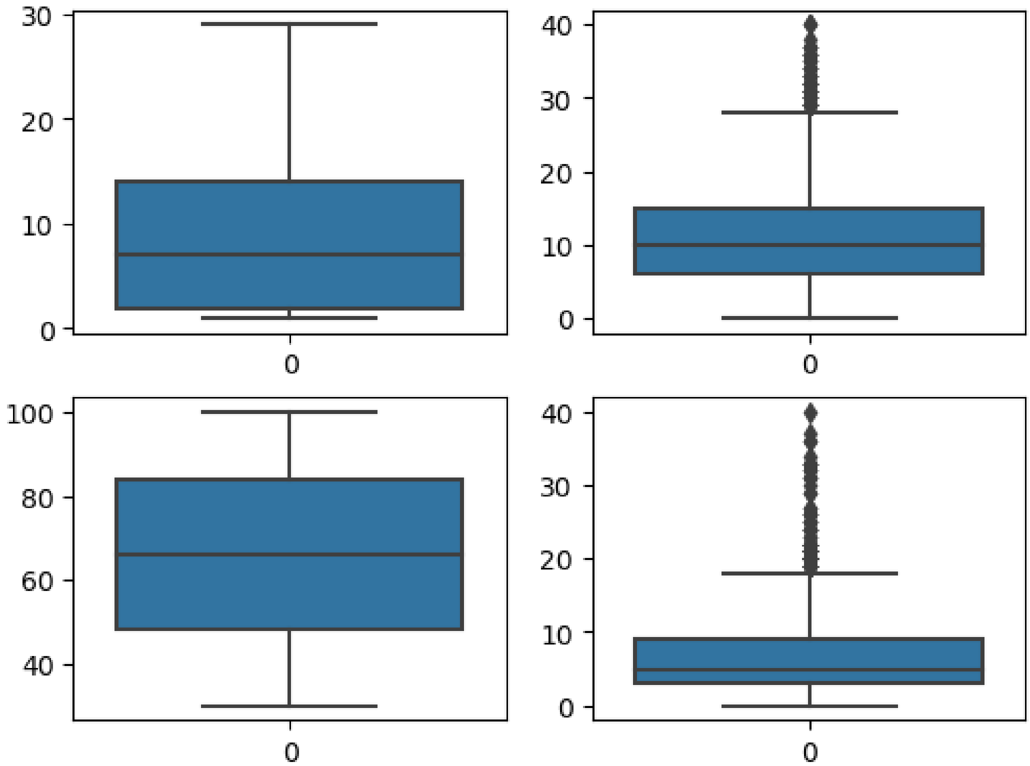
[15]:
```
fig, axes = plt.subplots(2,2)
sns.boxplot(data=data["YearsInCurrentRole"],ax=axes[0,0])
sns.boxplot(data=data["YearsSinceLastPromotion"],ax=axes[0,1])
sns.boxplot(data=data["YearsWithCurrManager"],ax=axes[1,0])
sns.boxplot(data=data["WorkLifeBalance"],ax=axes[1,1])
```

[15]: <Axes: >




```
[16]: fig, axes = plt.subplots(2,2)
      sns.boxplot(data=data["DistanceFromHome"],ax=axes[0,0])
      sns.boxplot(data=data["TotalWorkingYears"],ax=axes[0,1])
      sns.boxplot(data=data["HourlyRate"],ax=axes[1,0])
      sns.boxplot(data=data["YearsAtCompany"],ax=axes[1,1])
```

```
[16]: <Axes: >
```



2.3 Handling the Outliers

[17]:
```
YearsInCurrentRole_q1 = data.YearsInCurrentRole.quantile(0.25)
YearsInCurrentRole_q3 = data.YearsInCurrentRole.quantile(0.75)
IQR_YearsInCurrentRole=YearsInCurrentRole_q3-YearsInCurrentRole_q1
upperlimit_YearsInCurrentRole=YearsInCurrentRole_q3+1.5*IQR_YearsInCurrentRole
lower_limit_YearsInCurrentRole =YearsInCurrentRole_q1-1.5*IQR_YearsInCurrentRole
median_YearsInCurrentRole=data["YearsInCurrentRole"].median()
data['YearsInCurrentRole'] = np.where(
    (data['YearsInCurrentRole'] > upperlimit_YearsInCurrentRole),
    median_YearsInCurrentRole,
    data['YearsInCurrentRole']
)
```

[18]:
```
YearsSinceLastPromotion_q1 = data.YearsSinceLastPromotion.quantile(0.25)
YearsSinceLastPromotion_q3 = data.YearsSinceLastPromotion.quantile(0.75)
IQR_YearsSinceLastPromotion=YearsSinceLastPromotion_q3-YearsSinceLastPromotion_q1
upperlimit_YearsSinceLastPromotion=YearsSinceLastPromotion_q3+1.
 ↪5*IQR_YearsSinceLastPromotion
lower_limit_YearsSinceLastPromotion =YearsSinceLastPromotion_q1-1.
 ↪5*IQR_YearsSinceLastPromotion
```

```
median_YearsSinceLastPromotion=data["YearsSinceLastPromotion"].median()
data['YearsSinceLastPromotion'] = np.where(
    (data['YearsSinceLastPromotion'] > upperlimit_YearsSinceLastPromotion),
    median_YearsSinceLastPromotion,
    data['YearsSinceLastPromotion']
)
```

[19]:
```
YearsWithCurrManager_q1 = data.YearsWithCurrManager.quantile(0.25)
YearsWithCurrManager_q3 = data.YearsWithCurrManager.quantile(0.75)
IQR_YearsWithCurrManager=YearsWithCurrManager_q3-YearsWithCurrManager_q1
upperlimit_YearsWithCurrManager=YearsWithCurrManager_q3+1.
 ↪5*IQR_YearsWithCurrManager
lower_limit_YearsWithCurrManager =YearsWithCurrManager_q1-1.
 ↪5*IQR_YearsWithCurrManager
median_YearsWithCurrManager=data["YearsWithCurrManager"].median()
data['YearsWithCurrManager'] = np.where(
    (data['YearsWithCurrManager'] > upperlimit_YearsWithCurrManager),
    median_YearsWithCurrManager,
    data['YearsWithCurrManager']
)
```

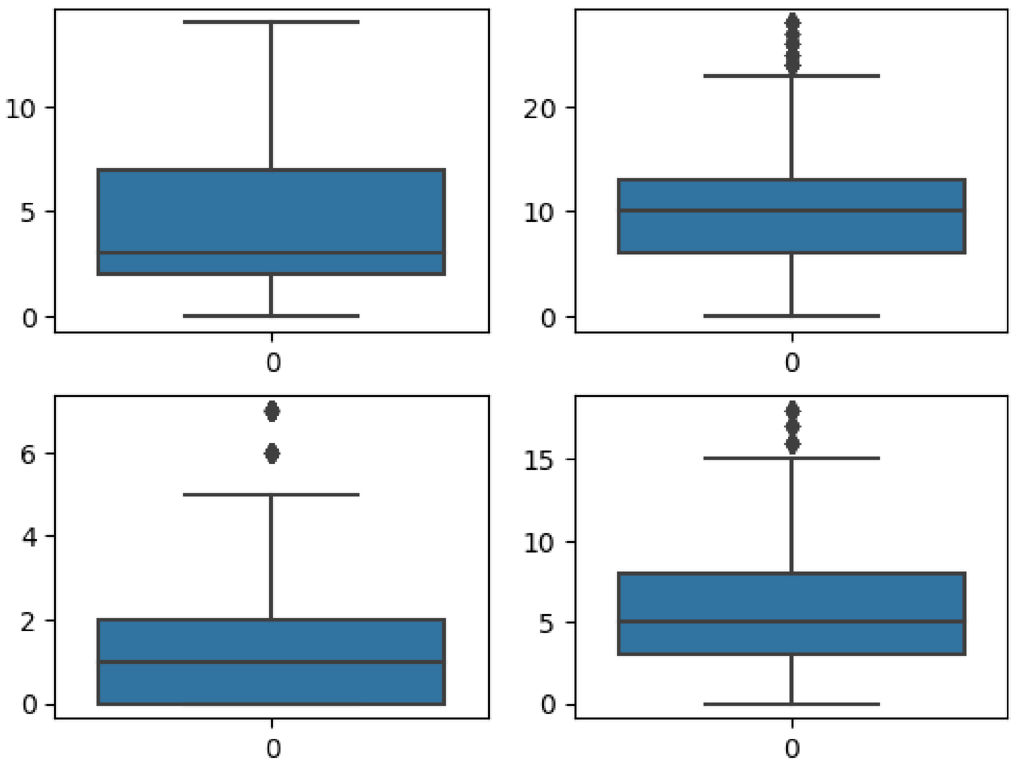
[20]:
```
TotalWorkingYears_q1 = data.TotalWorkingYears.quantile(0.25)
TotalWorkingYears_q3 = data.TotalWorkingYears.quantile(0.75)
IQR_TotalWorkingYears=TotalWorkingYears_q3-TotalWorkingYears_q1
upperlimit_TotalWorkingYears=TotalWorkingYears_q3+1.5*IQR_TotalWorkingYears
lower_limit_TotalWorkingYears=TotalWorkingYears_q1-1.5*IQR_TotalWorkingYears
median_TotalWorkingYears=data["TotalWorkingYears"].median()
data['TotalWorkingYears'] = np.where(
    (data['TotalWorkingYears'] > upperlimit_TotalWorkingYears),
    median_TotalWorkingYears,
    data['TotalWorkingYears']
)
```

[21]:
```
YearsAtCompany_q1 = data.YearsAtCompany.quantile(0.25)
YearsAtCompany_q3 = data.YearsAtCompany.quantile(0.75)
IQR_YearsAtCompany=YearsAtCompany_q3-YearsAtCompany_q1
upperlimit_YearsAtCompany=YearsAtCompany_q3+1.5*IQR_YearsAtCompany
lower_limit_YearsAtCompany=YearsAtCompany_q1-1.5*IQR_YearsAtCompany
median_YearsAtCompany=data["YearsAtCompany"].median()
data['YearsAtCompany'] = np.where(
    (data['YearsAtCompany'] > upperlimit_YearsAtCompany),
    median_YearsAtCompany,
    data['YearsAtCompany']
)
```

[22]:
```
fig, axes = plt.subplots(2,2)
sns.boxplot(data=data["YearsWithCurrManager"],ax=axes[0,0])
```

```python
sns.boxplot(data=data["TotalWorkingYears"],ax=axes[0,1])
sns.boxplot(data=data["YearsSinceLastPromotion"],ax=axes[1,0])
sns.boxplot(data=data["YearsAtCompany"],ax=axes[1,1])
```

[22]:
```
<Axes: >
```



[23]:
```python
data.head()
```

[23]:
```
   Age Attrition     BusinessTravel  DailyRate              Department  \
0   41       Yes      Travel_Rarely       1102                   Sales
1   49        No  Travel_Frequently        279  Research & Development
2   37       Yes      Travel_Rarely       1373  Research & Development
3   33        No  Travel_Frequently       1392  Research & Development
4   27        No      Travel_Rarely        591  Research & Development

   DistanceFromHome  Education EducationField  EmployeeCount  EmployeeNumber  \
0                 1          2  Life Sciences              1               1
1                 8          1  Life Sciences              1               2
2                 2          2          Other              1               4
3                 3          4  Life Sciences              1               5
4                 2          1        Medical              1               7
```

```
   …  RelationshipSatisfaction StandardHours  StockOptionLevel  \
0  …                         1            80                 0
1  …                         4            80                 1
2  …                         2            80                 0
3  …                         3            80                 0
4  …                         4            80                 1

   TotalWorkingYears  TrainingTimesLastYear WorkLifeBalance  YearsAtCompany  \
0                8.0                      0               1             6.0
1               10.0                      3               3            10.0
2                7.0                      3               3             0.0
3                8.0                      3               3             8.0
4                6.0                      3               3             2.0

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                4.0                      0.0                   5.0
1                7.0                      1.0                   7.0
2                0.0                      0.0                   0.0
3                7.0                      3.0                   0.0
4                2.0                      2.0                   2.0

[5 rows x 35 columns]
```

[24]:
```
data.drop("EducationField",axis=1,inplace=True)
```

[25]:
```
data.head()
```

[25]:
```
   Age Attrition     BusinessTravel  DailyRate              Department  \
0   41       Yes      Travel_Rarely       1102                   Sales
1   49        No  Travel_Frequently        279  Research & Development
2   37       Yes      Travel_Rarely       1373  Research & Development
3   33        No  Travel_Frequently       1392  Research & Development
4   27        No      Travel_Rarely        591  Research & Development

   DistanceFromHome  Education  EmployeeCount  EmployeeNumber  \
0                 1          2              1               1
1                 8          1              1               2
2                 2          2              1               4
3                 3          4              1               5
4                 2          1              1               7

   EnvironmentSatisfaction  … RelationshipSatisfaction  StandardHours  \
0                        2  …                        1             80
1                        3  …                        4             80
2                        4  …                        2             80
3                        4  …                        3             80
4                        1  …                        4             80
```

```
   StockOptionLevel  TotalWorkingYears TrainingTimesLastYear  WorkLifeBalance  \
0                 0                8.0                     0                1
1                 1               10.0                     3                3
2                 0                7.0                     3                3
3                 0                8.0                     3                3
4                 1                6.0                     3                3

  YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
0            6.0                 4.0                      0.0
1           10.0                 7.0                      1.0
2            0.0                 0.0                      0.0
3            8.0                 7.0                      3.0
4            2.0                 2.0                      2.0

   YearsWithCurrManager
0                   5.0
1                   7.0
2                   0.0
3                   0.0
4                   2.0

[5 rows x 34 columns]
```

[26]:
```
data["BusinessTravel"].unique()
```

[26]:
```
array(['Travel_Rarely', 'Travel_Frequently', 'Non-Travel'], dtype=object)
```

2.4 Splitting the data

[27]:
```
y=data["Attrition"]
```

[28]:
```
y.head()
```

[28]:
```
0    Yes
1     No
2    Yes
3     No
4     No
Name: Attrition, dtype: object
```

[29]:
```
data.drop("Attrition",axis=1,inplace=True)
```

[30]:
```
data.head()
```

[30]:
```
   Age     BusinessTravel  DailyRate              Department  \
0   41      Travel_Rarely       1102                   Sales
```

```
1   49  Travel_Frequently        279  Research & Development
2   37      Travel_Rarely       1373  Research & Development
3   33  Travel_Frequently       1392  Research & Development
4   27      Travel_Rarely        591  Research & Development

   DistanceFromHome  Education  EmployeeCount  EmployeeNumber  \
0                 1          2              1               1
1                 8          1              1               2
2                 2          2              1               4
3                 3          4              1               5
4                 2          1              1               7

   EnvironmentSatisfaction  Gender  …  RelationshipSatisfaction  \
0                        2  Female  …                         1
1                        3    Male  …                         4
2                        4    Male  …                         2
3                        4  Female  …                         3
4                        1    Male  …                         4

   StandardHours  StockOptionLevel TotalWorkingYears  TrainingTimesLastYear  \
0             80                 0               8.0                      0
1             80                 1              10.0                      3
2             80                 0               7.0                      3
3             80                 0               8.0                      3
4             80                 1               6.0                      3

  WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
0               1             6.0                 4.0
1               3            10.0                 7.0
2               3             0.0                 0.0
3               3             8.0                 7.0
4               3             2.0                 2.0

   YearsSinceLastPromotion YearsWithCurrManager
0                      0.0                  5.0
1                      1.0                  7.0
2                      0.0                  0.0
3                      3.0                  0.0
4                      2.0                  2.0

[5 rows x 33 columns]
```

2.5 Encoding

[31]:
```
from sklearn.preprocessing import LabelEncoder
```

[32]:
```
le=LabelEncoder()
```

[33]:
```
data["BusinessTravel"]=le.fit_transform(data["BusinessTravel"])
```

[34]:
```
data["Department"]=le.fit_transform(data["Department"])
```

[35]:
```
data["Gender"]=le.fit_transform(data["Gender"])
```

[36]:
```
y=le.fit_transform(y)
```

[37]:
```
y
```

[37]:
```
array([1, 0, 1, …, 0, 0, 0])
```

[38]:
```
data["JobRole"]=le.fit_transform(data["JobRole"])
```

[39]:
```
data["Over18"]=le.fit_transform(data["Over18"])
```

[40]:
```
data["MaritalStatus"]=le.fit_transform(data["MaritalStatus"])
```

[41]:
```
data["OverTime"]=le.fit_transform(data["OverTime"])
```

[42]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 33 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   Age                       1470 non-null   int64
 1   BusinessTravel            1470 non-null   int32
 2   DailyRate                 1470 non-null   int64
 3   Department                1470 non-null   int32
 4   DistanceFromHome          1470 non-null   int64
 5   Education                 1470 non-null   int64
 6   EmployeeCount             1470 non-null   int64
 7   EmployeeNumber            1470 non-null   int64
 8   EnvironmentSatisfaction   1470 non-null   int64
 9   Gender                    1470 non-null   int32
 10  HourlyRate                1470 non-null   int64
 11  JobInvolvement            1470 non-null   int64
 12  JobLevel                  1470 non-null   int64
 13  JobRole                   1470 non-null   int32
 14  JobSatisfaction           1470 non-null   int64
 15  MaritalStatus             1470 non-null   int32
 16  MonthlyIncome             1470 non-null   int64
 17  MonthlyRate               1470 non-null   int64
 18  NumCompaniesWorked        1470 non-null   int64
 19  Over18                    1470 non-null   int32
 20  OverTime                  1470 non-null   int32
```

```
 21  PercentSalaryHike          1470 non-null   int64
 22  PerformanceRating          1470 non-null   int64
 23  RelationshipSatisfaction   1470 non-null   int64
 24  StandardHours              1470 non-null   int64
 25  StockOptionLevel           1470 non-null   int64
 26  TotalWorkingYears          1470 non-null   float64
 27  TrainingTimesLastYear      1470 non-null   int64
 28  WorkLifeBalance            1470 non-null   int64
 29  YearsAtCompany             1470 non-null   float64
 30  YearsInCurrentRole         1470 non-null   float64
 31  YearsSinceLastPromotion    1470 non-null   float64
 32  YearsWithCurrManager       1470 non-null   float64
dtypes: float64(5), int32(7), int64(21)
memory usage: 338.9 KB
```

2.6 Train Test Split

[43]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(data,y,test_size=0.
 ↪3,random_state=0)
```

[44]:
```
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

[44]:
```
((1029, 33), (441, 33), (1029,), (441,))
```

2.7 Featuring Scaling

[45]:
```
from sklearn.preprocessing import StandardScaler
```

[46]:
```
sc=StandardScaler()
```

[47]:
```
x_train=sc.fit_transform(x_train)
```

[48]:
```
x_test=sc.fit_transform(x_test)
```

3 Building the model

3.1 Multi Linear Regression

[49]:
```
from sklearn.linear_model import LinearRegression
```

[50]:
```
lr = LinearRegression()
```

[51]:
```
lr.fit(x_train,y_train)
```

[51]:
```
LinearRegression()
```

```
[52]: lr.coef_  #slope(m)
```

```
[52]: array([-3.54940447e-02,  7.88352347e-05, -1.70825038e-02,  3.46389690e-02,
        2.44612841e-02,  3.65668214e-03,  5.37764278e-17, -9.46820520e-03,
       -4.11203734e-02,  1.06338881e-02, -2.97662154e-03, -3.84864283e-02,
       -1.52927977e-02, -1.57839139e-02, -3.67252862e-02,  3.35765928e-02,
       -5.90043558e-03,  5.81099165e-03,  3.78471890e-02,  6.93889390e-18,
        9.55263279e-02, -2.55800078e-02,  2.01844797e-02, -2.64773510e-02,
        8.67361738e-19, -1.79286106e-02, -3.30529386e-02, -1.09247807e-02,
       -3.10631611e-02, -2.47887717e-02, -1.10177742e-02,  2.11897289e-02,
       -6.60823991e-03])
```

```
[53]: lr.intercept_  #(c)
```

```
[53]: 0.16229348882410102
```

```
[54]: y_pred = lr.predict(x_test)
```

```
[55]: y_pred
```

```
[55]: array([ 1.30302477e-01,  2.17626230e-01,  3.46282415e-01,  5.41382549e-03,
        4.99292896e-01,  1.01628868e-01,  3.44742777e-01,  1.23994945e-01,
       -1.60694945e-01,  4.02435622e-01,  1.44159172e-01,  2.67416840e-01,
       -4.62559536e-02,  5.58671849e-01,  2.81858700e-01,  1.53537792e-02,
        1.78573363e-01,  2.77532834e-01,  9.37121052e-02,  2.17571624e-01,
        2.65936178e-01,  1.41499184e-02,  8.36251186e-02,  9.58849826e-02,
        5.09869963e-01,  2.94764240e-01,  7.85819529e-02,  1.26647773e-01,
        5.05518902e-01,  8.48456917e-02, -7.97229275e-02,  2.15516993e-02,
        1.08079105e-01,  3.65998400e-01,  1.24517362e-01,  5.13682786e-02,
        1.06749689e-01,  6.07640778e-02,  6.66425313e-02,  4.81312859e-02,
       -1.16761425e-02, -2.97852924e-02,  5.25135582e-02, -1.59076817e-02,
       -1.71522795e-02,  4.17777714e-01,  3.67341564e-01, -2.14569245e-01,
        5.47964121e-01,  4.40723777e-01,  1.96701754e-01,  4.42415223e-01,
        1.45760263e-01,  3.75821843e-01,  4.92762622e-01,  2.95885645e-01,
       -4.62363391e-02,  3.16337190e-01, -7.90813313e-03,  2.52644685e-01,
       -3.18239329e-02,  2.83907645e-01,  9.03615010e-02,  1.26934391e-01,
        3.58670014e-01,  2.40923530e-02,  3.55890111e-01,  1.95961225e-01,
        1.28554515e-01,  1.18806226e-01, -2.86217094e-02,  3.17635336e-01,
        1.08017895e-01,  1.25723940e-01,  2.30183307e-01,  9.84315444e-02,
        9.10911969e-02,  2.72901425e-01,  2.52029723e-01,  4.09210759e-02,
       -9.10277454e-02, -1.08769544e-02,  1.94114970e-01, -2.25933708e-02,
       -1.73984898e-02,  1.15587264e-01,  8.36037575e-02,  2.82744685e-03,
        4.96507732e-02,  2.41862504e-01,  3.14048594e-01,  2.26261102e-01,
        3.30118359e-01,  2.38527777e-01, -2.16338946e-02,  2.26553579e-01,
        3.01400098e-01,  2.98806055e-01,  9.89137248e-02,  8.90108718e-02,
        2.86485256e-01,  5.00403045e-01,  3.03125892e-01, -4.87373316e-03,
        1.71527163e-01, -5.37529492e-03,  2.54338027e-02,  2.15725447e-01,
```

```
 6.00786752e-02,  1.64813384e-01,  1.09106397e-01,  1.08287462e-01,
-3.09499535e-02,  1.96828572e-01,  9.71193504e-02,  3.19061388e-02,
 1.07934574e-01,  2.33635162e-01, -8.52754375e-02, -7.69198906e-02,
 2.00624349e-01,  3.35600477e-02,  1.28249663e-01,  6.03012321e-01,
 5.78155766e-03, -3.07808886e-02, -1.45938525e-01,  2.19398082e-01,
 2.76229397e-01,  1.67698116e-01, -2.88123044e-03,  2.62341213e-01,
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-4.10384806e-02,  1.34296605e-01, -1.03707555e-01, -5.60163735e-02,
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-3.51278477e-03, -8.95239598e-02,  4.14367926e-02,  1.31087001e-01,
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 2.47091987e-01,  5.86970935e-02,  1.28678988e-01,  2.80584025e-01,
 7.21059443e-02, -8.07006907e-02,  3.39791632e-01,  8.25270203e-02,
 2.20338157e-01,  2.47703594e-01,  4.97067397e-01,  1.36010592e-01,
 2.88153807e-01,  4.61306498e-02,  4.52544344e-01, -8.24037634e-02,
 2.26796295e-01,  1.42129836e-02,  1.62111340e-01,  2.32246950e-01,
 9.12503556e-02,  1.18866795e-01,  2.12735292e-01, -2.69559828e-02,
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 1.63285101e-01,  2.42669261e-01,  5.44757533e-01,  1.25881866e-01,
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 3.14270745e-01,  1.31598745e-02, -3.56345942e-02,  3.52829749e-01,
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 2.80094379e-01, -7.13513228e-02,  1.84517461e-01,  2.02965882e-01,
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```

```
 3.11830741e-01,  2.55878748e-01,  5.64831824e-01, -8.48534911e-02,
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 1.04636218e-01,  1.31700032e-01,  2.07655641e-01,  3.32733438e-01,
-2.01238580e-01, -9.51544438e-02,  4.94665237e-02, -7.32543548e-03,
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 1.92718914e-01,  1.38040637e-01,  3.13471437e-01,  3.03369774e-01,
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 7.74987760e-03,  2.34345722e-01,  6.10723706e-02,  3.41757613e-01,
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 1.97392018e-01,  2.06959344e-01, -1.09857091e-01,  3.54059406e-01,
 7.26868239e-02,  2.36653676e-01, -8.20686416e-02,  3.20816139e-01,
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 9.97831984e-02, -5.30137196e-02,  3.47224412e-01,  1.03944090e-01,
-4.09963236e-02, -5.78838569e-02,  3.09525724e-01,  1.02060488e-01,
 2.09447907e-01,  4.10525192e-01,  3.33473319e-01,  1.80971041e-01,
 2.76792072e-01,  2.86132531e-01,  2.62476320e-01, -1.83021903e-02,
 2.36094900e-01,  1.54018489e-01,  6.36220924e-02,  6.18224799e-03,
 1.85057193e-02,  7.69476922e-02,  1.34623859e-01,  1.87169316e-01,
 2.36666289e-01, -1.82114662e-01,  2.98547908e-01,  1.73398527e-01,
-8.87118635e-02,  3.51838607e-02,  1.35598577e-01,  1.70085191e-01,
 1.69932034e-01,  2.29056852e-01,  2.15573570e-01,  1.04403736e-01,
-8.21467550e-02])
```

[56]:
```
y_test
```

[56]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 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, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
```

```
0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 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, 1, 0,
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0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1,
0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0])
```

3.2 Logistic Regression

[57]:
```
from sklearn.linear_model import LogisticRegression
```

[58]:
```
lg=LogisticRegression()
```

[59]:
```
lg.fit(x_train,y_train)
```

[59]:
```
LogisticRegression()
```

[60]:
```
y_pred_lg=lg.predict(x_test)
```

[61]:
```
y_pred
```

[61]:
```
array([ 1.30302477e-01,  2.17626230e-01,  3.46282415e-01,  5.41382549e-03,
        4.99292896e-01,  1.01628868e-01,  3.44742777e-01,  1.23994945e-01,
       -1.60694945e-01,  4.02435622e-01,  1.44159172e-01,  2.67416840e-01,
       -4.62559536e-02,  5.58671849e-01,  2.81858700e-01,  1.53537792e-02,
        1.78573363e-01,  2.77532834e-01,  9.37121052e-02,  2.17571624e-01,
        2.65936178e-01,  1.41499184e-02,  8.36251186e-02,  9.58849826e-02,
        5.09869963e-01,  2.94764240e-01,  7.85819529e-02,  1.26647773e-01,
        5.05518902e-01,  8.48456917e-02, -7.97229275e-02,  2.15516993e-02,
        1.08079105e-01,  3.65998400e-01,  1.24517362e-01,  5.13682786e-02,
        1.06749689e-01,  6.07640778e-02,  6.66425313e-02,  4.81312859e-02,
       -1.16761425e-02, -2.97852924e-02,  5.25135582e-02, -1.59076817e-02,
       -1.71522795e-02,  4.17777714e-01,  3.67341564e-01, -2.14569245e-01,
        5.47964121e-01,  4.40723777e-01,  1.96701754e-01,  4.42415223e-01,
        1.45760263e-01,  3.75821843e-01,  4.92762622e-01,  2.95885645e-01,
       -4.62363391e-02,  3.16337190e-01, -7.90813313e-03,  2.52644685e-01,
       -3.18239329e-02,  2.83907645e-01,  9.03615010e-02,  1.26934391e-01,
        3.58670014e-01,  2.40923530e-02,  3.55890111e-01,  1.95961225e-01,
        1.28554515e-01,  1.18806226e-01, -2.86217094e-02,  3.17635336e-01,
```

```
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-9.10277454e-02, -1.08769544e-02,  1.94114970e-01, -2.25933708e-02,
-1.73984898e-02,  1.15587264e-01,  8.36037575e-02,  2.82744685e-03,
 4.96507732e-02,  2.41862504e-01,  3.14048594e-01,  2.26261102e-01,
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 3.01400098e-01,  2.98806055e-01,  9.89137248e-02,  8.90108718e-02,
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 1.71527163e-01, -5.37529492e-03,  2.54338027e-02,  2.15725447e-01,
 6.00786752e-02,  1.64813384e-01,  1.09106397e-01,  1.08287462e-01,
-3.09499535e-02,  1.96828572e-01,  9.71193504e-02,  3.19061388e-02,
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 2.08537425e-01,  2.79887773e-01,  1.16637429e-01,  2.74165030e-01,
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 3.36748074e-01, -9.48504896e-02,  2.11704189e-01,  6.18083877e-01,
 2.03467623e-01,  3.04552682e-01,  1.81990599e-01,  1.84838109e-01,
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 1.73558095e-01,  1.58265827e-01, -8.67210631e-02,  1.87726385e-01,
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-2.01238580e-01, -9.51544438e-02,  4.94665237e-02, -7.32543548e-03,
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-2.02255818e-01,  2.52065992e-01, -1.51719947e-01,  3.50282752e-01,
-9.84668529e-02,  2.14753151e-01,  2.46151971e-02,  2.09633480e-01,
 9.48374386e-02,  3.12075361e-01,  4.06959059e-01, -2.26761393e-02,
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 4.21237022e-01,  1.49225126e-01,  4.45704191e-02,  3.37793947e-02,
 9.97831984e-02, -5.30137196e-02,  3.47224412e-01,  1.03944090e-01,
-4.09963236e-02, -5.78838569e-02,  3.09525724e-01,  1.02060488e-01,
 2.09447907e-01,  4.10525192e-01,  3.33473319e-01,  1.80971041e-01,
 2.76792072e-01,  2.86132531e-01,  2.62476320e-01, -1.83021903e-02,
 2.36094900e-01,  1.54018489e-01,  6.36220924e-02,  6.18224799e-03,
 1.85057193e-02,  7.69476922e-02,  1.34623859e-01,  1.87169316e-01,
 2.36666289e-01, -1.82114662e-01,  2.98547908e-01,  1.73398527e-01,
-8.87118635e-02,  3.51838607e-02,  1.35598577e-01,  1.70085191e-01,
 1.69932034e-01,  2.29056852e-01,  2.15573570e-01,  1.04403736e-01,
-8.21467550e-02])
```

[62]:
```
y_test
```

[62]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 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, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 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, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0,
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       0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1,
       0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0])
```

[63]:
```
score = lg.score(x_test, y_test)
print(score)
```

```
0.8820861678004536
```

3.3 Confusion Matrix

[64]:
```
from sklearn import metrics
cm = metrics.confusion_matrix(y_test,y_pred_lg)
print(cm)
```

```
[[366   5]
 [ 47  23]]
```

3.4 Ridge and Lasso

[65]:
```
from sklearn.linear_model import Ridge
from sklearn.model_selection import GridSearchCV
```

[66]:
```
rg=Ridge()
```

[67]:
```
parametres={"alpha":[1,2,3,5,10,20,30,40,60,70,80,90]}
ridgecv=GridSearchCV(rg,parametres,scoring="neg_mean_squared_error",cv=5)
ridgecv.fit(x_train,y_train)
```

[67]:
```
GridSearchCV(cv=5, estimator=Ridge(),
             param_grid={'alpha': [1, 2, 3, 5, 10, 20, 30, 40, 60, 70, 80, 90]},
             scoring='neg_mean_squared_error')
```

[68]:
```
print(ridgecv.best_params_)
```

```
{'alpha': 90}
```

[69]:
```
print(ridgecv.best_score_)
```

```
-0.11390621139234185
```

[70]:
```
y_pred_rg=ridgecv.predict(x_test)
```

[71]:
```
y_pred_rg
```

[71]:
```
array([ 1.34413485e-01,  2.22561818e-01,  3.41692977e-01,  3.88209867e-03,
        4.84617338e-01,  1.16361483e-01,  3.30449743e-01,  1.27358807e-01,
       -1.34442619e-01,  3.77692888e-01,  1.33001445e-01,  2.69898751e-01,
       -2.54707392e-02,  5.25771894e-01,  2.67543514e-01,  2.78725024e-02,
        1.82233111e-01,  2.78896415e-01,  9.12689699e-02,  2.11494641e-01,
        2.70103341e-01,  8.44922044e-03,  8.74746722e-02,  1.05348798e-01,
        4.87749940e-01,  2.83080512e-01,  8.80556209e-02,  1.23817268e-01,
        4.82185624e-01,  9.34824523e-02, -7.16448509e-02,  4.07003104e-02,
        1.08437994e-01,  3.42151399e-01,  1.22270929e-01,  6.85889862e-02,
        1.06690533e-01,  7.08689637e-02,  7.51570276e-02,  6.05829413e-02,
        1.08782897e-02, -6.91368661e-03,  5.83191600e-02, -1.54680056e-02,
       -4.02267475e-03,  4.08010612e-01,  3.43668700e-01, -1.83519405e-01,
        5.29536511e-01,  4.27646098e-01,  1.95234877e-01,  4.25012930e-01,
        1.40754410e-01,  3.52173952e-01,  4.70372694e-01,  2.89240343e-01,
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       -1.40249115e-02,  2.75133912e-01,  8.64669565e-02,  1.24214885e-01,
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        1.12452197e-01,  1.30525275e-01,  2.19329505e-01,  9.44722098e-02,
        9.98185782e-02,  2.60042486e-01,  2.51475715e-01,  4.59039018e-02,
       -7.94007856e-02, -7.05812314e-03,  2.04344419e-01, -3.97180151e-03,
       -5.91286905e-03,  1.26797761e-01,  8.02495203e-02,  2.55422079e-02,
        4.65384158e-02,  2.32985240e-01,  3.16063931e-01,  2.02833301e-01,
        3.14235904e-01,  2.33427101e-01, -1.42446708e-02,  2.24789285e-01,
        2.94719863e-01,  2.94698323e-01,  1.19907108e-01,  9.47152062e-02,
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[72]:
```
y_test
```

[72]:
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```
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0])
```

[73]:
```
from sklearn import metrics
print(metrics.r2_score(y_test,y_pred_rg))
print(metrics.r2_score(y_train,ridgecv.predict(x_train)))
```

```
0.21073458438815884
0.2061567210285108
```

3.5 Lasso

[74]:
```
from sklearn.linear_model import Lasso
from sklearn.model_selection import GridSearchCV
```

[75]:
```
la=Ridge()
```

[76]:
```
parametres={"alpha":[1,2,3,5,10,20,30,40,60,70,80,90]}
ridgecv=GridSearchCV(la,parametres,scoring="neg_mean_squared_error",cv=5)
ridgecv.fit(x_train,y_train)
```

[76]:
```
GridSearchCV(cv=5, estimator=Ridge(),
             param_grid={'alpha': [1, 2, 3, 5, 10, 20, 30, 40, 60, 70, 80, 90]},
             scoring='neg_mean_squared_error')
```

[77]:
```
print(ridgecv.best_params_)
```

```
{'alpha': 90}
```

[78]:
```
print(ridgecv.best_score_)
```

```
-0.11390621139234185
```

[79]:
```
y_pred_la=ridgecv.predict(x_test)
```

[80]:
```
y_pred_la
```

[80]:
```
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 1.25404974e-01,  2.97241061e-01,  2.29580043e-01,  2.16006118e-03,
 2.94123343e-01,  2.48418344e-01,  5.44089373e-01, -6.68570736e-02,
 2.24222741e-01,  1.35207932e-01,  1.91240682e-01,  3.87158365e-02,
 1.17416027e-01,  1.20780070e-01,  2.19845528e-01,  3.11363894e-01,
-1.70611843e-01, -6.89093044e-02,  5.87182022e-02,  1.46846582e-02,
 2.07924051e-01,  2.57017951e-01,  2.33929422e-01,  2.81772193e-01,
 2.28214280e-01,  8.56533063e-02,  1.28782763e-01,  6.89964545e-03,
 2.66888647e-01,  1.25060071e-01,  3.71449815e-01,  3.23080605e-01,
 1.80691831e-01,  1.35736688e-01,  3.05937337e-01,  3.02505887e-01,
-1.61842349e-01,  1.22990350e-01,  1.33351902e-02,  3.42072173e-01,
 1.35302335e-01,  3.71921241e-01,  2.43987619e-01, -1.42777272e-01,
 2.54178774e-01, -1.97769860e-01,  3.22194537e-01,  1.46753524e-01,
 1.28207748e-01,  4.59813547e-01,  1.49345212e-01,  3.97978765e-01,
 1.11492990e-01,  2.94090069e-02,  2.30676290e-01,  1.19192017e-01,
 1.49461455e-02,  2.42284371e-01,  7.22361156e-02,  3.33852369e-01,
 1.61213354e-01,  9.69685794e-02,  2.32264965e-01, -6.93181380e-02,
 1.86467739e-01,  2.03098589e-01, -1.10349710e-02,  2.63095846e-01,
-2.48406147e-01, -3.25418955e-02,  1.74487006e-01,  2.62780720e-02,
 1.91428194e-01,  2.03493779e-01, -8.84696022e-02,  3.35631012e-01,
 6.29476544e-02,  2.28818932e-01, -7.72255471e-02,  3.05353195e-01,
 3.63634109e-02,  2.30128273e-01,  3.03522210e-01,  1.05913376e-01,
 1.26693452e-02,  9.53511494e-02,  4.52766233e-01, -4.37470263e-02,
 3.05687630e-01,  3.57706117e-02,  1.82867743e-01,  2.10106289e-01,
-1.71378996e-01,  2.60157245e-01, -1.38655420e-01,  3.36603939e-01,
-7.65297319e-02,  2.15165094e-01,  3.72947326e-02,  1.96608549e-01,
 1.07172893e-01,  3.07687901e-01,  3.97760529e-01,  1.06797074e-03,
```

```
 8.12866229e-02,  2.95445495e-01,  5.47994817e-02,  1.13818287e-01,
 4.07117263e-01,  1.48860323e-01,  3.88471838e-02,  3.79029267e-02,
 1.09895981e-01, -4.30946471e-02,  3.30298512e-01,  1.07254284e-01,
-1.13032643e-02, -3.69192632e-02,  2.87732288e-01,  9.91961213e-02,
 2.12225886e-01,  3.88660531e-01,  3.15623317e-01,  1.80996998e-01,
 2.69970366e-01,  2.81850174e-01,  2.49972461e-01, -2.33065542e-03,
 2.34240860e-01,  1.51536128e-01,  6.56810225e-02,  1.35221573e-02,
 3.03956323e-02,  9.22075626e-02,  1.28297232e-01,  2.04669352e-01,
 2.26917512e-01, -1.62627965e-01,  2.95984225e-01,  1.80934145e-01,
-6.34810776e-02,  4.36092057e-02,  1.39814157e-01,  1.72029014e-01,
 1.65538329e-01,  2.24411690e-01,  2.15315070e-01,  1.16342630e-01,
-6.24745967e-02])
```

[81]:
```python
from sklearn import metrics
print(metrics.r2_score(y_test,y_pred_la))
print(metrics.r2_score(y_train,ridgecv.predict(x_train)))
```

```
0.21073458438815884
0.2061567210285108
```

3.6 Decision Tree

[82]:
```python
from sklearn.tree import DecisionTreeClassifier
dtc=DecisionTreeClassifier()
```

[83]:
```python
dtc.fit(x_train,y_train)
```

[83]:
```
DecisionTreeClassifier()
```

[84]:
```python
pred=dtc.predict(x_test)
```

[85]:
```python
pred
```

[85]:
```
array([0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 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, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       0, 1, 1, 0, 0, 0, 0, 1, 1, 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, 0, 1, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1,
       0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0,
```

```
        0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
        0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
        0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0,
        0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
        0])
```

[86]:
```
y_test
```

[86]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 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, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 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, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 1, 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, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1,
       0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0])
```

[87]:
```
#Accuracy score
from sklearn.metrics import␣
↪accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

[88]:
```
accuracy_score(y_test,pred)
```

[88]:
```
0.7755102040816326
```

[89]:
```
confusion_matrix(y_test,pred)
```

[89]:
```
array([[320,  51],
       [ 48,  22]], dtype=int64)
```

[90]:
```
pd.crosstab(y_test,pred)
```

[90]:
```
col_0    0   1
row_0
0      320  51
1       48  22
```

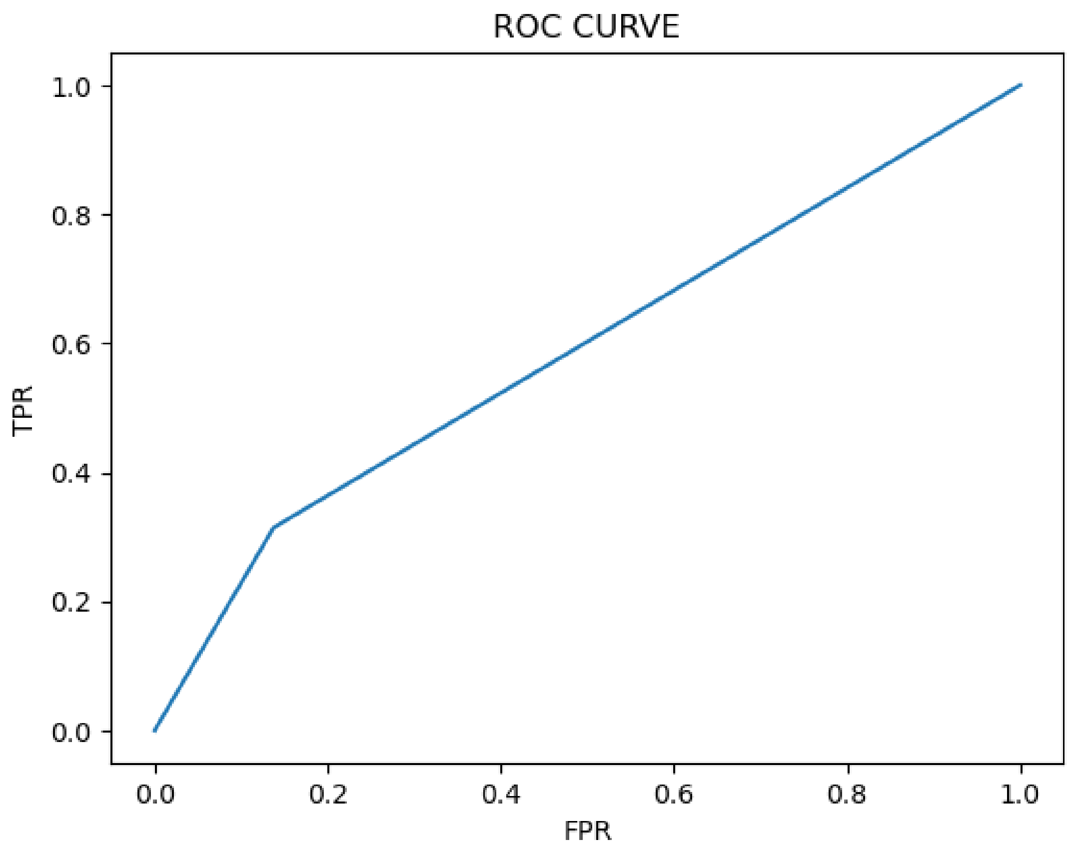
[91]:
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.87      0.86      0.87       371
           1       0.30      0.31      0.31        70

    accuracy                           0.78       441
   macro avg       0.59      0.59      0.59       441
weighted avg       0.78      0.78      0.78       441
```

[92]:
```
probability=dtc.predict_proba(x_test)[:,1]
```

[93]:
```
# roc_curve
fpr,tpr,threshsholds = roc_curve(y_test,probability)
```

[94]:
```
plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('ROC CURVE')
plt.show()
```



3.7 Random Forest

[95]:
```
from sklearn.ensemble import RandomForestClassifier
rfc=RandomForestClassifier()
```

[96]:
```
forest_params = [{'max_depth': list(range(10, 15)), 'max_features':␣
↪list(range(0,14))}]
```

[97]:
```
from sklearn.model_selection import GridSearchCV
```

[98]:
```
rfc_cv= GridSearchCV(rfc,param_grid=forest_params,cv=10,scoring="accuracy")
```

[99]:
```
rfc_cv.fit(x_train,y_train)
```

```
C:\ProgramData\anaconda3\Lib\site-
packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
50 fits failed out of a total of 700.
The score on these train-test partitions for these parameters will be set to
nan.
If these failures are not expected, you can try to debug them by setting
error_score='raise'.
```

```
Below are more details about the failures:
--------------------------------------------------------------------------------
50 fits failed with the following error:
Traceback (most recent call last):
  File "C:\ProgramData\anaconda3\Lib\site-
packages\sklearn\model_selection\_validation.py", line 732, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\ProgramData\anaconda3\Lib\site-packages\sklearn\base.py", line 1144,
in wrapper
    estimator._validate_params()
  File "C:\ProgramData\anaconda3\Lib\site-packages\sklearn\base.py", line 637,
in _validate_params
    validate_parameter_constraints(
  File "C:\ProgramData\anaconda3\Lib\site-
packages\sklearn\utils\_param_validation.py", line 95, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features'
parameter of RandomForestClassifier must be an int in the range [1, inf), a
float in the range (0.0, 1.0], a str among {'sqrt', 'log2'} or None. Got 0
instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\ProgramData\anaconda3\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [       nan 0.84353703 0.84645917 0.85229393
0.85226537 0.85517799
 0.85517799 0.85612983 0.84545022 0.85517799 0.85033314 0.85518751
 0.8541976  0.85227489        nan 0.8445079  0.84937179 0.847411
 0.85324576 0.85032362 0.85322673 0.84936227 0.85227489 0.85227489
 0.85614887 0.85031411 0.84740148 0.85227489        nan 0.84256615
 0.84546926 0.85422616 0.84935275 0.84644013 0.85712926 0.85227489
 0.85615839 0.85422616 0.85614887 0.85227489 0.85131354 0.84838188
        nan 0.84256615 0.85032362 0.85422616 0.84935275 0.85033314
 0.85325528 0.85032362 0.84644013 0.85225585 0.85227489 0.85420712
 0.85517799 0.85031411        nan 0.84645917 0.84936227 0.85422616
 0.85225585 0.85130402 0.85130402 0.85418808 0.85128498 0.85323625
 0.85224634 0.84935275 0.85420712 0.85711974]
  warnings.warn(
```

```
[99]: GridSearchCV(cv=10, estimator=RandomForestClassifier(),
                   param_grid=[{'max_depth': [10, 11, 12, 13, 14],
                                'max_features': [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
                                                 12, 13]}],
                   scoring='accuracy')
```

[100]:
```
pred=rfc_cv.predict(x_test)
```

[101]:
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.87      0.99      0.92       371
           1       0.74      0.20      0.31        70

    accuracy                           0.86       441
   macro avg       0.80      0.59      0.62       441
weighted avg       0.85      0.86      0.83       441
```

[102]:
```
rfc_cv.best_params_
```

[102]:
```
{'max_depth': 12, 'max_features': 6}
```

[103]:
```
rfc_cv.best_score_
```

[103]:
```
0.8571292594707784
```