21BIT0433_Assignment 4

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21BIT0433- REPAKULA YASODA RUSHITHA

Import necessary libraries

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

Import dataset Employee-Attrition

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

```python
[3]: df
```

```
[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
      ...    ...       ...                 ...        ...                     ...
      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  \
      0                    1          2  Life Sciences              1
      1                    8          1  Life Sciences              1
      2                    2          2          Other              1
      3                    3          4  Life Sciences              1
      4                    2          1        Medical              1
      ...                ...        ...            ...            ...
      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 \
0	1	…	1	80
1	2	…	4	80
2	4	…	2	80
3	5	…	3	80
4	7	…	4	80
…	…	…	…	…
1465	2061	…	3	80
1466	2062	…	1	80
1467	2064	…	2	80
1468	2065	…	4	80
1469	2068	…	1	80

	StockOptionLevel	TotalWorkingYears	TrainingTimesLastYear \
0	0	8	0
1	1	10	3
2	0	7	3
3	0	8	3
4	1	6	3
…	…	…	…
1465	1	17	3
1466	1	9	5
1467	1	6	0
1468	0	17	3
1469	0	6	3

	WorkLifeBalance	YearsAtCompany	YearsInCurrentRole \
0	1	6	4
1	3	10	7
2	3	0	0
3	3	8	7
4	3	2	2
…	…	…	…
1465	3	5	2
1466	3	7	7
1467	3	6	2
1468	2	9	6
1469	4	4	3

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

```
      …                                  …                          …
1465                                  0                             3
1466                                  1                             7
1467                                  0                             3
1468                                  0                             8
1469                                  1                             2

[1470 rows x 35 columns]
```

[4]: `df.head()`

[4]:
```
   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]
```

```
[5]: df.tail()
```

```
[5]:       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]
```

```
[6]: df.shape
```

```
[6]: (1470, 35)
```

```
[7]: df.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
```

```
[8]: df.describe()
```

[8]:

	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]
```

```python
[10]: corr=df.corr()
      corr
```

```
C:\Users\RUSHITHA REPAKULA\AppData\Local\Temp\ipykernel_12500\3182140910.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.
  corr=df.corr()
```

```
[10]:                               Age  DailyRate  DistanceFromHome  Education  \
      Age                      1.000000   0.010661         -0.001686   0.208034
      DailyRate                0.010661   1.000000         -0.004985  -0.016806
      DistanceFromHome        -0.001686  -0.004985          1.000000   0.021042
      Education                0.208034  -0.016806          0.021042   1.000000
      EmployeeCount                 NaN        NaN               NaN        NaN
      EmployeeNumber          -0.010145  -0.050990          0.032916   0.042070
      EnvironmentSatisfaction  0.010146   0.018355         -0.016075  -0.027128
      HourlyRate               0.024287   0.023381          0.031131   0.016775
      JobInvolvement           0.029820   0.046135          0.008783   0.042438
      JobLevel                 0.509604   0.002966          0.005303   0.101589
      JobSatisfaction         -0.004892   0.030571         -0.003669  -0.011296
      MonthlyIncome            0.497855   0.007707         -0.017014   0.094961
      MonthlyRate              0.028051  -0.032182          0.027473  -0.026084
      NumCompaniesWorked       0.299635   0.038153         -0.029251   0.126317
      PercentSalaryHike        0.003634   0.022704          0.040235  -0.011111
      PerformanceRating        0.001904   0.000473          0.027110  -0.024539
      RelationshipSatisfaction 0.053535   0.007846          0.006557  -0.009118
      StandardHours                 NaN        NaN               NaN        NaN
      StockOptionLevel         0.037510   0.042143          0.044872   0.018422
      TotalWorkingYears        0.680381   0.014515          0.004628   0.148280
      TrainingTimesLastYear   -0.019621   0.002453         -0.036942  -0.025100
      WorkLifeBalance         -0.021490  -0.037848         -0.026556   0.009819
      YearsAtCompany           0.311309  -0.034055          0.009508   0.069114
```

YearsInCurrentRole	0.212901	0.009932	0.018845	0.060236
YearsSinceLastPromotion	0.216513	-0.033229	0.010029	0.054254
YearsWithCurrManager	0.202089	-0.026363	0.014406	0.069065

	EmployeeCount	EmployeeNumber \
Age	NaN	-0.010145
DailyRate	NaN	-0.050990
DistanceFromHome	NaN	0.032916
Education	NaN	0.042070
EmployeeCount	NaN	NaN
EmployeeNumber	NaN	1.000000
EnvironmentSatisfaction	NaN	0.017621
HourlyRate	NaN	0.035179
JobInvolvement	NaN	-0.006888
JobLevel	NaN	-0.018519
JobSatisfaction	NaN	-0.046247
MonthlyIncome	NaN	-0.014829
MonthlyRate	NaN	0.012648
NumCompaniesWorked	NaN	-0.001251
PercentSalaryHike	NaN	-0.012944
PerformanceRating	NaN	-0.020359
RelationshipSatisfaction	NaN	-0.069861
StandardHours	NaN	NaN
StockOptionLevel	NaN	0.062227
TotalWorkingYears	NaN	-0.014365
TrainingTimesLastYear	NaN	0.023603
WorkLifeBalance	NaN	0.010309
YearsAtCompany	NaN	-0.011240
YearsInCurrentRole	NaN	-0.008416
YearsSinceLastPromotion	NaN	-0.009019
YearsWithCurrManager	NaN	-0.009197

	EnvironmentSatisfaction	HourlyRate	JobInvolvement \
Age	0.010146	0.024287	0.029820
DailyRate	0.018355	0.023381	0.046135
DistanceFromHome	-0.016075	0.031131	0.008783
Education	-0.027128	0.016775	0.042438
EmployeeCount	NaN	NaN	NaN
EmployeeNumber	0.017621	0.035179	-0.006888
EnvironmentSatisfaction	1.000000	-0.049857	-0.008278
HourlyRate	-0.049857	1.000000	0.042861
JobInvolvement	-0.008278	0.042861	1.000000
JobLevel	0.001212	-0.027853	-0.012630
JobSatisfaction	-0.006784	-0.071335	-0.021476
MonthlyIncome	-0.006259	-0.015794	-0.015271
MonthlyRate	0.037600	-0.015297	-0.016322
NumCompaniesWorked	0.012594	0.022157	0.015012

PercentSalaryHike	-0.031701	-0.009062	-0.017205
PerformanceRating	-0.029548	-0.002172	-0.029071
RelationshipSatisfaction	0.007665	0.001330	0.034297
StandardHours	NaN	NaN	NaN
StockOptionLevel	0.003432	0.050263	0.021523
TotalWorkingYears	-0.002693	-0.002334	-0.005533
TrainingTimesLastYear	-0.019359	-0.008548	-0.015338
WorkLifeBalance	0.027627	-0.004607	-0.014617
YearsAtCompany	0.001458	-0.019582	-0.021355
YearsInCurrentRole	0.018007	-0.024106	0.008717
YearsSinceLastPromotion	0.016194	-0.026716	-0.024184
YearsWithCurrManager	-0.004999	-0.020123	0.025976

	JobLevel	…	RelationshipSatisfaction \
Age	0.509604	…	0.053535
DailyRate	0.002966	…	0.007846
DistanceFromHome	0.005303	…	0.006557
Education	0.101589	…	-0.009118
EmployeeCount	NaN	…	NaN
EmployeeNumber	-0.018519	…	-0.069861
EnvironmentSatisfaction	0.001212	…	0.007665
HourlyRate	-0.027853	…	0.001330
JobInvolvement	-0.012630	…	0.034297
JobLevel	1.000000	…	0.021642
JobSatisfaction	-0.001944	…	-0.012454
MonthlyIncome	0.950300	…	0.025873
MonthlyRate	0.039563	…	-0.004085
NumCompaniesWorked	0.142501	…	0.052733
PercentSalaryHike	-0.034730	…	-0.040490
PerformanceRating	-0.021222	…	-0.031351
RelationshipSatisfaction	0.021642	…	1.000000
StandardHours	NaN	…	NaN
StockOptionLevel	0.013984	…	-0.045952
TotalWorkingYears	0.782208	…	0.024054
TrainingTimesLastYear	-0.018191	…	0.002497
WorkLifeBalance	0.037818	…	0.019604
YearsAtCompany	0.534739	…	0.019367
YearsInCurrentRole	0.389447	…	-0.015123
YearsSinceLastPromotion	0.353885	…	0.033493
YearsWithCurrManager	0.375281	…	-0.000867

	StandardHours	StockOptionLevel	TotalWorkingYears \
Age	NaN	0.037510	0.680381
DailyRate	NaN	0.042143	0.014515
DistanceFromHome	NaN	0.044872	0.004628
Education	NaN	0.018422	0.148280
EmployeeCount	NaN	NaN	NaN

EmployeeNumber	NaN	0.062227	-0.014365
EnvironmentSatisfaction	NaN	0.003432	-0.002693
HourlyRate	NaN	0.050263	-0.002334
JobInvolvement	NaN	0.021523	-0.005533
JobLevel	NaN	0.013984	0.782208
JobSatisfaction	NaN	0.010690	-0.020185
MonthlyIncome	NaN	0.005408	0.772893
MonthlyRate	NaN	-0.034323	0.026442
NumCompaniesWorked	NaN	0.030075	0.237639
PercentSalaryHike	NaN	0.007528	-0.020608
PerformanceRating	NaN	0.003506	0.006744
RelationshipSatisfaction	NaN	-0.045952	0.024054
StandardHours	NaN	NaN	NaN
StockOptionLevel	NaN	1.000000	0.010136
TotalWorkingYears	NaN	0.010136	1.000000
TrainingTimesLastYear	NaN	0.011274	-0.035662
WorkLifeBalance	NaN	0.004129	0.001008
YearsAtCompany	NaN	0.015058	0.628133
YearsInCurrentRole	NaN	0.050818	0.460365
YearsSinceLastPromotion	NaN	0.014352	0.404858
YearsWithCurrManager	NaN	0.024698	0.459188

	TrainingTimesLastYear	WorkLifeBalance \
Age	-0.019621	-0.021490
DailyRate	0.002453	-0.037848
DistanceFromHome	-0.036942	-0.026556
Education	-0.025100	0.009819
EmployeeCount	NaN	NaN
EmployeeNumber	0.023603	0.010309
EnvironmentSatisfaction	-0.019359	0.027627
HourlyRate	-0.008548	-0.004607
JobInvolvement	-0.015338	-0.014617
JobLevel	-0.018191	0.037818
JobSatisfaction	-0.005779	-0.019459
MonthlyIncome	-0.021736	0.030683
MonthlyRate	0.001467	0.007963
NumCompaniesWorked	-0.066054	-0.008366
PercentSalaryHike	-0.005221	-0.003280
PerformanceRating	-0.015579	0.002572
RelationshipSatisfaction	0.002497	0.019604
StandardHours	NaN	NaN
StockOptionLevel	0.011274	0.004129
TotalWorkingYears	-0.035662	0.001008
TrainingTimesLastYear	1.000000	0.028072
WorkLifeBalance	0.028072	1.000000
YearsAtCompany	0.003569	0.012089
YearsInCurrentRole	-0.005738	0.049856

```
YearsSinceLastPromotion                    -0.002067           0.008941
YearsWithCurrManager                       -0.004096           0.002759
```

	YearsAtCompany	YearsInCurrentRole
Age	0.311309	0.212901
DailyRate	-0.034055	0.009932
DistanceFromHome	0.009508	0.018845
Education	0.069114	0.060236
EmployeeCount	NaN	NaN
EmployeeNumber	-0.011240	-0.008416
EnvironmentSatisfaction	0.001458	0.018007
HourlyRate	-0.019582	-0.024106
JobInvolvement	-0.021355	0.008717
JobLevel	0.534739	0.389447
JobSatisfaction	-0.003803	-0.002305
MonthlyIncome	0.514285	0.363818
MonthlyRate	-0.023655	-0.012815
NumCompaniesWorked	-0.118421	-0.090754
PercentSalaryHike	-0.035991	-0.001520
PerformanceRating	0.003435	0.034986
RelationshipSatisfaction	0.019367	-0.015123
StandardHours	NaN	NaN
StockOptionLevel	0.015058	0.050818
TotalWorkingYears	0.628133	0.460365
TrainingTimesLastYear	0.003569	-0.005738
WorkLifeBalance	0.012089	0.049856
YearsAtCompany	1.000000	0.758754
YearsInCurrentRole	0.758754	1.000000
YearsSinceLastPromotion	0.618409	0.548056
YearsWithCurrManager	0.769212	0.714365

	YearsSinceLastPromotion	YearsWithCurrManager
Age	0.216513	0.202089
DailyRate	-0.033229	-0.026363
DistanceFromHome	0.010029	0.014406
Education	0.054254	0.069065
EmployeeCount	NaN	NaN
EmployeeNumber	-0.009019	-0.009197
EnvironmentSatisfaction	0.016194	-0.004999
HourlyRate	-0.026716	-0.020123
JobInvolvement	-0.024184	0.025976
JobLevel	0.353885	0.375281
JobSatisfaction	-0.018214	-0.027656
MonthlyIncome	0.344978	0.344079
MonthlyRate	0.001567	-0.036746
NumCompaniesWorked	-0.036814	-0.110319
PercentSalaryHike	-0.022154	-0.011985

PerformanceRating	0.017896	0.022827
RelationshipSatisfaction	0.033493	-0.000867
StandardHours	NaN	NaN
StockOptionLevel	0.014352	0.024698
TotalWorkingYears	0.404858	0.459188
TrainingTimesLastYear	-0.002067	-0.004096
WorkLifeBalance	0.008941	0.002759
YearsAtCompany	0.618409	0.769212
YearsInCurrentRole	0.548056	0.714365
YearsSinceLastPromotion	1.000000	0.510224
YearsWithCurrManager	0.510224	1.000000

[26 rows x 26 columns]

```python
[11]: plt.subplots(figsize=(20,15))
      sns.heatmap(corr,annot=True)
```

[11]: <Axes: >
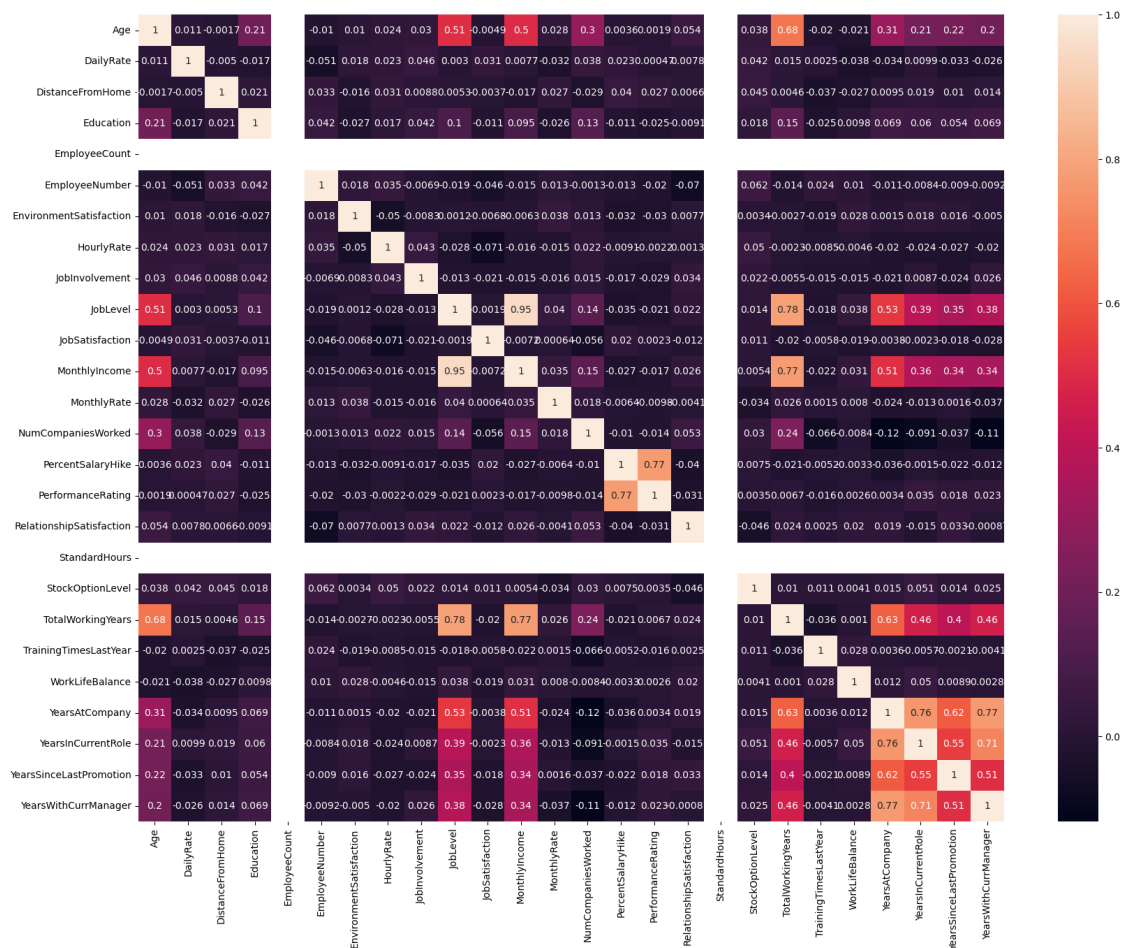
```
[12]: df.Attrition.value_counts()
```

```
[12]: No      1233
      Yes      237
      Name: Attrition, dtype: int64
```

```
[13]: df.isnull().any()
```

```
[13]: 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
```

```
[14]: df.isnull().sum()
```

```
[14]: 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
```

```
[15]: df.head()
```

```
[15]:    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]
```

[17]: `sns.boxplot(df.Age)`

[17]: `<Axes: >`
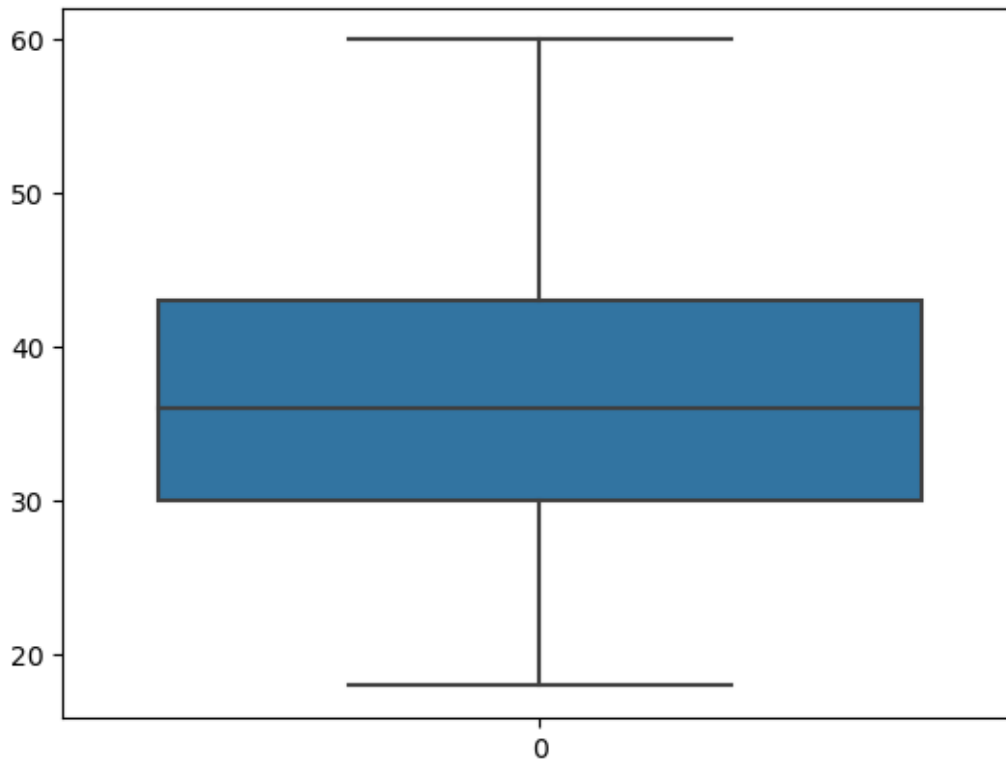
```
[18]: sns.boxplot(df.MonthlyIncome)
```

```
[18]: <Axes: >
```
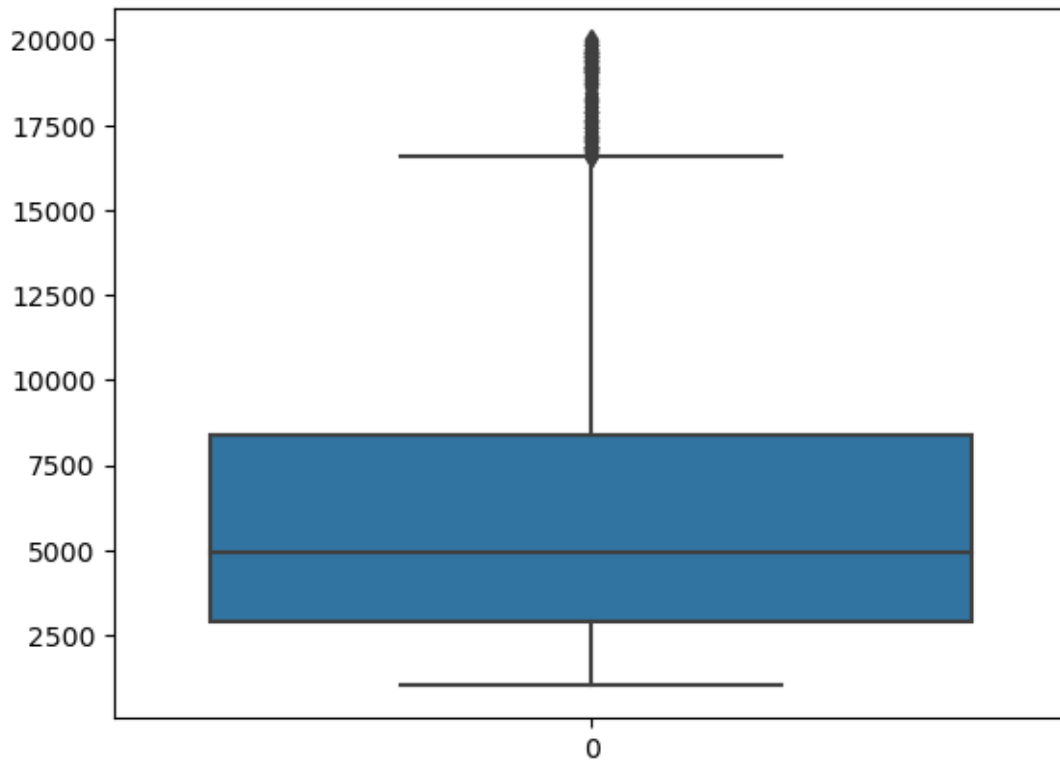
```
[19]: q1=df.MonthlyIncome.quantile(0.25)
      q3=df.MonthlyIncome.quantile(0.75)
```

```
[20]: IQR=q3-q1
      IQR
```

[20]: 5468.0

```
[21]: ul=q3 + 1.5*IQR
      ul
```

[21]: 16581.0

```
[22]: df['MonthlyIncome'].median()
```

[22]: 4919.0

```
[23]: df['MonthlyIncome']=np.where(df['MonthlyIncome']>ul,4919.0,df['MonthlyIncome'])
```

```
[24]: df.shape
```

[24]: (1470, 35)

```
[25]: sns.boxplot(df.TotalWorkingYears)
```

```
[25]: <Axes: >
```
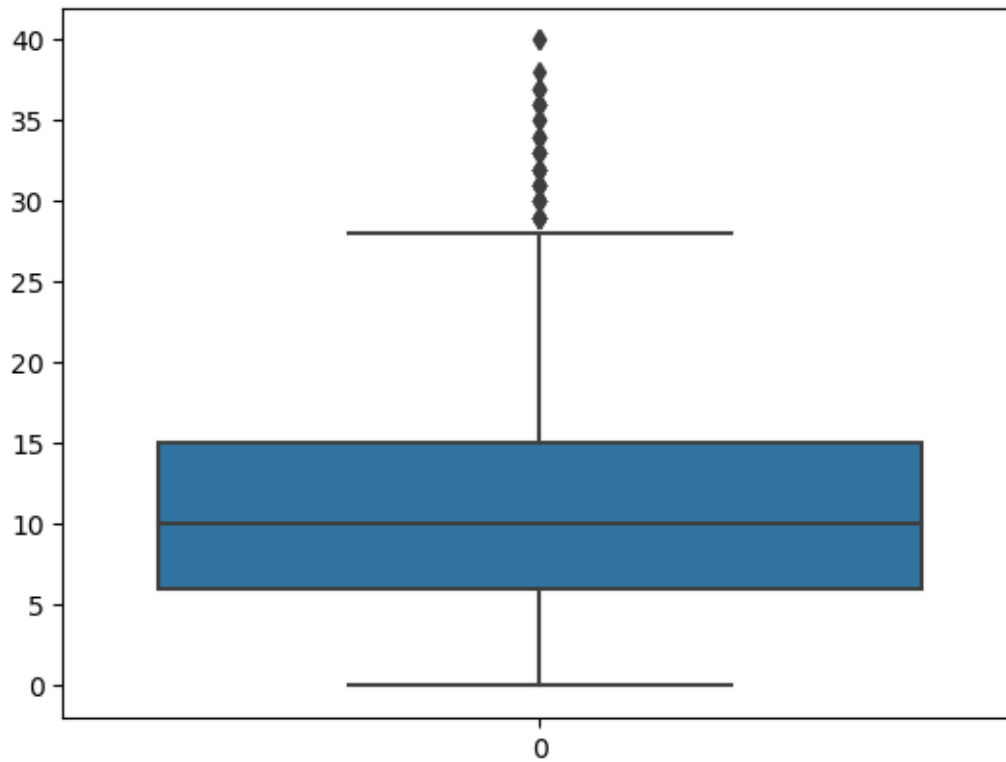


```
[26]: q1=df.TotalWorkingYears.quantile(0.25)
      q3=df.TotalWorkingYears.quantile(0.75)
```

```
[27]: IQR=q3-q1
      IQR
```

```
[27]: 9.0
```

```
[29]: ul=q3+1.5*IQR
      ul
```

```
[29]: 28.5
```

```
[30]: df['TotalWorkingYears'].median()
```

```
[30]: 10.0
```

```
[31]: df['TotalWorkingYears']=np.
      ↪where(df['TotalWorkingYears']>ul,10,df['TotalWorkingYears'])
```

```
[32]: sns.boxplot(df.YearsAtCompany)
```

```
[32]: <Axes: >
```
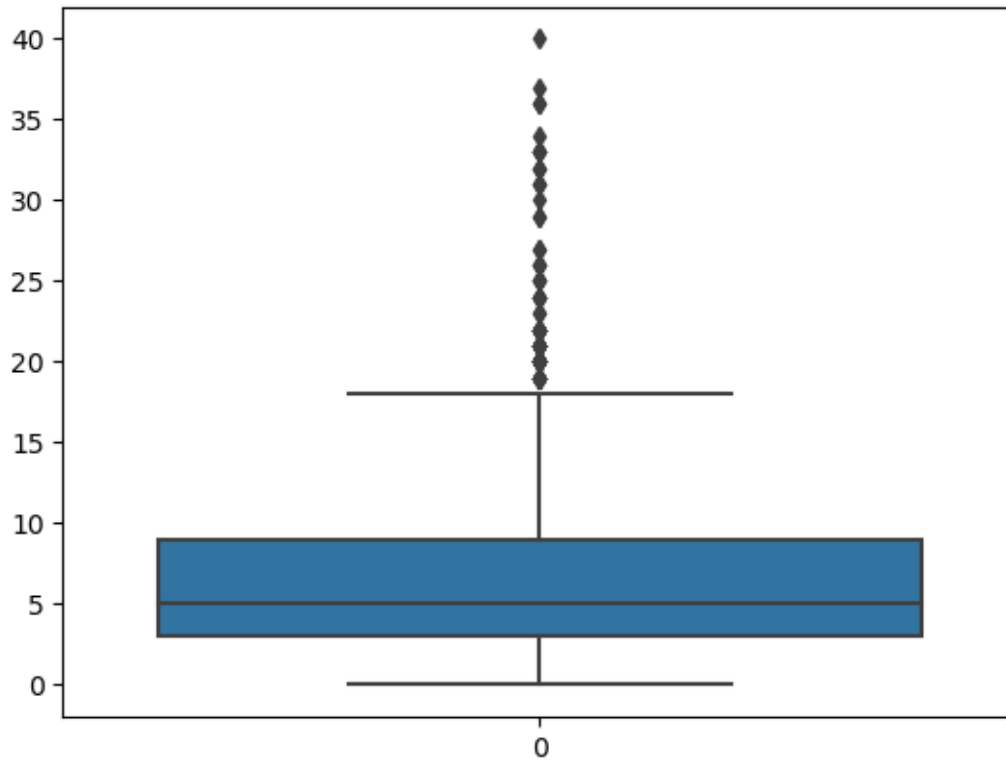


```
[33]: q1=df.YearsAtCompany.quantile(0.25)
      q3=df.YearsAtCompany.quantile(0.75)
```

```
[34]: IQR=q3-q1
      IQR
```

```
[34]: 6.0
```

```
[35]: ul=q3+1.5*IQR
      ul
```

```
[35]: 18.0
```

```
[36]: df['YearsAtCompany'].mean()
```

[36]: 7.0081632653061225

[37]: ```python
df['YearsAtCompany']=np.where(df['YearsAtCompany']>ul,7.
↪0081632653061225,df['YearsAtCompany'])
```

[38]: ```python
sns.boxplot(df.DistanceFromHome)
```

[38]: <Axes: >
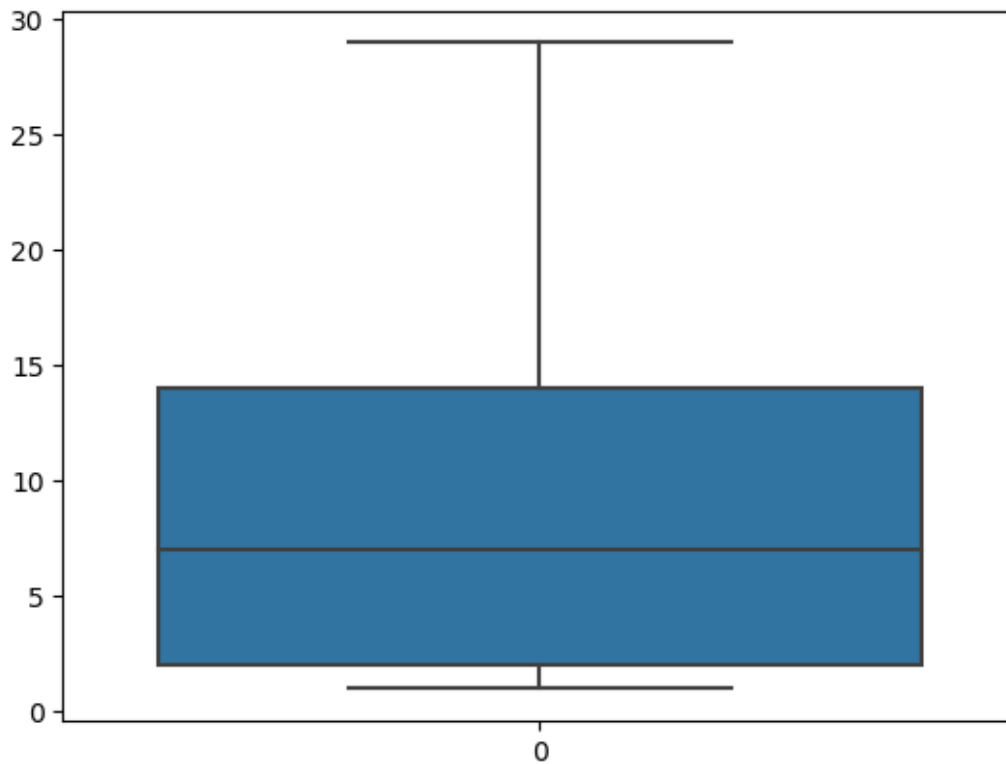
[40]: ```python
sns.boxplot(df.YearsWithCurrManager)
```

[40]: <Axes: >

```
[41]: q1=df.YearsWithCurrManager.quantile(0.25)
      q3=df.YearsWithCurrManager.quantile(0.75)
```

```
[42]: IQR=q3-q1
      IQR
```

```
[42]: 5.0
```

```
[43]: ul=q3+1.5*IQR
      ul
```

```
[43]: 14.5
```

```
[44]: df['YearsWithCurrManager'].median()
```

```
[44]: 3.0
```

```
[45]: df['YearsWithCurrManager']=np.
      ↪where(df['YearsWithCurrManager']>ul,3,df['YearsWithCurrManager'])
```

```
[46]: x=df.iloc[:,df.columns != "Attrition"]
      y=df.iloc[:,1:2]
```

```
[47]: x.head()
```

```
[47]:    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
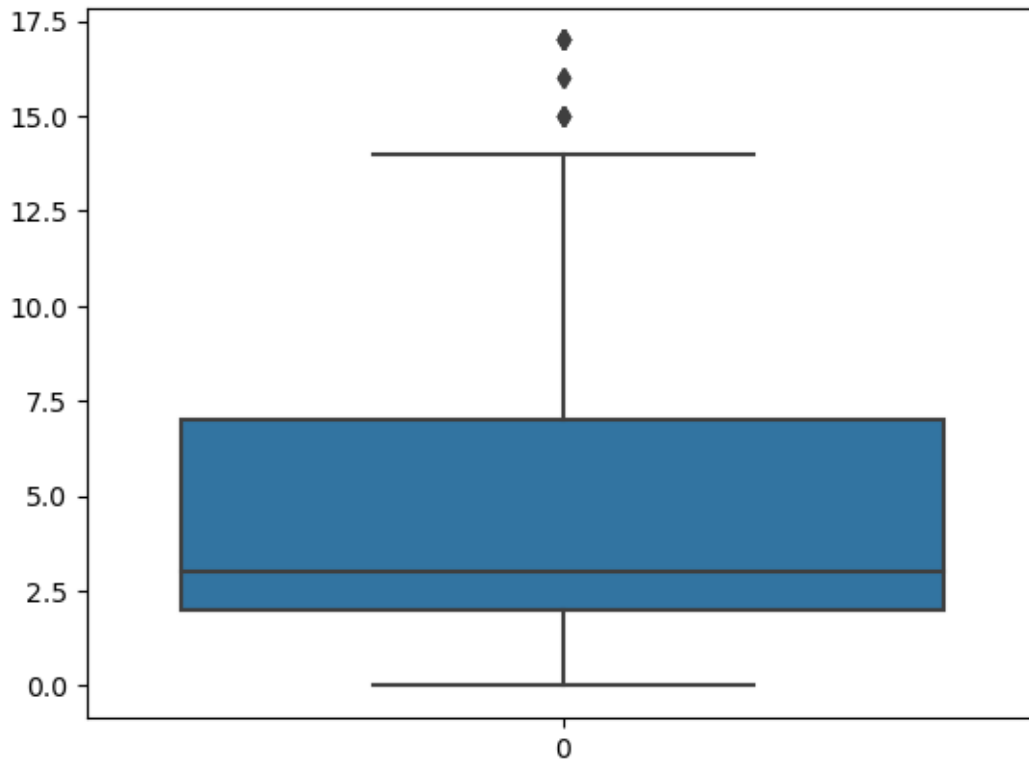
        DistanceFromHome  Education EducationField  EmployeeCount  EmployeeNumber  \
     0                 1          2  Life Sciences              1               1
     1                 8          1  Life Sciences              1               2
     2                 2          2          Other              1               4
     3                 3          4  Life Sciences              1               5
     4                 2          1        Medical              1               7

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

        YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
     0             6.0                   4                        0
     1            10.0                   7                        1
     2             0.0                   0                        0
     3             8.0                   7                        3
     4             2.0                   2                        2

        YearsWithCurrManager
     0                     5
     1                     7
     2                     0
     3                     0
     4                     2

     [5 rows x 34 columns]
```

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

```
[48]:    Attrition
     0      Yes
     1       No
     2      Yes
     3       No
     4       No
```

```
[49]: df.shape
```

```
[49]: (1470, 35)
```

```
[50]: x.shape
```

```
[50]: (1470, 34)
```

```
[51]: y.shape
```

```
[51]: (1470, 1)
```

```
[52]: BusinessTravel=pd.get_dummies(x["BusinessTravel"],drop_first=True)
      BusinessTravel
```

```
[52]:        Travel_Frequently   Travel_Rarely
     0                     0               1
     1                     1               0
     2                     0               1
     3                     1               0
     4                     0               1
     ...                 ...             ...
     1465                  1               0
     1466                  0               1
     1467                  0               1
     1468                  1               0
     1469                  0               1

     [1470 rows x 2 columns]
```

```
[53]: x=pd.concat([x,BusinessTravel],axis=1)
```

```
[54]: x.drop(["BusinessTravel"],axis=1,inplace=True)
```

```
[57]: Department=pd.get_dummies(x["Department"],drop_first=True)
      Department
```

```
[57]:        Research & Development   Sales
     0                          0       1
     1                          1       0
     2                          1       0
```

```
3                         1      0
4                         1      0
...                      ...    ...
1465                      1      0
1466                      1      0
1467                      1      0
1468                      0      1
1469                      1      0

[1470 rows x 2 columns]
```

[58]:
```python
x=pd.concat([x,Department],axis=1)
x.drop(["Department"],axis=1,inplace=True)
```

[59]:
```python
x.head()
```

[59]:
```
    Age  DailyRate  DistanceFromHome  Education EducationField  EmployeeCount  \
0    41       1102                 1          2  Life Sciences              1
1    49        279                 8          1  Life Sciences              1
2    37       1373                 2          2          Other              1
3    33       1392                 3          4  Life Sciences              1
4    27        591                 2          1        Medical              1

   EmployeeNumber  EnvironmentSatisfaction  Gender  HourlyRate  ... \
0               1                        2  Female          94  ...
1               2                        3    Male          61  ...
2               4                        4    Male          92  ...
3               5                        4  Female          56  ...
4               7                        1    Male          40  ...

   TrainingTimesLastYear  WorkLifeBalance YearsAtCompany  YearsInCurrentRole  \
0                      0                1            6.0                   4
1                      3                3           10.0                   7
2                      3                3            0.0                   0
3                      3                3            8.0                   7
4                      3                3            2.0                   2

   YearsSinceLastPromotion  YearsWithCurrManager  Travel_Frequently  \
0                        0                     5                  0
1                        1                     7                  1
2                        0                     0                  0
3                        3                     0                  1
4                        2                     2                  0

   Travel_Rarely Research & Development Sales
0              1                      0     1
1              0                      1     0
```

24

```
2              1                    1      0
3              0                    1      0
4              1                    1      0
```

[5 rows x 36 columns]

[60]: EducationField=pd.get_dummies(x["EducationField"],drop_first=True)
      EducationField

[60]:   Life Sciences Marketing Medical Other Technical Degree
      0   1   0   0   0   0
      1   1   0   0   0   0
      2   0   0   0   1   0
      3   1   0   0   0   0
      4   0   0   1   0   0
      ...   .
      1465   0   0   1   0   0
      1466   0   0   1   0   0
      1467   1   0   0   0   0
      1468   0   0   1   0   0
      1469   0   0   1   0   0

      [1470 rows x 5 columns]

[61]: x=pd.concat([x,EducationField],axis=1)
      x.drop(["EducationField"],axis=1,inplace=True)

[62]: Gender=pd.get_dummies(x["Gender"],drop_first=True)
      Gender

[62]:   Male
      0   0
      1   1
      2   1
      3   0
      4   1
      ...   ...
      1465   1
      1466   1
      1467   1
      1468   1
      1469   1

      [1470 rows x 1 columns]

[63]: x=pd.concat([x,Gender],axis=1)
      x.drop(["Gender"],axis=1,inplace=True)

```
[64]: JobRole=pd.get_dummies(x["JobRole"],drop_first=True)
      JobRole
```

```
[64]:       Human Resources  Laboratory Technician  Manager  Manufacturing Director  \
      0                   0                      0        0                       0
      1                   0                      0        0                       0
      2                   0                      1        0                       0
      3                   0                      0        0                       0
      4                   0                      1        0                       0
      ...               ...                    ...      ...                     ...
      1465                0                      1        0                       0
      1466                0                      0        0                       0
      1467                0                      0        0                       1
      1468                0                      0        0                       0
      1469                0                      1        0                       0

            Research Director  Research Scientist  Sales Executive  \
      0                     0                   0                1
      1                     0                   1                0
      2                     0                   0                0
      3                     0                   1                0
      4                     0                   0                0
      ...                 ...                 ...              ...
      1465                  0                   0                0
      1466                  0                   0                0
      1467                  0                   0                0
      1468                  0                   0                1
      1469                  0                   0                0

            Sales Representative
      0                        0
      1                        0
      2                        0
      3                        0
      4                        0
      ...                    ...
      1465                     0
      1466                     0
      1467                     0
      1468                     0
      1469                     0

      [1470 rows x 8 columns]
```

```
[65]: x=pd.concat([x,JobRole],axis=1)
      x.drop(["JobRole"],axis=1,inplace=True)
```

```
[66]: x.shape
```

```
[66]: (1470, 47)
```

```
[67]: MaritalStatus=pd.get_dummies(x["MaritalStatus"],drop_first=True)
      MaritalStatus
```

```
[67]:       Married  Single
      0           0       1
      1           1       0
      2           0       1
      3           1       0
      4           1       0
      ...       ...     ...
      1465        1       0
      1466        1       0
      1467        1       0
      1468        1       0
      1469        1       0

      [1470 rows x 2 columns]
```

```
[68]: x=pd.concat([x,MaritalStatus],axis=1)
      x.drop(["MaritalStatus"],axis=1,inplace=True)
```

```
[70]: x.shape
```

```
[70]: (1470, 48)
```

```
[69]: Over18=pd.get_dummies(x["Over18"],drop_first=True)
      Over18
```

```
[69]: Empty DataFrame
      Columns: []
      Index: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
      20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39,
      40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59,
      60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79,
      80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99,
      …]

      [1470 rows x 0 columns]
```

```
[71]: x=pd.concat([x,MaritalStatus],axis=1)
      x.drop(["Over18"],axis=1,inplace=True)
```

```
[72]: OverTime=pd.get_dummies(x["OverTime"],drop_first=True)
      OverTime
```

```
[72]:        Yes
        0      1
        1      0
        2      1
        3      1
        4      0
        …      …
        1465   0
        1466   0
        1467   1
        1468   0
        1469   0

        [1470 rows x 1 columns]
```

[73]:
```python
x=pd.concat([x,OverTime],axis=1)
x.drop(["OverTime"],axis=1,inplace=True)
```

[74]:
```python
Attrition=pd.get_dummies(y["Attrition"],drop_first=True)
Attrition
```

```
[74]:        Yes
        0      1
        1      0
        2      1
        3      0
        4      0
        …      …
        1465   0
        1466   0
        1467   0
        1468   0
        1469   0

        [1470 rows x 1 columns]
```

[75]:
```python
y=pd.concat([y,Attrition],axis=1)
y.drop(["Attrition"],axis=1,inplace=True)
```

[76]:
```python
y.head()
```

```
[76]:     Yes
        0    1
        1    0
        2    1
        3    0
        4    0
```

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

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

```
[79]: x["Education"]=le.fit_transform(x["Education"])
      x["Education"]
```

```
[79]: 0        1
      1        0
      2        1
      3        3
      4        0
              ..
      1465     1
      1466     0
      1467     2
      1468     2
      1469     2
      Name: Education, Length: 1470, dtype: int64
```

```
[80]: x["EnvironmentSatisfaction"]=le.fit_transform(x["EnvironmentSatisfaction"])
```

```
[81]: x["JobInvolvement"]=le.fit_transform(x["JobInvolvement"])
```

```
[82]: x["JobSatisfaction"]=le.fit_transform(x["JobSatisfaction"])
```

```
[83]: x["PerformanceRating"]=le.fit_transform(x["PerformanceRating"])
```

```
[84]: x["RelationshipSatisfaction"]=le.fit_transform(x["RelationshipSatisfaction"])
```

```
[85]: x.head()
```

```
[85]:    Age  DailyRate  DistanceFromHome  Education  EmployeeCount  EmployeeNumber  \
      0   41       1102                 1          1              1               1
      1   49        279                 8          0              1               2
      2   37       1373                 2          1              1               4
      3   33       1392                 3          3              1               5
      4   27        591                 2          0              1               7

         EnvironmentSatisfaction  HourlyRate  JobInvolvement  JobLevel  … \
      0                        1          94               2         2  …
      1                        2          61               1         2  …
      2                        3          92               1         1  …
      3                        3          56               2         1  …
      4                        0          40               2         1  …

         Manufacturing Director  Research Director  Research Scientist  \
      0                       0                  0                   0
```

```
       1                      0                0                    1
       2                      0                0                    0
       3                      0                0                    1
       4                      0                0                    0

          Sales Executive  Sales Representative  Married  Single  Married  Single  \
       0                1                     0        0       1        0       1
       1                0                     0        1       0        1       0
       2                0                     0        0       1        0       1
       3                0                     0        1       0        1       0
       4                0                     0        1       0        1       0

          Yes
       0    1
       1    0
       2    1
       3    1
       4    0

       [5 rows x 49 columns]
```

[86]: `x.info()`

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 49 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   Age                      1470 non-null   int64
 1   DailyRate                1470 non-null   int64
 2   DistanceFromHome         1470 non-null   int64
 3   Education                1470 non-null   int64
 4   EmployeeCount            1470 non-null   int64
 5   EmployeeNumber           1470 non-null   int64
 6   EnvironmentSatisfaction  1470 non-null   int64
 7   HourlyRate               1470 non-null   int64
 8   JobInvolvement           1470 non-null   int64
 9   JobLevel                 1470 non-null   int64
 10  JobSatisfaction          1470 non-null   int64
 11  MonthlyIncome            1470 non-null   float64
 12  MonthlyRate              1470 non-null   int64
 13  NumCompaniesWorked       1470 non-null   int64
 14  PercentSalaryHike        1470 non-null   int64
 15  PerformanceRating        1470 non-null   int64
 16  RelationshipSatisfaction 1470 non-null   int64
 17  StandardHours            1470 non-null   int64
 18  StockOptionLevel         1470 non-null   int64
 19  TotalWorkingYears        1470 non-null   int64
```

```
20  TrainingTimesLastYear    1470 non-null   int64
21  WorkLifeBalance          1470 non-null   int64
22  YearsAtCompany           1470 non-null   float64
23  YearsInCurrentRole       1470 non-null   int64
24  YearsSinceLastPromotion  1470 non-null   int64
25  YearsWithCurrManager     1470 non-null   int64
26  Travel_Frequently        1470 non-null   uint8
27  Travel_Rarely            1470 non-null   uint8
28  Research & Development   1470 non-null   uint8
29  Sales                    1470 non-null   uint8
30  Life Sciences            1470 non-null   uint8
31  Marketing                1470 non-null   uint8
32  Medical                  1470 non-null   uint8
33  Other                    1470 non-null   uint8
34  Technical Degree         1470 non-null   uint8
35  Male                     1470 non-null   uint8
36  Human Resources          1470 non-null   uint8
37  Laboratory Technician    1470 non-null   uint8
38  Manager                  1470 non-null   uint8
39  Manufacturing Director   1470 non-null   uint8
40  Research Director        1470 non-null   uint8
41  Research Scientist       1470 non-null   uint8
42  Sales Executive          1470 non-null   uint8
43  Sales Representative     1470 non-null   uint8
44  Married                  1470 non-null   uint8
45  Single                   1470 non-null   uint8
46  Married                  1470 non-null   uint8
47  Single                   1470 non-null   uint8
48  Yes                      1470 non-null   uint8
dtypes: float64(2), int64(24), uint8(23)
memory usage: 331.7 KB
```

[87]:
```python
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.3,random_state=0)
```

[88]:
```python
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

[88]: ((1029, 49), (441, 49), (1029, 1), (441, 1))

[89]:
```python
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
```

[90]:
```python
x_train=sc.fit_transform(x_train)
x_test=sc.fit_transform(x_test)
```

[91]:
```python
x_train
```

```
[91]: array([[-0.75016842, -0.58244694, -0.51036458, …, -0.90267093,
               -0.69784971, -0.61441846],
              [-0.41863372, -1.12354988, -0.51036458, …, -0.90267093,
                1.43297329,  1.62755527],
              [ 0.90750511, -0.04626313,  1.84630474, …, -0.90267093,
                1.43297329, -0.61441846],
              …,
              [ 0.68648197,  0.91542436, -0.88247026, …,  1.10782342,
               -0.69784971,  1.62755527],
              [ 0.13392413, -1.3252337 , -0.88247026, …,  1.10782342,
               -0.69784971,  1.62755527],
              [ 0.35494726, -0.36600577,  0.10981156, …, -0.90267093,
               -0.69784971, -0.61441846]])
```

[92]: `x_test`

```
[92]: array([[-0.13313793, -0.3978601 ,  0.07634069, …, -0.95780546,
                1.52177182, -0.66066791],
              [-0.45515161, -0.54952521,  1.90602783, …, -0.95780546,
                1.52177182, -0.66066791],
              [-0.24047582, -0.32961081,  1.05217383, …,  1.04405335,
               -0.65712874,  1.51361976],
              …,
              [ 0.29621364,  0.76237796,  2.27196526, …, -0.95780546,
               -0.65712874, -0.66066791],
              [ 1.58426835, -1.19662966, -0.77751331, …,  1.04405335,
               -0.65712874,  1.51361976],
              [-0.45515161, -1.46457135, -0.28959674, …,  1.04405335,
               -0.65712874, -0.66066791]])
```

1 Logistic Regression

```python
[93]: from sklearn.linear_model import LogisticRegression
      model=LogisticRegression()
```

```python
[94]: model.fit(x_train,y_train)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\utils\validation.py:1184: DataConversionWarning: A column-
vector y was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  y = column_or_1d(y, warn=True)

[94]: LogisticRegression()

```python
[95]: pred=model.predict(x_test)
```

```
[96]: pred
```

```
[96]: array([0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 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, 1, 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, 0, 0, 0, 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, 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, 0,
              1, 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, 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, 1, 0, 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, 0, 0, 0, 0, 0, 0,
              0, 0, 1, 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, 0, 0, 0, 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, 1, 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, 1,
              0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 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, 0, 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, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 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, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
              0], dtype=uint8)
```

```
[97]: y_test
```

```
[97]:         Yes
      442      0
      1091     0
      981      1
      785      0
      1332     1
      …        …
      817      0
      399      0
      458      0
      406      0
      590      0

      [441 rows x 1 columns]
```

2 Model Classification

```
[98]: from sklearn.metrics import␣
       ↪accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

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

```
[99]: 0.8866213151927438
```

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

```
[100]: array([[362,   9],
              [ 41,  29]], dtype=int64)
```

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

```
              precision    recall  f1-score   support

           0       0.90      0.98      0.94       371
           1       0.76      0.41      0.54        70

    accuracy                           0.89       441
   macro avg       0.83      0.70      0.74       441
weighted avg       0.88      0.89      0.87       441
```

```
[102]: prob=model.predict_proba(x_test)[:,1]
       prob
```

```
[102]: array([9.78796690e-02, 6.49693921e-02, 6.07481146e-01, 1.83162250e-01,
              8.31084648e-01, 5.36392103e-02, 4.32850819e-01, 3.14266433e-02,
              4.44634741e-04, 6.01649262e-01, 2.00126658e-02, 1.72875273e-01,
              1.35432484e-02, 6.13546704e-01, 5.48696953e-02, 1.25074596e-02,
              1.17401377e-01, 4.61662962e-02, 3.34247564e-02, 2.93915157e-01,
              1.68598420e-01, 8.37652504e-03, 1.21719673e-02, 6.32241866e-02,
              7.75894857e-01, 4.74787345e-01, 5.33696627e-02, 3.79406056e-02,
              6.67224841e-01, 4.77326470e-02, 5.10200006e-03, 2.57723249e-01,
              3.44646694e-02, 2.16176812e-01, 2.21640011e-02, 3.05570340e-03,
              1.49171594e-01, 4.32273605e-02, 2.40340735e-02, 1.25059338e-01,
              1.00460399e-01, 9.20489402e-03, 6.70928324e-04, 1.03062961e-02,
              6.68856203e-03, 5.77491219e-01, 4.31402098e-01, 1.21367756e-03,
              4.05592771e-01, 3.79607455e-01, 3.81580646e-02, 8.49277879e-01,
              2.95953756e-02, 4.85176455e-01, 4.23160010e-01, 2.66465926e-01,
              8.72672403e-03, 4.32518565e-01, 1.67403507e-02, 3.57052308e-01,
              1.31315939e-02, 1.96567213e-01, 8.61257435e-02, 5.48437472e-02,
              9.60323031e-02, 2.20585134e-02, 2.87914859e-01, 1.80117569e-01,
              9.74594292e-02, 1.85851697e-01, 4.06587491e-02, 1.51033053e-01,
              6.43832781e-02, 3.53040608e-02, 1.08767146e-01, 4.32579625e-02,
              3.77016174e-02, 1.83059419e-01, 4.61556301e-01, 2.14908949e-02,
              1.25883864e-03, 2.60234237e-02, 2.69275940e-01, 1.46485917e-02,
              1.61445485e-02, 8.53742071e-02, 4.95616689e-03, 1.55530770e-02,
              1.40747973e-02, 7.08803509e-02, 1.01528686e-01, 9.44966673e-02,
              3.35931374e-01, 1.39668465e-01, 5.48641117e-04, 9.41450016e-02,
              4.77921886e-01, 6.06499153e-01, 6.58457434e-02, 9.30497362e-02,
              1.68660449e-01, 5.05528660e-01, 4.46602572e-01, 6.26135722e-03,
```

```
1.72756707e-01, 6.06200602e-03, 9.94495564e-02, 2.35511586e-01,
2.50353979e-02, 2.24177879e-01, 2.65882117e-02, 1.47976461e-02,
3.15372416e-03, 3.21640113e-01, 2.15467440e-02, 4.26902651e-02,
1.17230640e-02, 2.52517047e-02, 1.55271978e-03, 7.37535894e-03,
1.22702270e-01, 2.11512579e-02, 7.37084448e-02, 8.80911304e-01,
1.01464501e-02, 2.01795636e-02, 3.77424095e-03, 1.18857368e-01,
2.05660422e-01, 1.28212586e-02, 1.19466645e-03, 2.54336966e-01,
6.83862689e-01, 2.74020557e-01, 5.41900291e-02, 2.13125260e-01,
5.93265178e-01, 3.35349938e-01, 2.38722275e-01, 4.30977268e-01,
2.08287637e-02, 4.32312196e-02, 3.65855261e-02, 1.87818891e-01,
5.53619885e-01, 3.34527076e-02, 1.96485980e-01, 6.48546577e-03,
5.02024421e-02, 1.65555812e-01, 3.75738415e-03, 1.01466331e-01,
6.49887183e-02, 5.08421286e-02, 5.21376626e-02, 2.67089375e-02,
4.01450235e-02, 3.11310492e-01, 4.22448598e-03, 9.33124086e-03,
7.81418490e-01, 2.59763563e-03, 4.99285495e-02, 9.46891747e-01,
1.25249803e-02, 2.81150057e-01, 2.12055192e-01, 1.10252018e-01,
3.17055605e-02, 5.08137486e-04, 1.00498329e-01, 5.66290109e-02,
5.16883408e-02, 1.28910757e-01, 9.02804220e-03, 6.23858003e-02,
4.21165422e-02, 5.30222528e-02, 3.99641445e-02, 2.63812209e-02,
2.10250011e-02, 2.22732621e-01, 9.62804687e-03, 8.95772250e-01,
7.61117948e-02, 9.18558307e-02, 6.20870224e-01, 1.44456104e-02,
5.61108036e-01, 2.23627428e-01, 2.77306814e-01, 2.85548561e-01,
1.24019734e-01, 2.14808320e-02, 3.00132908e-02, 1.92345315e-01,
2.57466513e-02, 8.91412850e-03, 2.94503157e-01, 1.53149284e-02,
3.97068258e-01, 2.50381556e-01, 7.74802139e-01, 2.98550538e-02,
9.79176976e-02, 1.13594343e-02, 4.04736156e-01, 1.95442644e-03,
2.75447795e-01, 1.63009364e-02, 6.01083903e-02, 3.18333647e-01,
5.00362374e-02, 3.28783645e-01, 1.57176748e-01, 4.25288050e-03,
5.75574998e-03, 5.17405788e-02, 2.36732531e-02, 1.28804020e-01,
1.34302982e-01, 4.39618611e-01, 5.22066102e-01, 1.19250826e-01,
2.40717554e-01, 4.02557421e-03, 9.58923312e-02, 2.90979957e-01,
7.56914230e-01, 7.06421081e-02, 5.57090442e-02, 2.49241355e-01,
3.14683680e-02, 3.10204624e-02, 1.53733673e-01, 1.27604748e-01,
3.63699825e-01, 1.06125879e-03, 7.70865077e-02, 6.89991745e-03,
1.55922866e-01, 1.92337152e-01, 6.17429844e-03, 1.76374883e-01,
7.15763002e-02, 1.06093123e-02, 1.41596481e-01, 3.75288747e-01,
7.90772087e-02, 5.86356412e-02, 2.94634475e-01, 1.02183392e-01,
5.88393259e-01, 8.65631725e-03, 1.14327076e-01, 7.08774499e-02,
1.82859002e-03, 6.94124038e-01, 6.88418695e-01, 3.77702931e-01,
1.60408349e-01, 3.73438153e-02, 2.55822094e-01, 7.35121303e-02,
5.77759036e-02, 8.82445083e-02, 1.12495644e-03, 3.97007877e-01,
5.37660814e-01, 4.64528704e-02, 3.72755709e-02, 1.58323255e-02,
8.28137544e-02, 3.86789690e-02, 1.06116730e-02, 8.86540833e-03,
1.55032343e-01, 4.73269342e-01, 1.70447878e-01, 1.73926778e-01,
7.12428953e-01, 3.22852894e-03, 5.02353746e-02, 6.06592606e-02,
3.30098041e-02, 8.86162342e-02, 3.36876695e-04, 1.25967516e-01,
1.84537176e-03, 9.98455150e-03, 9.78501437e-02, 7.56009417e-01,
```

```
       2.45925124e-02, 6.59141937e-02, 4.33927247e-02, 3.12662254e-02,
       4.78772831e-01, 6.33881559e-02, 9.33838870e-01, 6.11375300e-03,
       2.07747746e-01, 3.93356726e-02, 6.01603324e-02, 5.07841575e-03,
       3.26352050e-02, 9.31981726e-02, 4.72478251e-01, 9.31123821e-01,
       1.13511249e-03, 3.18788110e-02, 3.53982173e-01, 1.39866017e-02,
       1.17292351e-01, 6.69597602e-02, 1.05365545e-01, 1.66076320e-01,
       7.47401091e-02, 6.15752530e-02, 5.60925232e-02, 5.18658274e-03,
       4.31644060e-01, 1.54872889e-02, 2.95692896e-01, 2.71973828e-01,
       3.88023847e-02, 1.70753340e-02, 2.35969324e-01, 1.33024417e-01,
       2.43234850e-03, 1.46446371e-02, 1.53939632e-02, 2.35216731e-01,
       6.81982634e-02, 3.94132256e-01, 1.80752417e-01, 8.72236474e-02,
       7.31484062e-02, 7.29981364e-04, 8.38406603e-02, 4.97134554e-02,
       1.40067425e-01, 5.71254372e-01, 2.46895181e-02, 2.57965968e-01,
       3.15199536e-02, 5.59383981e-03, 9.44886352e-02, 2.13266413e-01,
       9.68401104e-03, 8.49517283e-02, 1.08099557e-02, 2.73906824e-01,
       6.25214570e-02, 1.65044989e-01, 6.53722879e-02, 4.78455216e-03,
       6.42388765e-02, 8.99104148e-02, 3.79332993e-03, 2.70835292e-01,
       4.96742383e-03, 4.29077834e-03, 1.08815311e-02, 2.21587385e-03,
       2.23421522e-01, 6.47147717e-02, 2.00641849e-03, 4.30790071e-01,
       1.51268070e-02, 8.23374179e-02, 4.78748775e-03, 5.55329137e-01,
       1.17147513e-02, 4.36125499e-02, 4.55052186e-01, 3.26172268e-01,
       6.64959011e-03, 2.04738377e-02, 7.47671150e-01, 1.09558095e-01,
       2.51037501e-01, 2.81302949e-02, 3.34975318e-02, 6.02059546e-02,
       1.20560672e-03, 7.72182819e-01, 4.81119258e-04, 2.82029097e-01,
       9.17385752e-03, 8.31867948e-02, 3.85578733e-02, 6.84097282e-01,
       3.83505730e-02, 6.46943487e-02, 8.06682328e-01, 1.64778495e-02,
       7.83417589e-02, 5.66998055e-01, 9.46883610e-03, 3.76385423e-02,
       7.48120581e-01, 3.22493646e-02, 2.16143874e-02, 3.64865854e-02,
       5.36704416e-02, 5.82953030e-03, 1.72080662e-01, 5.07316544e-02,
       1.61265576e-02, 1.75292136e-03, 2.79114759e-01, 1.61827033e-02,
       2.10847532e-02, 4.47978489e-01, 4.52640047e-01, 3.42846902e-01,
       2.80919776e-02, 3.56562691e-01, 8.66195889e-02, 3.08977895e-02,
       2.19886880e-01, 9.84291161e-02, 4.95304390e-02, 2.03314116e-03,
       1.86101979e-03, 2.03859038e-02, 1.03879381e-01, 8.55390066e-02,
       2.59636309e-01, 6.97127835e-03, 1.21093498e-01, 2.16623712e-01,
       6.77560665e-03, 1.35869166e-01, 1.54017661e-01, 1.19158489e-01,
       1.23249508e-02, 1.54454121e-01, 6.15739824e-02, 4.12836693e-03,
       4.58878117e-04])
```

[103]:
```python
fpr,tpr,threshsholds = roc_curve(y_test,prob)
```

[104]:
```python
plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('ROC CURVE')
plt.show()
```

ROC CURVE
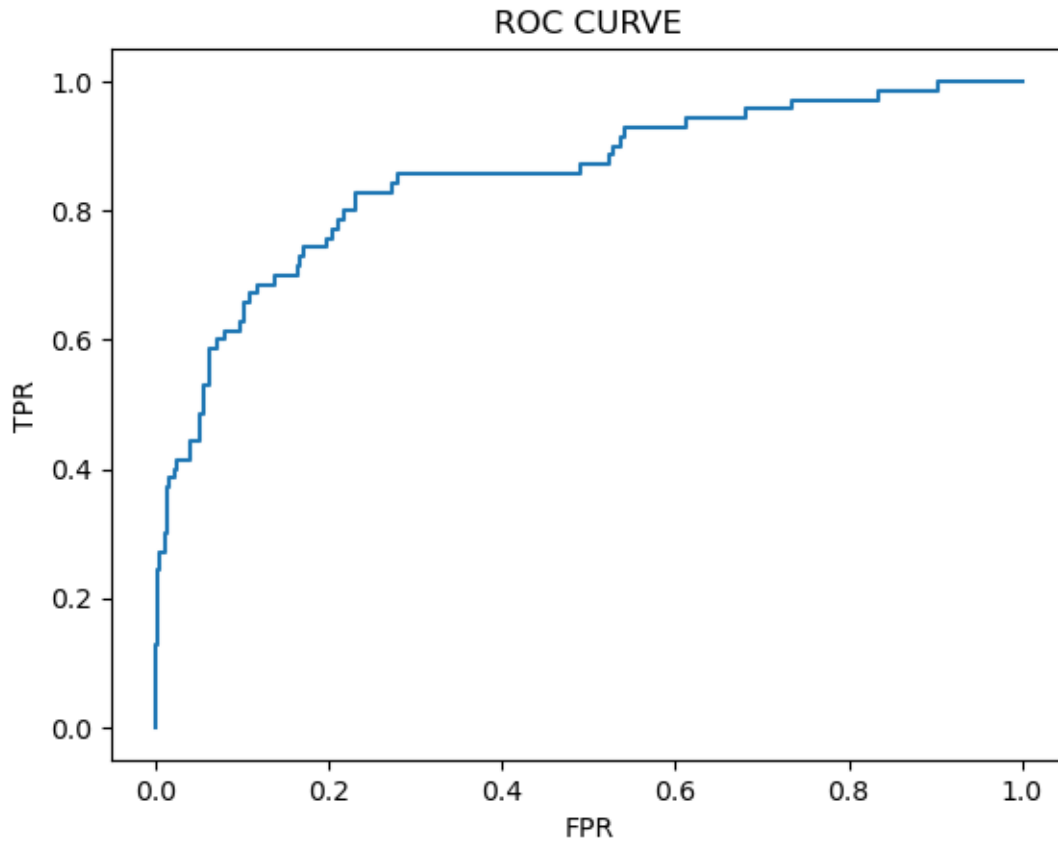
3 Decision Tree

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

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

```
[106]: DecisionTreeClassifier()
```

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

```
[107]: array([0, 0, 0, 0, 1, 1, 1, 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, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0,
               0, 1, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0,
               0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0,
               0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 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, 1, 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, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1,
         0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
         0, 1, 1, 0, 1, 0, 0, 1, 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, 0, 1, 0, 1, 0, 0, 0, 0,
         0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1,
         0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0,
         0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 1, 0, 0,
         0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 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, 1, 1, 0, 1, 0,
         0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 1, 0,
         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0], dtype=uint8)
```

[108]: `y_test`

[108]:
```
         Yes
442      0
1091     0
981      1
785      0
1332     1
...     ...
817      0
399      0
458      0
406      0
590      0

[441 rows x 1 columns]
```

[109]:
```python
from sklearn.metrics import␣
 ↪accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

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

[110]: 0.7777777777777778

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

[111]:
```
array([[319,  52],
       [ 46,  24]], dtype=int64)
```

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

```
              precision    recall  f1-score    support
```

	precision	recall	f1-score	support
0	0.87	0.86	0.87	371
1	0.32	0.34	0.33	70
accuracy			0.78	441
macro avg	0.59	0.60	0.60	441
weighted avg	0.79	0.78	0.78	441

4 ROC-AUC CURVE

```
[113]: prob=dtc.predict_proba(x_test)[:,1]
       prob
```

```
[113]: array([0., 0., 0., 0., 1., 1., 1., 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., 1., 0.,
              0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 1., 0., 1., 0., 0.,
              0., 1., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0.,
              0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0.,
              0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1.,
              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., 1., 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., 1., 0., 1., 1., 0., 0., 0., 0., 0., 0.,
              0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 1., 0., 0., 0.,
              1., 0., 0., 1., 1., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0.,
              0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
              1., 1., 0., 1., 0., 0., 1., 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., 0., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0.,
              0., 0., 0., 0., 0., 0., 0., 1., 1., 0., 0., 0., 0., 1., 0., 0., 0.,
              0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0., 0.,
              0., 0., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0.,
              1., 1., 0., 1., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0.,
              0., 1., 0., 1., 0., 0., 0., 0., 0., 1., 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.,
              1., 1., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0.,
              0., 0., 0., 0., 1., 1., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0.,
              0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.])
```

```
[114]: fpr,tpr,threshsholds = roc_curve(y_test,prob)
```

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

ROC CURVE
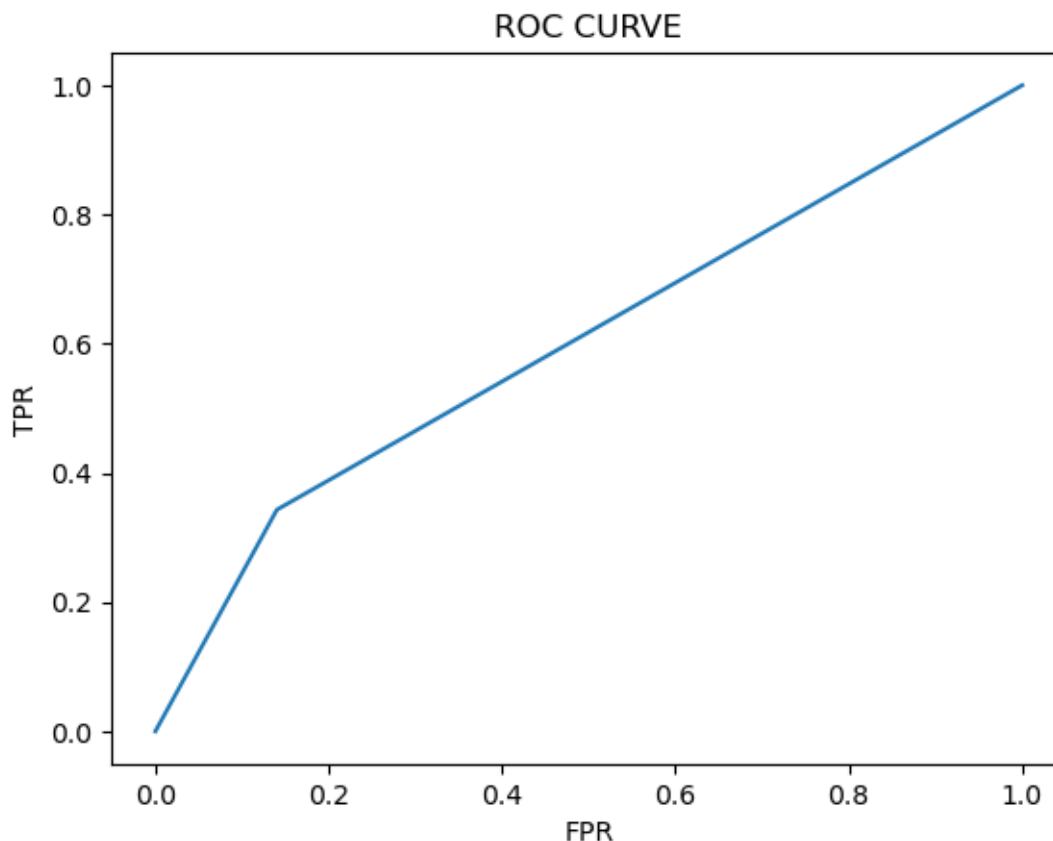
5 Hyperparameter Tuning

```
[116]: from sklearn import tree
       plt.figure(figsize=(25,15))
       tree.plot_tree(dtc,filled=True)
```

```
[116]: [Text(0.5248130471789884, 0.9642857142857143, 'x[48] <= 0.507\ngini =
       0.272\nsamples = 1029\nvalue = [862, 167]'),
        Text(0.2221698686770428, 0.8928571428571429, 'x[22] <= -1.115\ngini =
       0.191\nsamples = 747\nvalue = [667, 80]'),
        Text(0.08560311284046693, 0.8214285714285714, 'x[0] <= -0.584\ngini =
       0.397\nsamples = 110\nvalue = [80, 30]'),
        Text(0.042801556420233464, 0.75, 'x[26] <= 0.804\ngini = 0.499\nsamples =
       46\nvalue = [24, 22]'),
        Text(0.03501945525291829, 0.6785714285714286, 'x[1] <= -1.14\ngini =
       0.473\nsamples = 39\nvalue = [24, 15]'),
        Text(0.01556420233463035, 0.6071428571428571, 'x[27] <= -0.464\ngini =
       0.245\nsamples = 7\nvalue = [1, 6]'),
        Text(0.007782101167315175, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue
```

= [1, 0]'),
 Text(0.023346303501945526, 0.5357142857142857, 'gini = 0.0\nsamples = 6\nvalue
= [0, 6]'),
 Text(0.054474708171206226, 0.6071428571428571, 'x[21] <= -0.355\ngini =
0.404\nsamples = 32\nvalue = [23, 9]'),
 Text(0.038910505836575876, 0.5357142857142857, 'x[18] <= 0.823\ngini =
0.42\nsamples = 10\nvalue = [3, 7]'),
 Text(0.0311284046692607, 0.4642857142857143, 'gini = 0.0\nsamples = 7\nvalue =
[0, 7]'),
 Text(0.04669260700389105, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.07003891050583658, 0.5357142857142857, 'x[0] <= -0.695\ngini =
0.165\nsamples = 22\nvalue = [20, 2]'),
 Text(0.0622568093385214, 0.4642857142857143, 'gini = 0.0\nsamples = 19\nvalue =
[19, 0]'),
 Text(0.07782101167315175, 0.4642857142857143, 'x[41] <= 0.691\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.07003891050583658, 0.39285714285714285, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
 Text(0.08560311284046693, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
 Text(0.05058365758754864, 0.6785714285714286, 'gini = 0.0\nsamples = 7\nvalue =
[0, 7]'),
 Text(0.12840466926070038, 0.75, 'x[6] <= -1.134\ngini = 0.219\nsamples =
64\nvalue = [56, 8]'),
 Text(0.10894941634241245, 0.6785714285714286, 'x[13] <= 0.697\ngini =
0.457\nsamples = 17\nvalue = [11, 6]'),
 Text(0.09338521400778210, 0.6071428571428571, 'x[18] <= 0.823\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
 Text(0.08560311284046693, 0.5357142857142857, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(0.10116731517509728, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.1245136186770428, 0.6071428571428571, 'x[14] <= 0.761\ngini =
0.408\nsamples = 7\nvalue = [2, 5]'),
 Text(0.11673151750972763, 0.5357142857142857, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),
 Text(0.13229571984435798, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.14785992217898833, 0.6785714285714286, 'x[12] <= -1.512\ngini =
0.081\nsamples = 47\nvalue = [45, 2]'),
 Text(0.14007782101167315, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.1556420233463035, 0.6071428571428571, 'x[12] <= 1.684\ngini =
0.043\nsamples = 46\nvalue = [45, 1]'),
 Text(0.14785992217898833, 0.5357142857142857, 'gini = 0.0\nsamples = 45\nvalue
= [45, 0]'),

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```
Text(0.16342412451361868, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.35873662451361865, 0.8214285714285714, 'x[10] <= -1.119\ngini =
0.145\nsamples = 637\nvalue = [587, 50]'),
 Text(0.2509727626459144, 0.75, 'x[18] <= -0.354\ngini = 0.265\nsamples =
121\nvalue = [102, 19]'),
 Text(0.20622568093385213, 0.6785714285714286, 'x[16] <= 0.754\ngini =
0.393\nsamples = 52\nvalue = [38, 14]'),
 Text(0.19844357976653695, 0.6071428571428571, 'x[13] <= -0.487\ngini =
0.475\nsamples = 36\nvalue = [22, 14]'),
 Text(0.17898832684824903, 0.5357142857142857, 'x[34] <= 1.429\ngini =
0.332\nsamples = 19\nvalue = [15, 4]'),
 Text(0.17120622568093385, 0.4642857142857143, 'x[24] <= 3.369\ngini =
0.208\nsamples = 17\nvalue = [15, 2]'),
 Text(0.16342412451361868, 0.39285714285714285, 'x[21] <= -1.741\ngini =
0.117\nsamples = 16\nvalue = [15, 1]'),
 Text(0.1556420233463035, 0.32142857142857145, 'x[7] <= -0.403\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.14785992217898833, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.16342412451361868, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.17120622568093385, 0.32142857142857145, 'gini = 0.0\nsamples = 14\nvalue
= [14, 0]'),
 Text(0.17898832684824903, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
 Text(0.1867704280155642, 0.4642857142857143, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.2178988326848249, 0.5357142857142857, 'x[2] <= -0.82\ngini =
0.484\nsamples = 17\nvalue = [7, 10]'),
 Text(0.20233463035019456, 0.4642857142857143, 'x[11] <= -0.731\ngini =
0.375\nsamples = 8\nvalue = [6, 2]'),
 Text(0.19455252918287938, 0.39285714285714285, 'x[23] <= 0.086\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.1867704280155642, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.20233463035019456, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
 Text(0.21011673151750973, 0.39285714285714285, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
 Text(0.23346303501945526, 0.4642857142857143, 'x[21] <= -1.741\ngini =
0.198\nsamples = 9\nvalue = [1, 8]'),
 Text(0.22568093385214008, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
 Text(0.24124513618677043, 0.39285714285714285, 'gini = 0.0\nsamples = 8\nvalue
= [0, 8]'),
 Text(0.2140077821011673, 0.6071428571428571, 'gini = 0.0\nsamples = 16\nvalue =
[16, 0]'),
 Text(0.29571984435797666, 0.6785714285714286, 'x[1] <= 1.506\ngini =
```

0.134\nsamples = 69\nvalue = [64, 5]'),
 Text(0.28793774319066145, 0.6071428571428571, 'x[0] <= -0.253\ngini =
0.111\nsamples = 68\nvalue = [64, 4]'),
 Text(0.2801556420233463, 0.5357142857142857, 'x[11] <= -0.076\ngini =
0.238\nsamples = 29\nvalue = [25, 4]'),
 Text(0.26459143968871596, 0.4642857142857143, 'x[6] <= -1.134\ngini =
0.095\nsamples = 20\nvalue = [19, 1]'),
 Text(0.25680933852140075, 0.39285714285714285, 'x[20] <= 0.583\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.2490272373540856, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.26459143968871596, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
 Text(0.2723735408560311, 0.39285714285714285, 'gini = 0.0\nsamples = 18\nvalue
= [18, 0]'),
 Text(0.29571984435797666, 0.4642857142857143, 'x[19] <= -0.114\ngini =
0.444\nsamples = 9\nvalue = [6, 3]'),
 Text(0.28793774319066145, 0.39285714285714285, 'gini = 0.0\nsamples = 4\nvalue
= [4, 0]'),
 Text(0.3035019455252918, 0.39285714285714285, 'x[20] <= -0.223\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
 Text(0.29571984435797666, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
 Text(0.311284046692607, 0.32142857142857145, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.29571984435797666, 0.5357142857142857, 'gini = 0.0\nsamples = 39\nvalue
= [39, 0]'),
 Text(0.3035019455252918, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.46650048638132297, 0.75, 'x[1] <= -1.7\ngini = 0.113\nsamples =
516\nvalue = [485, 31]'),
 Text(0.42485408560311283, 0.6785714285714286, 'x[16] <= -1.082\ngini =
0.5\nsamples = 4\nvalue = [2, 2]'),
 Text(0.4170719844357977, 0.6071428571428571, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.43263618677042803, 0.6071428571428571, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.508146887159533, 0.6785714285714286, 'x[11] <= 0.612\ngini =
0.107\nsamples = 512\nvalue = [483, 29]'),
 Text(0.4482003891050584, 0.6071428571428571, 'x[19] <= -0.432\ngini =
0.077\nsamples = 400\nvalue = [384, 16]'),
 Text(0.4022373540856031, 0.5357142857142857, 'x[13] <= 0.697\ngini =
0.155\nsamples = 154\nvalue = [141, 13]'),
 Text(0.35700389105058367, 0.4642857142857143, 'x[25] <= -1.036\ngini =
0.085\nsamples = 135\nvalue = [129, 6]'),
 Text(0.3346303501945525, 0.39285714285714285, 'x[11] <= -0.822\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),

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Text(0.32684824902723736, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.3424124513618677, 0.32142857142857145, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(0.37937743190661477, 0.39285714285714285, 'x[24] <= 1.188\ngini = 0.061\nsamples = 128\nvalue = [124, 4]'),
 Text(0.35797665369649806, 0.32142857142857145, 'x[11] <= -1.048\ngini = 0.046\nsamples = 126\nvalue = [123, 3]'),
 Text(0.33852140077821014, 0.25, 'x[46] <= 0.103\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.33073929961089493, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.3463035019455253, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.377431906614786, 0.25, 'x[13] <= 0.302\ngini = 0.032\nsamples = 124\nvalue = [122, 2]'),
 Text(0.36186770428015563, 0.17857142857142858, 'x[0] <= -1.69\ngini = 0.017\nsamples = 118\nvalue = [117, 1]'),
 Text(0.3540856031128405, 0.10714285714285714, 'x[15] <= 0.956\ngini = 0.278\nsamples = 6\nvalue = [5, 1]'),
 Text(0.3463035019455253, 0.03571428571428571, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(0.36186770428015563, 0.03571428571428571, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.36964980544747084, 0.10714285714285714, 'gini = 0.0\nsamples = 112\nvalue = [112, 0]'),
 Text(0.39299610894941633, 0.17857142857142858, 'x[16] <= -1.082\ngini = 0.278\nsamples = 6\nvalue = [5, 1]'),
 Text(0.3852140077821012, 0.10714285714285714, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.40077821011673154, 0.10714285714285714, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(0.40077821011673154, 0.32142857142857145, 'x[35] <= -0.228\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.39299610894941633, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.4085603112840467, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.4474708171206226, 0.4642857142857143, 'x[1] <= 1.373\ngini = 0.465\nsamples = 19\nvalue = [12, 7]'),
 Text(0.4396887159533074, 0.39285714285714285, 'x[0] <= -0.584\ngini = 0.375\nsamples = 16\nvalue = [12, 4]'),
 Text(0.43190661478599224, 0.32142857142857145, 'x[1] <= 0.334\ngini = 0.5\nsamples = 8\nvalue = [4, 4]'),
 Text(0.42412451361867703, 0.25, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
 Text(0.4396887159533074, 0.25, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(0.4474708171206226, 0.32142857142857145, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
 Text(0.45525291828793774, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue

= [0, 3]'),
 Text(0.49416342412451364, 0.5357142857142857, 'x[0] <= 1.626\ngini =
0.024\nsamples = 246\nvalue = [243, 3]'),
 Text(0.4785992217898833, 0.4642857142857143, 'x[25] <= -0.737\ngini =
0.009\nsamples = 221\nvalue = [220, 1]'),
 Text(0.4708171206225681, 0.39285714285714285, 'x[37] <= 0.878\ngini =
0.091\nsamples = 21\nvalue = [20, 1]'),
 Text(0.46303501945525294, 0.32142857142857145, 'gini = 0.0\nsamples = 18\nvalue
= [18, 0]'),
 Text(0.4785992217898833, 0.32142857142857145, 'x[12] <= 0.37\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(0.4708171206225681, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(0.48638132295719844, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.48638132295719844, 0.39285714285714285, 'gini = 0.0\nsamples =
200\nvalue = [200, 0]'),
 Text(0.5097276264591439, 0.4642857142857143, 'x[11] <= -0.943\ngini =
0.147\nsamples = 25\nvalue = [23, 2]'),
 Text(0.5019455252918288, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.5175097276264592, 0.39285714285714285, 'x[31] <= 1.272\ngini =
0.08\nsamples = 24\nvalue = [23, 1]'),
 Text(0.5097276264591439, 0.32142857142857145, 'gini = 0.0\nsamples = 22\nvalue
= [22, 0]'),
 Text(0.5252918287937743, 0.32142857142857145, 'x[16] <= 0.754\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.5175097276264592, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.5330739299610895, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.5680933852140078, 0.6071428571428571, 'x[1] <= -1.619\ngini =
0.205\nsamples = 112\nvalue = [99, 13]'),
 Text(0.5486381322957199, 0.5357142857142857, 'x[5] <= -0.421\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
 Text(0.5408560311284046, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.556420233463035, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.5875486381322957, 0.5357142857142857, 'x[14] <= -1.017\ngini =
0.168\nsamples = 108\nvalue = [98, 10]'),
 Text(0.5719844357976653, 0.4642857142857143, 'x[19] <= 1.001\ngini =
0.397\nsamples = 22\nvalue = [16, 6]'),
 Text(0.5642023346303502, 0.39285714285714285, 'x[13] <= -0.487\ngini =
0.266\nsamples = 19\nvalue = [16, 3]'),
 Text(0.556420233463035, 0.32142857142857145, 'x[13] <= -0.882\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
 Text(0.5486381322957199, 0.25, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(0.5642023346303502, 0.25, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(0.5719844357976653, 0.32142857142857145, 'gini = 0.0\nsamples = 13\nvalue
= [13, 0]'),

Text(0.5797665369649806, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.603112840466926, 0.4642857142857143, 'x[11] <= 0.633\ngini =
0.089\nsamples = 86\nvalue = [82, 4]'),
 Text(0.5953307392996109, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6108949416342413, 0.39285714285714285, 'x[0] <= 1.294\ngini =
0.068\nsamples = 85\nvalue = [82, 3]'),
 Text(0.603112840466926, 0.32142857142857145, 'gini = 0.0\nsamples = 62\nvalue =
[62, 0]'),
 Text(0.6186770428015564, 0.32142857142857145, 'x[11] <= 1.562\ngini =
0.227\nsamples = 23\nvalue = [20, 3]'),
 Text(0.6108949416342413, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.6264591439688716, 0.25, 'x[12] <= 1.488\ngini = 0.091\nsamples =
21\nvalue = [20, 1]'),
 Text(0.6186770428015564, 0.17857142857142858, 'gini = 0.0\nsamples = 20\nvalue
= [20, 0]'),
 Text(0.6342412451361867, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.8274562256809338, 0.8928571428571429, 'x[11] <= -0.434\ngini =
0.427\nsamples = 282\nvalue = [195, 87]'),
 Text(0.7453793774319066, 0.8214285714285714, 'x[8] <= 1.094\ngini =
0.493\nsamples = 109\nvalue = [48, 61]'),
 Text(0.7008754863813229, 0.75, 'x[0] <= -1.137\ngini = 0.474\nsamples =
96\nvalue = [37, 59]'),
 Text(0.6536964980544747, 0.6785714285714286, 'x[24] <= -0.214\ngini =
0.204\nsamples = 26\nvalue = [3, 23]'),
 Text(0.6381322957198443, 0.6071428571428571, 'x[7] <= -1.528\ngini =
0.083\nsamples = 23\nvalue = [1, 22]'),
 Text(0.6303501945525292, 0.5357142857142857, 'x[5] <= 0.251\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.622568093385214, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6381322957198443, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.6459143968871596, 0.5357142857142857, 'gini = 0.0\nsamples = 21\nvalue =
[0, 21]'),
 Text(0.669260700389105, 0.6071428571428571, 'x[37] <= 0.878\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(0.6614785992217899, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.6770428015564203, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.7480544747081712, 0.6785714285714286, 'x[1] <= 0.807\ngini =
0.5\nsamples = 70\nvalue = [34, 36]'),
 Text(0.7217898832684825, 0.6071428571428571, 'x[14] <= 0.898\ngini =
0.468\nsamples = 51\nvalue = [19, 32]'),

```
Text(0.6926070038910506, 0.5357142857142857, 'x[0] <= -0.142\ngini =
0.497\nsamples = 39\nvalue = [18, 21]'),
 Text(0.6575875486381323, 0.4642857142857143, 'x[0] <= -0.916\ngini =
0.434\nsamples = 22\nvalue = [7, 15]'),
 Text(0.642023346303502, 0.39285714285714285, 'x[18] <= 2.001\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
 Text(0.6342412451361867, 0.32142857142857145, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
 Text(0.6498054474708171, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6731517509727627, 0.39285714285714285, 'x[14] <= 0.077\ngini =
0.291\nsamples = 17\nvalue = [3, 14]'),
 Text(0.6653696498054474, 0.32142857142857145, 'x[12] <= 1.15\ngini =
0.124\nsamples = 15\nvalue = [1, 14]'),
 Text(0.6575875486381323, 0.25, 'gini = 0.0\nsamples = 13\nvalue = [0, 13]'),
 Text(0.6731517509727627, 0.25, 'x[37] <= 0.878\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
 Text(0.6653696498054474, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.6809338521400778, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6809338521400778, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.7276264591439688, 0.4642857142857143, 'x[0] <= 1.073\ngini =
0.457\nsamples = 17\nvalue = [11, 6]'),
 Text(0.7198443579766537, 0.39285714285714285, 'x[24] <= -0.525\ngini =
0.337\nsamples = 14\nvalue = [11, 3]'),
 Text(0.7120622568093385, 0.32142857142857145, 'x[5] <= 0.13\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
 Text(0.7042801556420234, 0.25, 'x[16] <= -1.082\ngini = 0.375\nsamples =
4\nvalue = [3, 1]'),
 Text(0.6964980544747081, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.7120622568093385, 0.17857142857142858, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.7198443579766537, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.7276264591439688, 0.32142857142857145, 'gini = 0.0\nsamples = 8\nvalue =
[8, 0]'),
 Text(0.7354085603112841, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.7509727626459144, 0.5357142857142857, 'x[11] <= -0.459\ngini =
0.153\nsamples = 12\nvalue = [1, 11]'),
 Text(0.7431906614785992, 0.4642857142857143, 'gini = 0.0\nsamples = 11\nvalue =
[0, 11]'),
 Text(0.7587548638132295, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.77431906614786, 0.6071428571428571, 'x[6] <= -1.134\ngini =
```

0.332\nsamples = 19\nvalue = [15, 4]'),
 Text(0.7665369649805448, 0.5357142857142857, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(0.7821011673151751, 0.5357142857142857, 'x[5] <= -1.467\ngini = 0.117\nsamples = 16\nvalue = [15, 1]'),
 Text(0.77431906614786, 0.4642857142857143, 'x[19] <= -0.83\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.7665369649805448, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.7821011673151751, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.7898832684824902, 0.4642857142857143, 'gini = 0.0\nsamples = 14\nvalue = [14, 0]'),
 Text(0.7898832684824902, 0.75, 'x[22] <= -1.374\ngini = 0.26\nsamples = 13\nvalue = [11, 2]'),
 Text(0.7821011673151751, 0.6785714285714286, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.7976653696498055, 0.6785714285714286, 'x[26] <= 0.804\ngini = 0.153\nsamples = 12\nvalue = [11, 1]'),
 Text(0.7898832684824902, 0.6071428571428571, 'gini = 0.0\nsamples = 11\nvalue = [11, 0]'),
 Text(0.8054474708171206, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.9095330739299611, 0.8214285714285714, 'x[45] <= 0.368\ngini = 0.255\nsamples = 173\nvalue = [147, 26]'),
 Text(0.8618677042801557, 0.75, 'x[12] <= 1.46\ngini = 0.123\nsamples = 121\nvalue = [113, 8]'),
 Text(0.8404669260700389, 0.6785714285714286, 'x[25] <= -1.036\ngini = 0.085\nsamples = 113\nvalue = [108, 5]'),
 Text(0.8210116731517509, 0.6071428571428571, 'x[10] <= 0.709\ngini = 0.42\nsamples = 10\nvalue = [7, 3]'),
 Text(0.8132295719844358, 0.5357142857142857, 'x[0] <= 0.079\ngini = 0.375\nsamples = 4\nvalue = [1, 3]'),
 Text(0.8054474708171206, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.8210116731517509, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(0.8287937743190662, 0.5357142857142857, 'gini = 0.0\nsamples = 6\nvalue = [6, 0]'),
 Text(0.8599221789883269, 0.6071428571428571, 'x[2] <= 2.404\ngini = 0.038\nsamples = 103\nvalue = [101, 2]'),
 Text(0.8443579766536965, 0.5357142857142857, 'x[8] <= -1.733\ngini = 0.02\nsamples = 101\nvalue = [100, 1]'),
 Text(0.8365758754863813, 0.4642857142857143, 'x[23] <= -0.465\ngini = 0.32\nsamples = 5\nvalue = [4, 1]'),
 Text(0.8287937743190662, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),

Text(0.8443579766536965, 0.39285714285714285, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(0.8521400778210116, 0.4642857142857143, 'gini = 0.0\nsamples = 96\nvalue = [96, 0]'),
 Text(0.8754863813229572, 0.5357142857142857, 'x[11] <= 1.66\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.867704280155642, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.8832684824902723, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.8832684824902723, 0.6785714285714286, 'x[6] <= -0.221\ngini = 0.469\nsamples = 8\nvalue = [5, 3]'),
 Text(0.8754863813229572, 0.6071428571428571, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(0.8910505836575876, 0.6071428571428571, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(0.9571984435797666, 0.75, 'x[42] <= 0.67\ngini = 0.453\nsamples = 52\nvalue = [34, 18]'),
 Text(0.9299610894941635, 0.6785714285714286, 'x[24] <= 1.188\ngini = 0.252\nsamples = 27\nvalue = [23, 4]'),
 Text(0.914396887159533, 0.6071428571428571, 'x[5] <= -1.454\ngini = 0.153\nsamples = 24\nvalue = [22, 2]'),
 Text(0.9066147859922179, 0.5357142857142857, 'x[2] <= 0.234\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.8988326848249028, 0.4642857142857143, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.914396887159533, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.9221789883268483, 0.5357142857142857, 'gini = 0.0\nsamples = 21\nvalue = [21, 0]'),
 Text(0.9455252918287937, 0.6071428571428571, 'x[5] <= -0.74\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.9377431906614786, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.953307392996109, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.9844357976653697, 0.6785714285714286, 'x[24] <= -0.214\ngini = 0.493\nsamples = 25\nvalue = [11, 14]'),
 Text(0.9766536964980544, 0.6071428571428571, 'x[8] <= 1.094\ngini = 0.457\nsamples = 17\nvalue = [11, 6]'),
 Text(0.9688715953307393, 0.5357142857142857, 'x[16] <= -1.082\ngini = 0.337\nsamples = 14\nvalue = [11, 3]'),
 Text(0.953307392996109, 0.4642857142857143, 'x[35] <= -0.228\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.9455252918287937, 0.39285714285714285, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.9610894941634242, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =

```
[1, 0]'),
 Text(0.9844357976653697, 0.4642857142857143, 'x[5] <= 1.155\ngini =
0.165\nsamples = 11\nvalue = [10, 1]'),
 Text(0.9766536964980544, 0.39285714285714285, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
 Text(0.9922178988326849, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.9844357976653697, 0.5357142857142857, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.9922178988326849, 0.6071428571428571, 'gini = 0.0\nsamples = 8\nvalue =
[0, 8]')]
```
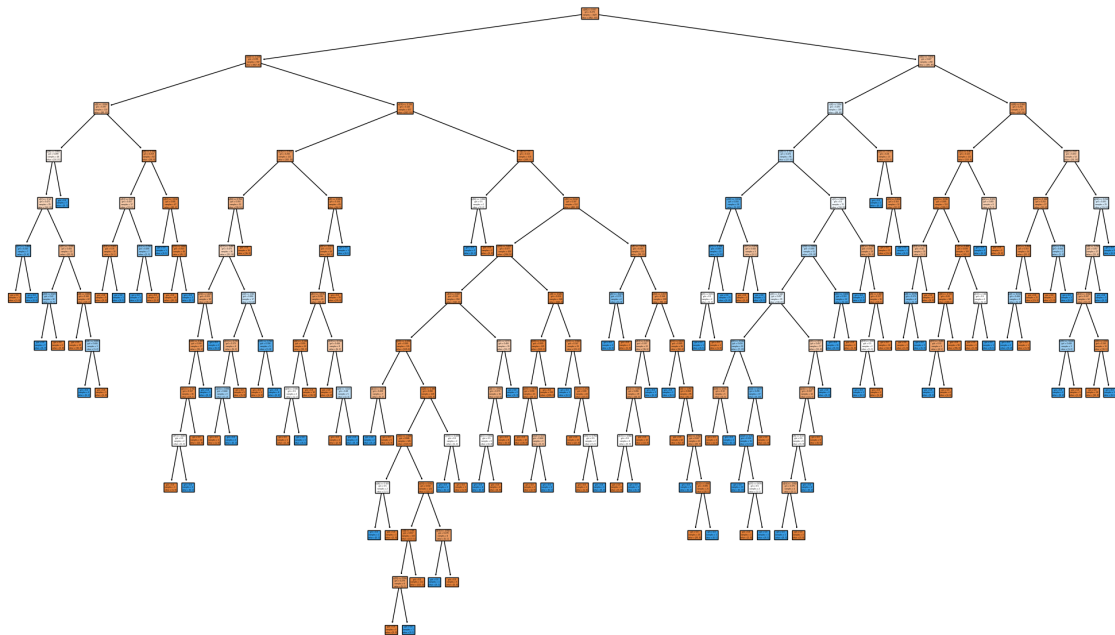


```python
[121]: from sklearn.model_selection import GridSearchCV
       parameter={
       'criterion':['gini','entropy'],
       'splitter':['best','random'],
       d'max_depth':[1,2,3,4,5],
       'max_features':['auto', 'sqrt', 'log2']
       }
```

```python
[122]: grid_search=GridSearchCV(estimator=dtc,param_grid=parameter,cv=5,scoring="accuracy")
```

```python
[123]: grid_search.fit(x_train,y_train)
```

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
```

```
100 fits failed out of a total of 300.
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:
--------------------------------------------------------------------------------
100 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\RUSHITHA REPAKULA\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:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\RUSHITHA REPAKULA\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 DecisionTreeClassifier must be an int in the range [1, inf), a
float in the range (0.0, 1.0], a str among {'log2', 'sqrt'} or None. Got 'auto'
instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [       nan        nan 0.83770779 0.83770779
0.83867866 0.83770779
         nan        nan 0.83770305 0.84062041 0.83576604 0.83770779
         nan        nan 0.83575657 0.84450864 0.82895098 0.83770779
         nan        nan 0.8415534  0.84451338 0.82990291 0.83089273
         nan        nan 0.82507222 0.82701397 0.82605257 0.84743074
         nan        nan 0.83770779 0.83770779 0.83770779 0.83770779
         nan        nan 0.83965901 0.83770779 0.8338243  0.83770779
         nan        nan 0.84062515 0.83673692 0.83674639 0.83867866
         nan        nan 0.8513095  0.83965901 0.84157234 0.83867393
         nan        nan 0.82308785 0.84450391 0.83086905 0.83575657]
  warnings.warn(
[123]: GridSearchCV(cv=5, estimator=DecisionTreeClassifier(),
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [1, 2, 3, 4, 5],
```

```
                          'max_features': ['auto', 'sqrt', 'log2'],
                          'splitter': ['best', 'random']},
                  scoring='accuracy')
```

[124]: `grid_search.best_params_`

[124]:
```
{'criterion': 'entropy',
 'max_depth': 4,
 'max_features': 'sqrt',
 'splitter': 'best'}
```

[125]:
```
dtc_cv=DecisionTreeClassifier(criterion= 'entropy',
max_depth=4,
max_features='sqrt',
splitter='best')
dtc_cv.fit(x_train,y_train)
```

[125]: `DecisionTreeClassifier(criterion='entropy', max_depth=4, max_features='sqrt')`

[126]: `pred=dtc_cv.predict(x_test)`

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

```
              precision    recall  f1-score   support

           0       0.84      0.98      0.91       371
           1       0.33      0.04      0.08        70

    accuracy                           0.83       441
   macro avg       0.59      0.51      0.49       441
weighted avg       0.76      0.83      0.78       441
```

After performing Hyperparameter tuning the accuracy has been improved.

6 Random Forest

[128]:
```
from sklearn.ensemble import RandomForestClassifier
rfc=RandomForestClassifier()
```

[129]:
```
forest_params = [{'max_depth': list(range(10, 15)), 'max_features':
 ↪list(range(0,14))}]
```

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

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

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
```

expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
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C:\Users\RUSHITHA REPAKULA\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:\Users\RUSHITHA REPAKULA\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:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
```

```
line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\RUSHITHA REPAKULA\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 {'log2', 'sqrt'} or None. Got 0
instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [       nan 0.84159528 0.84547877 0.84936227
0.85519703 0.85227489
 0.85518751 0.85325528 0.85421664 0.85615839 0.8483914  0.85421664
 0.85421664 0.847411          nan 0.84353703 0.85132305 0.85032362
 0.85228441 0.85422616 0.85518751 0.85033314 0.85323625 0.85032362
 0.84547877 0.85226537 0.84448886 0.85324576        nan 0.84355606
 0.85132305 0.85229393 0.84936227 0.85712926 0.85520655 0.85324576
 0.85324576 0.85130402 0.85712926 0.85518751 0.85033314 0.85032362
        nan 0.8445079  0.84449838 0.85228441 0.85032362 0.8512945
 0.85226537 0.85226537 0.85713878 0.85421664 0.85032362 0.85420712
 0.85907101 0.84545974        nan 0.8445079  0.84936227 0.85131354
 0.85032362 0.85324576 0.85130402 0.84937179 0.85131354 0.84937179
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```
[131]: 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')
```

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

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

               precision    recall  f1-score   support
```

```
                0       0.87       0.99       0.93        371
                1       0.79       0.21       0.34         70

         accuracy                             0.87        441
        macro avg       0.83       0.60       0.63        441
     weighted avg       0.86       0.87       0.83        441
```

[134]: `rfc_cv.best_params_`

[134]: `{'max_depth': 13, 'max_features': 12}`

[ ]: