

# Abhinav Kalluri Assignment-4

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

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

```
In [3]: df
```

```
Out[3]:
```

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	Educa
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life
4	27	No	Travel_Rarely	591	Research & Development	2	1	
...	...	...	...	...	...	...	...	
1465	36	No	Travel_Frequently	884	Research & Development	23	2	
1466	39	No	Travel_Rarely	613	Research & Development	6	1	
1467	27	No	Travel_Rarely	155	Research & Development	4	3	Life
1468	49	No	Travel_Frequently	1023	Sales	2	3	
1469	34	No	Travel_Rarely	628	Research & Development	8	3	

1470 rows × 35 columns

```
In [4]: df.head()
```

Out[4]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	Education
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sci
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sci
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sci
4	27	No	Travel_Rarely	591	Research & Development	2	1	Me

5 rows × 35 columns

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

Out[5]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	Educa
1465	36	No	Travel_Frequently	884	Research & Development	23	2	
1466	39	No	Travel_Rarely	613	Research & Development	6	1	
1467	27	No	Travel_Rarely	155	Research & Development	4	3	Life
1468	49	No	Travel_Frequently	1023	Sales	2	3	
1469	34	No	Travel_Rarely	628	Research & Development	8	3	

5 rows × 35 columns

In [6]: `df.shape`

Out[6]: (1470, 35)

In [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

```

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

Out[8]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber
<b>count</b>	1470.000000	1470.000000	1470.000000	1470.000000	1470.0	1470.000000
<b>mean</b>	36.923810	802.485714	9.192517	2.912925	1.0	1024.865306
<b>std</b>	9.135373	403.509100	8.106864	1.024165	0.0	602.024335
<b>min</b>	18.000000	102.000000	1.000000	1.000000	1.0	1.000000
<b>25%</b>	30.000000	465.000000	2.000000	2.000000	1.0	491.250000
<b>50%</b>	36.000000	802.000000	7.000000	3.000000	1.0	1020.500000
<b>75%</b>	43.000000	1157.000000	14.000000	4.000000	1.0	1555.750000
<b>max</b>	60.000000	1499.000000	29.000000	5.000000	1.0	2068.000000

8 rows × 6 columns

In [10]:

```
corr=df.corr()  
corr
```

C:\Users\RUSHITHA REPAKULA\AppData\Local\Temp\ipykernel\_12500\3182140910.py:1: Future Warning: 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()

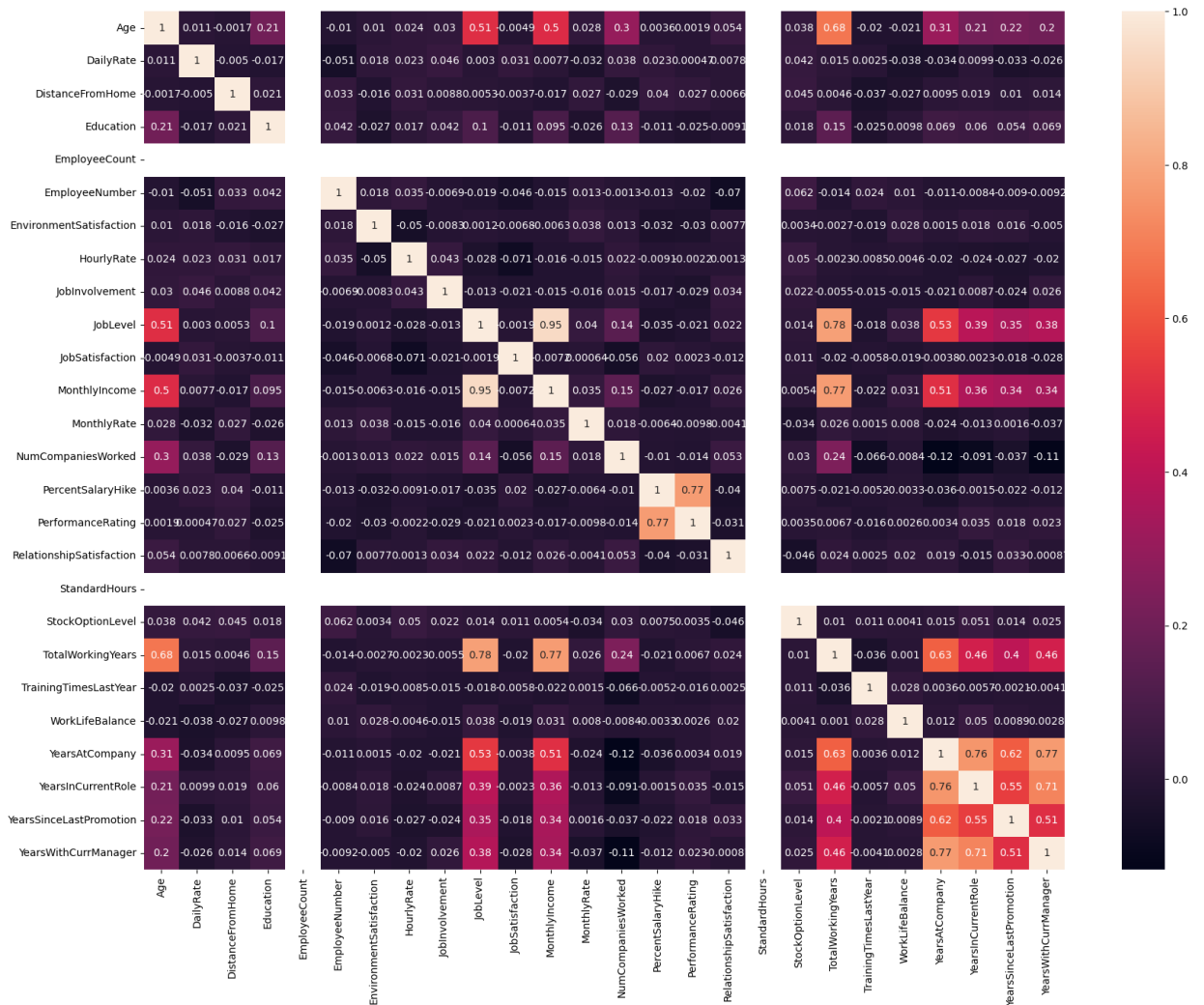
Out[10]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	Empleo
<b>Age</b>	1.000000	0.010661	-0.001686	0.208034	NaN	
<b>DailyRate</b>	0.010661	1.000000	-0.004985	-0.016806	NaN	
<b>DistanceFromHome</b>	-0.001686	-0.004985	1.000000	0.021042	NaN	
<b>Education</b>	0.208034	-0.016806	0.021042	1.000000	NaN	
<b>EmployeeCount</b>	NaN	NaN	NaN	NaN	NaN	
<b>EmployeeNumber</b>	-0.010145	-0.050990	0.032916	0.042070	NaN	
<b>EnvironmentSatisfaction</b>	0.010146	0.018355	-0.016075	-0.027128	NaN	
<b>HourlyRate</b>	0.024287	0.023381	0.031131	0.016775	NaN	
<b>JobInvolvement</b>	0.029820	0.046135	0.008783	0.042438	NaN	
<b>JobLevel</b>	0.509604	0.002966	0.005303	0.101589	NaN	
<b>JobSatisfaction</b>	-0.004892	0.030571	-0.003669	-0.011296	NaN	
<b>MonthlyIncome</b>	0.497855	0.007707	-0.017014	0.094961	NaN	
<b>MonthlyRate</b>	0.028051	-0.032182	0.027473	-0.026084	NaN	
<b>NumCompaniesWorked</b>	0.299635	0.038153	-0.029251	0.126317	NaN	
<b>PercentSalaryHike</b>	0.003634	0.022704	0.040235	-0.011111	NaN	
<b>PerformanceRating</b>	0.001904	0.000473	0.027110	-0.024539	NaN	
<b>RelationshipSatisfaction</b>	0.053535	0.007846	0.006557	-0.009118	NaN	
<b>StandardHours</b>	NaN	NaN	NaN	NaN	NaN	
<b>StockOptionLevel</b>	0.037510	0.042143	0.044872	0.018422	NaN	
<b>TotalWorkingYears</b>	0.680381	0.014515	0.004628	0.148280	NaN	
<b>TrainingTimesLastYear</b>	-0.019621	0.002453	-0.036942	-0.025100	NaN	
<b>WorkLifeBalance</b>	-0.021490	-0.037848	-0.026556	0.009819	NaN	
<b>YearsAtCompany</b>	0.311309	-0.034055	0.009508	0.069114	NaN	
<b>YearsInCurrentRole</b>	0.212901	0.009932	0.018845	0.060236	NaN	
<b>YearsSinceLastPromotion</b>	0.216513	-0.033229	0.010029	0.054254	NaN	
<b>YearsWithCurrManager</b>	0.202089	-0.026363	0.014406	0.069065	NaN	

26 rows × 26 columns

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

Out[11]: <Axes: >



```
In [12]: df.Attrition.value_counts()
```

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

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

```
Out[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
```

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

```
Out[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
```

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

```
Out[15]:
```

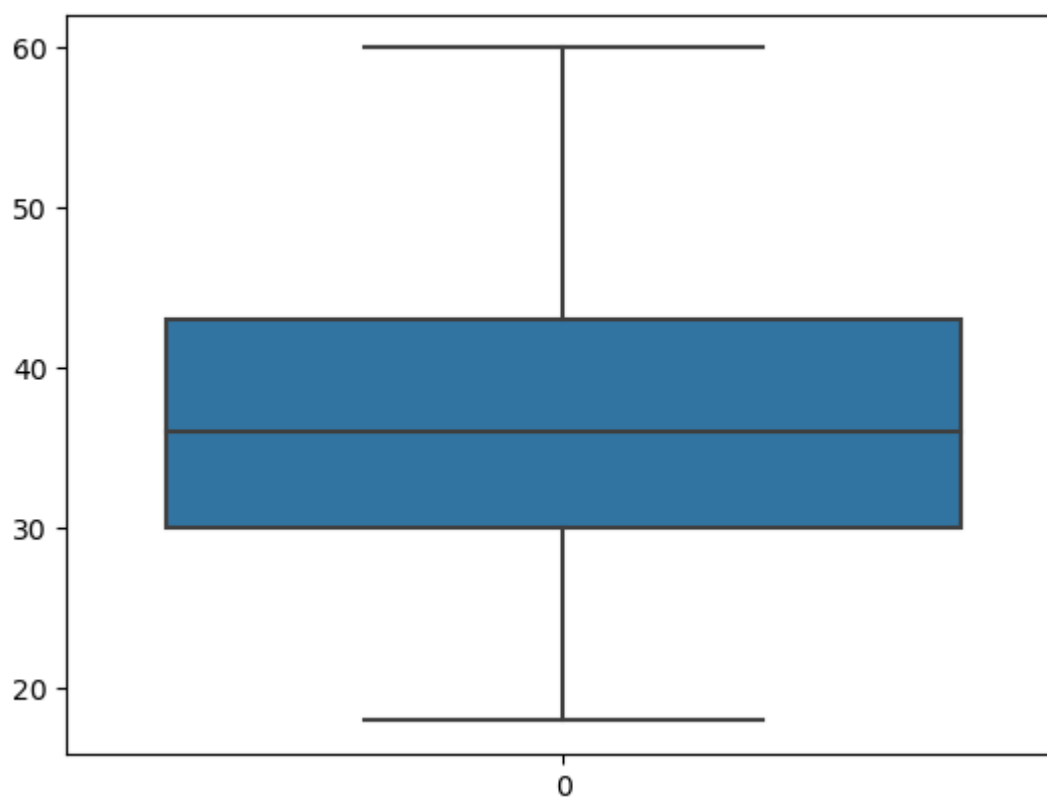
	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Life Sciences
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences
4	27	No	Travel_Rarely	591	Research & Development	2	1	Life Sciences

5 rows × 9 columns

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

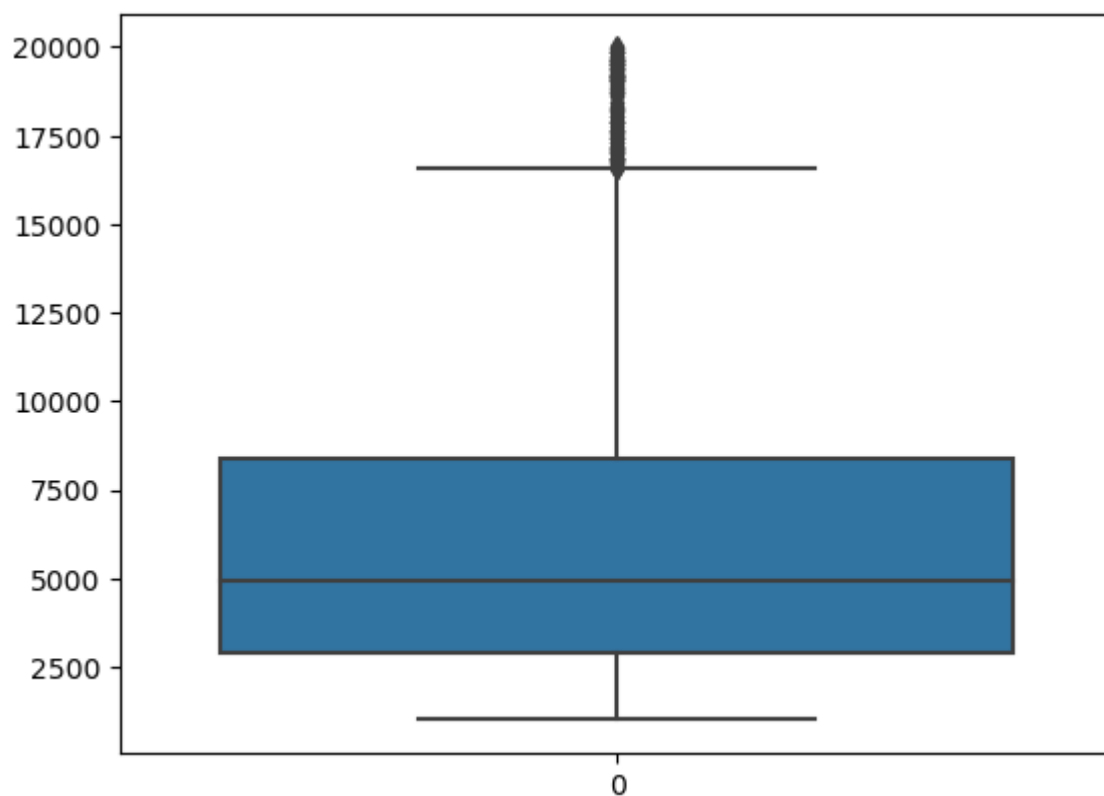


Out[17]: <Axes: >



In [18]: `sns.boxplot(df.MonthlyIncome)`

Out[18]: <Axes: >



```
In [19]: q1=df.MonthlyIncome.quantile(0.25)
q3=df.MonthlyIncome.quantile(0.75)
```

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

```
Out[20]: 5468.0
```

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

```
Out[21]: 16581.0
```

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

```
Out[22]: 4919.0
```

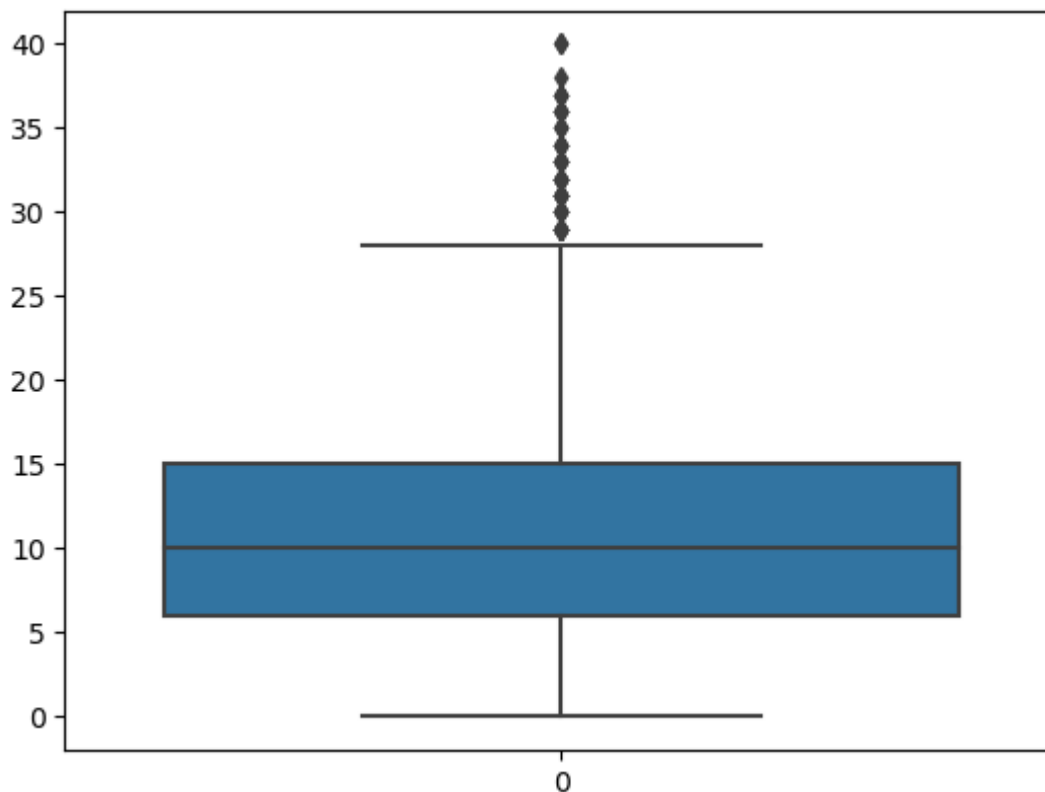
```
In [23]: df['MonthlyIncome']=np.where(df['MonthlyIncome']>ul,4919.0,df['MonthlyIncome'])
```

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

```
Out[24]: (1470, 35)
```

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

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



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

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

```
Out[27]: 9.0
```

```
In [29]: u1=q3+1.5*IQR  
u1
```

```
Out[29]: 28.5
```

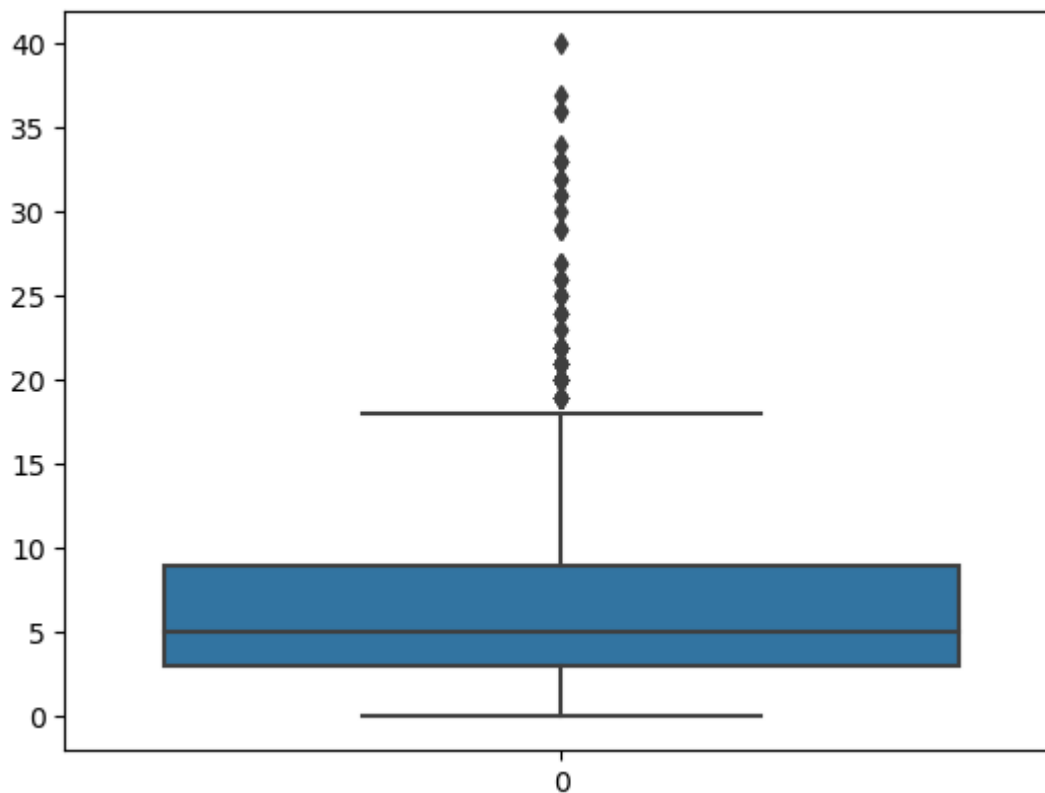
```
In [30]: df['TotalWorkingYears'].median()
```

```
Out[30]: 10.0
```

```
In [31]: df['TotalWorkingYears']=np.where(df['TotalWorkingYears']>u1,10,df['TotalWorkingYears'])
```

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

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



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

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

```
Out[34]: 6.0
```

```
In [35]: u1=q3+1.5*IQR  
u1
```

Out[35]: 18.0

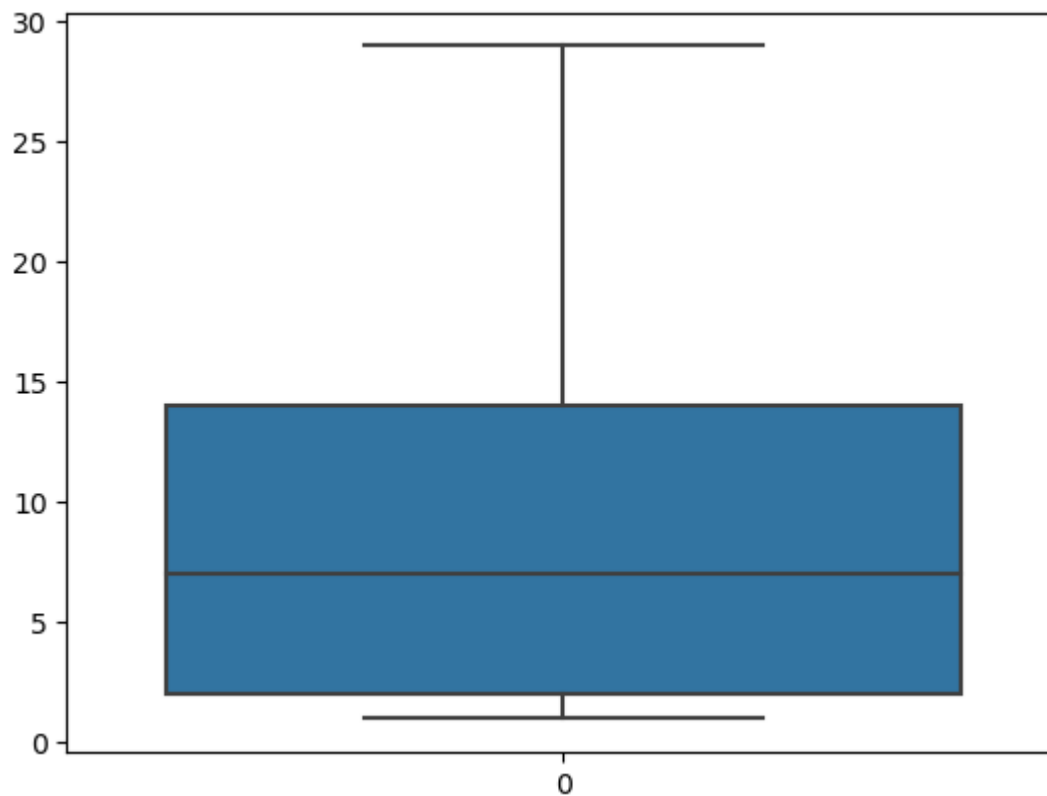
```
In [36]: df['YearsAtCompany'].mean()
```

Out[36]: 7.0081632653061225

```
In [37]: df['YearsAtCompany'] = np.where(df['YearsAtCompany'] > u1, 7.0081632653061225, df['YearsAtCo
```

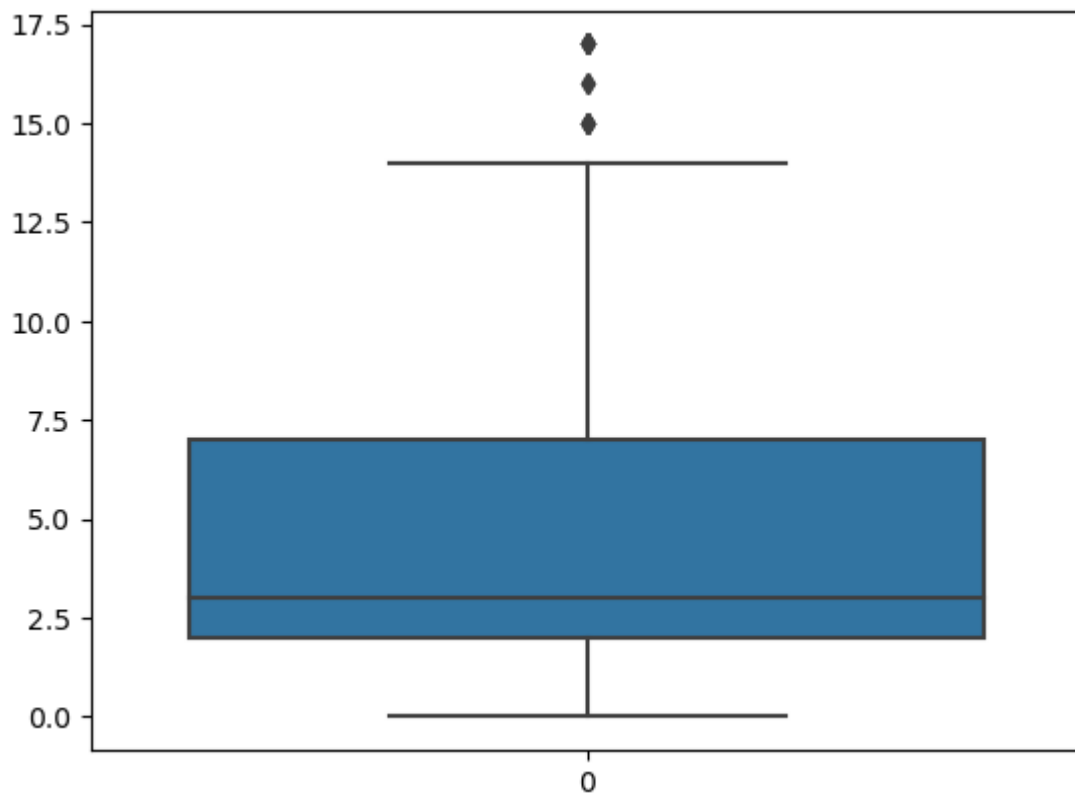
```
In [38]: sns.boxplot(df.DistanceFromHome)
```

Out[38]: <Axes: >



```
In [40]: sns.boxplot(df.YearsWithCurrManager)
```

Out[40]: <Axes: >



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

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

```
Out[42]: 5.0
```

```
In [43]: u1=q3+1.5*IQR
         u1
```

```
Out[43]: 14.5
```

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

```
Out[44]: 3.0
```

```
In [45]: df['YearsWithCurrManager']=np.where(df['YearsWithCurrManager']>u1,3,df['YearsWithCurrManager'])
```

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

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

```
Out[47]:
```

	Age	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	Emp
0	41	Travel_Rarely	1102	Sales	1	2	Life Sciences	
1	49	Travel_Frequently	279	Research & Development	8	1	Life Sciences	
2	37	Travel_Rarely	1373	Research & Development	2	2	Other	
3	33	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	
4	27	Travel_Rarely	591	Research & Development	2	1	Medical	

5 rows × 34 columns

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

```
Out[48]:
```

	Attrition
0	Yes
1	No
2	Yes
3	No
4	No

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

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

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

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

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

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

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

Out[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

	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 × 2 columns

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

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

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

Out[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

	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 × 2 columns

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

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

```
Out[59]:
```

	Age	DailyRate	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	1102	1	2	Life Sciences	1	1
1	49	279	8	1	Life Sciences	1	2
2	37	1373	2	2	Other	1	4
3	33	1392	3	4	Life Sciences	1	5
4	27	591	2	1	Medical	1	7

5 rows × 36 columns

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

```
Out[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 × 5 columns

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

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



```
Out[62]:
```

	Male
0	0
1	1
2	1
3	0
4	1
...	...
1465	1
1466	1
1467	1
1468	1
1469	1

1470 rows × 1 columns

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

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

```
Out[64]:
```

	Human Resources	Laboratory Technician	Manager	Manufacturing Director	Research Director	Research Scientist	Sales Executive	Sales Representative
0	0	0	0	0	0	0	1	0
1	0	0	0	0	0	1	0	0
2	0	1	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0
4	0	1	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...
1465	0	1	0	0	0	0	0	0
1466	0	0	0	0	0	0	0	0
1467	0	0	0	1	0	0	0	0
1468	0	0	0	0	0	0	1	0
1469	0	1	0	0	0	0	0	0

1470 rows × 8 columns



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

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

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

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

```
Out[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 × 2 columns

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

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

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

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

Out[69]:

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

1470 rows × 0 columns

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

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

Out[72]:

	Yes
0	1
1	0
2	1
3	1
4	0
...	...
1465	0
1466	0
1467	1
1468	0
1469	0

1470 rows × 1 columns

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

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

```
Out[74]:
```

	Yes
0	1
1	0
2	1
3	0
4	0
...	...
1465	0
1466	0
1467	0
1468	0
1469	0

1470 rows × 1 columns

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

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

```
Out[76]:
```

	Yes
0	1
1	0
2	1
3	0
4	0

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

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

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

```
Out[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
```

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

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

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

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

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

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

```
Out[85]:
```

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSat
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	

5 rows × 49 columns

```
In [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

```

```

In [87]: 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)

```

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

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

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

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

```
In [91]: x_train
```

```
Out[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]])
```

```
In [92]: x_test
```

```
Out[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]])
```

## Logistic Regression

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

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

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\utils\validation.py:11  
84: 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)
```

```
Out[94]: ▼ LogisticRegression
LogisticRegression()
```

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

```
In [96]: pred
```

[illegible]

```
In [97]: y_test
```

Out[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



# Model Classification

```
In [98]: from sklearn.metrics import accuracy_score, confusion_matrix, classification_report, roc_
```

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

```
Out[99]: 0.8866213151927438
```

```
In [100... confusion_matrix(y_test, pred)
```

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

```
In [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

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

```
Out[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,
```

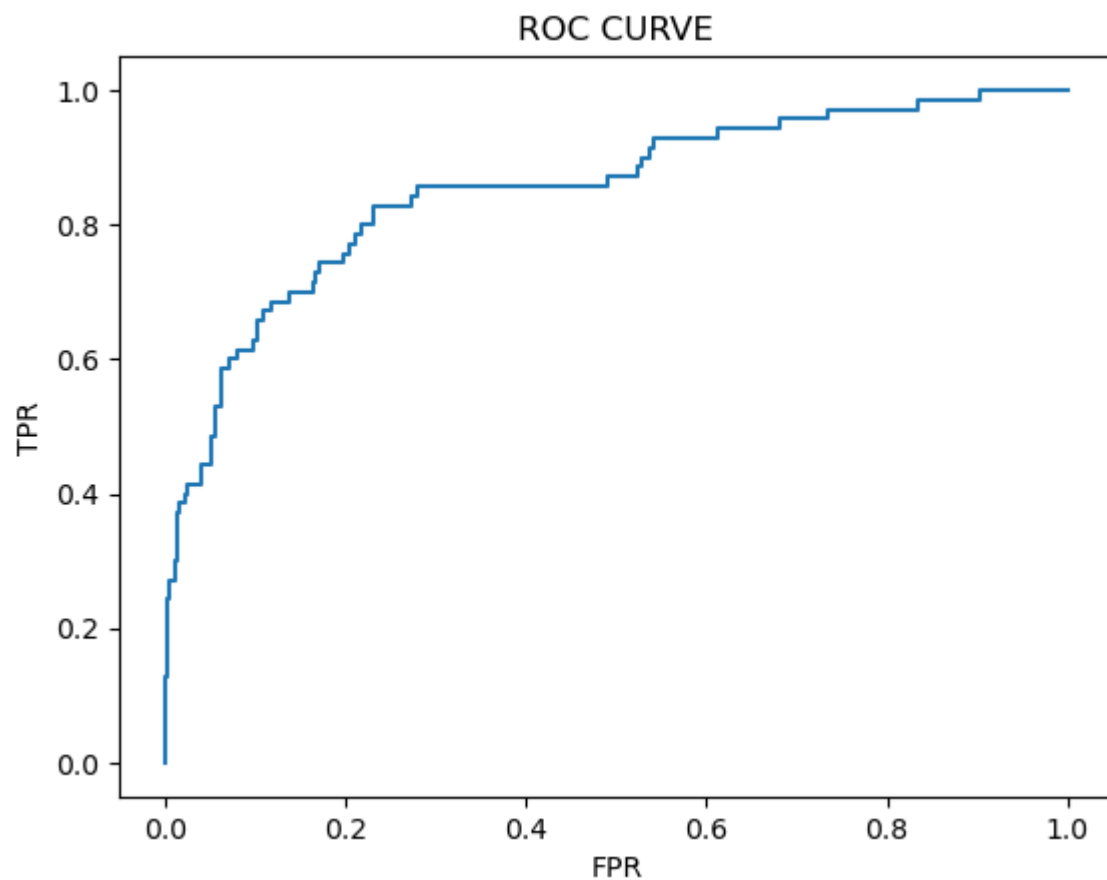
```

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,
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3.15199536e-02, 5.59383981e-03, 9.44886352e-02, 2.13266413e-01,
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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])

```

```
In [103... fpr,tpr,threshholds = roc_curve(y_test,prob)
```

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



## Decision Tree

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

```
In [106... dtc.fit(x_train,y_train)
```

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

```
In [107... pred=dtc.predict(x_test)  
pred
```

```
Out[107]: array([0, 0, 0, 0, 1, 1, 1, 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, 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, 0, 1, 0,
0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
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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, 0, 1, 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)
```

```
In [108... y_test
```

```
Out[108]:
```

	Yes
442	0
1091	0
981	1
785	0
1332	1
...	...
817	0
399	0
458	0
406	0
590	0

441 rows × 1 columns

```
In [109... from sklearn.metrics import accuracy_score, confusion_matrix, classification_report, roc_
```

```
In [110... accuracy_score(y_test, pred)
```

```
Out[110]: 0.7777777777777778
```

```
In [111... confusion_matrix(y_test, pred)
```

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

```
In [112... print(classification_report(y_test,pred))
```

	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

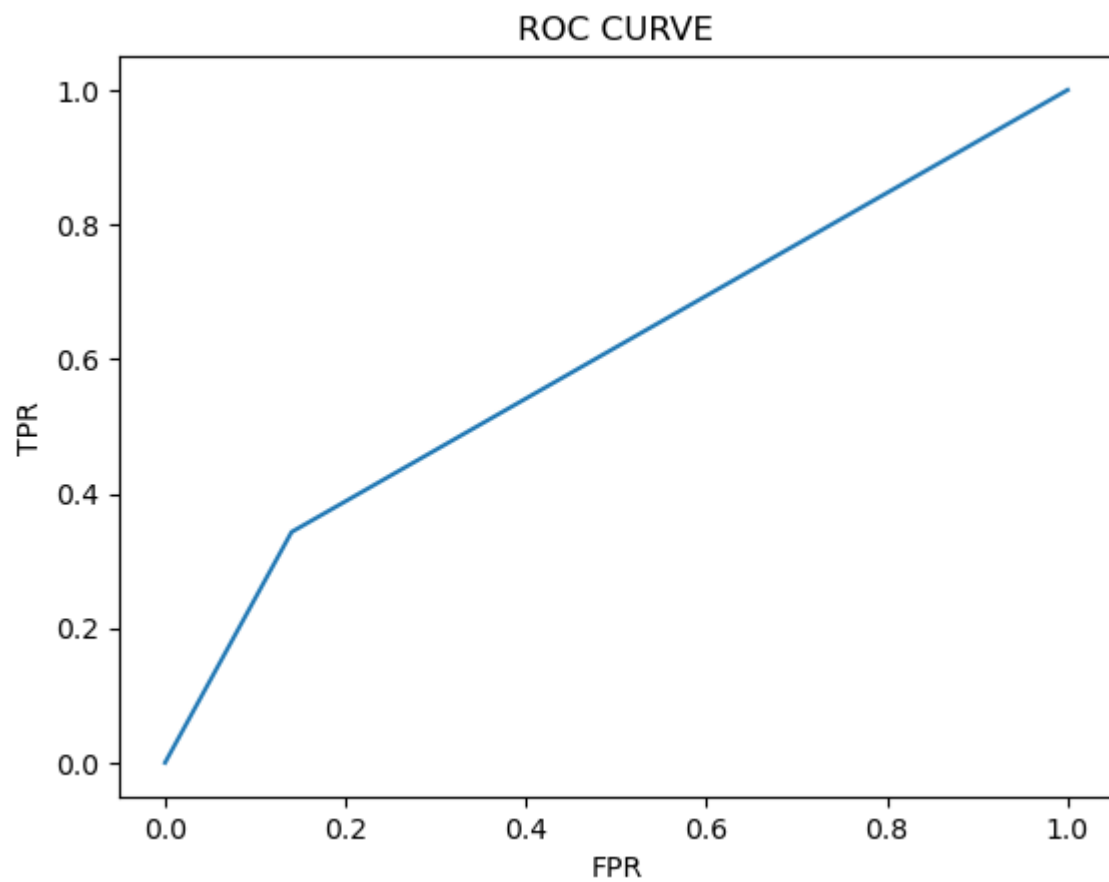
## ROC-AUC CURVE

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

[illegible]

```
In [114... fpr,tpr,threshsholds = roc_curve(y_test,prob)
```

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



## Hyperparameter Tuning

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

```
Out[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\nsample
s = 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\nsampl
es = 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(0.0933852140077821, 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\nsampl
es = 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 = [4
5, 0]'),
```



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]'),  
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\nsample
s = 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

```

```

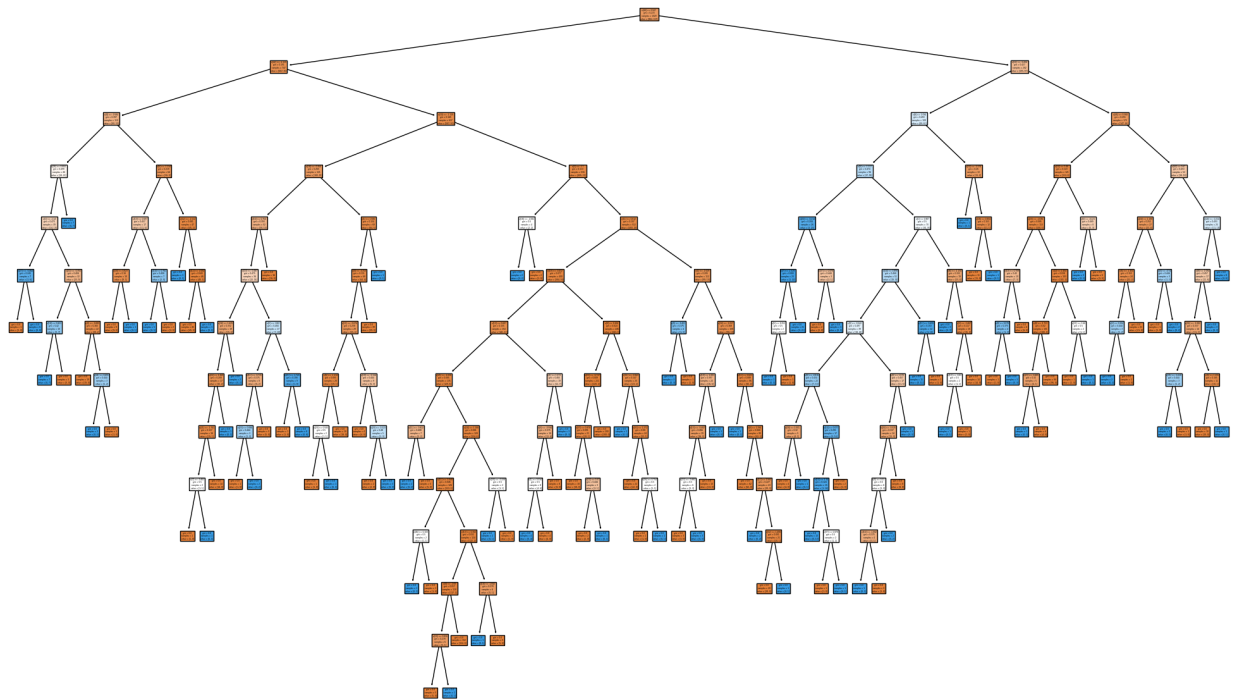
= 12\nvalue = [11, 1]'),
Text(0.7898832684824902, 0.6071428571428571, 'gini = 0.0\nsamples = 11\nvalue = [11,
0]'),
Text(0.8054474708171206, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
Text(0.9095330739299611, 0.8214285714285714, 'x[45] <= 0.368\ngini = 0.255\nsamples
= 173\nvalue = [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 = [1
0, 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]')]

```



In [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']
}

```

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

```
In [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(

Out[123]:

```
GridSearchCV
  estimator: DecisionTreeClassifier
    DecisionTreeClassifier
```

```
In [124...] grid_search.best_params_
```

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



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

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

```
In [126... pred=dtc_cv.predict(x_test)
```

```
In [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.

## Random Forest

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

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

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

```
In [131... rfc_cv.fit(x_train,y_train)
```

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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\skearn\base.py:1151: DataConv  
ersionWarning: A column-vector y was passed when a 1d array was expected. Please chan  
ge 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().  
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[illegible]

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C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\model_selection\_valid
ation.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_selectio
n\_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_v
alidation.py", line 95, in validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features' parameter o
f 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\_searc
h.py:976: UserWarning: One or more of the test scores are non-finite: [      nan 0.8
4159528 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
0.85323625 0.85324576 0.85032362 0.85228441]
warnings.warn(
C:\Users\RUSHITHA\REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConv
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```

Out[131]:

► **GridSearchCV**

► **estimator: RandomForestClassifier**

► **RandomForestClassifier**

```
In [132... pred=rfc_cv.predict(x_test)
```

```
In [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

```
In [134... rfc_cv.best_params_
```

Out[134]: {'max\_depth': 13, 'max\_features': 12}

```
In [ ]:
```