Assignment-4

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Slot- Morning

Data Preprocessing

1. import the necessary libraries
2. import the dataset
3. Handling null values
4. Data visualization
5. outlier detection
6. Seperate Dependent and Independent variables.
7. Encoding
8. Splitting into training and testing set
9. Perform feature scaling

1. Import the necessary libraries.

In [155…

```
import numpy as np
import seaborn as sns
import pandas as pd
import matplotlib.pyplot as plt
```

2. import the dataset

In [156…

```
dataset=pd.read_csv("Employee-Attrition.csv")
dataset.head()
```

Out[156]:

	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	

5 rows × 35 columns

In [157…
```
dataset.tail()
```

Out[157]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	Ed
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	
1468	49	No	Travel_Frequently	1023	Sales	2	3	
1469	34	No	Travel_Rarely	628	Research & Development	8	3	

5 rows × 35 columns

In [158…
```
dataset.shape
```

Out[158]:
```
(1470, 35)
```

In [159…
```
dataset.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
```

Each row in the dataset represents an employee of a fictional company ABC, and contains the following features:

Age: Age of employees

Department: Department of work

Distance from home

Education: 1-Below College; 2-College; 3-Bachelor; 4-Master; 5-Doctor;

Education Field

Environment Satisfaction: 1-Low; 2-Medium; 3-High; 4-Very High

Job Satisfaction: 1-Low; 2-Medium; 3-High; 4-Very High

Marital Status

Monthly Income

Num Companies Worked: Number of companies worked prior to ABC

Work Life Balance: 1-Bad; 2-Good; 3-Better; 4-Best

Years At Company: Current years of service

Attrition: Employee attrition status

In [160…
```
dataset.describe()
```

Out[160]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNum
count	1470.000000	1470.000000	1470.000000	1470.000000	1470.0	1470.000
mean	36.923810	802.485714	9.192517	2.912925	1.0	1024.865
std	9.135373	403.509100	8.106864	1.024165	0.0	602.024
min	18.000000	102.000000	1.000000	1.000000	1.0	1.000
25%	30.000000	465.000000	2.000000	2.000000	1.0	491.250
50%	36.000000	802.000000	7.000000	3.000000	1.0	1020.500
75%	43.000000	1157.000000	14.000000	4.000000	1.0	1555.750
max	60.000000	1499.000000	29.000000	5.000000	1.0	2068.000

8 rows × 26 columns

In [161…
```
dataset.corr()
```

```
<ipython-input-161-c187c74d1e71>:1: FutureWarning: The default value of numeric_on
ly 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 war
ning.
  dataset.corr()
```

Out[161]:

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

26 rows × 26 columns

3. Checking for Null Values

In [162…

```
dataset.isnull().any()
```

Out[162]:

```
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 [163…

```
dataset.isnull().sum()
```

Out[163]:
```
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
```

4. Data Visualization

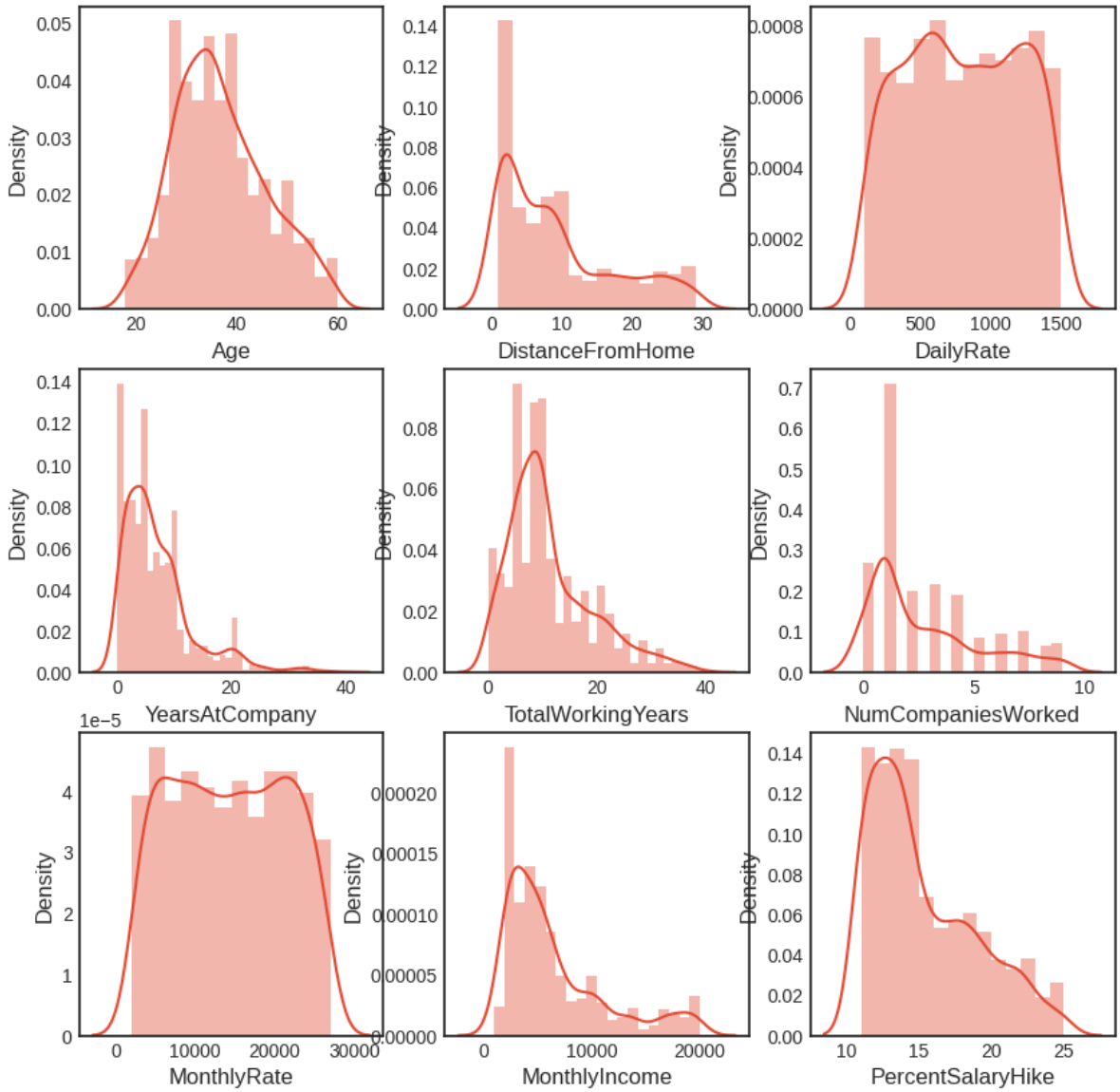
Visualizing Distribution of features

In [164…
```
plt.figure(figsize = (15, 7))
plt.style.use('seaborn-white')
plt.subplot(331)
sns.distplot(dataset['Age'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(332)
sns.distplot(dataset['DistanceFromHome'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(333)
sns.distplot(dataset['DailyRate'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(334)
sns.distplot(dataset['YearsAtCompany'])
fig = plt.gcf()
fig.set_size_inches(10,10)
```

```
plt.subplot(335)
sns.distplot(dataset['TotalWorkingYears'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(336)
sns.distplot(dataset['NumCompaniesWorked'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(337)
sns.distplot(dataset['MonthlyRate'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(338)
sns.distplot(dataset['MonthlyIncome'])
fig = plt.gcf()
fig.set_size_inches(10,10)

plt.subplot(339)
sns.distplot(dataset['PercentSalaryHike'])
fig = plt.gcf()
fig.set_size_inches(10,10)
```

```
<ipython-input-164-2e0bc05fbe5a>:2: MatplotlibDeprecationWarning: The seaborn styl
es shipped by Matplotlib are deprecated since 3.6, as they no longer correspond to
the styles shipped by seaborn. However, they will remain available as 'seaborn-v0_
8-<style>'. Alternatively, directly use the seaborn API instead.
  plt.style.use('seaborn-white')
<ipython-input-164-2e0bc05fbe5a>:4: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['Age'])
<ipython-input-164-2e0bc05fbe5a>:9: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['DistanceFromHome'])
<ipython-input-164-2e0bc05fbe5a>:14: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['DailyRate'])
<ipython-input-164-2e0bc05fbe5a>:19: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['YearsAtCompany'])
<ipython-input-164-2e0bc05fbe5a>:24: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['TotalWorkingYears'])
<ipython-input-164-2e0bc05fbe5a>:29: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.
```

```
Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['NumCompaniesWorked'])
<ipython-input-164-2e0bc05fbe5a>:34: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['MonthlyRate'])
<ipython-input-164-2e0bc05fbe5a>:39: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['MonthlyIncome'])
<ipython-input-164-2e0bc05fbe5a>:44: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['PercentSalaryHike'])
```



Inference:

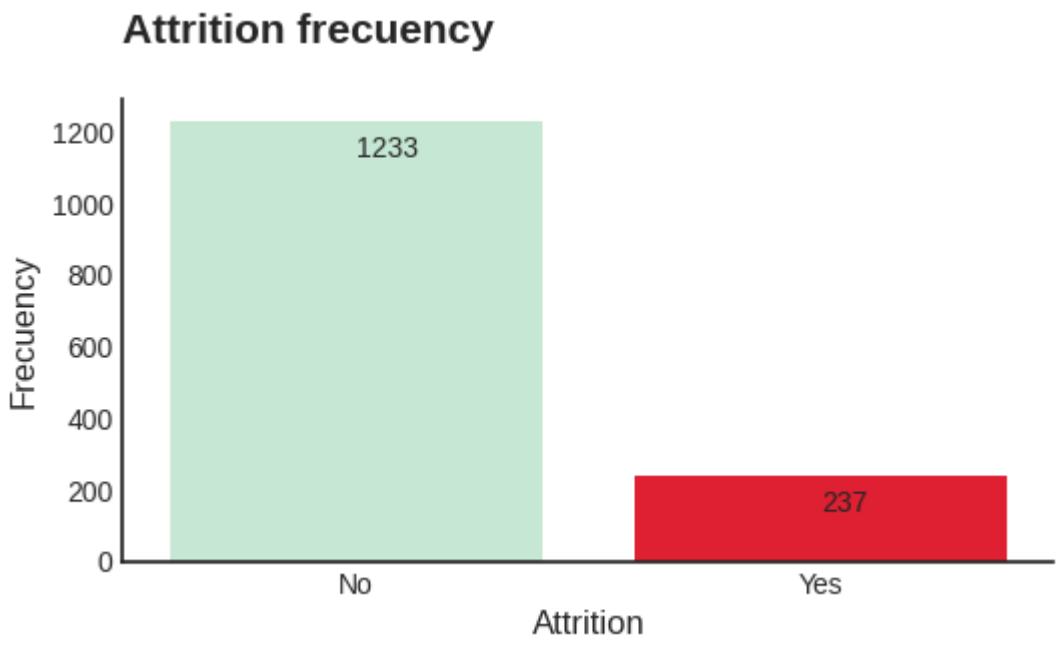
Monthly and Daily Rates has proportional normal distribution

Most of the features except age parameter are right skewed

Attrition frecuency plotting

In [165…

```
colors = ["#C0EDD2","#FF0018"]
df_class = dataset["Attrition"].value_counts().reset_index()
plt.figure(figsize=(6,3))
ax = sns.barplot(x="index",y="Attrition",data=df_class,palette=colors)
sns.despine()
ax.text(-0.5,1450,"Attrition frecuency",
        fontsize=15,
         fontweight='bold')
for num,text in enumerate(df_class["Attrition"]):
        ax.text(num,text-100,text)
plt.xlabel("Attrition")
plt.ylabel("Frecuency")
plt.show(block=False)
```



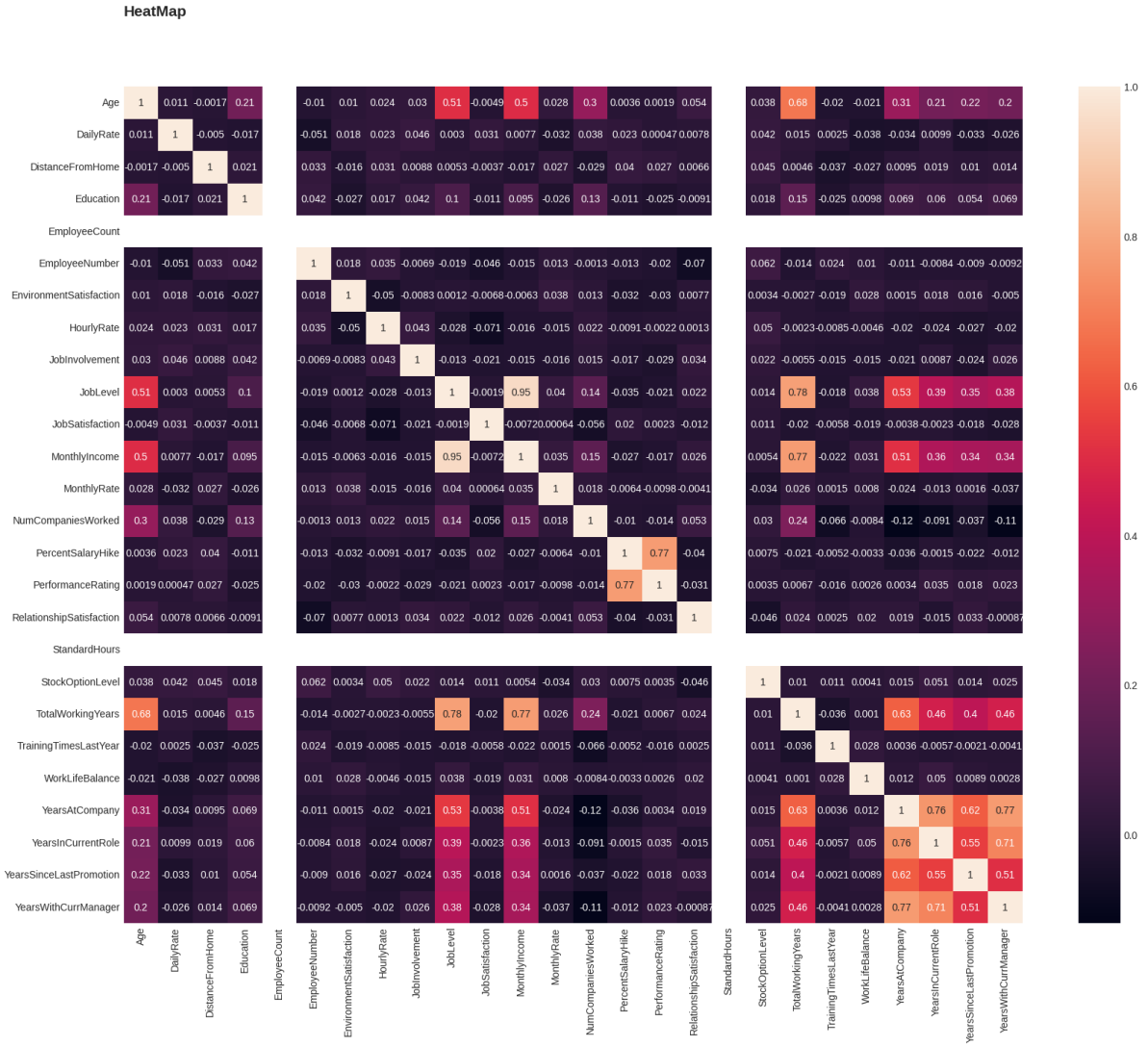
Inference

Attriction frecuency is plotted, which clearly shows no's frquency more than yes'.

Numeric and Categoric data heatmap plotting

In [166…

```
# numeric and categoric
num_col = dataset.describe().columns.tolist()
cat_col = dataset.describe(include="object").columns.tolist()
corr = dataset[num_col].corr()
plt.subplots(figsize=(20,15))
ax = sns.heatmap(
    corr,annot=True)
ax.text(0,-2.2,"HeatMap",
        fontsize=15,
         fontweight='bold')
plt.show(block=False)
```



Inference- The band which has lighter colour has high correlation

Boxes in lower right corner have high correlation,but those are relationship between their working period which obviously correlates and has nothing to aid for our objective, so we neglect that

Job level and Monthly income has perfect positive correlation which means higher the job level, better the income

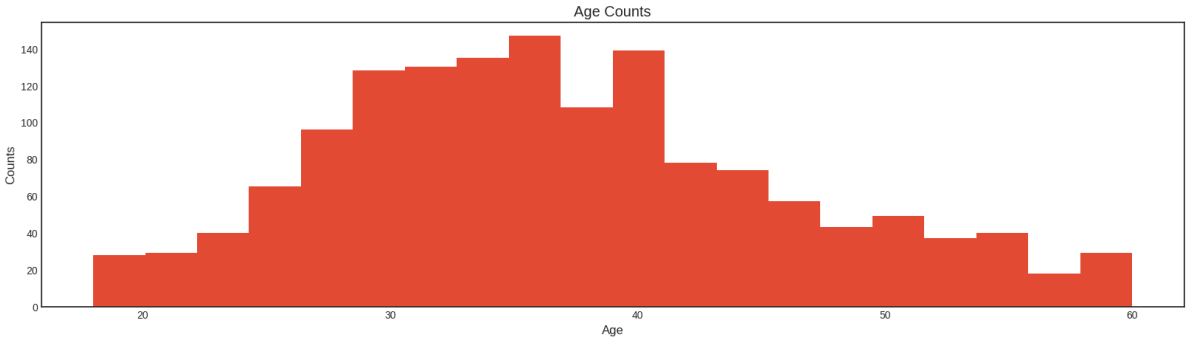
Also Job level has high correlation with Working years, when the employyee's year of working increases he/she is being promoted based on seniority

There is also a high correlation between Monthly Income and Total working years which depicts that employees earn higher income owing to their seniority with the firm

Age Distribution-Histogram

In [167…

```
plt.figure(figsize=(20,5))
plt.hist(dataset.Age,bins=20)
plt.xlabel("Age")
plt.ylabel("Counts")
plt.title("Age Counts")
plt.show()
```



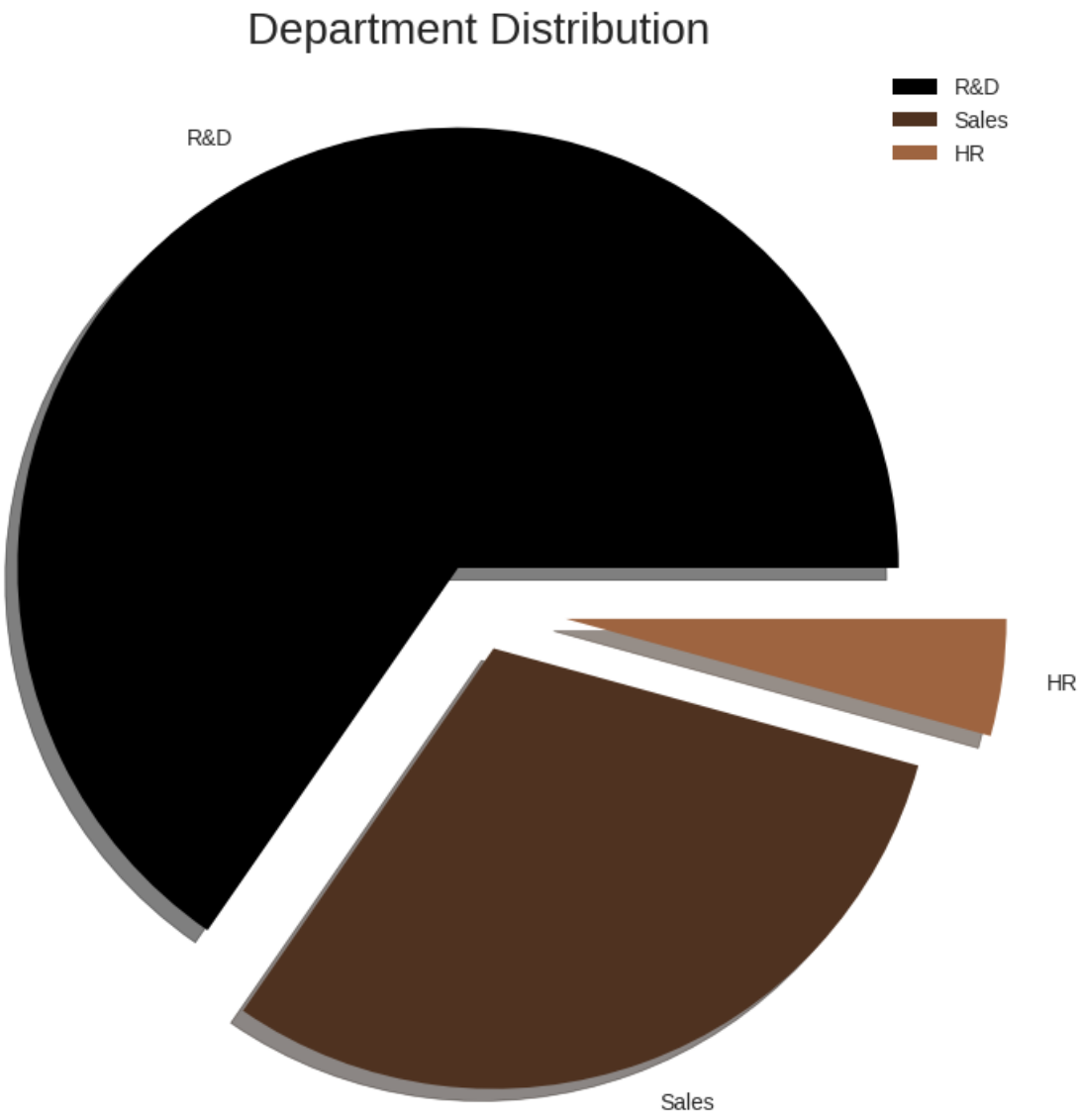
Inference

From the age distribution histogram, we can conclude that employees aged between 30-40 are working in IBM

Department Distribution-Pie Chart

In [168…

```
labels = ['R&D', 'Sales', 'HR']
sizes = dataset['Department'].value_counts()
colors = plt.cm.copper(np.linspace(0, 1, 5))
explode = [0.1, 0.1, 0.2]

plt.rcParams['figure.figsize'] = (9, 9)
plt.pie(sizes, labels = labels, colors = colors, explode = explode, shadow = True)
plt.title('Department Distribution', fontsize = 20)
plt.legend()
plt.show()
```



Inference:

The given dataset has majority of employees from Research and Development followed by Sales and HR department

Distribution of Salary across Job Roles-Boxplot

In [169…

```
plt.rcParams['figure.figsize'] = (16, 8)
ax = sns.boxplot(x = dataset['JobRole'], y =dataset['MonthlyIncome'], data = datase
ax.set_xlabel(xlabel = 'Names of Job Roles', fontsize = 20)
ax.set_ylabel(ylabel = 'Monthly Income', fontsize = 20)
ax.set_title(label = 'Distribution of Salary across Job Roles', fontsize = 30)
plt.xticks(rotation = 90)
plt.show()
```

Inference

Highest average monthly income(17500) is given to Managers

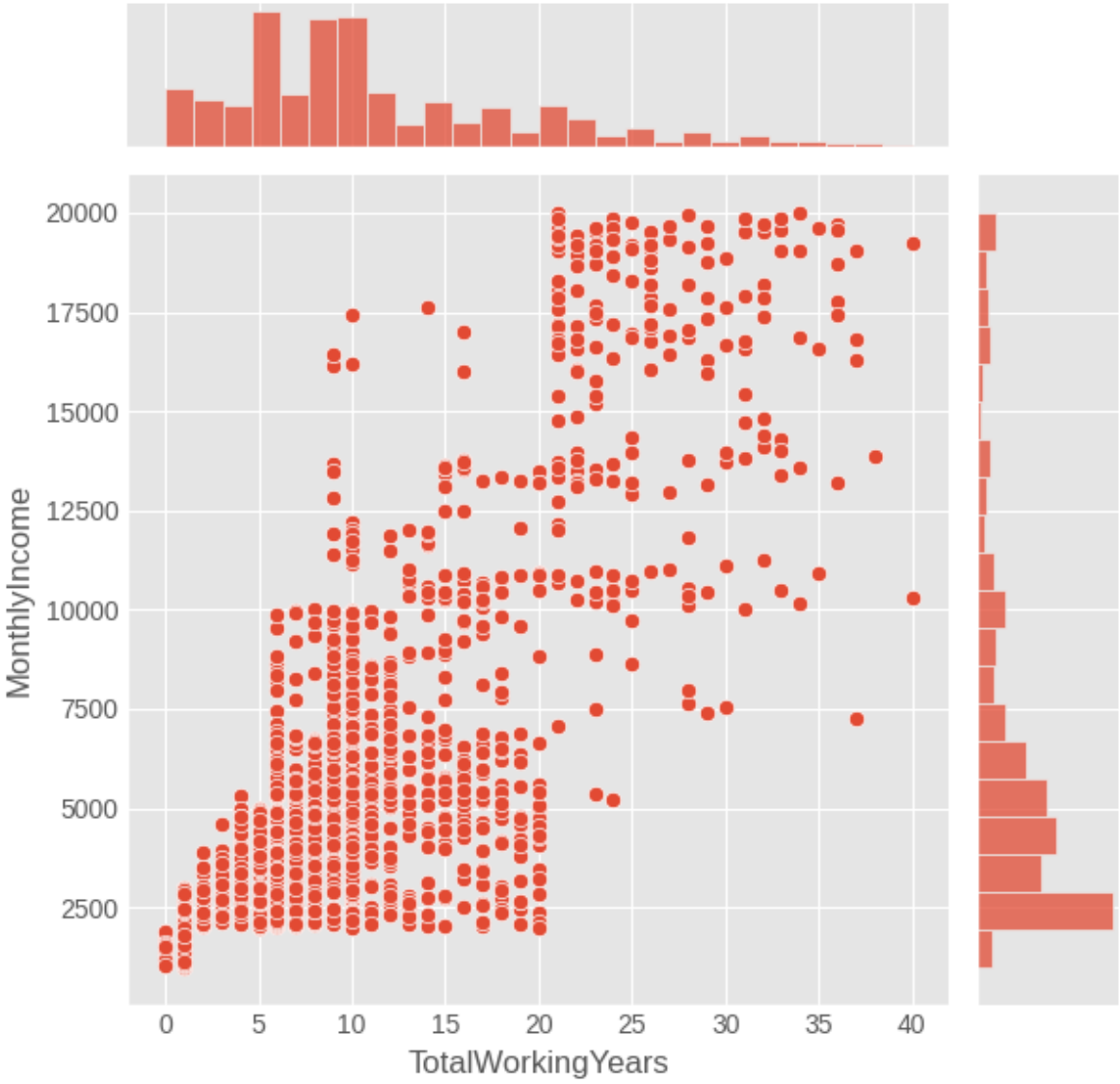
Lowest average monthly income(2500) is given to Sales Representative, But there are many outliers in Sales Representative income

Research Scientist, Laboratory Technician and HR gets almost same average income

Relationship with working years and income- Joint & lm Plot

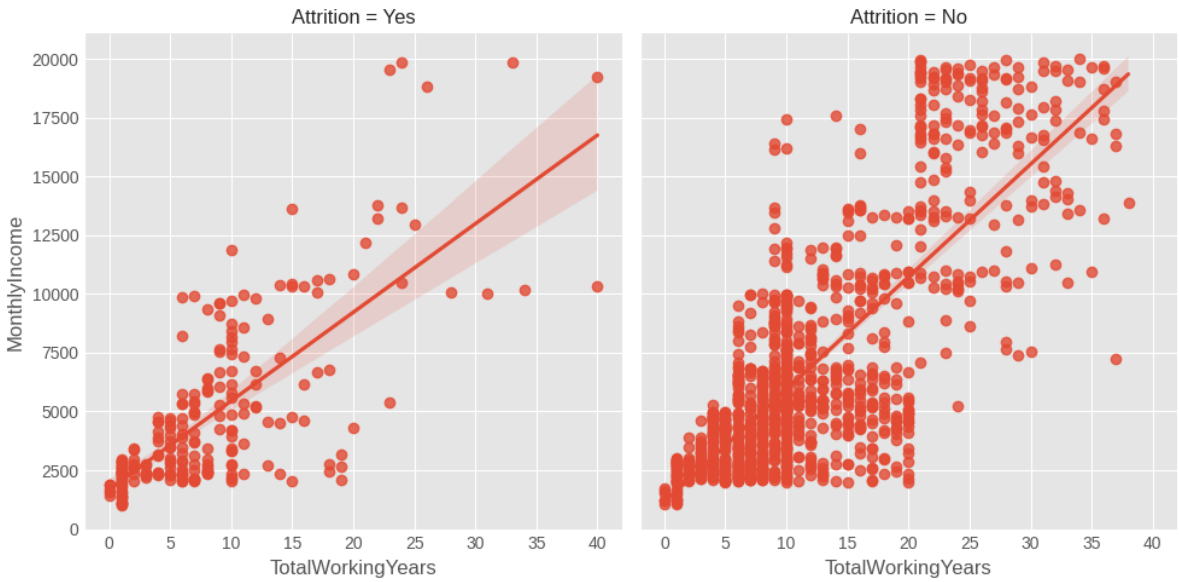
In [170…
```
plt.figure(figsize=(10,5))
plt.style.use('ggplot')
sns.jointplot(x='TotalWorkingYears', y='MonthlyIncome', data=dataset)
```

Out[170]:
```
<seaborn.axisgrid.JointGrid at 0x7a874f3eada0>

<Figure size 1000x500 with 0 Axes>
```



In [171…

```
sns.lmplot(x = 'TotalWorkingYears', y = 'MonthlyIncome', data = dataset, col = 'Att
plt.show()
```



Inference

Employees who had less working years were receiving comparitively lower salary

There are many fresher employees working in IBM

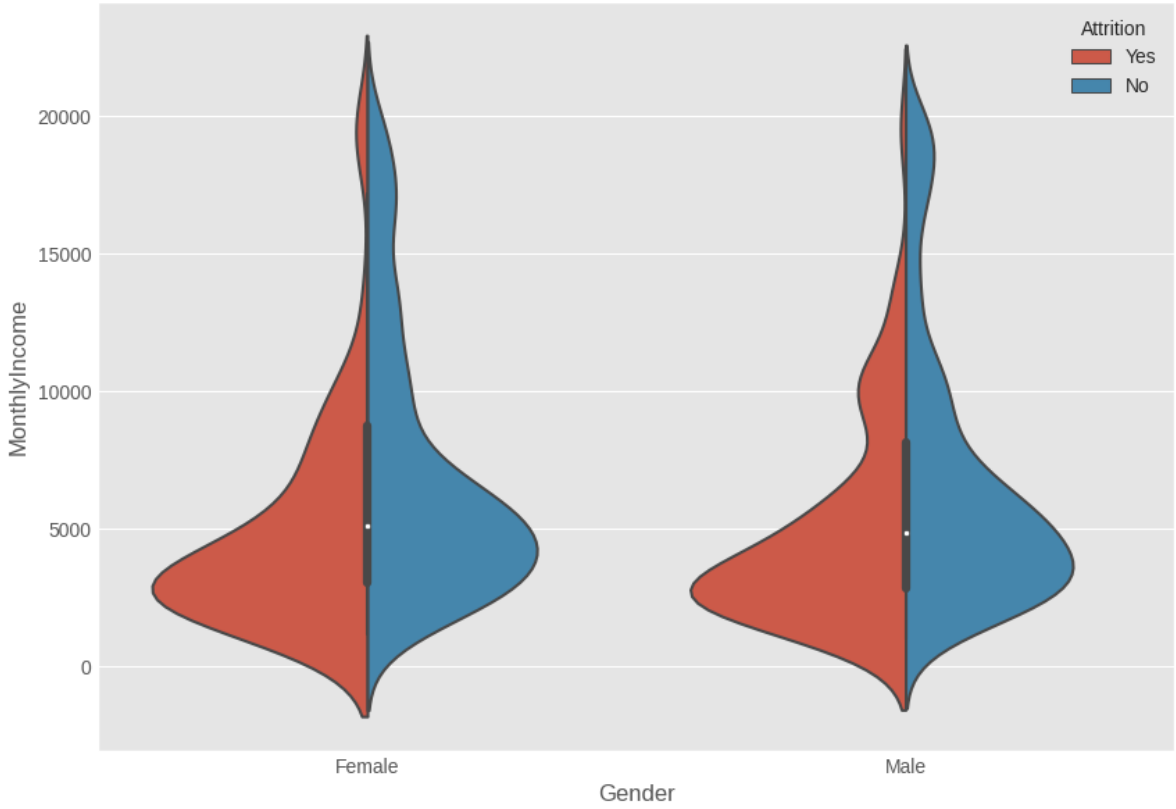
Most of the employees who got laid off had less working years(fresher and junior level) and they were receiving less salary

Very few people from senior category and receiving higher income got laid off

Gender vs Monthly Income-Violin Plot

In [172…
```
fig,ax = plt.subplots(figsize=(10,7))
sns.violinplot(x='Gender', y='MonthlyIncome',hue='Attrition',split=True,data=datase
```

Out[172]:
```
<Axes: xlabel='Gender', ylabel='MonthlyIncome'>
```



Inference

Both the genders weren't discriminated in income and the attrition is at the same rate in both the cases

Relationship with Age and Monthly income-Pair plot

In [173…
```
plt.style.use('ggplot')
g = sns.pairplot(dataset, vars=["MonthlyIncome", "Age"],hue="Attrition",size=5)
```

```
/usr/local/lib/python3.10/dist-packages/seaborn/axisgrid.py:2095: UserWarning: The
`size` parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```

Inference

The Income band widens for elder employees between 40-60 years of age and the income band restricts to 10000 for 20-30 year old employees

The employee who were laid off falll under low income(5000-1000) and young age(20-30) category

In [174…

```
dataset.describe(include="object").T  #quick summary of categorical variables
```

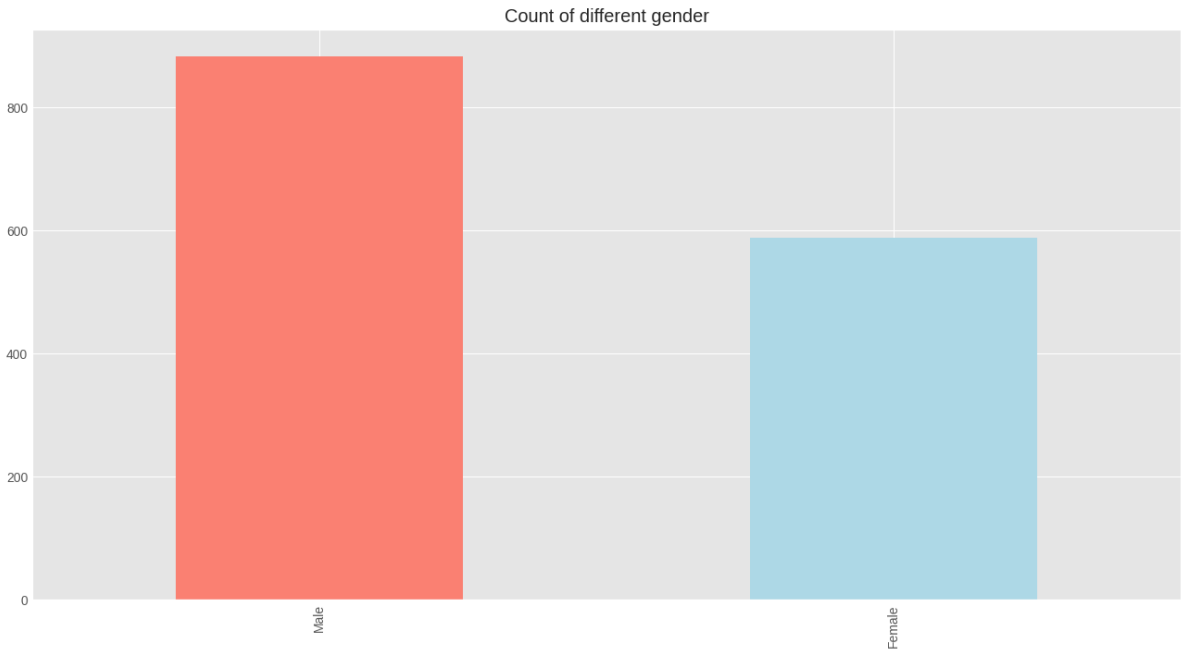
Out[174]:

	count	unique	top	freq
Attrition	1470	2	No	1233
BusinessTravel	1470	3	Travel_Rarely	1043
Department	1470	3	Research & Development	961
EducationField	1470	6	Life Sciences	606
Gender	1470	2	Male	882
JobRole	1470	9	Sales Executive	326
MaritalStatus	1470	3	Married	673
Over18	1470	1	Y	1470
OverTime	1470	2	No	1054

Gender count-Bar Plot

In [175…
```
dataset['Gender'].value_counts().plot(kind='bar',color=['salmon','lightblue'],title
```

Out[175]:
```
<Axes: title={'center': 'Count of different gender'}>
```



Inference

Shows the gender count.

5. Outlier Detector

In [176…
```
dataset.head()
```

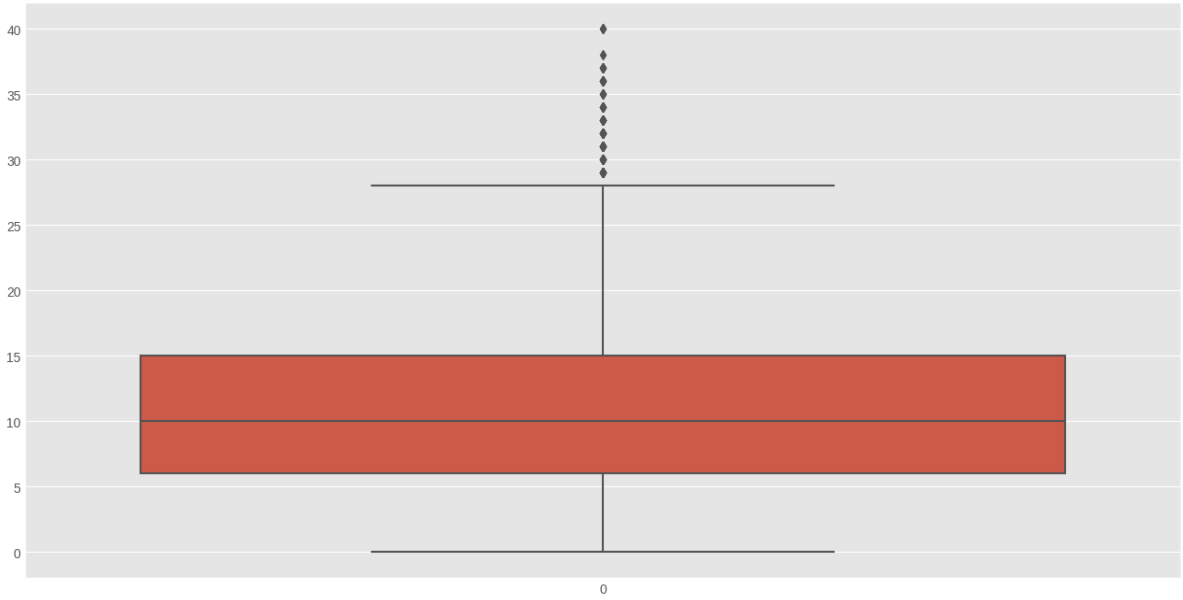
Out[176]:

	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	

5 rows × 35 columns

In [177…
```
sns.boxplot(dataset["TotalWorkingYears"])
```

Out[177]:
```
<Axes: >
```



In [178…
```
q1=dataset.TotalWorkingYears.quantile(0.25)
q3=dataset.TotalWorkingYears.quantile(0.75)
print(q1)
print(q3)
IQR=q3-q1
IQR
upper_limit = q3+1.5*IQR
upper_limit
lower_limit = q1-1.5*IQR
lower_limit
dataset.median()
```

```
6.0
15.0
```

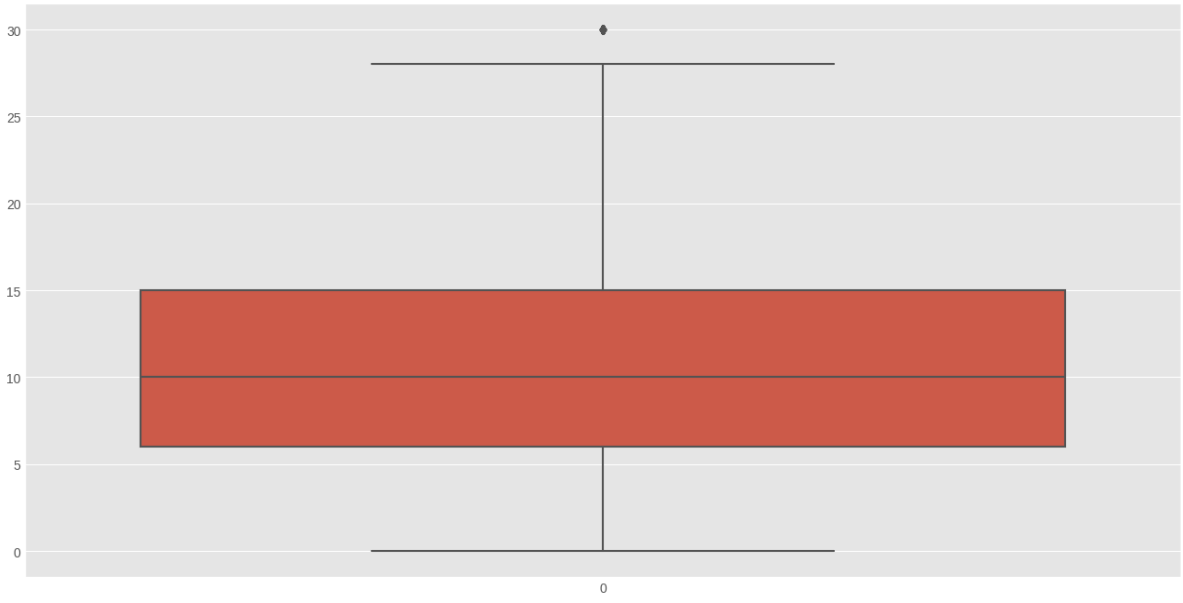
```
<ipython-input-178-7c0c8ed094ab>:11: FutureWarning: The default value of numeric_only in DataFrame.median is deprecated. In a future version, it will default to False. In addition, specifying 'numeric_only=None' is deprecated. Select only valid columns or specify the value of numeric_only to silence this warning.
  dataset.median()
```

Out[178]:
```
Age                         36.0
DailyRate                  802.0
DistanceFromHome             7.0
Education                    3.0
EmployeeCount                1.0
EmployeeNumber            1020.5
EnvironmentSatisfaction      3.0
HourlyRate                  66.0
JobInvolvement               3.0
JobLevel                     2.0
JobSatisfaction              3.0
MonthlyIncome             4919.0
MonthlyRate              14235.5
NumCompaniesWorked           2.0
PercentSalaryHike           14.0
PerformanceRating            3.0
RelationshipSatisfaction     3.0
StandardHours               80.0
StockOptionLevel             1.0
TotalWorkingYears           10.0
TrainingTimesLastYear        3.0
WorkLifeBalance              3.0
YearsAtCompany               5.0
YearsInCurrentRole           3.0
YearsSinceLastPromotion      1.0
YearsWithCurrManager         3.0
dtype: float64
```

In [179…
```
dataset['TotalWorkingYears']= np.where(dataset['TotalWorkingYears']>upper_limit,30,
```

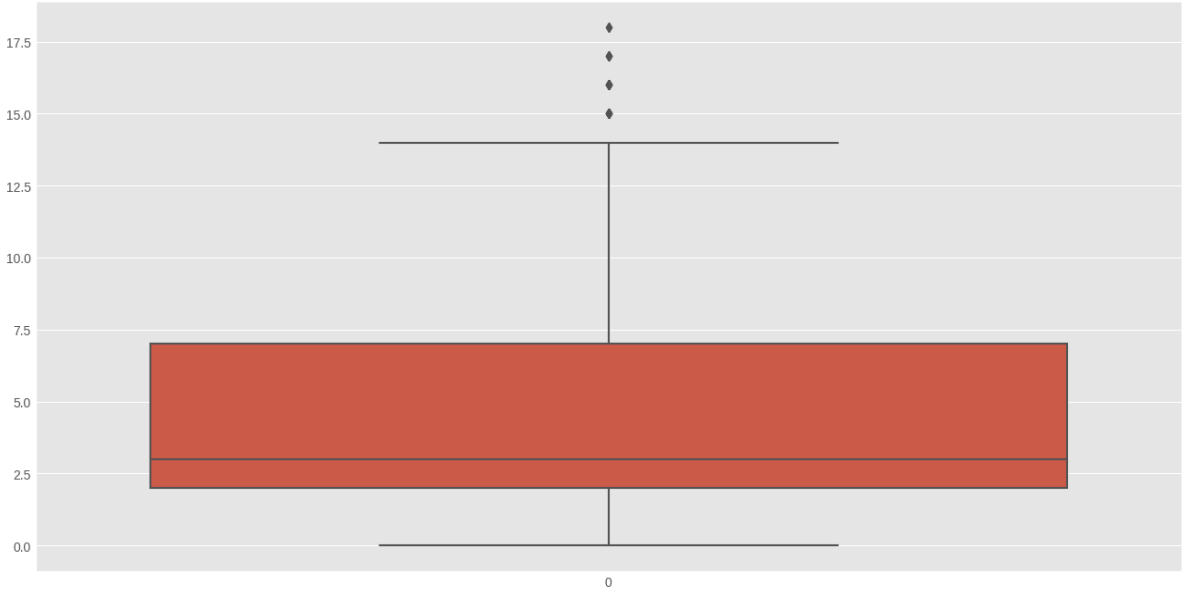
In [180…
```
sns.boxplot(dataset["TotalWorkingYears"])
```

Out[180]:
```
<Axes: >
```



In [181…
```
sns.boxplot(dataset["YearsInCurrentRole"])
```

Out[181]:
```
<Axes: >
```



In [182…

```
q1=dataset.YearsInCurrentRole.quantile(0.25)
q3=dataset.YearsInCurrentRole.quantile(0.75)
print(q1)
print(q3)
IQR=q3-q1
IQR
upper_limit = q3+1.5*IQR
upper_limit
lower_limit = q1-1.5*IQR
lower_limit
dataset.median()
```

```
2.0
7.0
```

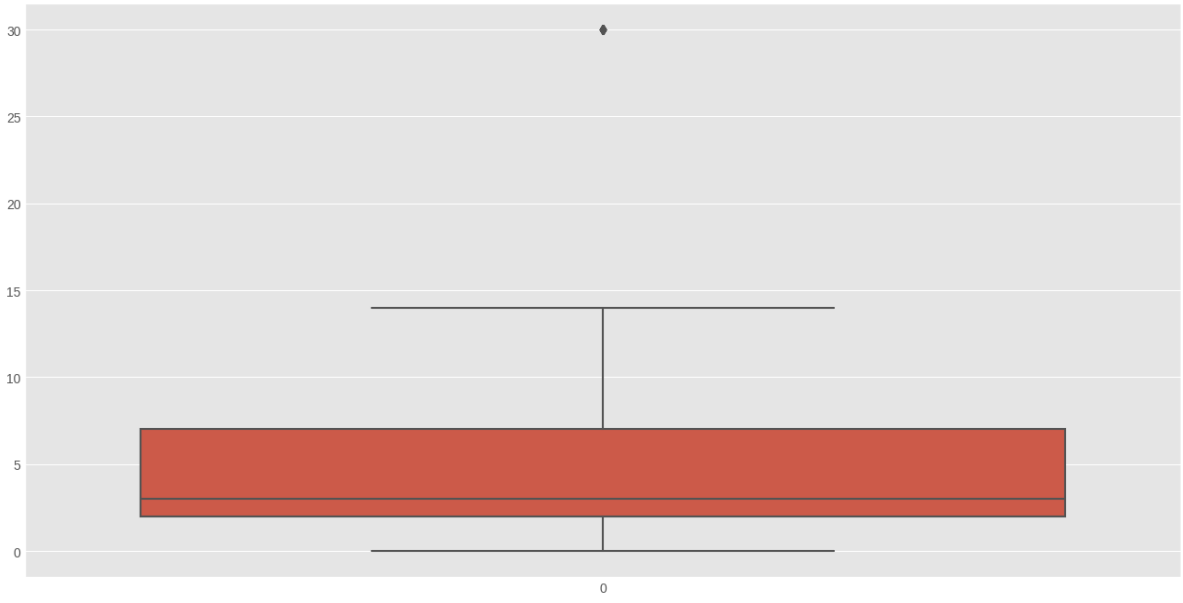
```
<ipython-input-182-830ef09e96cd>:11: FutureWarning: The default value of numeric_o
nly in DataFrame.median is deprecated. In a future version, it will default to Fal
se. In addition, specifying 'numeric_only=None' is deprecated. Select only valid c
olumns or specify the value of numeric_only to silence this warning.
  dataset.median()
```

Out[182]:
```
Age                          36.0
DailyRate                   802.0
DistanceFromHome              7.0
Education                     3.0
EmployeeCount                 1.0
EmployeeNumber             1020.5
EnvironmentSatisfaction       3.0
HourlyRate                   66.0
JobInvolvement                3.0
JobLevel                      2.0
JobSatisfaction               3.0
MonthlyIncome              4919.0
MonthlyRate               14235.5
NumCompaniesWorked            2.0
PercentSalaryHike            14.0
PerformanceRating             3.0
RelationshipSatisfaction      3.0
StandardHours                80.0
StockOptionLevel              1.0
TotalWorkingYears            10.0
TrainingTimesLastYear         3.0
WorkLifeBalance               3.0
YearsAtCompany                5.0
YearsInCurrentRole            3.0
YearsSinceLastPromotion       1.0
YearsWithCurrManager          3.0
dtype: float64
```

In [183…
```
dataset['YearsInCurrentRole']= np.where(dataset['YearsInCurrentRole']>upper_limit,
```

In [184…
```
sns.boxplot(dataset["YearsInCurrentRole"])
```

Out[184]:
```
<Axes: >
```



6. Seperate Dependent and Independent variables.

In [185…
```
dataset.head()
```

Out[185]:

	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	

5 rows × 35 columns

In [186…
```
y=dataset['Attrition']
y
```

Out[186]:
```
0       Yes
1        No
2       Yes
3        No
4        No
       ...
1465     No
1466     No
1467     No
1468     No
1469     No
Name: Attrition, Length: 1470, dtype: object
```

In [187…
```
x=dataset.drop(labels='Attrition',axis=1)
```

In [188…
```
x.head()
```

Out[188]:

	Age	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField
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 [189…
```
y
```

Out[189]:
```
0       Yes
1        No
2       Yes
3        No
4        No
       ...
1465     No
1466     No
1467     No
1468     No
1469     No
Name: Attrition, Length: 1470, dtype: object
```

6. Encoding

In [190…
```
dataset.head()
```

Out[190]:

	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	

5 rows × 35 columns

In [191…
```
s = (dataset.dtypes == 'object')
object_cols = list(s[s].index)

print("Categorical variables:")
print(object_cols)
```

```
Categorical variables:
['Attrition', 'BusinessTravel', 'Department', 'EducationField', 'Gender', 'JobRol
e', 'MaritalStatus', 'Over18', 'OverTime']
```

In [192…
```
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
```

In [193…
```
x['Gender'].value_counts()
```

Out[193]:
```
Male      882
Female    588
Name: Gender, dtype: int64
```

In [194…
```
x["Gender"]=le.fit_transform(x["Gender"])
x["Gender"]
```

Out[194]:
```
0       0
1       1
2       1
3       0
4       1
       ..
1465    1
1466    1
1467    1
1468    1
1469    1
Name: Gender, Length: 1470, dtype: int64
```

In [195…
```
x["Gender"].value_counts()
```

Out[195]:
```
1    882
0    588
Name: Gender, dtype: int64
```

1- male

2- female

In [196…
```
x["Gender"].nunique()
```

Out[196]:
```
2
```

In [197…
```
x.BusinessTravel.value_counts()
```

Out[197]:
```
Travel_Rarely        1043
Travel_Frequently     277
Non-Travel            150
Name: BusinessTravel, dtype: int64
```

In [198…
```
x["BusinessTravel"]=le.fit_transform(x["BusinessTravel"])
x["BusinessTravel"]
```

Out[198]:
```
0       2
1       1
2       2
3       1
4       2
       ..
1465    1
1466    2
1467    2
1468    1
1469    2
Name: BusinessTravel, Length: 1470, dtype: int64
```

In [199…
```
x.BusinessTravel.value_counts()
```

Out[199]:
```
2    1043
1     277
0     150
Name: BusinessTravel, dtype: int64
```

0- Non-Travel

1- Travel-frequently

2- Travel-Rarely

In [200…
```
x.Department.value_counts()
```

Out[200]:
```
Research & Development    961
Sales                     446
Human Resources            63
Name: Department, dtype: int64
```

In [201…
```
x["Department"]=le.fit_transform(x["Department"])
x["Department"]
```

Out[201]:
```
0       2
1       1
2       1
3       1
4       1
       ..
1465    1
1466    1
1467    1
1468    2
1469    1
Name: Department, Length: 1470, dtype: int64
```

In [202…
```
x.Department.value_counts()
```

Out[202]:
```
1    961
2    446
0     63
Name: Department, dtype: int64
```

0- Human Resources

1- Sales

2- Research & Development

In [203…
```
x['EducationField'].value_counts()
```

Out[203]:
```
Life Sciences       606
Medical             464
Marketing           159
Technical Degree    132
Other                82
Human Resources      27
Name: EducationField, dtype: int64
```

In [204…
```
x["EducationField"]=le.fit_transform(x["EducationField"])
x["EducationField"]
```

Out[204]:
```
0       1
1       1
2       4
3       1
4       3
       ..
1465    3
1466    3
1467    1
1468    3
1469    3
Name: EducationField, Length: 1470, dtype: int64
```

In [205…
```
x['EducationField'].value_counts()
```

Out[205]:
```
1    606
3    464
2    159
5    132
4     82
0     27
Name: EducationField, dtype: int64
```

0-Human Resources

1-Life Sciences

2-Marketing

3-Medical

4-Other

5-Technical Degree

In [206…
```
x.JobRole.value_counts()
```

Out[206]:
```
Sales Executive              326
Research Scientist           292
Laboratory Technician        259
Manufacturing Director       145
Healthcare Representative    131
Manager                      102
Sales Representative          83
Research Director             80
Human Resources               52
Name: JobRole, dtype: int64
```

In [207…
```
x["JobRole"]=le.fit_transform(x["JobRole"])
x["JobRole"]
```

Out[207]:
```
0       7
1       6
2       2
3       6
4       2
       ..
1465    2
1466    0
1467    4
1468    7
1469    2
Name: JobRole, Length: 1470, dtype: int64
```

In [208…
```
x.JobRole.value_counts()
```

Out[208]:
```
7    326
6    292
2    259
4    145
0    131
3    102
8     83
5     80
1     52
Name: JobRole, dtype: int64
```

0-Helathcare Representative

1-Human Resource

2-Laboratory Technician

3-Manager

4-Manufacturing Director

5-Research Director

6-Research Scientist

7-Sales Executive

8-Sales Representative

In [209…
```
x.MaritalStatus.value_counts()
```

Out[209]:
```
Married     673
Single      470
Divorced    327
Name: MaritalStatus, dtype: int64
```

In [210…
```
x["MaritalStatus"]=le.fit_transform(x["MaritalStatus"])
x["MaritalStatus"]
```

Out[210]:
```
0       2
1       1
2       2
3       1
4       1
       ..
1465    1
1466    1
1467    1
1468    1
1469    1
Name: MaritalStatus, Length: 1470, dtype: int64
```

In [211…
```
x.MaritalStatus.value_counts()
```

Out[211]:
```
1    673
2    470
0    327
Name: MaritalStatus, dtype: int64
```

0- Divorced

1- Married

2- Single

In [212…
```
x.Over18.value_counts()
```

Out[212]:
```
Y    1470
Name: Over18, dtype: int64
```

In [213…
```
x["Over18"]=le.fit_transform(x["Over18"])
x["Over18"]
```

Out[213]:
```
0       0
1       0
2       0
3       0
4       0
       ..
1465    0
1466    0
1467    0
1468    0
1469    0
Name: Over18, Length: 1470, dtype: int64
```

In [214…
```
x.Over18.value_counts()
```

Out[214]:
```
0    1470
Name: Over18, dtype: int64
```

0- Yes

In [215…
```
x.OverTime.value_counts()
```

Out[215]:
```
No     1054
Yes     416
Name: OverTime, dtype: int64
```

In [216…
```
x["OverTime"]=le.fit_transform(x["OverTime"])
x["OverTime"]
```

Out[216]:
```
0       1
1       0
2       1
3       1
4       0
       ..
1465    0
1466    0
1467    1
1468    0
1469    0
Name: OverTime, Length: 1470, dtype: int64
```

In [217…
```
x.OverTime.value_counts()
```

Out[217]:
```
0    1054
1     416
Name: OverTime, dtype: int64
```

0- No

1- Yes

In [218…
```
x.shape
```

Out[218]:
```
(1470, 34)
```

In [219…
```
x.head()
```

Out[219]:

	Age	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	Er
0	41	2	1102	2	1	2	1	
1	49	1	279	1	8	1	1	
2	37	2	1373	1	2	2	4	
3	33	1	1392	1	3	4	1	
4	27	2	591	1	2	1	3	

5 rows × 34 columns

In [220…
```
y.head()
```

Out[220]:
```
0    Yes
1     No
2    Yes
3     No
4     No
Name: Attrition, dtype: object
```

In [222…
```
y.value_counts()
```

Out[222]:
```
No     1233
Yes     237
Name: Attrition, dtype: int64
```

In [224…
```
y=le.fit_transform(y)
y
```

Out[224]:
```
array([1, 0, 1, ..., 0, 0, 0])
```

In [227…
```
#feature scaling
from sklearn.preprocessing import MinMaxScaler
ms=MinMaxScaler()
x_scaled=pd.DataFrame(ms.fit_transform(x),columns=x.columns)
x_scaled
```

Out[227]:

	Age	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationI
0	0.547619	1.0	0.715820	1.0	0.000000	0.25	
1	0.738095	0.5	0.126700	0.5	0.250000	0.00	
2	0.452381	1.0	0.909807	0.5	0.035714	0.25	
3	0.357143	0.5	0.923407	0.5	0.071429	0.75	
4	0.214286	1.0	0.350036	0.5	0.035714	0.00	
...	...	...	...	...	...	...	
1465	0.428571	0.5	0.559771	0.5	0.785714	0.25	
1466	0.500000	1.0	0.365784	0.5	0.178571	0.00	
1467	0.214286	1.0	0.037938	0.5	0.107143	0.50	
1468	0.738095	0.5	0.659270	1.0	0.035714	0.50	
1469	0.380952	1.0	0.376521	0.5	0.250000	0.50	

1470 rows × 34 columns

In [228…

```
#spliting data into train and test
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x_scaled,y,test_size=0.2,random_stat
```

In [229…

```
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

Out[229]:

```
((1176, 34), (294, 34), (1176,), (294,))
```

Model Building

o Import the model building Libraries

o Initializing the model

o Training and testing the model

o Evaluation of Model

o Save the Model

Logistic Regression

In [230…

```
from sklearn.linear_model import LogisticRegression
model=LogisticRegression()
```

In [231…

```
model.fit(x_train,y_train)
```

Out[231]:

```
▾ LogisticRegression
LogisticRegression()
```

In [232…
```
pred=model.predict(x_test)
pred
```

Out[232]:
```
array([0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 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, 0, 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, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 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, 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, 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, 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, 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])
```

In [233…
```
y_test
```

Out[233]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 0, 1, 0, 0])
```

In [234…
```
#evaluation of classification model
#Accuracy score
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report,r
```

In [235…
```
accuracy_score(y_test,pred)
```

Out[235]:
```
0.8809523809523809
```

In [236…
```
confusion_matrix(y_test,pred)
```

Out[236]:
```
array([[242,   3],
       [ 32,  17]])
```

In [237…
```
pd.crosstab(y_test,pred)
```

Out[237]:

col_0	0	1
row_0		
0	242	3
1	32	17

In [238…
```
(242+17)/(242+17+32+3) #accuracy score
```

Out[238]:
```
0.8809523809523809
```

In [239…
```
print(classification_report(y_test,pred))
```

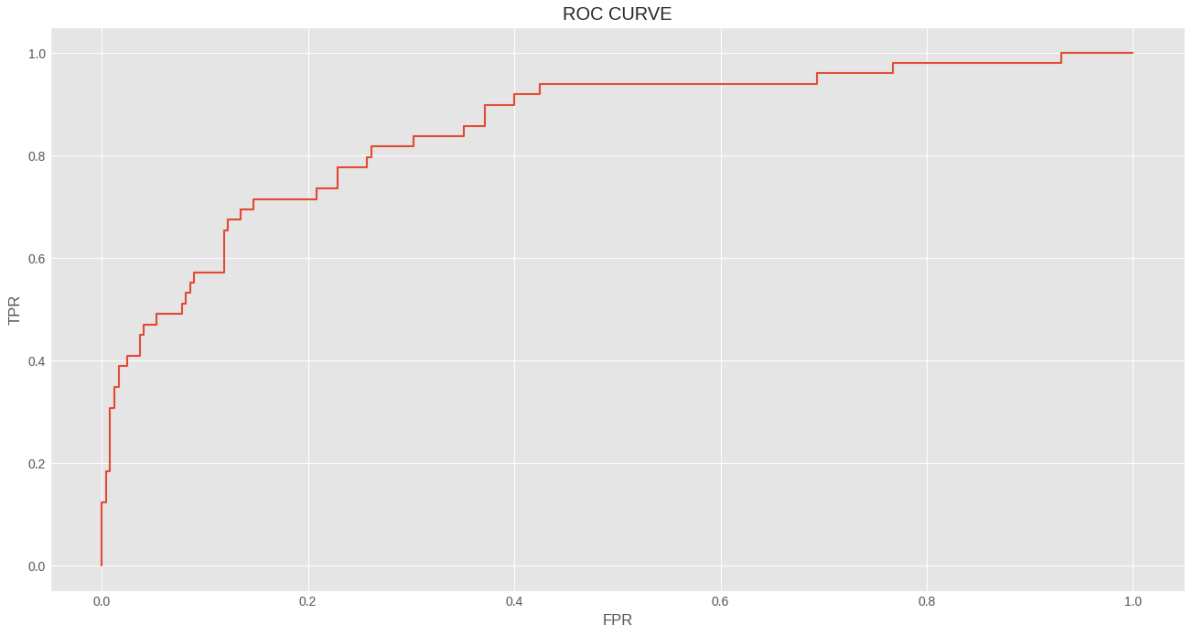
```
              precision    recall  f1-score   support

           0       0.88      0.99      0.93       245
           1       0.85      0.35      0.49        49

    accuracy                           0.88       294
   macro avg       0.87      0.67      0.71       294
weighted avg       0.88      0.88      0.86       294
```

In [240…
```
#Roc-AUC Curve
probability=model.predict_proba(x_test)[:,1]
probability
```

Out[240]:
```
array([0.15217402, 0.21632349, 0.31448937, 0.11552231, 0.63195007,
       0.06110795, 0.61205171, 0.08073788, 0.00740246, 0.42236585,
       0.05133183, 0.32469008, 0.02237374, 0.6920699 , 0.18976212,
       0.02894311, 0.11110158, 0.17159697, 0.05136821, 0.21685107,
       0.23350228, 0.01976108, 0.07290817, 0.05153163, 0.60410648,
       0.49152701, 0.08029735, 0.05034051, 0.67674278, 0.05779457,
       0.01808775, 0.03116965, 0.05629576, 0.17137281, 0.07754204,
       0.04011103, 0.08277844, 0.066222  , 0.04473409, 0.05074883,
       0.0453298 , 0.02518108, 0.01390803, 0.01430808, 0.02992714,
       0.47717853, 0.42463578, 0.00342564, 0.73804972, 0.48329632,
       0.08750612, 0.50973356, 0.08356101, 0.26756878, 0.63342172,
       0.22261944, 0.01664791, 0.27789879, 0.02738251, 0.1516253 ,
       0.02255381, 0.21819211, 0.11921312, 0.03932104, 0.32671669,
       0.03013093, 0.32903292, 0.15813444, 0.09364017, 0.09358887,
       0.0910726 , 0.31432242, 0.09789755, 0.07483434, 0.12863802,
       0.05837452, 0.0493793 , 0.06218263, 0.19638662, 0.03325248,
       0.00761511, 0.02692652, 0.14003752, 0.02550772, 0.03405416,
       0.08306553, 0.00372029, 0.03841149, 0.0385455 , 0.15582131,
       0.25915316, 0.16446146, 0.2605143 , 0.2170274 , 0.02308859,
       0.17411709, 0.34105565, 0.2836754 , 0.06979948, 0.05412718,
       0.23058355, 0.71467057, 0.29623588, 0.01981856, 0.09155609,
       0.03062145, 0.06306983, 0.14829133, 0.07471827, 0.131319  ,
       0.09039381, 0.04550021, 0.0234031 , 0.14007801, 0.07915213,
       0.03325378, 0.05904139, 0.10244746, 0.00769902, 0.01356191,
       0.1899012 , 0.04854069, 0.09989016, 0.82471562, 0.02395718,
       0.02480647, 0.00740718, 0.13995083, 0.1676497 , 0.06179059,
       0.0153163 , 0.27844187, 0.53392829, 0.36999997, 0.04365391,
       0.36760733, 0.62429365, 0.1278725 , 0.07357853, 0.20034431,
       0.08198194, 0.07412797, 0.11514013, 0.22048825, 0.21971106,
       0.03120375, 0.13280402, 0.00281934, 0.11143174, 0.16183701,
       0.0632159 , 0.17069567, 0.05761521, 0.12594416, 0.03701899,
       0.03134031, 0.05938977, 0.0852415 , 0.01621121, 0.01882977,
       0.3645953 , 0.01470022, 0.1478167 , 0.80600097, 0.11850163,
       0.28135372, 0.19690363, 0.15121366, 0.02658214, 0.00620571,
       0.03477834, 0.11262055, 0.10009029, 0.09904116, 0.01267428,
       0.13933536, 0.10267279, 0.13081418, 0.05184247, 0.07418267,
       0.02732516, 0.10911227, 0.00416416, 0.75017934, 0.04437636,
       0.04324425, 0.3940623 , 0.05143664, 0.71301171, 0.09775088,
       0.37841904, 0.37731749, 0.34241499, 0.04783579, 0.08374629,
       0.15060733, 0.047484  , 0.01525795, 0.27533347, 0.06190423,
       0.15515891, 0.15822481, 0.66396633, 0.06007485, 0.30507983,
       0.05444403, 0.45863441, 0.00260234, 0.14983251, 0.03055447,
       0.11599359, 0.16925832, 0.08265742, 0.09971406, 0.15622642,
       0.02095842, 0.01859019, 0.08868262, 0.02462549, 0.13927623,
       0.09226204, 0.21627391, 0.72737143, 0.15794236, 0.41508798,
       0.01633093, 0.09689161, 0.21311155, 0.31087529, 0.03492884,
       0.04588433, 0.32368325, 0.05863244, 0.02807638, 0.17020541,
       0.28403941, 0.24319541, 0.00853641, 0.08857797, 0.01190675,
       0.14307901, 0.28821893, 0.01166466, 0.18415389, 0.04799148,
       0.04083938, 0.40349113, 0.34270419, 0.03801019, 0.13633343,
       0.3579905 , 0.34773119, 0.79705153, 0.04762894, 0.22929036,
       0.05777684, 0.00532319, 0.65735633, 0.3691595 , 0.38214768,
       0.35711771, 0.03375219, 0.22133642, 0.0614842 , 0.07525809,
       0.09793662, 0.00859601, 0.26368491, 0.39075382, 0.06385042,
       0.10236432, 0.01395833, 0.14225579, 0.05150353, 0.0246592 ,
       0.03247425, 0.07929253, 0.25427181, 0.28548567, 0.19978486,
       0.26904127, 0.01644442, 0.15255598, 0.07893817, 0.02843614,
       0.19025185, 0.00800355, 0.25237563, 0.00220511, 0.02847355,
       0.24199687, 0.73687967, 0.06887902, 0.22136975])
```

In [241…
```
#roc_curve
fpr,tpr,thresholds=roc_curve(y_test,probability)
```

In [242…
```
plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('ROC CURVE')
plt.show()
```



Decision Tree

In [243…
```
from sklearn.tree import DecisionTreeClassifier
dtc=DecisionTreeClassifier()
```

In [244…
```
dtc.fit(x_train,y_train)
```

Out[244]:
```
DecisionTreeClassifier
DecisionTreeClassifier()
```

In [246…
```
pred=dtc.predict(x_test)
pred
```

Out[246]:
```
array([0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0,
       1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 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, 1,
       0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1,
       0, 0, 1, 0, 0, 0, 0, 1, 1, 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, 1, 0, 0, 0, 0, 0, 0,
       0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 1,
       0, 0, 1, 0, 0, 0, 0, 0])
```

In [247…
```
y_test
```

Out[247]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 0, 1, 0, 0])
```

In [248…
```
#evaluation of classification model
#Accuracy score
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report,r
```

In [249…
```
accuracy_score(y_test,pred)
```

Out[249]:
```
0.7619047619047619
```

In [250…
```
confusion_matrix(y_test,pred)
```

Out[250]:
```
array([[208,  37],
       [ 33,  16]])
```

In [251…
```
pd.crosstab(y_test,pred)
```

Out[251]:

col_0	0	1
row_0		
0	208	37
1	33	16

In [252…
```
#Roc-AUC Curve
probability=dtc.predict_proba(x_test)[:,1]
probability
```

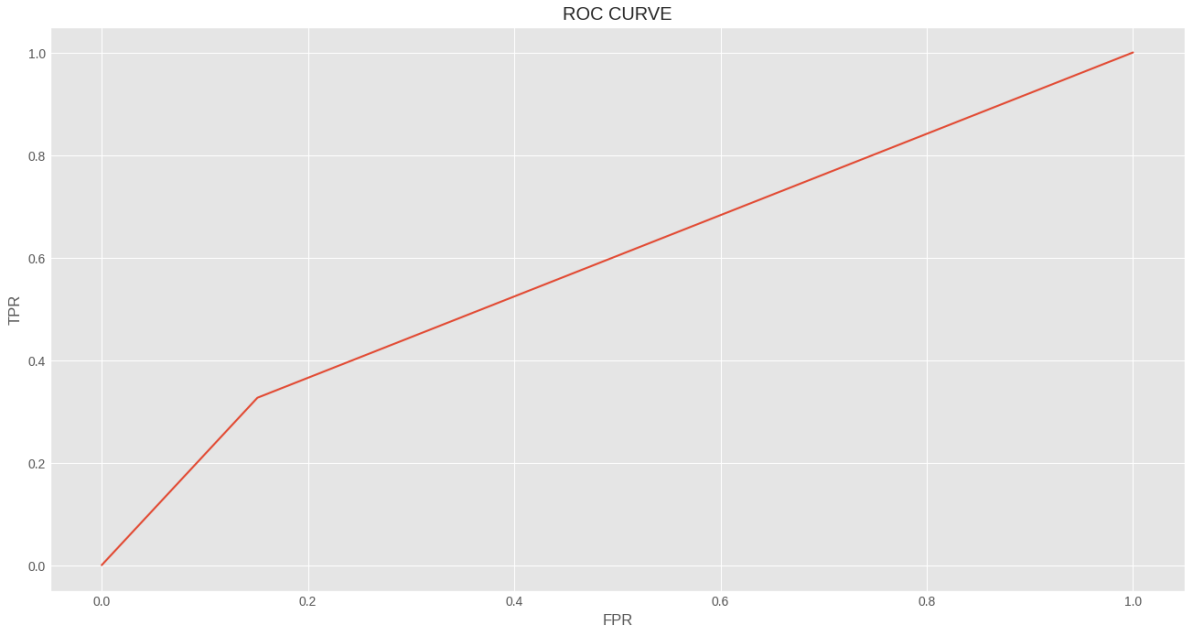
Out[252]:
```
array([0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.,
       0., 0., 1., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 1., 1.,
       1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 1., 0., 0., 0.,
       0., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0.,
       0., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0.,
       1., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0.,
       0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 1., 1., 1., 1., 0.,
       0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 1., 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., 1., 0., 1., 1., 0., 0., 0., 0., 1., 0., 0., 1.,
       0., 0., 1., 0., 1., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
       1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 1., 1., 0.,
       0., 1., 0., 0., 0., 0., 1., 1., 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., 1., 0., 0., 0., 0., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 1., 0., 1., 0., 0., 1.,
       0., 0., 0., 0., 0.])
```

In [253…
```
#roc_curve
```

```
fpr,tpr,thresholds=roc_curve(y_test,probability)
```

In [254…

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



Pre Parameter Tuning

In [256…

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

Out[256]:
```
[Text(0.32785292288557216, 0.9722222222222222, 'x[27] <= 0.05\ngini = 0.269\nsampl
es = 1176\nvalue = [988, 188]'),
 Text(0.07960199004975124, 0.9166666666666666, 'x[16] <= 0.75\ngini = 0.5\nsamples
= 78\nvalue = [39, 39]'),
 Text(0.04975124378109453, 0.8611111111111112, 'x[4] <= 0.554\ngini = 0.426\nsampl
es = 39\nvalue = [27, 12]'),
 Text(0.03316749585406302, 0.8055555555555556, 'x[15] <= 0.167\ngini = 0.312\nsamp
les = 31\nvalue = [25, 6]'),
 Text(0.01990049751243781, 0.75, 'x[21] <= 0.5\ngini = 0.49\nsamples = 7\nvalue =
[3, 4]'),
 Text(0.013266998341625208, 0.6944444444444444, 'x[10] <= 0.5\ngini = 0.375\nsampl
es = 4\nvalue = [3, 1]'),
 Text(0.006633499170812604, 0.6388888888888888, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.01990049751243781, 0.6388888888888888, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.026533996683250415, 0.6944444444444444, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.04643449419568822, 0.75, 'x[19] <= 0.056\ngini = 0.153\nsamples = 24\nvalu
e = [22, 2]'),
 Text(0.03980099502487562, 0.6944444444444444, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.05306799336650083, 0.6944444444444444, 'x[9] <= 0.167\ngini = 0.083\nsampl
es = 23\nvalue = [22, 1]'),
 Text(0.04643449419568822, 0.6388888888888888, 'x[23] <= 0.5\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.03980099502487562, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.05306799336650083, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.05970149253731343, 0.6388888888888888, 'gini = 0.0\nsamples = 21\nvalue =
[21, 0]'),
 Text(0.06633499170812604, 0.8055555555555556, 'x[8] <= 0.385\ngini = 0.375\nsampl
es = 8\nvalue = [2, 6]'),
 Text(0.05970149253731343, 0.75, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(0.07296849087893864, 0.75, 'gini = 0.0\nsamples = 6\nvalue = [0, 6]'),
 Text(0.10945273631840796, 0.8611111111111112, 'x[11] <= 0.364\ngini = 0.426\nsamp
les = 39\nvalue = [12, 27]'),
 Text(0.09286898839137644, 0.8055555555555556, 'x[29] <= 0.167\ngini = 0.133\nsamp
les = 14\nvalue = [1, 13]'),
 Text(0.08623548922056384, 0.75, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.09950248756218906, 0.75, 'gini = 0.0\nsamples = 13\nvalue = [0, 13]'),
 Text(0.12603648424543948, 0.8055555555555556, 'x[8] <= 0.105\ngini = 0.493\nsampl
es = 25\nvalue = [11, 14]'),
 Text(0.11276948590381426, 0.75, 'x[22] <= 0.464\ngini = 0.278\nsamples = 6\nvalue
= [5, 1]'),
 Text(0.10613598673300166, 0.6944444444444444, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(0.11940298507462686, 0.6944444444444444, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.13930348258706468, 0.75, 'x[15] <= 0.5\ngini = 0.432\nsamples = 19\nvalue
= [6, 13]'),
 Text(0.13266998341625208, 0.6944444444444444, 'gini = 0.0\nsamples = 7\nvalue =
[0, 7]'),
 Text(0.14593698175787728, 0.6944444444444444, 'x[6] <= 0.4\ngini = 0.5\nsamples =
12\nvalue = [6, 6]'),
 Text(0.13266998341625208, 0.6388888888888888, 'x[3] <= 0.75\ngini = 0.278\nsample
s = 6\nvalue = [5, 1]'),
 Text(0.12603648424543948, 0.5833333333333334, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(0.13930348258706468, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.15920398009950248, 0.6388888888888888, 'x[8] <= 0.249\ngini = 0.278\nsampl
es = 6\nvalue = [1, 5]'),
```

```
 Text(0.15257048092868988, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.16583747927031509, 0.5833333333333334, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),
 Text(0.576103855721393, 0.9166666666666666, 'x[21] <= 0.5\ngini = 0.235\nsamples
= 1098\nvalue = [949, 149]'),
 Text(0.3279954394693201, 0.8611111111111112, 'x[29] <= 0.167\ngini = 0.162\nsampl
es = 798\nvalue = [727, 71]'),
 Text(0.1791044776119403, 0.8055555555555556, 'x[8] <= 0.445\ngini = 0.38\nsamples
= 47\nvalue = [35, 12]'),
 Text(0.16583747927031509, 0.75, 'x[16] <= 0.75\ngini = 0.1\nsamples = 19\nvalue =
[18, 1]'),
 Text(0.15920398009950248, 0.6944444444444444, 'gini = 0.0\nsamples = 18\nvalue =
[18, 0]'),
 Text(0.1724709784411277, 0.6944444444444444, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.19237147595356552, 0.75, 'x[17] <= 0.094\ngini = 0.477\nsamples = 28\nvalu
e = [17, 11]'),
 Text(0.1857379767827529, 0.6944444444444444, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
 Text(0.19900497512437812, 0.6944444444444444, 'x[8] <= 0.524\ngini = 0.413\nsampl
es = 24\nvalue = [17, 7]'),
 Text(0.19237147595356552, 0.6388888888888888, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.20563847429519072, 0.6388888888888888, 'x[33] <= 0.324\ngini = 0.351\nsamp
les = 22\nvalue = [17, 5]'),
 Text(0.19237147595356552, 0.5833333333333334, 'x[2] <= 0.025\ngini = 0.133\nsampl
es = 14\nvalue = [13, 1]'),
 Text(0.1857379767827529, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.19900497512437812, 0.5277777777777778, 'gini = 0.0\nsamples = 13\nvalue =
[13, 0]'),
 Text(0.21890547263681592, 0.5833333333333334, 'x[2] <= 0.329\ngini = 0.5\nsamples
= 8\nvalue = [4, 4]'),
 Text(0.21227197346600332, 0.5277777777777778, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.22553897180762852, 0.5277777777777778, 'x[12] <= 0.333\ngini = 0.32\nsampl
es = 5\nvalue = [4, 1]'),
 Text(0.21890547263681592, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.23217247097844113, 0.4722222222222222, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
 Text(0.47688640132669985, 0.8055555555555556, 'x[30] <= 0.963\ngini = 0.145\nsamp
les = 751\nvalue = [692, 59]'),
 Text(0.4702529021558872, 0.75, 'x[30] <= 0.113\ngini = 0.143\nsamples = 750\nvalu
e = [692, 58]'),
 Text(0.34618573797678276, 0.6944444444444444, 'x[9] <= 0.167\ngini = 0.218\nsampl
es = 257\nvalue = [225, 32]'),
 Text(0.3034825870646766, 0.6388888888888888, 'x[33] <= 0.147\ngini = 0.355\nsampl
es = 65\nvalue = [50, 15]'),
 Text(0.28192371475953565, 0.5833333333333334, 'x[33] <= 0.029\ngini = 0.303\nsamp
les = 59\nvalue = [48, 11]'),
 Text(0.25870646766169153, 0.5277777777777778, 'x[12] <= 0.5\ngini = 0.463\nsample
s = 22\nvalue = [14, 8]'),
 Text(0.24543946932006633, 0.4722222222222222, 'x[11] <= 0.179\ngini = 0.198\nsamp
les = 9\nvalue = [8, 1]'),
 Text(0.23880597014925373, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.25207296849087896, 0.4166666666666667, 'gini = 0.0\nsamples = 8\nvalue =
[8, 0]'),
 Text(0.27197346600331673, 0.4722222222222222, 'x[11] <= 0.4\ngini = 0.497\nsample
s = 13\nvalue = [6, 7]'),
 Text(0.26533996683250416, 0.4166666666666667, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
```

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 Text(0.27860696517412936, 0.4166666666666667, 'x[4] <= 0.286\ngini = 0.346\nsampl
es = 9\nvalue = [2, 7]'),
 Text(0.27197346600331673, 0.3611111111111111, 'x[19] <= 0.944\ngini = 0.444\nsamp
les = 3\nvalue = [2, 1]'),
 Text(0.26533996683250416, 0.3055555555555556, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.27860696517412936, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.28524046434494194, 0.3611111111111111, 'gini = 0.0\nsamples = 6\nvalue =
[0, 6]'),
 Text(0.30514096185737977, 0.5277777777777778, 'x[15] <= 0.167\ngini = 0.149\nsamp
les = 37\nvalue = [34, 3]'),
 Text(0.29850746268656714, 0.4722222222222222, 'x[29] <= 0.5\ngini = 0.5\nsamples
= 6\nvalue = [3, 3]'),
 Text(0.29187396351575456, 0.4166666666666667, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.30514096185737977, 0.4166666666666667, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.3117744610281924, 0.4722222222222222, 'gini = 0.0\nsamples = 31\nvalue =
[31, 0]'),
 Text(0.3250414593698176, 0.5833333333333334, 'x[8] <= 0.065\ngini = 0.444\nsample
s = 6\nvalue = [2, 4]'),
 Text(0.31840796019900497, 0.5277777777777778, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.33167495854063017, 0.5277777777777778, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
 Text(0.3888888888888889, 0.6388888888888888, 'x[0] <= 0.321\ngini = 0.161\nsample
s = 192\nvalue = [175, 17]'),
 Text(0.351575456053068, 0.5833333333333334, 'x[6] <= 0.1\ngini = 0.294\nsamples =
67\nvalue = [55, 12]'),
 Text(0.3449419568822554, 0.5277777777777778, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.3582089552238806, 0.5277777777777778, 'x[29] <= 0.5\ngini = 0.26\nsamples
= 65\nvalue = [55, 10]'),
 Text(0.33499170812603646, 0.4722222222222222, 'x[6] <= 0.5\ngini = 0.469\nsamples
= 16\nvalue = [10, 6]'),
 Text(0.3283582089552239, 0.4166666666666667, 'gini = 0.0\nsamples = 7\nvalue =
[7, 0]'),
 Text(0.3416252072968491, 0.4166666666666667, 'x[9] <= 0.833\ngini = 0.444\nsample
s = 9\nvalue = [3, 6]'),
 Text(0.33499170812603646, 0.3611111111111111, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),
 Text(0.3482587064676617, 0.3611111111111111, 'x[18] <= 0.072\ngini = 0.375\nsampl
es = 4\nvalue = [3, 1]'),
 Text(0.3416252072968491, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.3548922056384743, 0.3055555555555556, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.3814262023217247, 0.4722222222222222, 'x[2] <= 0.037\ngini = 0.15\nsamples
= 49\nvalue = [45, 4]'),
 Text(0.3747927031509121, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.3880597014925373, 0.4166666666666667, 'x[2] <= 0.938\ngini = 0.117\nsample
s = 48\nvalue = [45, 3]'),
 Text(0.3814262023217247, 0.3611111111111111, 'x[5] <= 0.875\ngini = 0.081\nsample
s = 47\nvalue = [45, 2]'),
 Text(0.3681592039800995, 0.3055555555555556, 'x[12] <= 0.167\ngini = 0.043\nsampl
es = 45\nvalue = [44, 1]'),
 Text(0.3615257048092869, 0.25, 'x[8] <= 0.839\ngini = 0.444\nsamples = 3\nvalue =
[2, 1]'),
 Text(0.3548922056384743, 0.19444444444444445, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.3681592039800995, 0.19444444444444445, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
```

```
 Text(0.3747927031509121, 0.25, 'gini = 0.0\nsamples = 42\nvalue = [42, 0]'),
 Text(0.3946932006633499, 0.3055555555555556, 'x[8] <= 0.246\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.3880597014925373, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(0.4013266998341625, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.3946932006633499, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.4262023217247098, 0.5833333333333334, 'x[8] <= 0.022\ngini = 0.077\nsample
s = 125\nvalue = [120, 5]'),
 Text(0.4079601990049751, 0.5277777777777778, 'x[27] <= 0.25\ngini = 0.5\nsamples
= 4\nvalue = [2, 2]'),
 Text(0.4013266998341625, 0.4722222222222222, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.41459369817578773, 0.4722222222222222, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.4444444444444444, 0.5277777777777778, 'x[18] <= 0.968\ngini = 0.048\nsampl
es = 121\nvalue = [118, 3]'),
 Text(0.42786069651741293, 0.4722222222222222, 'x[2] <= 0.98\ngini = 0.033\nsample
s = 118\nvalue = [116, 2]'),
 Text(0.41459369817578773, 0.4166666666666667, 'x[14] <= 0.938\ngini = 0.017\nsamp
les = 114\nvalue = [113, 1]'),
 Text(0.4079601990049751, 0.3611111111111111, 'gini = 0.0\nsamples = 107\nvalue =
[107, 0]'),
 Text(0.42122719734660036, 0.3611111111111111, 'x[12] <= 0.167\ngini = 0.245\nsamp
les = 7\nvalue = [6, 1]'),
 Text(0.41459369817578773, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.42786069651741293, 0.3055555555555556, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
 Text(0.44112769485903813, 0.4166666666666667, 'x[3] <= 0.75\ngini = 0.375\nsample
s = 4\nvalue = [3, 1]'),
 Text(0.43449419568822556, 0.3611111111111111, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.44776119402985076, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.46102819237147596, 0.4722222222222222, 'x[19] <= 0.278\ngini = 0.444\nsamp
les = 3\nvalue = [2, 1]'),
 Text(0.45439469320066334, 0.4166666666666667, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.46766169154228854, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.5943200663349917, 0.6944444444444444, 'x[30] <= 0.787\ngini = 0.1\nsamples
= 493\nvalue = [467, 26]'),
 Text(0.5601160862354893, 0.6388888888888888, 'x[15] <= 0.5\ngini = 0.094\nsamples
= 486\nvalue = [462, 24]'),
 Text(0.511608623548922, 0.5833333333333334, 'x[14] <= 0.938\ngini = 0.154\nsample
s = 191\nvalue = [175, 16]'),
 Text(0.5049751243781094, 0.5277777777777778, 'x[18] <= 0.481\ngini = 0.145\nsampl
es = 190\nvalue = [175, 15]'),
 Text(0.48756218905472637, 0.4722222222222222, 'x[18] <= 0.47\ngini = 0.221\nsampl
es = 95\nvalue = [83, 12]'),
 Text(0.48092868988391374, 0.4166666666666667, 'x[33] <= 0.794\ngini = 0.207\nsamp
les = 94\nvalue = [83, 11]'),
 Text(0.47429519071310117, 0.3611111111111111, 'x[5] <= 0.375\ngini = 0.192\nsampl
es = 93\nvalue = [83, 10]'),
 Text(0.4527363184079602, 0.3055555555555556, 'x[6] <= 0.9\ngini = 0.363\nsamples
= 21\nvalue = [16, 5]'),
 Text(0.4461028192371476, 0.25, 'x[17] <= 0.413\ngini = 0.266\nsamples = 19\nvalue
= [16, 3]'),
 Text(0.43283582089552236, 0.19444444444444445, 'x[8] <= 0.215\ngini = 0.117\nsamp
les = 16\nvalue = [15, 1]'),
 Text(0.4262023217247098, 0.1388888888888889, 'x[0] <= 0.369\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.41956882255389716, 0.08333333333333333, 'gini = 0.0\nsamples = 1\nvalue =
```

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[0, 1]'),
 Text(0.43283582089552236, 0.08333333333333333, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.439469320066335, 0.1388888888888889, 'gini = 0.0\nsamples = 14\nvalue = [1
4, 0]'),
 Text(0.4593698175787728, 0.19444444444444445, 'x[24] <= 0.833\ngini = 0.444\nsamp
les = 3\nvalue = [1, 2]'),
 Text(0.4527363184079602, 0.1388888888888889, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.4660033167495854, 0.1388888888888889, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.4593698175787728, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(0.49585406301824214, 0.3055555555555556, 'x[31] <= 0.083\ngini = 0.129\nsamp
les = 72\nvalue = [67, 5]'),
 Text(0.4792703150912106, 0.25, 'x[8] <= 0.68\ngini = 0.444\nsamples = 6\nvalue =
[4, 2]'),
 Text(0.472636815920398, 0.19444444444444445, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
 Text(0.4859038142620232, 0.19444444444444445, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.5124378109452736, 0.25, 'x[11] <= 0.993\ngini = 0.087\nsamples = 66\nvalue
= [63, 3]'),
 Text(0.49917081260364843, 0.19444444444444445, 'x[28] <= 0.583\ngini = 0.061\nsam
ples = 64\nvalue = [62, 2]'),
 Text(0.4925373134328358, 0.1388888888888889, 'gini = 0.0\nsamples = 51\nvalue =
[51, 0]'),
 Text(0.5058043117744611, 0.1388888888888889, 'x[9] <= 0.5\ngini = 0.26\nsamples =
13\nvalue = [11, 2]'),
 Text(0.49917081260364843, 0.08333333333333333, 'x[17] <= 0.335\ngini = 0.5\nsampl
es = 4\nvalue = [2, 2]'),
 Text(0.4925373134328358, 0.027777777777777776, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.5058043117744611, 0.027777777777777776, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.5124378109452736, 0.08333333333333333, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(0.5257048092868989, 0.19444444444444445, 'x[1] <= 0.25\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.5190713101160862, 0.1388888888888889, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.5323383084577115, 0.1388888888888889, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.48756218905472637, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.494195688225539, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.5223880597014925, 0.4722222222222222, 'x[19] <= 0.5\ngini = 0.061\nsamples
= 95\nvalue = [92, 3]'),
 Text(0.5157545605306799, 0.4166666666666667, 'gini = 0.0\nsamples = 76\nvalue =
[76, 0]'),
 Text(0.5290215588723052, 0.4166666666666667, 'x[33] <= 0.088\ngini = 0.266\nsampl
es = 19\nvalue = [16, 3]'),
 Text(0.5157545605306799, 0.3611111111111111, 'x[3] <= 0.75\ngini = 0.444\nsamples
= 3\nvalue = [1, 2]'),
 Text(0.5091210613598673, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.5223880597014925, 0.3055555555555556, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.5422885572139303, 0.3611111111111111, 'x[17] <= 0.108\ngini = 0.117\nsampl
es = 16\nvalue = [15, 1]'),
 Text(0.5356550580431177, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.548922056384743, 0.3055555555555556, 'gini = 0.0\nsamples = 15\nvalue = [1
5, 0]'),
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 Text(0.5182421227197347, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6086235489220564, 0.5833333333333334, 'x[22] <= 0.036\ngini = 0.053\nsampl
es = 295\nvalue = [287, 8]'),
 Text(0.5854063018242123, 0.5277777777777778, 'x[32] <= 0.7\ngini = 0.159\nsamples
= 46\nvalue = [42, 4]'),
 Text(0.5787728026533997, 0.4722222222222222, 'x[12] <= 0.167\ngini = 0.124\nsampl
es = 45\nvalue = [42, 3]'),
 Text(0.5621890547263682, 0.4166666666666667, 'x[27] <= 0.4\ngini = 0.5\nsamples =
2\nvalue = [1, 1]'),
 Text(0.5555555555555556, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.5688225538971807, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.5953565505804311, 0.4166666666666667, 'x[27] <= 0.917\ngini = 0.089\nsampl
es = 43\nvalue = [41, 2]'),
 Text(0.582089552238806, 0.3611111111111111, 'x[14] <= 0.062\ngini = 0.048\nsample
s = 41\nvalue = [40, 1]'),
 Text(0.5754560530679934, 0.3055555555555556, 'x[9] <= 0.167\ngini = 0.375\nsample
s = 4\nvalue = [3, 1]'),
 Text(0.5688225538971807, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.582089552238806, 0.25, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(0.5887230514096186, 0.3055555555555556, 'gini = 0.0\nsamples = 37\nvalue =
[37, 0]'),
 Text(0.6086235489220564, 0.3611111111111111, 'x[30] <= 0.212\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.6019900497512438, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.615257048092869, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.5920398009950248, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6318407960199005, 0.5277777777777778, 'x[17] <= 0.056\ngini = 0.032\nsampl
es = 249\nvalue = [245, 4]'),
 Text(0.615257048092869, 0.4722222222222222, 'x[16] <= 0.75\ngini = 0.32\nsamples
= 5\nvalue = [4, 1]'),
 Text(0.6086235489220564, 0.4166666666666667, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
 Text(0.6218905472636815, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.648424543946932, 0.4722222222222222, 'x[2] <= 0.015\ngini = 0.024\nsamples
= 244\nvalue = [241, 3]'),
 Text(0.6351575456053068, 0.4166666666666667, 'x[11] <= 0.129\ngini = 0.278\nsampl
es = 6\nvalue = [5, 1]'),
 Text(0.6285240464344942, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6417910447761194, 0.3611111111111111, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(0.6616915422885572, 0.4166666666666667, 'x[24] <= 0.167\ngini = 0.017\nsampl
es = 238\nvalue = [236, 2]'),
 Text(0.6550580431177446, 0.3611111111111111, 'x[29] <= 0.833\ngini = 0.073\nsampl
es = 53\nvalue = [51, 2]'),
 Text(0.6417910447761194, 0.3055555555555556, 'x[33] <= 0.088\ngini = 0.041\nsampl
es = 48\nvalue = [47, 1]'),
 Text(0.6351575456053068, 0.25, 'x[14] <= 0.312\ngini = 0.245\nsamples = 7\nvalue
= [6, 1]'),
 Text(0.6285240464344942, 0.19444444444444445, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.6417910447761194, 0.19444444444444445, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
 Text(0.648424543946932, 0.25, 'gini = 0.0\nsamples = 41\nvalue = [41, 0]'),
 Text(0.6683250414593698, 0.3055555555555556, 'x[31] <= 0.25\ngini = 0.32\nsamples
= 5\nvalue = [4, 1]'),
 Text(0.6616915422885572, 0.25, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
```
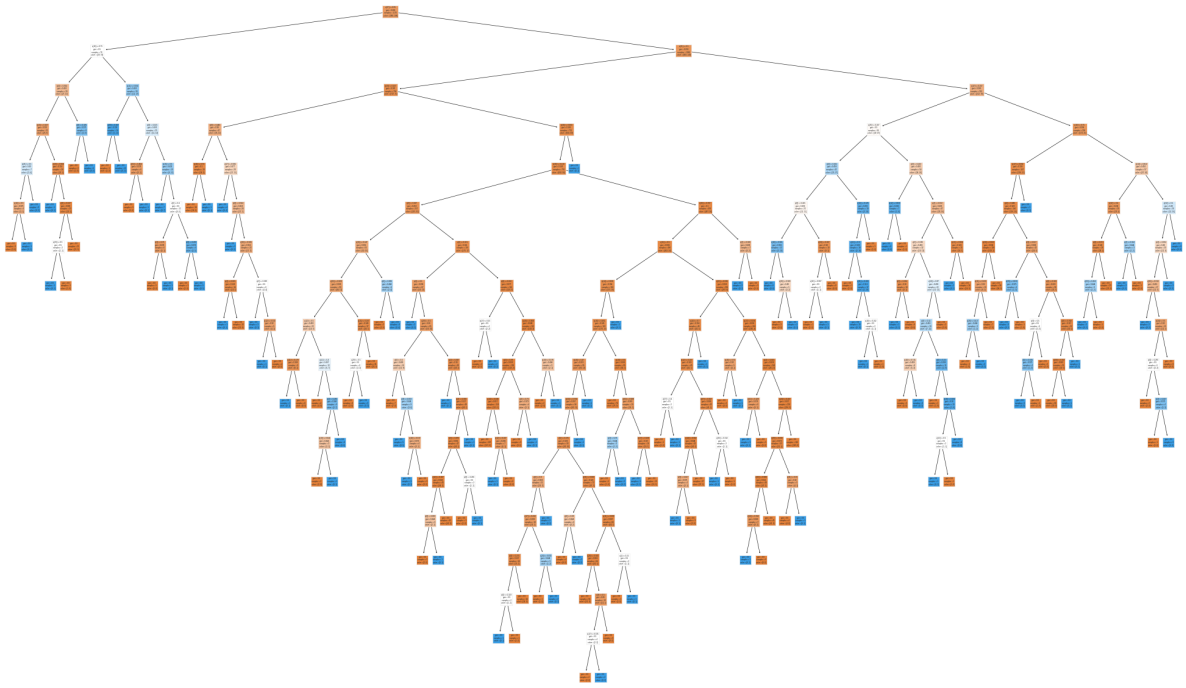

```
 Text(0.6749585406301825, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.6683250414593698, 0.3611111111111111, 'gini = 0.0\nsamples = 185\nvalue =
[185, 0]'),
 Text(0.6285240464344942, 0.6388888888888888, 'x[2] <= 0.366\ngini = 0.408\nsample
s = 7\nvalue = [5, 2]'),
 Text(0.6218905472636815, 0.5833333333333334, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.6351575456053068, 0.5833333333333334, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(0.4835199004975124, 0.75, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.824212271973466, 0.8611111111111112, 'x[17] <= 0.157\ngini = 0.385\nsample
s = 300\nvalue = [222, 78]'),
 Text(0.7371475953565506, 0.8055555555555556, 'x[26] <= 0.167\ngini = 0.5\nsamples
= 96\nvalue = [49, 47]'),
 Text(0.7014925373134329, 0.75, 'x[4] <= 0.161\ngini = 0.459\nsamples = 42\nvalue
= [15, 27]'),
 Text(0.6749585406301825, 0.6944444444444444, 'x[8] <= 0.415\ngini = 0.499\nsample
s = 23\nvalue = [12, 11]'),
 Text(0.6550580431177446, 0.6388888888888888, 'x[18] <= 0.561\ngini = 0.355\nsampl
es = 13\nvalue = [3, 10]'),
 Text(0.648424543946932, 0.5833333333333334, 'gini = 0.0\nsamples = 8\nvalue = [0,
8]'),
 Text(0.6616915422885572, 0.5833333333333334, 'x[28] <= 0.583\ngini = 0.48\nsample
s = 5\nvalue = [3, 2]'),
 Text(0.6550580431177446, 0.5277777777777778, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.6683250414593698, 0.5277777777777778, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.6948590381426202, 0.6388888888888888, 'x[24] <= 0.167\ngini = 0.18\nsample
s = 10\nvalue = [9, 1]'),
 Text(0.6882255389718076, 0.5833333333333334, 'x[32] <= 0.067\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.681592039800995, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.6948590381426202, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.7014925373134329, 0.5833333333333334, 'gini = 0.0\nsamples = 8\nvalue =
[8, 0]'),
 Text(0.7280265339966833, 0.6944444444444444, 'x[13] <= 0.125\ngini = 0.266\nsampl
es = 19\nvalue = [3, 16]'),
 Text(0.7213930348258707, 0.6388888888888888, 'x[11] <= 0.2\ngini = 0.198\nsamples
= 18\nvalue = [2, 16]'),
 Text(0.714759535655058, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.7280265339966833, 0.5833333333333334, 'x[31] <= 0.183\ngini = 0.111\nsampl
es = 17\nvalue = [1, 16]'),
 Text(0.7213930348258707, 0.5277777777777778, 'gini = 0.0\nsamples = 15\nvalue =
[0, 15]'),
 Text(0.7346600331674958, 0.5277777777777778, 'x[18] <= 0.162\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(0.7280265339966833, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.7412935323383084, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.7346600331674958, 0.6388888888888888, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.7728026533996684, 0.75, 'x[0] <= 0.202\ngini = 0.466\nsamples = 54\nvalue
= [34, 20]'),
 Text(0.7545605306799337, 0.6944444444444444, 'x[12] <= 0.833\ngini = 0.245\nsampl
es = 7\nvalue = [1, 6]'),
 Text(0.7479270315091211, 0.6388888888888888, 'gini = 0.0\nsamples = 6\nvalue =
[0, 6]'),
 Text(0.7611940298507462, 0.6388888888888888, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
```

```
 Text(0.7910447761194029, 0.6944444444444444, 'x[2] <= 0.622\ngini = 0.418\nsample
s = 47\nvalue = [33, 14]'),
 Text(0.7744610281923715, 0.6388888888888888, 'x[2] <= 0.145\ngini = 0.482\nsample
s = 32\nvalue = [19, 13]'),
 Text(0.7611940298507462, 0.5833333333333334, 'x[2] <= 0.024\ngini = 0.18\nsamples
= 10\nvalue = [9, 1]'),
 Text(0.7545605306799337, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.7678275290215588, 0.5277777777777778, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(0.7877280265339967, 0.5833333333333334, 'x[18] <= 0.87\ngini = 0.496\nsample
s = 22\nvalue = [10, 12]'),
 Text(0.7810945273631841, 0.5277777777777778, 'x[8] <= 0.41\ngini = 0.465\nsamples
= 19\nvalue = [7, 12]'),
 Text(0.7678275290215588, 0.4722222222222222, 'x[18] <= 0.715\ngini = 0.469\nsampl
es = 8\nvalue = [5, 3]'),
 Text(0.7611940298507462, 0.4166666666666667, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(0.7744610281923715, 0.4166666666666667, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.7943615257048093, 0.4722222222222222, 'x[0] <= 0.25\ngini = 0.298\nsamples
= 11\nvalue = [2, 9]'),
 Text(0.7877280265339967, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.8009950248756219, 0.4166666666666667, 'x[18] <= 0.202\ngini = 0.18\nsample
s = 10\nvalue = [1, 9]'),
 Text(0.7943615257048093, 0.3611111111111111, 'x[15] <= 0.5\ngini = 0.5\nsamples =
2\nvalue = [1, 1]'),
 Text(0.7877280265339967, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.8009950248756219, 0.3055555555555556, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.8076285240464345, 0.3611111111111111, 'gini = 0.0\nsamples = 8\nvalue =
[0, 8]'),
 Text(0.7943615257048093, 0.5277777777777778, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(0.8076285240464345, 0.6388888888888888, 'x[11] <= 0.064\ngini = 0.124\nsampl
es = 15\nvalue = [14, 1]'),
 Text(0.8009950248756219, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.814262023217247, 0.5833333333333334, 'gini = 0.0\nsamples = 14\nvalue = [1
4, 0]'),
 Text(0.9112769485903814, 0.8055555555555556, 'x[16] <= 0.75\ngini = 0.258\nsample
s = 204\nvalue = [173, 31]'),
 Text(0.8590381426202321, 0.75, 'x[17] <= 0.992\ngini = 0.138\nsamples = 147\nvalu
e = [136, 11]'),
 Text(0.8524046434494196, 0.6944444444444444, 'x[4] <= 0.482\ngini = 0.128\nsample
s = 146\nvalue = [136, 10]'),
 Text(0.8341625207296849, 0.6388888888888888, 'x[30] <= 0.063\ngini = 0.038\nsampl
es = 104\nvalue = [102, 2]'),
 Text(0.8275290215588723, 0.5833333333333334, 'x[11] <= 0.193\ngini = 0.32\nsample
s = 10\nvalue = [8, 2]'),
 Text(0.8208955223880597, 0.5277777777777778, 'x[28] <= 0.417\ngini = 0.444\nsampl
es = 3\nvalue = [1, 2]'),
 Text(0.814262023217247, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.8275290215588723, 0.4722222222222222, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.8341625207296849, 0.5277777777777778, 'gini = 0.0\nsamples = 7\nvalue =
[7, 0]'),
 Text(0.8407960199004975, 0.5833333333333334, 'gini = 0.0\nsamples = 94\nvalue =
[94, 0]'),
 Text(0.8706467661691543, 0.6388888888888888, 'x[9] <= 0.167\ngini = 0.308\nsample
s = 42\nvalue = [34, 8]'),
```

```
 Text(0.8540630182421227, 0.5833333333333334, 'x[29] <= 0.833\ngini = 0.375\nsampl
es = 4\nvalue = [1, 3]'),
 Text(0.8474295190713101, 0.5277777777777778, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.8606965174129353, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.8872305140961857, 0.5833333333333334, 'x[0] <= 0.393\ngini = 0.229\nsample
s = 38\nvalue = [33, 5]'),
 Text(0.8739635157545605, 0.5277777777777778, 'x[9] <= 0.5\ngini = 0.5\nsamples =
6\nvalue = [3, 3]'),
 Text(0.867330016583748, 0.4722222222222222, 'x[5] <= 0.625\ngini = 0.375\nsamples
= 4\nvalue = [1, 3]'),
 Text(0.8606965174129353, 0.4166666666666667, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.8739635157545605, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.8805970149253731, 0.4722222222222222, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(0.900497512437811, 0.5277777777777778, 'x[8] <= 0.992\ngini = 0.117\nsamples
= 32\nvalue = [30, 2]'),
 Text(0.8938640132669984, 0.4722222222222222, 'x[28] <= 0.917\ngini = 0.062\nsampl
es = 31\nvalue = [30, 1]'),
 Text(0.8872305140961857, 0.4166666666666667, 'gini = 0.0\nsamples = 30\nvalue =
[30, 0]'),
 Text(0.900497512437811, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.9071310116086235, 0.4722222222222222, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.8656716417910447, 0.6944444444444444, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(0.9635157545605307, 0.75, 'x[14] <= 0.812\ngini = 0.456\nsamples = 57\nvalue
= [37, 20]'),
 Text(0.9402985074626866, 0.6944444444444444, 'x[32] <= 0.4\ngini = 0.238\nsamples
= 29\nvalue = [25, 4]'),
 Text(0.9270315091210614, 0.6388888888888888, 'x[8] <= 0.071\ngini = 0.142\nsample
s = 26\nvalue = [24, 2]'),
 Text(0.9203980099502488, 0.5833333333333334, 'x[33] <= 0.412\ngini = 0.444\nsampl
es = 3\nvalue = [1, 2]'),
 Text(0.9137645107794361, 0.5277777777777778, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.9270315091210614, 0.5277777777777778, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.9336650082918739, 0.5833333333333334, 'gini = 0.0\nsamples = 23\nvalue =
[23, 0]'),
 Text(0.9535655058043118, 0.6388888888888888, 'x[2] <= 0.324\ngini = 0.444\nsample
s = 3\nvalue = [1, 2]'),
 Text(0.9469320066334992, 0.5833333333333334, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(0.9601990049751243, 0.5833333333333334, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.9867330016583747, 0.6944444444444444, 'x[32] <= 0.1\ngini = 0.49\nsamples
= 28\nvalue = [12, 16]'),
 Text(0.9800995024875622, 0.6388888888888888, 'x[4] <= 0.804\ngini = 0.48\nsamples
= 20\nvalue = [12, 8]'),
 Text(0.9734660033167496, 0.5833333333333334, 'x[30] <= 0.013\ngini = 0.415\nsampl
es = 17\nvalue = [12, 5]'),
 Text(0.966832504145937, 0.5277777777777778, 'gini = 0.0\nsamples = 2\nvalue = [0,
2]'),
 Text(0.9800995024875622, 0.5277777777777778, 'x[24] <= 0.5\ngini = 0.32\nsamples
= 15\nvalue = [12, 3]'),
 Text(0.9734660033167496, 0.4722222222222222, 'x[0] <= 0.286\ngini = 0.5\nsamples
= 6\nvalue = [3, 3]'),
 Text(0.966832504145937, 0.4166666666666667, 'gini = 0.0\nsamples = 2\nvalue = [2,
0]'),
```

```
 Text(0.9800995024875622, 0.4166666666666667, 'x[2] <= 0.197\ngini = 0.375\nsample
s = 4\nvalue = [1, 3]'),
 Text(0.9734660033167496, 0.3611111111111111, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(0.9867330016583747, 0.3611111111111111, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.9867330016583747, 0.4722222222222222, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(0.9867330016583747, 0.5833333333333334, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
 Text(0.9933665008291874, 0.6388888888888888, 'gini = 0.0\nsamples = 8\nvalue =
[0, 8]')]
```



In [258…

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

In [259…

```
grid_search=GridSearchCV(estimator=dtc,param_grid=parameter,cv=5,scoring="accuracy"
```

In [260…

```
grid_search.fit(x_train,y_train)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/tree/_classes.py:269: FutureWarnin
g: `max_features='auto'` has been deprecated in 1.1 and will be removed in 1.3. To
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```

```
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```

```
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```

Out[260]:

```
▸ GridSearchCV
▸ estimator: DecisionTreeClassifier
    ▸ DecisionTreeClassifier
```

In [261…

```
grid_search.best_params_
```

Out[261]:

```
{'criterion': 'entropy',
 'max_depth': 3,
 'max_features': 'sqrt',
 'splitter': 'best'}
```

In [265…

```
dtc_cv=DecisionTreeClassifier(criterion= 'entropy',
 max_depth= 3,
 max_features= 'sqrt',
 splitter= 'best')
dtc_cv.fit(x_train,y_train)
```

Out[265]:

```
▾ DecisionTreeClassifier
DecisionTreeClassifier(criterion='entropy', max_depth=3, max_features='sq
rt')
```

In [268…

```
pred=dtc_cv.predict(x_test)
```

In [270…

```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.83      1.00      0.91       245
           1       0.00      0.00      0.00        49

    accuracy                           0.83       294
   macro avg       0.42      0.50      0.45       294
weighted avg       0.69      0.83      0.76       294
```

After hyperparameter tuning, accuracy is 83%

Random Forest

In [271…

```
from sklearn.ensemble import RandomForestClassifier
rfc=RandomForestClassifier()
```

In [272…
```
forest_params=[{'max_depth': list(range(10,15)), 'max_features': list(range(0,14))}
```

In [273…
```
rfc_cv=GridSearchCV(rfc,forest_params,cv=10,scoring="accuracy")
```

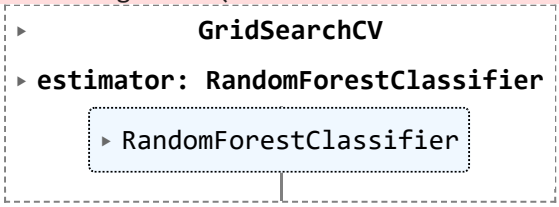
In [274…
```
rfc_cv.fit(x_train,y_train)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/model_selection/_validation.py:37
8: 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_sco
re='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
50 fits failed with the following error:
Traceback (most recent call last):
  File "/usr/local/lib/python3.10/dist-packages/sklearn/model_selection/_validatio
n.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "/usr/local/lib/python3.10/dist-packages/sklearn/ensemble/_forest.py", line
340, in fit
    self._validate_params()
  File "/usr/local/lib/python3.10/dist-packages/sklearn/base.py", line 600, in _va
lidate_params
    validate_parameter_constraints(
  File "/usr/local/lib/python3.10/dist-packages/sklearn/utils/_param_validation.p
y", line 97, in validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features' paramete
r of RandomForestClassifier must be an int in the range [1, inf), a float in the r
ange (0.0, 1.0], a str among {'sqrt', 'auto' (deprecated), 'log2'} or None. Got 0
instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
/usr/local/lib/python3.10/dist-packages/sklearn/model_selection/_search.py:952: Us
erWarning: One or more of the test scores are non-finite: [       nan 0.85120238
0.85630885 0.85459221 0.85291178 0.86053165
 0.86137911 0.85798204 0.85882949 0.85966971 0.85798204 0.85966247
 0.8605389  0.85797479        nan 0.8443865  0.85204259 0.86224105
 0.86052441 0.85967695 0.85969144 0.86138635 0.86477618 0.86137911
 0.86393597 0.86137911 0.86052441 0.86307403        nan 0.85034043
 0.85373026 0.85714182 0.85712734 0.85712009 0.85714182 0.85627264
 0.86221932 0.85457048 0.86222657 0.85627988 0.85542518 0.85795306
        nan 0.85204983 0.85969868 0.85712734 0.85457048 0.85966247
 0.86137911 0.86051717 0.86478343 0.85287556 0.85628712 0.85798204
 0.86052441 0.86647834        nan 0.84950746 0.85546139 0.85971317
 0.86138635 0.85627988 0.85967695 0.85882225 0.86223381 0.85628712
 0.86221932 0.85458496 0.85880776 0.85882225]
  warnings.warn(
```

Out[274]:



In [275…
```
pred=rfc_cv.predict(x_test)
```

In [276…
```
print(classification_report(y_test,pred))
```

	precision	recall	f1-score	support
0	0.86	0.98	0.91	245
1	0.62	0.20	0.31	49
accuracy			0.85	294
macro avg	0.74	0.59	0.61	294
weighted avg	0.82	0.85	0.81	294

Accuracy of this model is 85%

In [ ]: