

# signment-04-smartinternz-21bce9322

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0.0.3 Assignment - 4

0.0.4 Importing Libraries

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

0.0.5 Importing DataSet

```
[3]: df = pd.read_csv('D:\Smartbridge_Externship\WA_Fn-UseC_-HR-Employee-Attrition.
↳csv')
```

```
[4]: df
```

```
[4]:      Age Attrition   BusinessTravel  DailyRate      Department \
0      41        Yes   Travel_Rarely      1102             Sales
1      49         No  Travel_Frequently      279  Research & Development
2      37        Yes   Travel_Rarely     1373  Research & Development
3      33         No  Travel_Frequently     1392  Research & Development
4      27         No   Travel_Rarely      591  Research & Development
...  ...      ...      ...      ...      ...
1465   36         No  Travel_Frequently      884  Research & Development
1466   39         No   Travel_Rarely      613  Research & Development
1467   27         No   Travel_Rarely      155  Research & Development
1468   49         No  Travel_Frequently     1023             Sales
1469   34         No   Travel_Rarely      628  Research & Development

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

...	...	...	...	...
1465	23	2	Medical	1
1466	6	1	Medical	1
1467	4	3	Life Sciences	1
1468	2	3	Medical	1
1469	8	3	Medical	1

	EmployeeNumber	...	RelationshipSatisfaction	StandardHours	\
0	1	...	1	80	
1	2	...	4	80	
2	4	...	2	80	
3	5	...	3	80	
4	7	...	4	80	
...	...	...	...	...	
1465	2061	...	3	80	
1466	2062	...	1	80	
1467	2064	...	2	80	
1468	2065	...	4	80	
1469	2068	...	1	80	

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

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

YearsSinceLastPromotion	YearsWithCurrManager
-------------------------	----------------------

0		0	5
1		1	7
2		0	0
3		3	0
4		2	2
...	...		...
1465		0	3
1466		1	7
1467		0	3
1468		0	8
1469		1	2

[1470 rows x 35 columns]

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

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

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

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

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

      YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                   4                   0             5
1                   7                   1             7
```

2	0	0	0
3	7	3	0
4	2	2	2

[5 rows x 35 columns]

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

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

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

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

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

```
      WorkLifeBalance  YearsAtCompany  YearsInCurrentRole \
1465                3              5              2
1466                3              7              7
1467                3              6              2
1468                2              9              6
1469                4              4              3
```

```
      YearsSinceLastPromotion  YearsWithCurrManager
1465                0              3
1466                1              7
1467                0              3
```

```

1468          0          8
1469          1          2

```

[5 rows x 35 columns]

```
[7]: df.info()
```

```

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

```

```
dtypes: int64(26), object(9)
memory usage: 402.1+ KB
```

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

```
[8]:
```

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

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

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

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

	WorkLifeBalance	YearsAtCompany	YearsInCurrentRole \
count	1470.000000	1470.000000	1470.000000

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

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

[8 rows x 26 columns]

```
[9]: df.shape
```

```
[9]: (1470, 35)
```

```
[10]: numeric_df = df.select_dtypes(include=['number'])
correlation_matrix = numeric_df.corr()
print(correlation_matrix)
```

	Age	DailyRate	DistanceFromHome	Education	\
Age	1.000000	0.010661	-0.001686	0.208034	
DailyRate	0.010661	1.000000	-0.004985	-0.016806	
DistanceFromHome	-0.001686	-0.004985	1.000000	0.021042	
Education	0.208034	-0.016806	0.021042	1.000000	
EmployeeCount	NaN	NaN	NaN	NaN	
EmployeeNumber	-0.010145	-0.050990	0.032916	0.042070	
EnvironmentSatisfaction	0.010146	0.018355	-0.016075	-0.027128	
HourlyRate	0.024287	0.023381	0.031131	0.016775	
JobInvolvement	0.029820	0.046135	0.008783	0.042438	
JobLevel	0.509604	0.002966	0.005303	0.101589	
JobSatisfaction	-0.004892	0.030571	-0.003669	-0.011296	
MonthlyIncome	0.497855	0.007707	-0.017014	0.094961	
MonthlyRate	0.028051	-0.032182	0.027473	-0.026084	
NumCompaniesWorked	0.299635	0.038153	-0.029251	0.126317	
PercentSalaryHike	0.003634	0.022704	0.040235	-0.011111	
PerformanceRating	0.001904	0.000473	0.027110	-0.024539	
RelationshipSatisfaction	0.053535	0.007846	0.006557	-0.009118	
StandardHours	NaN	NaN	NaN	NaN	

StockOptionLevel	0.037510	0.042143	0.044872	0.018422
TotalWorkingYears	0.680381	0.014515	0.004628	0.148280
TrainingTimesLastYear	-0.019621	0.002453	-0.036942	-0.025100
WorkLifeBalance	-0.021490	-0.037848	-0.026556	0.009819
YearsAtCompany	0.311309	-0.034055	0.009508	0.069114
YearsInCurrentRole	0.212901	0.009932	0.018845	0.060236
YearsSinceLastPromotion	0.216513	-0.033229	0.010029	0.054254
YearsWithCurrManager	0.202089	-0.026363	0.014406	0.069065

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

	EnvironmentSatisfaction	HourlyRate	JobInvolvement \
Age	0.010146	0.024287	0.029820
DailyRate	0.018355	0.023381	0.046135
DistanceFromHome	-0.016075	0.031131	0.008783
Education	-0.027128	0.016775	0.042438
EmployeeCount	NaN	NaN	NaN
EmployeeNumber	0.017621	0.035179	-0.006888
EnvironmentSatisfaction	1.000000	-0.049857	-0.008278
HourlyRate	-0.049857	1.000000	0.042861
JobInvolvement	-0.008278	0.042861	1.000000
JobLevel	0.001212	-0.027853	-0.012630



JobSatisfaction	-0.006784	-0.071335	-0.021476
MonthlyIncome	-0.006259	-0.015794	-0.015271
MonthlyRate	0.037600	-0.015297	-0.016322
NumCompaniesWorked	0.012594	0.022157	0.015012
PercentSalaryHike	-0.031701	-0.009062	-0.017205
PerformanceRating	-0.029548	-0.002172	-0.029071
RelationshipSatisfaction	0.007665	0.001330	0.034297
StandardHours	NaN	NaN	NaN
StockOptionLevel	0.003432	0.050263	0.021523
TotalWorkingYears	-0.002693	-0.002334	-0.005533
TrainingTimesLastYear	-0.019359	-0.008548	-0.015338
WorkLifeBalance	0.027627	-0.004607	-0.014617
YearsAtCompany	0.001458	-0.019582	-0.021355
YearsInCurrentRole	0.018007	-0.024106	0.008717
YearsSinceLastPromotion	0.016194	-0.026716	-0.024184
YearsWithCurrManager	-0.004999	-0.020123	0.025976

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

	StandardHours	StockOptionLevel	TotalWorkingYears	\
Age	NaN	0.037510	0.680381	
DailyRate	NaN	0.042143	0.014515	

DistanceFromHome	NaN	0.044872	0.004628
Education	NaN	0.018422	0.148280
EmployeeCount	NaN	NaN	NaN
EmployeeNumber	NaN	0.062227	-0.014365
EnvironmentSatisfaction	NaN	0.003432	-0.002693
HourlyRate	NaN	0.050263	-0.002334
JobInvolvement	NaN	0.021523	-0.005533
JobLevel	NaN	0.013984	0.782208
JobSatisfaction	NaN	0.010690	-0.020185
MonthlyIncome	NaN	0.005408	0.772893
MonthlyRate	NaN	-0.034323	0.026442
NumCompaniesWorked	NaN	0.030075	0.237639
PercentSalaryHike	NaN	0.007528	-0.020608
PerformanceRating	NaN	0.003506	0.006744
RelationshipSatisfaction	NaN	-0.045952	0.024054
StandardHours	NaN	NaN	NaN
StockOptionLevel	NaN	1.000000	0.010136
TotalWorkingYears	NaN	0.010136	1.000000
TrainingTimesLastYear	NaN	0.011274	-0.035662
WorkLifeBalance	NaN	0.004129	0.001008
YearsAtCompany	NaN	0.015058	0.628133
YearsInCurrentRole	NaN	0.050818	0.460365
YearsSinceLastPromotion	NaN	0.014352	0.404858
YearsWithCurrManager	NaN	0.024698	0.459188

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

YearsAtCompany	0.003569	0.012089
YearsInCurrentRole	-0.005738	0.049856
YearsSinceLastPromotion	-0.002067	0.008941
YearsWithCurrManager	-0.004096	0.002759

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

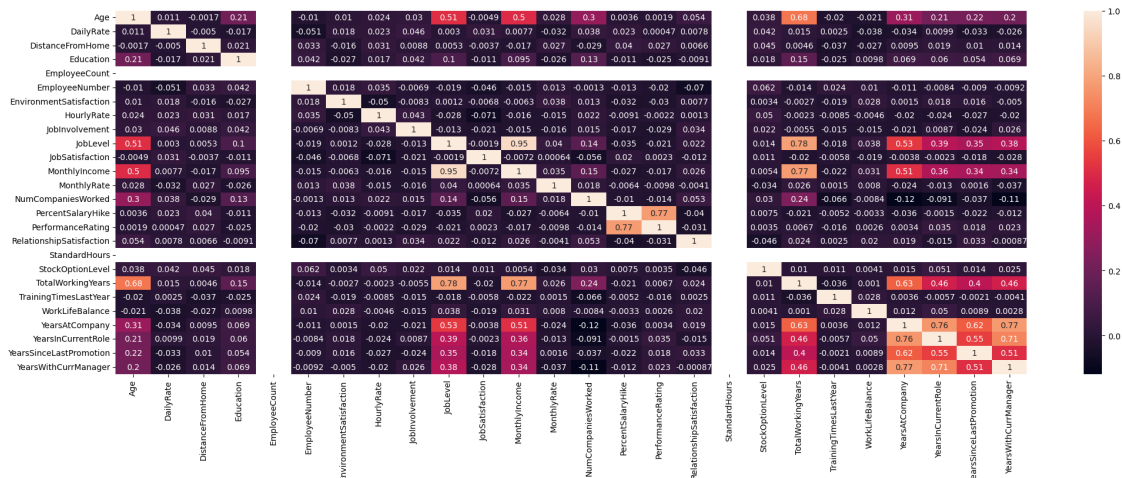
	YearsSinceLastPromotion	YearsWithCurrManager
Age	0.216513	0.202089
DailyRate	-0.033229	-0.026363
DistanceFromHome	0.010029	0.014406
Education	0.054254	0.069065
EmployeeCount	NaN	NaN
EmployeeNumber	-0.009019	-0.009197
EnvironmentSatisfaction	0.016194	-0.004999
HourlyRate	-0.026716	-0.020123
JobInvolvement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

PercentSalaryHike	-0.022154	-0.011985
PerformanceRating	0.017896	0.022827
RelationshipSatisfaction	0.033493	-0.000867
StandardHours	NaN	NaN
StockOptionLevel	0.014352	0.024698
TotalWorkingYears	0.404858	0.459188
TrainingTimesLastYear	-0.002067	-0.004096
WorkLifeBalance	0.008941	0.002759
YearsAtCompany	0.618409	0.769212
YearsInCurrentRole	0.548056	0.714365
YearsSinceLastPromotion	1.000000	0.510224
YearsWithCurrManager	0.510224	1.000000

[26 rows x 26 columns]

```
[11]: plt.subplots(figsize=(25,8))
sns.heatmap(correlation_matrix,annot=True)
```

[11]: <Axes: >



## 0.0.6 Checking and Handling Null Values

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

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

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

```
[13]: 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
```

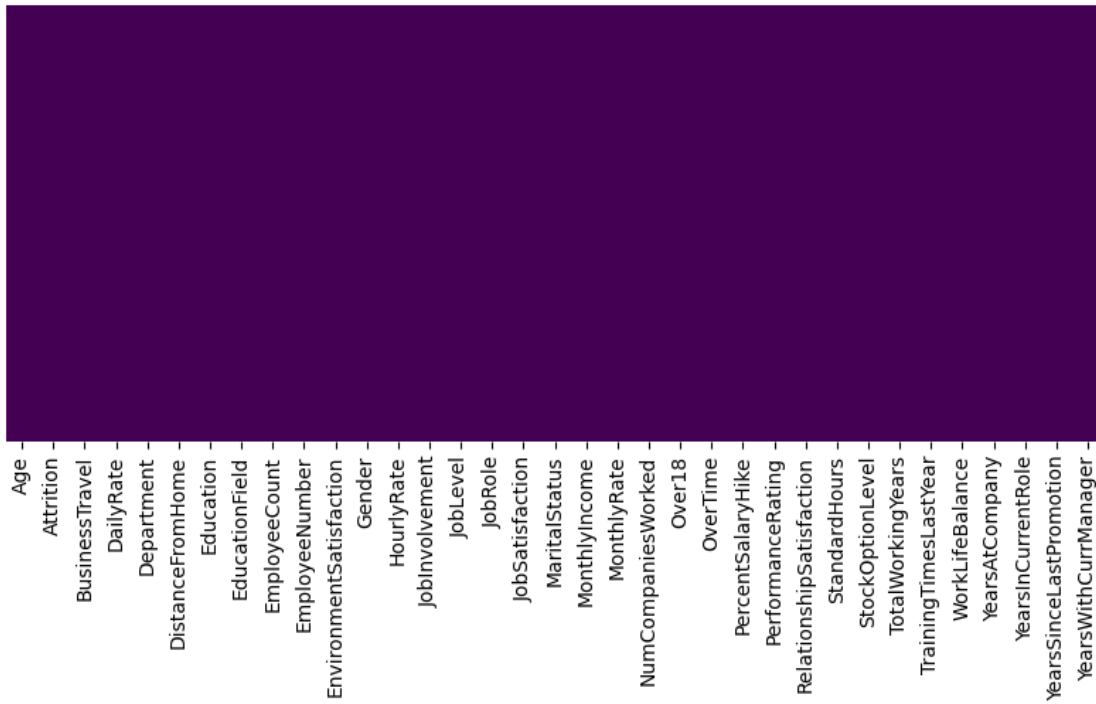
JobRole	0
JobSatisfaction	0
MaritalStatus	0
MonthlyIncome	0
MonthlyRate	0
NumCompaniesWorked	0
Over18	0
OverTime	0
PercentSalaryHike	0
PerformanceRating	0
RelationshipSatisfaction	0
StandardHours	0
StockOptionLevel	0
TotalWorkingYears	0
TrainingTimesLastYear	0
WorkLifeBalance	0
YearsAtCompany	0
YearsInCurrentRole	0
YearsSinceLastPromotion	0
YearsWithCurrManager	0

dtype: int64

### 0.0.7 Data Visualization.

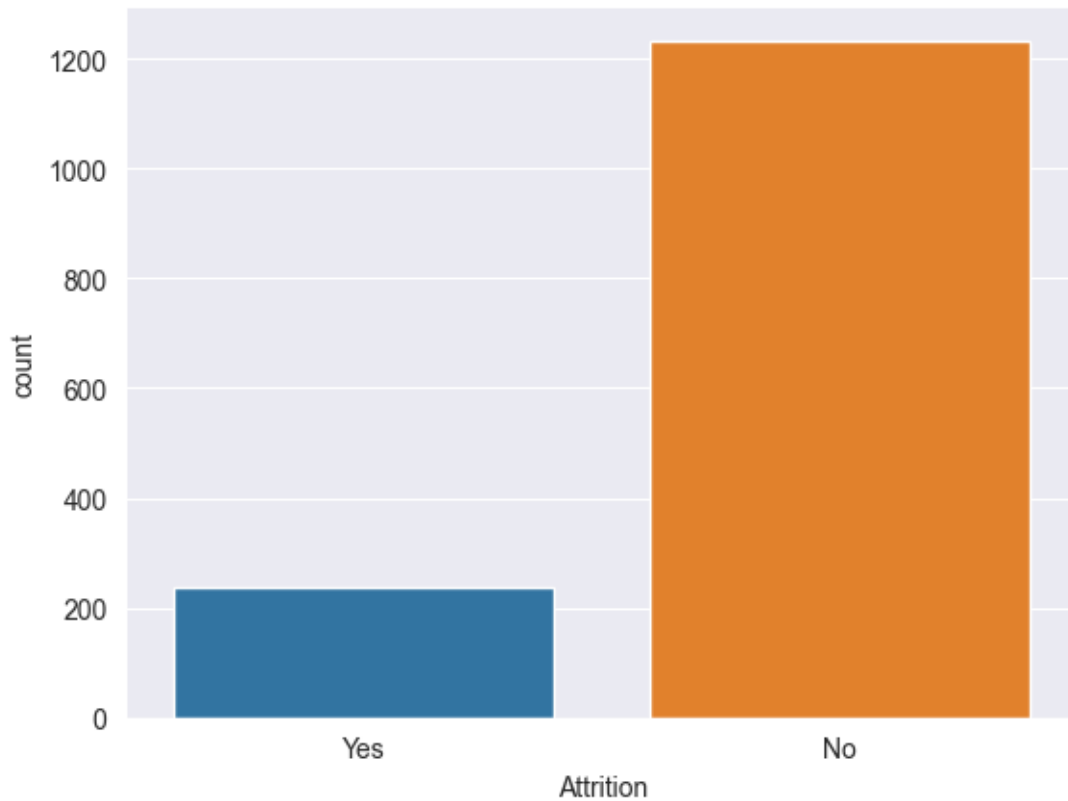
```
[14]: # heatmap to check the missing value
plt.figure(figsize =(10, 4))
sns.heatmap(df.isnull(), yticklabels = False, cbar = False, cmap ='viridis')
```

```
[14]: <Axes: >
```



```
[15]: sns.set_style('darkgrid')
      sns.countplot(x='Attrition', data=df)

[15]: <Axes: xlabel='Attrition', ylabel='count'>
```

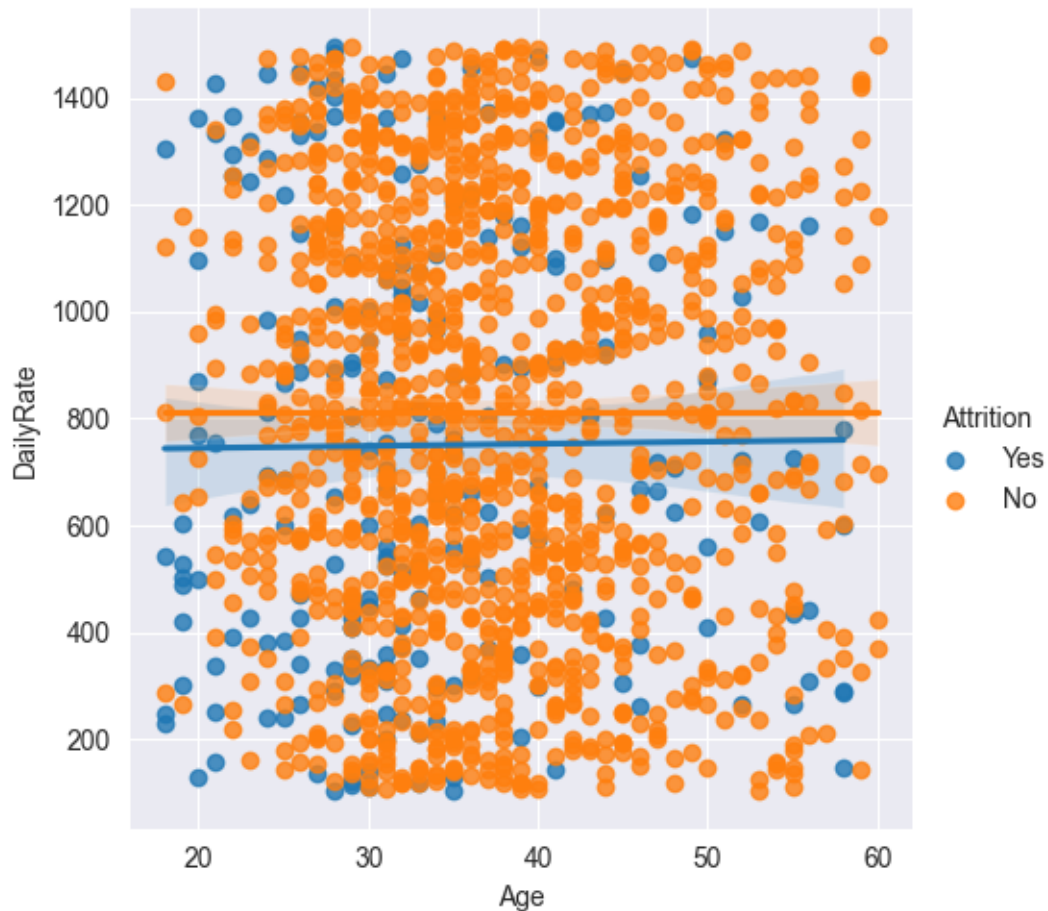


```
[16]: sns.lmplot(x = 'Age', y = 'DailyRate', hue = 'Attrition', data = df)
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-  
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to  
tight  
    self._figure.tight_layout(*args, **kwargs)
```

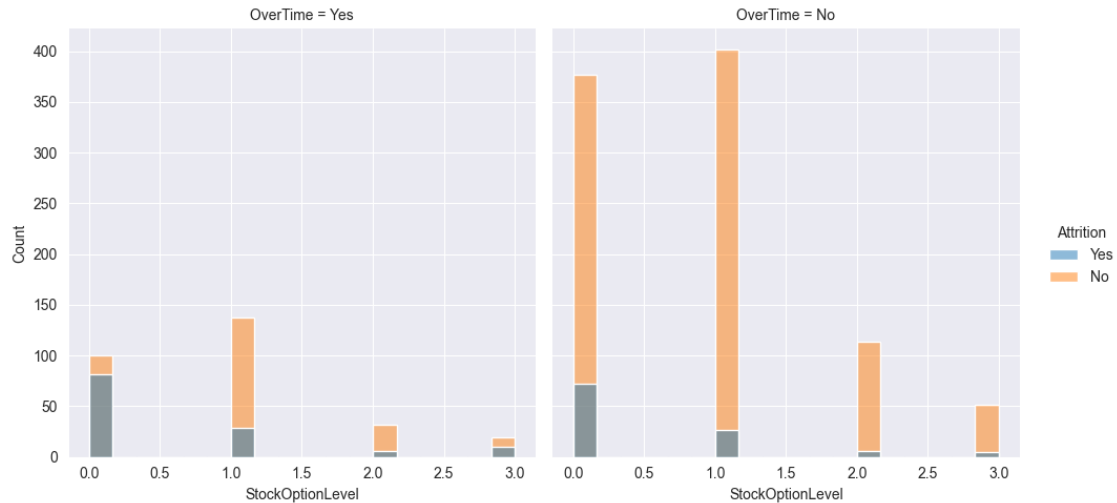
```
[16]: <seaborn.axisgrid.FacetGrid at 0x22b60741ed0>
```





```
[17]: sns.displot(data=df, x="StockOptionLevel", hue="Attrition", col="OverTime")
plt.show()
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to
tight
    self._figure.tight_layout(*args, **kwargs)
```

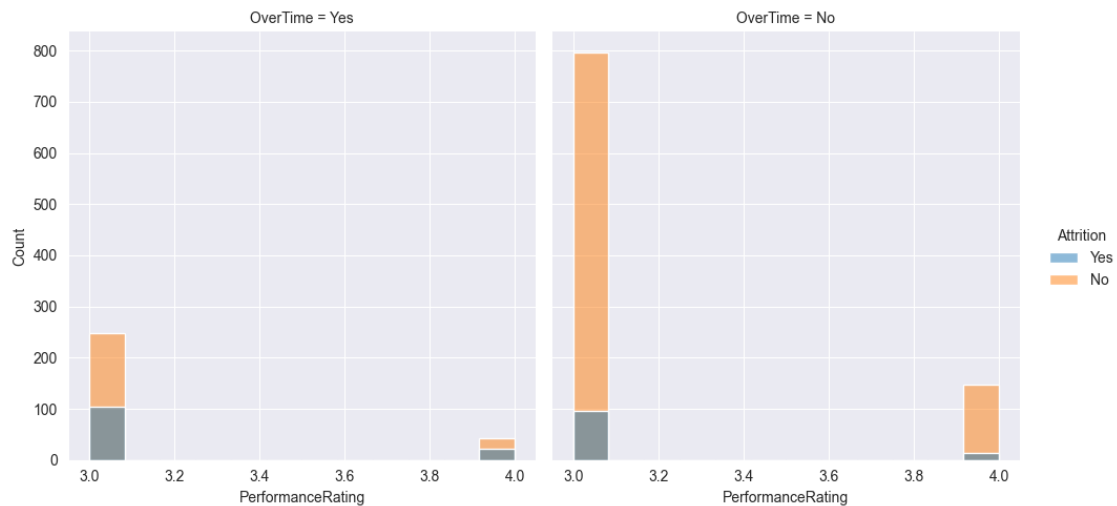


```
[18]: sns.displot(data = df, x = "PerformanceRating", hue = "Attrition", col = "OverTime")
```

c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to tight

```
self._figure.tight_layout(*args, **kwargs)
```

```
[18]: <seaborn.axisgrid.FacetGrid at 0x22b5fb79510>
```

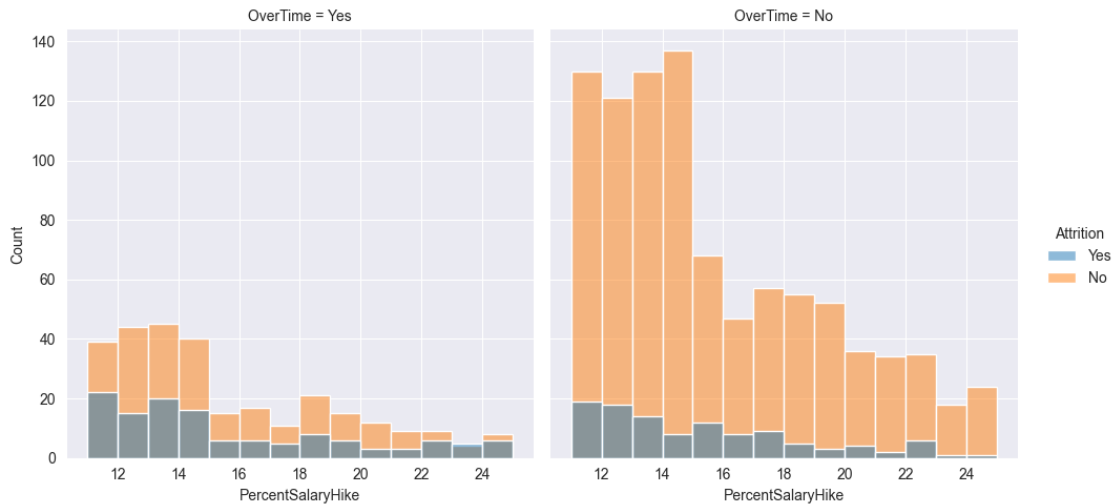


```
[19]: sns.displot(data = df, x = "PercentSalaryHike", hue = "Attrition", col = "OverTime")
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-  
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to  
tight
```

```
self._figure.tight_layout(*args, **kwargs)
```

```
[19]: <seaborn.axisgrid.FacetGrid at 0x22b5fed2350>
```

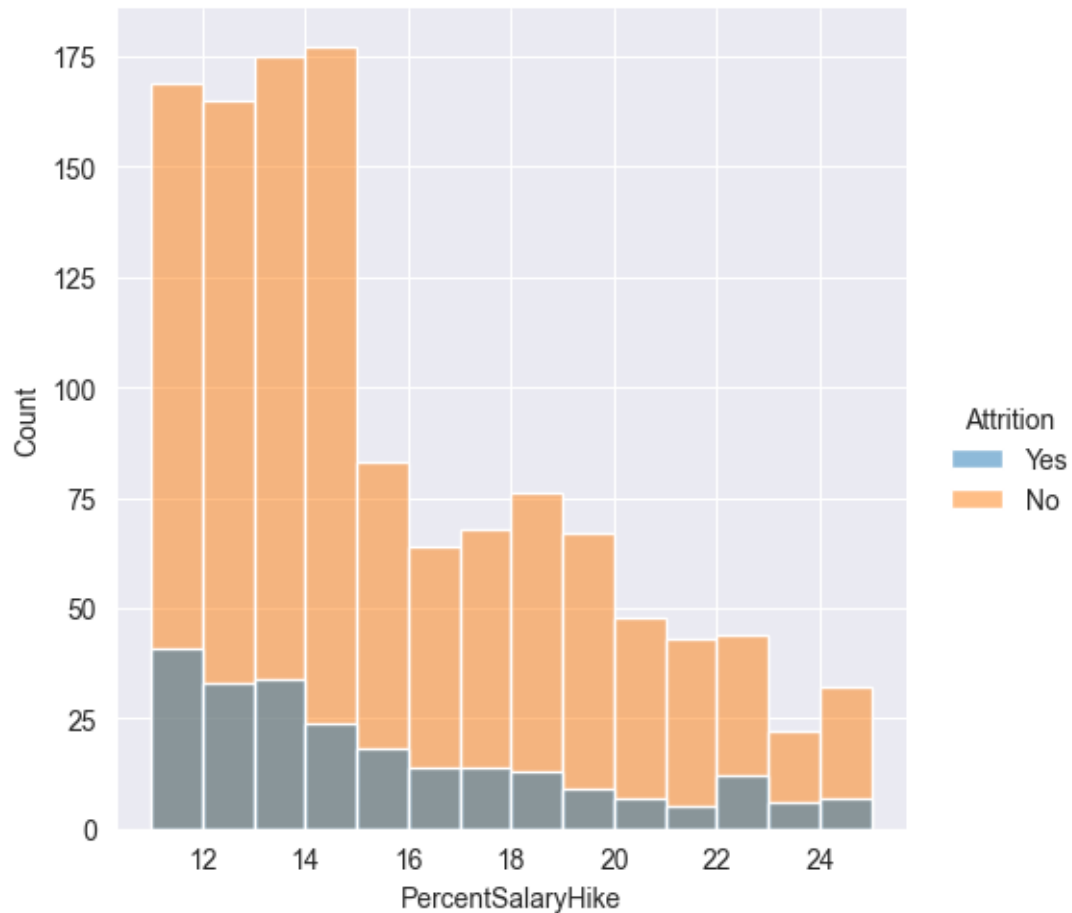


```
[20]: sns.displot(data = df, x = "PercentSalaryHike", hue = "Attrition")
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-  
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to  
tight
```

```
self._figure.tight_layout(*args, **kwargs)
```

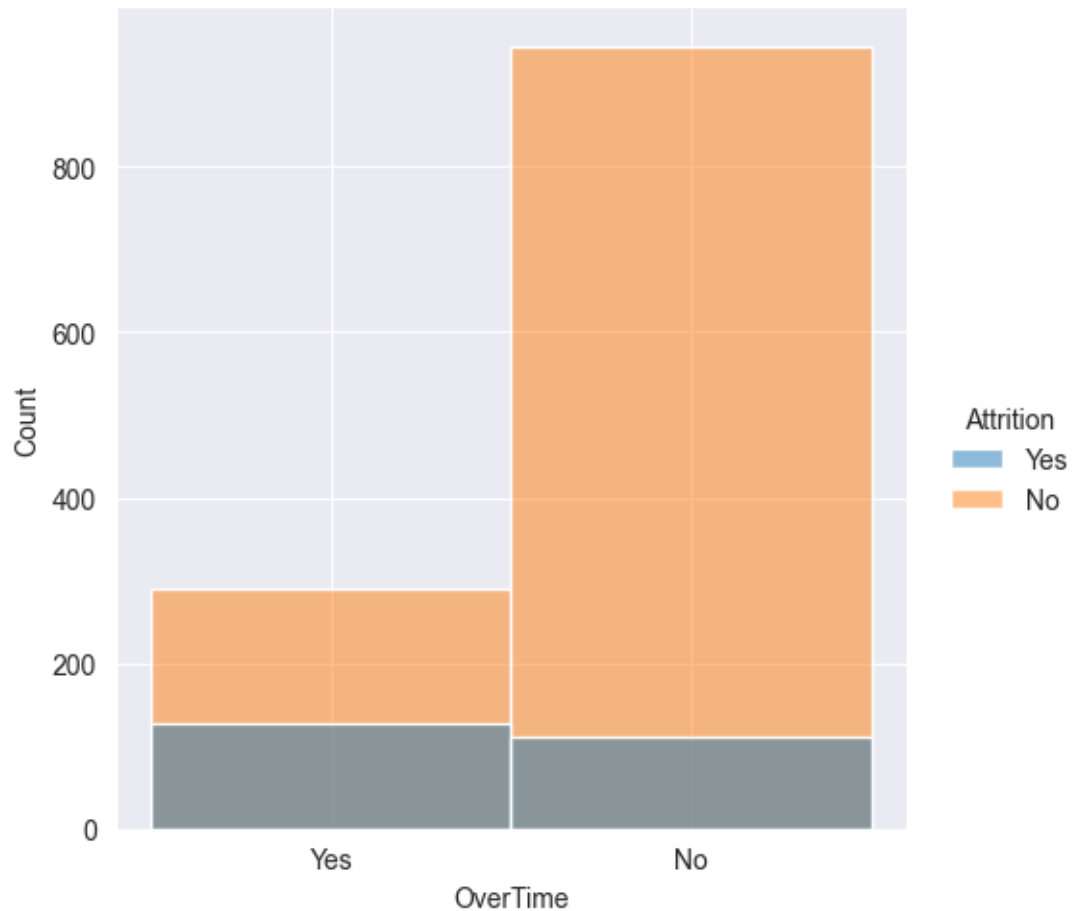
```
[20]: <seaborn.axisgrid.FacetGrid at 0x22b601e37d0>
```



```
[21]: sns.displot(data = df, x = "OverTime", hue = "Attrition")
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to
tight
    self._figure.tight_layout(*args, **kwargs)
```

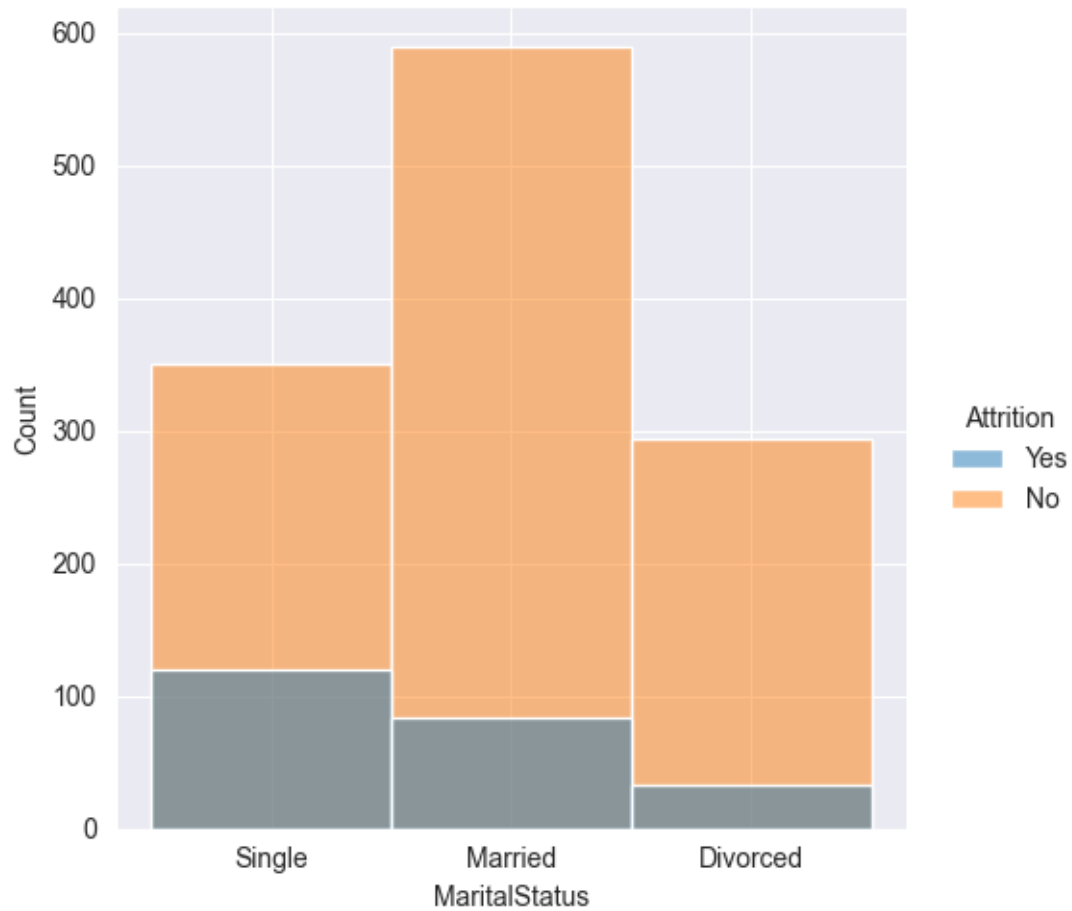
```
[21]: <seaborn.axisgrid.FacetGrid at 0x22b6066eed0>
```



```
[22]: sns.displot(data = df, x = "MaritalStatus", hue = "Attrition")
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-  
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to  
tight  
    self._figure.tight_layout(*args, **kwargs)
```

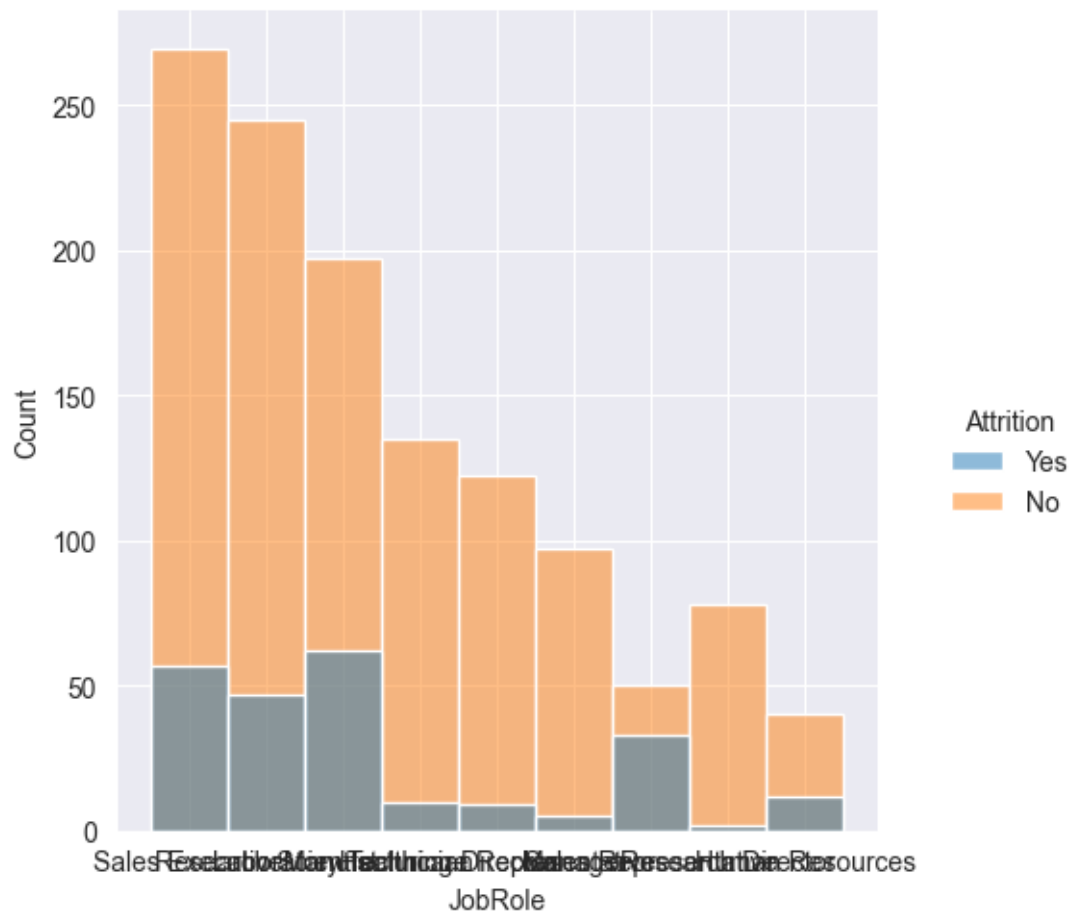
```
[22]: <seaborn.axisgrid.FacetGrid at 0x22b61c40b10>
```



```
[23]: sns.displot(data = df, x = "JobRole", hue = "Attrition", height = 5)
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-  
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to  
tight  
    self._figure.tight_layout(*args, **kwargs)
```

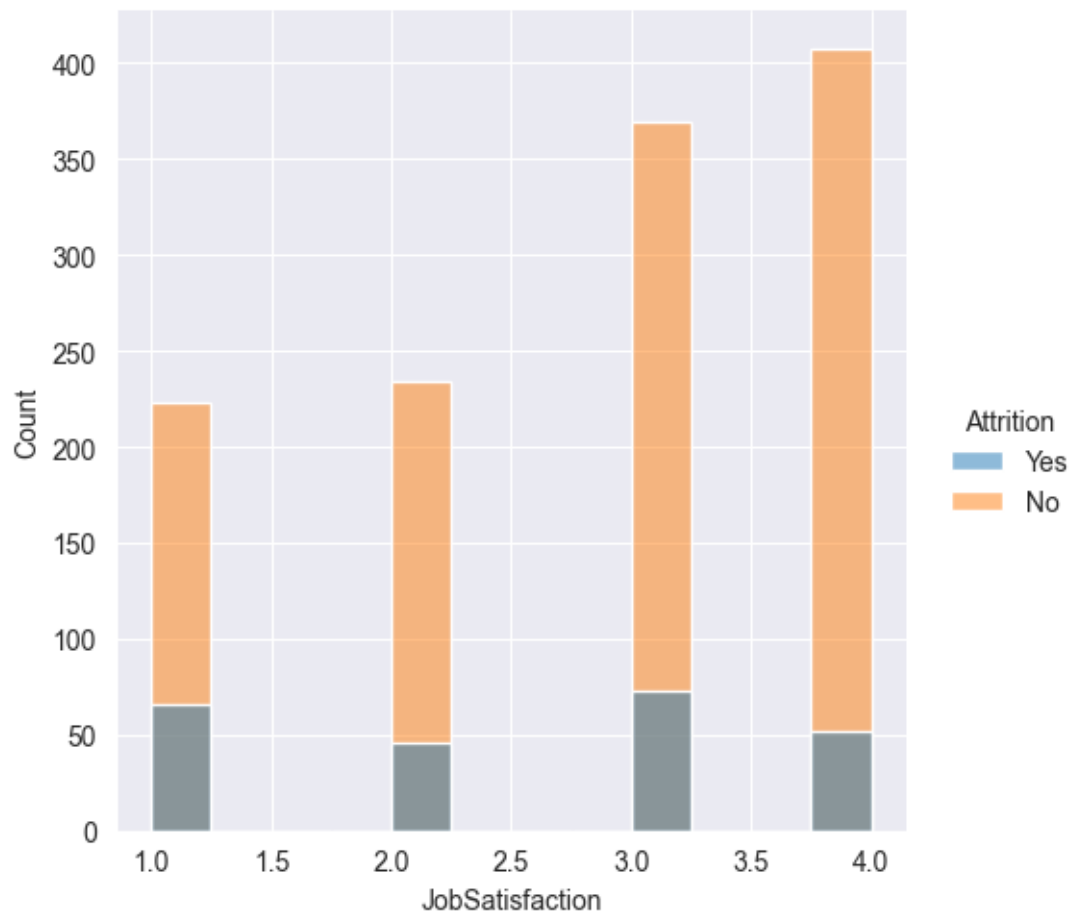
```
[23]: <seaborn.axisgrid.FacetGrid at 0x22b61ca3ed0>
```



```
[24]: sns.displot(data = df, x = "JobSatisfaction", hue = "Attrition")
```

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to
tight
    self._figure.tight_layout(*args, **kwargs)
```

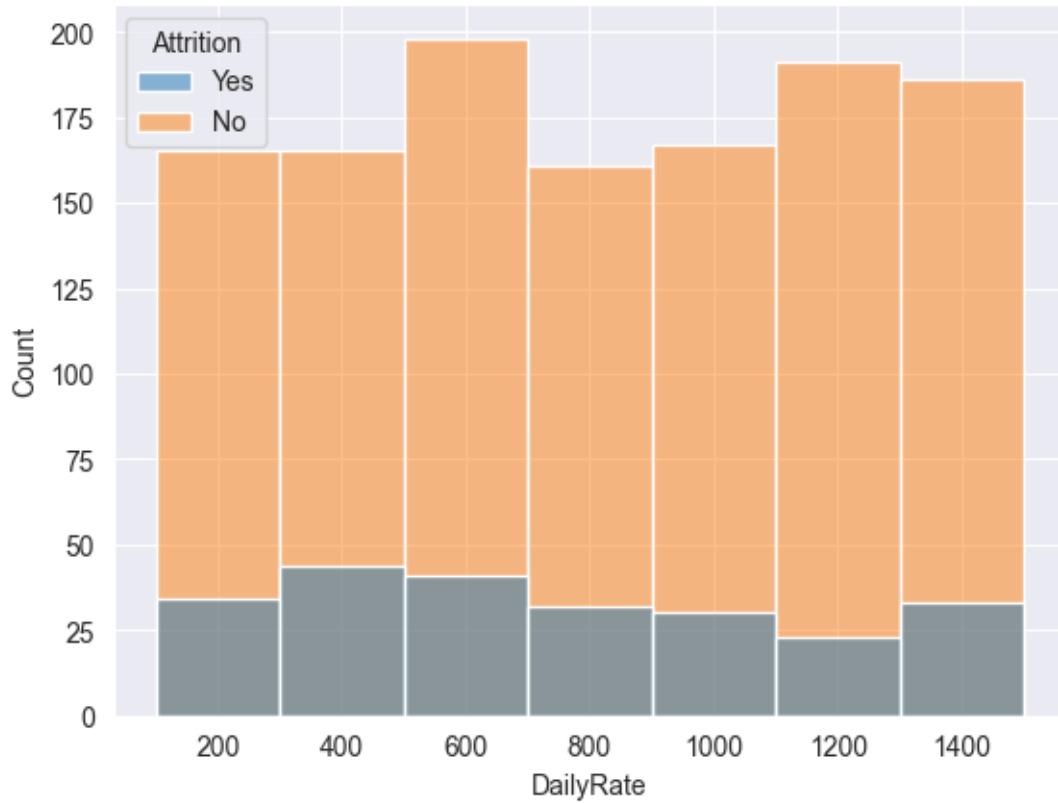
```
[24]: <seaborn.axisgrid.FacetGrid at 0x22b61d01410>
```



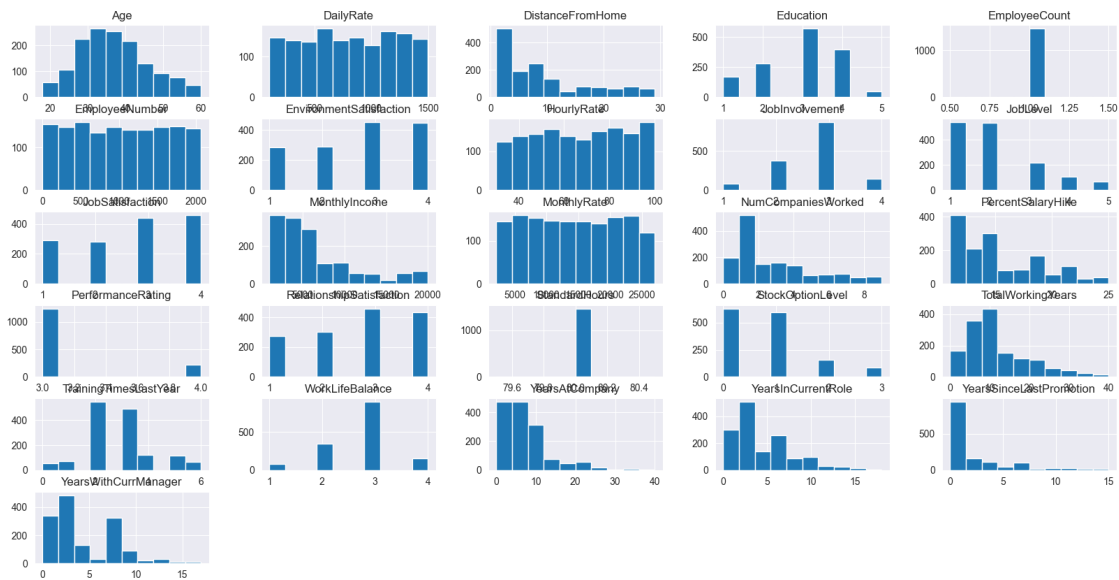
```
[25]: plt.figure()  
sns.histplot(data = df, x = "DailyRate", hue = "Attrition", bins = 7)
```

```
[25]: <Axes: xlabel='DailyRate', ylabel='Count'>
```

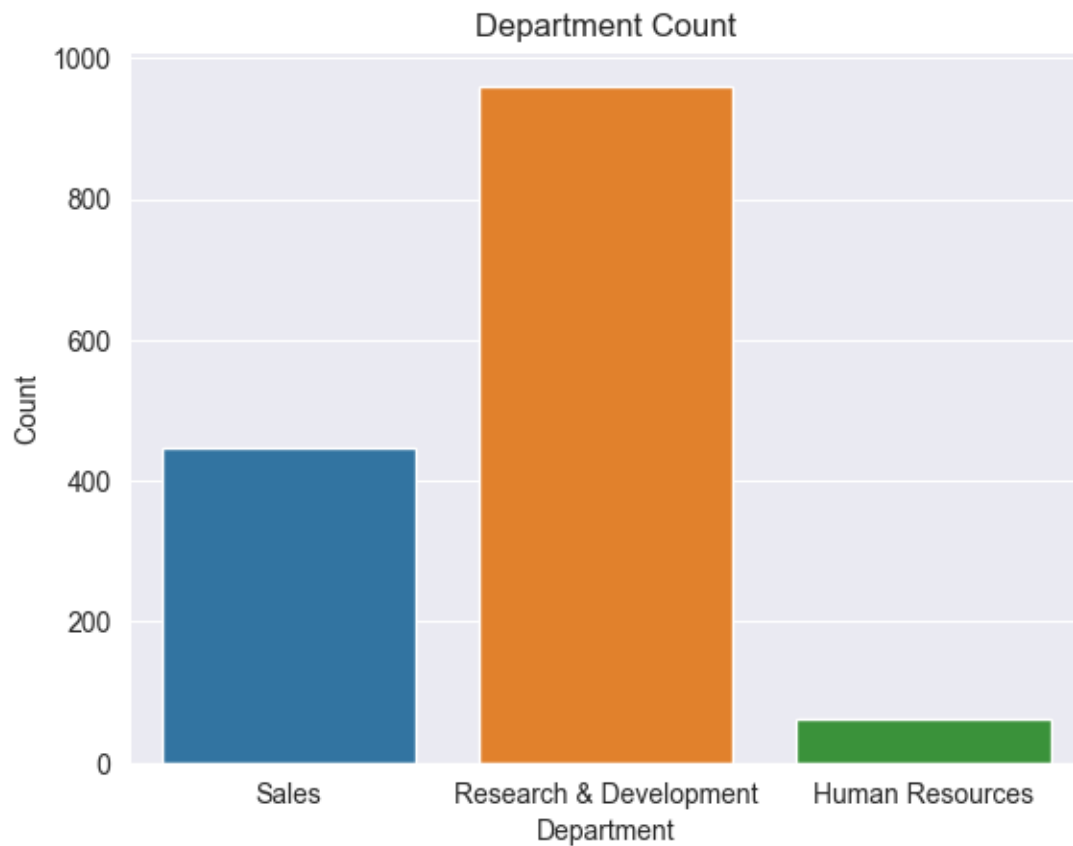




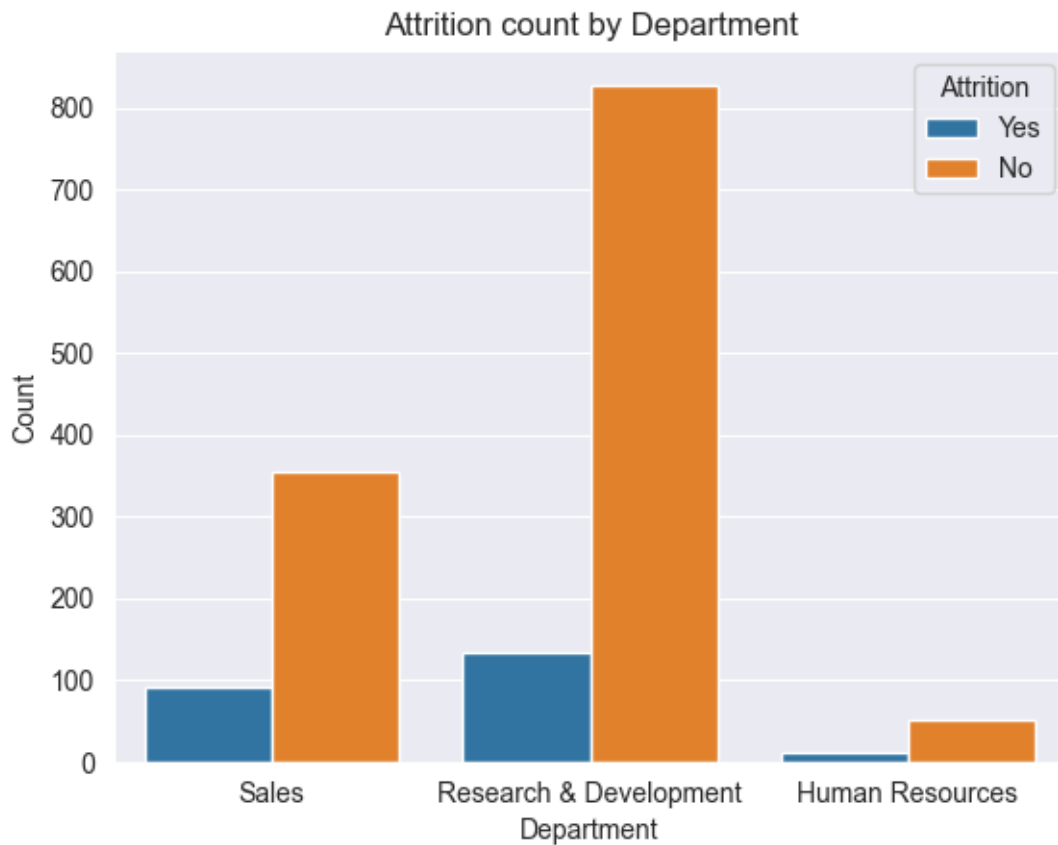
```
[26]: df.hist(figsize=(20,10))
plt.show()
```



```
[27]: sns.countplot(x='Department', data=df)
plt.title('Department Count')
plt.xlabel('Department')
plt.ylabel('Count')
plt.show()
```

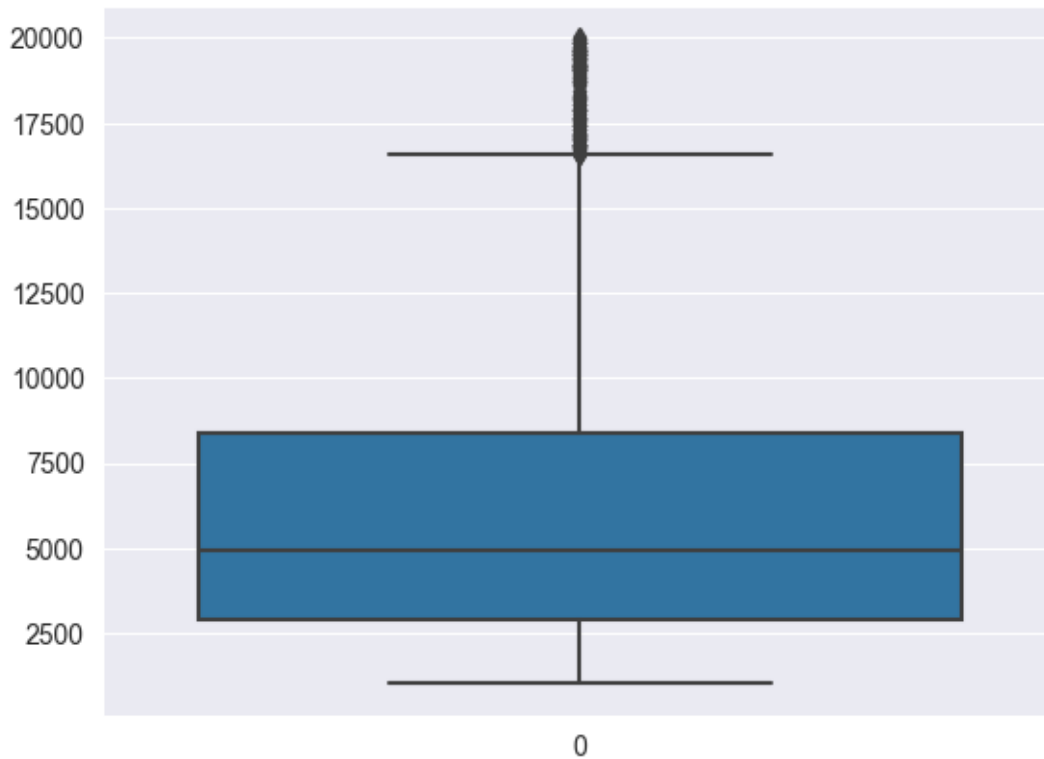


```
[28]: sns.countplot(x='Department', hue='Attrition', data=df)
plt.title('Attrition count by Department')
plt.xlabel('Department')
plt.ylabel('Count')
plt.show()
```



```
[29]: sns.histplot(df['Attrition'], bins=20, kde=True)
plt.title('Attrition count')
plt.xlabel('Attrition')
plt.ylabel('Frequency')
plt.show()
```





```
[32]: q1 = df.MonthlyIncome.quantile(0.25)
      q3 = df.MonthlyIncome.quantile(0.75)
      print(q1)
      print(q3)
      IQR = q3-q1
      print(IQR)
      ul = q3+1.5*IQR
      print(ul)
      ll = q1-1.5*IQR
      print(ll)
```

```
2911.0
8379.0
5468.0
16581.0
-5291.0
```

```
[33]: numeric_columns = df.select_dtypes(include=['number']).columns
      df[numeric_columns].median()
```

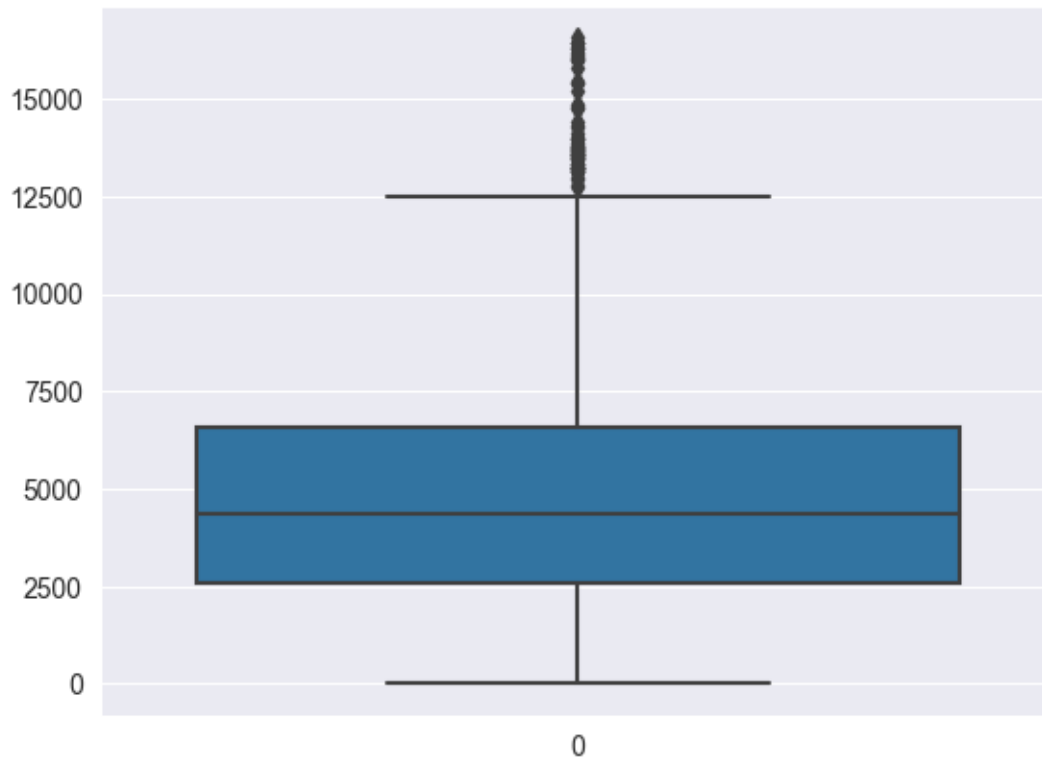
```
[33]: Age                36.0
      DailyRate          802.0
```

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

```
[34]: df['MonthlyIncome'] = np.where(df['MonthlyIncome']>u1,0,df['MonthlyIncome'])
```

```
[35]: sns.boxplot(df.MonthlyIncome)
```

```
[35]: <Axes: >
```



```
[36]: q1 = df.MonthlyIncome.quantile(0.25)
q3 = df.MonthlyIncome.quantile(0.75)
print(q1)
print(q3)
IQR = q3-q1
print(IQR)
ul = q3+1.5*IQR
print(ul)
ll = q1-1.5*IQR
print(ll)
```

```
2579.25
6581.0
4001.75
12583.625
-3423.375
```

```
[37]: numeric_columns = df.select_dtypes(include=['number']).columns
df[numeric_columns].median()
```

```
[37]: Age                36.0
DailyRate              802.0
```

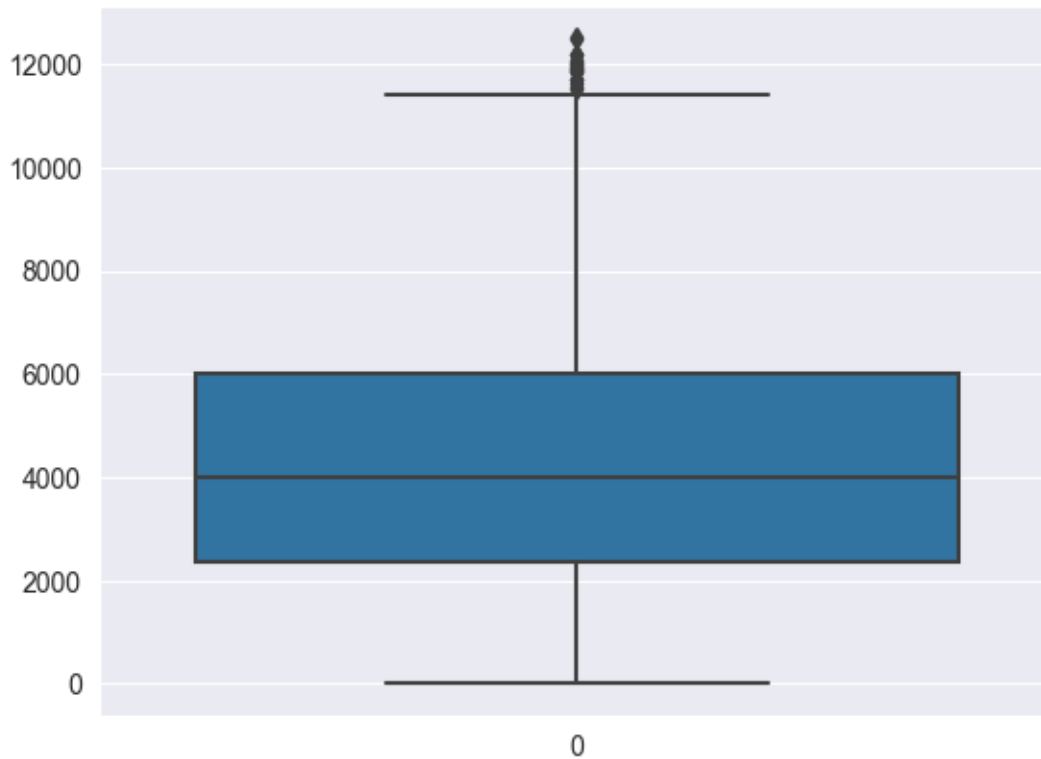
DistanceFromHome	7.0
Education	3.0
EmployeeCount	1.0
EmployeeNumber	1020.5
EnvironmentSatisfaction	3.0
HourlyRate	66.0
JobInvolvement	3.0
JobLevel	2.0
JobSatisfaction	3.0
MonthlyIncome	4373.5
MonthlyRate	14235.5
NumCompaniesWorked	2.0
PercentSalaryHike	14.0
PerformanceRating	3.0
RelationshipSatisfaction	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

```
[38]: df['MonthlyIncome'] = np.where(df['MonthlyIncome']>u1,0,df['MonthlyIncome'])
```

```
[39]: sns.boxplot(df.MonthlyIncome)
```

```
[39]: <Axes: >
```





```
[40]: q1 = df.MonthlyIncome.quantile(0.25)
      q3 = df.MonthlyIncome.quantile(0.75)
      print(q1)
      print(q3)
      IQR = q3-q1
      print(IQR)
      ul = q3+1.5*IQR
      print(ul)
      ll = q1-1.5*IQR
      print(ll)
```

```
2372.0
5993.0
3621.0
11424.5
-3059.5
```

```
[41]: numeric_columns = df.select_dtypes(include=['number']).columns
      df[numeric_columns].median()
```

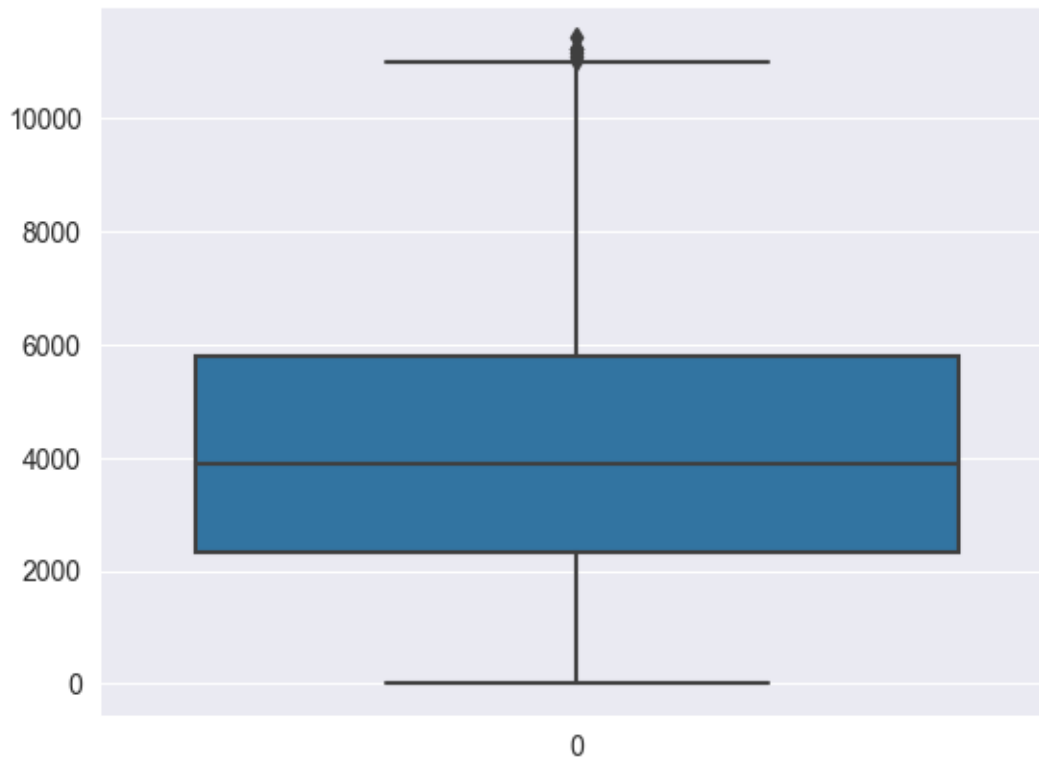
```
[41]: Age                36.0
      DailyRate          802.0
```

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	4012.5
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

```
[42]: df['MonthlyIncome'] = np.where(df['MonthlyIncome']>u1,0,df['MonthlyIncome'])
```

```
[43]: sns.boxplot(df.MonthlyIncome)
```

```
[43]: <Axes: >
```



### 0.0.9 Splitting Dependent and independent Variables

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

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

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

   ... RelationshipSatisfaction  StandardHours  StockOptionLevel \
0   ...                1             80             0
1   ...                4             80             1
2   ...                2             80             0
```

3	...	3	80	0
4	...	4	80	1

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

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

[5 rows x 35 columns]

From the correlation table we can observe that Joblevel, MonthlyIncome, TotalWorkingYears, YearsAtCompany, YearsInCurrentRole, YearsSinceLastPromotion, and YearsWithCurrManager are highly correlated. So, we can take these attributes as consideration and we can split the data. Along with this I am taking the Gender attribute also.

```
[45]: x=df.
      ↪drop(columns=["Age","BusinessTravel","DailyRate","Department","DistanceFromHome","Education"])
      x.head()
```

```
[45]:   Gender  JobLevel  MonthlyIncome  TotalWorkingYears  YearsAtCompany \
0  Female         2         5993             8             6
1   Male         2         5130            10            10
2   Male         1         2090             7             0
3  Female         1         2909             8             8
4   Male         1         3468             6             2

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

```
[46]: type(x)
```

```
[46]: pandas.core.frame.DataFrame
```

```
[47]: y=df["Attrition"]
      y.head()
```

```
[47]: 0    Yes
      1    No
      2    Yes
      3    No
      4    No
      Name: Attrition, dtype: object
```

```
[48]: type(y)
```

```
[48]: pandas.core.series.Series
```

```
[49]: df.Attrition.value_counts()
```

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

### 0.0.10 Encoding

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

```
[50]:   Gender  JobLevel  MonthlyIncome  TotalWorkingYears  YearsAtCompany  \
0  Female         2         5993             8             6
1   Male         2         5130            10            10
2   Male         1         2090             7             0
3  Female         1         2909             8             8
4   Male         1         3468             6             2

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

```
[51]: from sklearn.preprocessing import LabelEncoder
      le=LabelEncoder()
```

```
[52]: x["Gender"]=le.fit_transform(x["Gender"])
```

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

```
[53]:
```

	Gender	JobLevel	MonthlyIncome	TotalWorkingYears	YearsAtCompany	\
0	0	2	5993	8	6	
1	1	2	5130	10	10	
2	1	1	2090	7	0	
3	0	1	2909	8	8	
4	1	1	3468	6	2	

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

```
[54]: type(x)
```

```
[54]: pandas.core.frame.DataFrame
```

```
[55]: print(le.classes_)
```

```
['Female' 'Male']
```

```
[56]: mapping=dict(zip(le.classes_,range(len(le.classes_))))
mapping
```

```
[56]: {'Female': 0, 'Male': 1}
```

```
[57]: y=le.fit_transform(y)
y = pd.DataFrame({'Encoded_Column': y})
print(y)
```

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

```
[1470 rows x 1 columns]
```

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

```
[58]: Encoded_Column
      0          1
      1          0
      2          1
      3          0
      4          0
```

```
[59]: print(le.classes_)

['No' 'Yes']
```

```
[60]: mapping=dict(zip(le.classes_,range(len(le.classes_))))
      mapping
```

```
[60]: {'No': 0, 'Yes': 1}
```

### 0.0.11 Feature Scaling

```
[61]: from sklearn.preprocessing import MinMaxScaler
      ms=MinMaxScaler()
```

```
[62]: X_Scaled=ms.fit_transform(x)
```

```
[63]: X_Scaled=pd.DataFrame(ms.fit_transform(x),columns=x.columns)
```

```
[64]: X_Scaled.head()
```

```
[64]:   Gender  JobLevel  MonthlyIncome  TotalWorkingYears  YearsAtCompany  \
0     0.0     0.25     0.524965         0.200         0.15
1     1.0     0.25     0.449369         0.250         0.25
2     1.0     0.00     0.183076         0.175         0.00
3     0.0     0.00     0.254818         0.200         0.20
4     1.0     0.00     0.303784         0.150         0.05

      YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0          0.222222         0.000000         0.294118
1          0.388889         0.066667         0.411765
2          0.000000         0.000000         0.000000
3          0.388889         0.200000         0.000000
4          0.111111         0.133333         0.117647
```

### 0.0.12 Splitting and Training

```
[65]: 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.
      ↪3,random_state =0)
```

```
[66]: print(x_train.shape,x_test.shape,y_train.shape,y_test.shape)
```

```
(1029, 8) (441, 8) (1029, 1) (441, 1)
```

```
[67]: x_test.head()
```

```
[67]:      Gender  JobLevel  MonthlyIncome  TotalWorkingYears  YearsAtCompany  \
442      1.0      0.50      0.874212          0.250          0.250
1091     1.0      0.25      0.378416          0.125          0.125
981      0.0      0.25      0.404170          0.125          0.100
785      1.0      0.50      0.904170          0.350          0.275
1332     1.0      0.00      0.213648          0.025          0.025

      YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
442              0.166667              0.600000          0.411765
1091              0.166667              0.000000          0.117647
981              0.111111              0.200000          0.117647
785              0.555556              0.733333          0.058824
1332              0.000000              0.066667          0.000000
```

```
[68]: x_train.head()
```

```
[68]:      Gender  JobLevel  MonthlyIncome  TotalWorkingYears  YearsAtCompany  \
338      0.0      0.25      0.535915          0.250          0.250
363      0.0      0.00      0.249737          0.025          0.025
759      1.0      0.00      0.190697          0.150          0.150
793      1.0      0.00      0.193325          0.100          0.100
581      1.0      0.00      0.335757          0.175          0.050

      YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
338              0.500000              0.066667          0.117647
363              0.000000              0.000000          0.000000
759              0.166667              0.000000          0.235294
793              0.111111              0.133333          0.117647
581              0.111111              0.000000          0.117647
```

```
[69]: y_train.head()
```

```
[69]:      Encoded_Column
338              0
363              1
759              0
793              0
581              0
```

```
[70]: y_test.head()
```



[70]:	Encoded_Column
442	0
1091	0
981	1
785	0
1332	1

### 0.0.13 Model Building

### 0.0.14 1.Logestic Regression

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

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

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\utils\validation.py:1184: DataConversionWarning: A column-
vector y was passed when a 1d array was expected. Please change the shape of y
to (n_samples, ), for example using ravel().
    y = column_or_1d(y, warn=True)
```

```
[72]: LogisticRegression()
```

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

```
[74]: pred
```

[illegible]

[illegible]

```
[75]: comparison_df = pd.DataFrame({'Original_Target': y_test.values.ravel(),  
    ↪ 'Predicted_Target': pred})  
print(comparison_df)
```

	Original_Target	Predicted_Target
0	0	0
1	0	0
2	1	0
3	0	0
4	1	0
..	...	...
436	0	0
437	0	0
438	0	0
439	0	0
440	0	0

```
[441 rows x 2 columns]
```

### 0.0.15 Evaluation of classification model

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

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

```
[77]: 0.8412698412698413
```

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

```
[78]: array([[371, 0],
            [ 70, 0]], dtype=int64)
```

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

	precision	recall	f1-score	support
0	0.84	1.00	0.91	371
1	0.00	0.00	0.00	70
accuracy			0.84	441
macro avg	0.42	0.50	0.46	441
weighted avg	0.71	0.84	0.77	441

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
_warn_prf(average, modifier, msg_start, len(result))
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
_warn_prf(average, modifier, msg_start, len(result))
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
_warn_prf(average, modifier, msg_start, len(result))
```

## 0.0.16 Roc-Curve

```
[80]: probability=model.predict_proba(x_test)[: ,1]
```

```
[81]: probability
```

```
[81]: array([0.17928973, 0.17235767, 0.21251875, 0.18682805, 0.32226918,
0.2880949 , 0.12070868, 0.08697143, 0.04827248, 0.24054033,
0.04381157, 0.21823068, 0.167615 , 0.13858794, 0.05215219,
0.19962552, 0.16009079, 0.17413158, 0.06884617, 0.25884685,
0.28926723, 0.01867211, 0.18197724, 0.20455115, 0.19240775,
0.12271286, 0.15536886, 0.09270403, 0.25924301, 0.18877013,
0.06528336, 0.12206556, 0.09310193, 0.04852661, 0.17363179,
0.08883879, 0.07174179, 0.22233128, 0.09205499, 0.2918774 ,
0.08444337, 0.11419479, 0.02241212, 0.05067629, 0.11788116,
0.20761755, 0.26069612, 0.09560411, 0.2736557 , 0.31736368,
0.08114789, 0.21282847, 0.1386984 , 0.15320618, 0.24706442,
0.1522631 , 0.13495744, 0.13846162, 0.21904135, 0.19341346,
0.1207491 , 0.19395866, 0.13804866, 0.13709587, 0.11948668,
0.11977759, 0.18586792, 0.09346655, 0.23833981, 0.26303437,
0.06640817, 0.18565026, 0.11802655, 0.16125075, 0.18354227,
0.24113531, 0.16165553, 0.06831245, 0.28029144, 0.08831622,
0.02622413, 0.11069344, 0.25587007, 0.21837539, 0.11492076,
0.18467003, 0.00792889, 0.26136542, 0.12533397, 0.10939975,
0.29088359, 0.13463884, 0.15447928, 0.18529657, 0.08063305,
0.1738178 , 0.16766288, 0.20663194, 0.25213605, 0.1639086 ,
0.1914529 , 0.18632593, 0.08644676, 0.07130602, 0.25834625,
0.18018113, 0.12321397, 0.30392497, 0.15662407, 0.24198624,
0.11854459, 0.06943499, 0.16502458, 0.21253824, 0.15133859,
0.12204522, 0.08736364, 0.12924031, 0.0336808 , 0.11936262,
0.17478781, 0.2175629 , 0.16407931, 0.21469649, 0.137653 ,
```

0.04654064, 0.11049109, 0.18349002, 0.15687705, 0.05732723,  
0.03305747, 0.21013081, 0.27452667, 0.09291664, 0.06607172,  
0.07180071, 0.15208607, 0.28054725, 0.14578284, 0.12193026,  
0.09340079, 0.11905094, 0.08937215, 0.1689817 , 0.12886478,  
0.16438803, 0.12519846, 0.02028862, 0.0808012 , 0.17522701,  
0.15164141, 0.08434763, 0.20426694, 0.01599429, 0.0390376 ,  
0.09824207, 0.09609393, 0.21858545, 0.06709742, 0.10844805,  
0.05992828, 0.07715355, 0.25815025, 0.28875452, 0.16433107,  
0.1585242 , 0.12159424, 0.23245948, 0.2119499 , 0.02493386,  
0.05509406, 0.19072116, 0.19826297, 0.27088766, 0.04909396,  
0.28951421, 0.15735876, 0.04745344, 0.18583331, 0.06115958,  
0.16870129, 0.12372826, 0.06301364, 0.13849933, 0.15034112,  
0.20064423, 0.19183469, 0.08025039, 0.20528894, 0.25478597,  
0.17673892, 0.28868813, 0.2247058 , 0.20446223, 0.29237209,  
0.15885628, 0.14555431, 0.04786139, 0.27485392, 0.16900995,  
0.23248215, 0.22706665, 0.26304947, 0.12375204, 0.13242417,  
0.13125748, 0.30795913, 0.03431375, 0.15648887, 0.11380294,  
0.14978217, 0.26757694, 0.17184478, 0.2481253 , 0.20132747,  
0.1767685 , 0.02325213, 0.2835322 , 0.06076103, 0.30183428,  
0.18962273, 0.3036028 , 0.22644408, 0.14610813, 0.16187623,  
0.17367027, 0.16572088, 0.22540572, 0.32096975, 0.20428905,  
0.09634582, 0.24572579, 0.15488047, 0.13754712, 0.13571371,  
0.19574647, 0.25659961, 0.06576389, 0.12635639, 0.0284863 ,  
0.23407701, 0.17160117, 0.03578006, 0.12650585, 0.11244211,  
0.15140212, 0.16124224, 0.26377101, 0.14553565, 0.06227627,  
0.27249455, 0.08574322, 0.20182483, 0.09392694, 0.20145408,  
0.1751731 , 0.01790509, 0.27885769, 0.25456207, 0.16154177,  
0.14015053, 0.15069401, 0.08342698, 0.16154408, 0.08420864,  
0.27132818, 0.08561788, 0.22085795, 0.1728082 , 0.1618706 ,  
0.14448567, 0.09791806, 0.21270025, 0.12574143, 0.11186701,  
0.05247997, 0.06726115, 0.24394946, 0.14431126, 0.2272068 ,  
0.25335146, 0.2074908 , 0.23207381, 0.06150974, 0.01569933,  
0.27020576, 0.08834694, 0.19400596, 0.01856783, 0.10016424,  
0.19843164, 0.14931788, 0.19655635, 0.17239418, 0.07427077,  
0.18603866, 0.18518469, 0.05987106, 0.31962719, 0.05207641,  
0.26898557, 0.23929452, 0.2880008 , 0.06542656, 0.16952171,  
0.09189516, 0.22395103, 0.12085571, 0.09484432, 0.2849013 ,  
0.18453641, 0.12987407, 0.19161146, 0.09211488, 0.22078786,  
0.20942539, 0.24359511, 0.30258514, 0.2213112 , 0.08415501,  
0.30377356, 0.05275134, 0.16288743, 0.22952154, 0.0987294 ,  
0.05322334, 0.20299044, 0.23720639, 0.04577136, 0.21045024,  
0.08274638, 0.27244724, 0.07054763, 0.25330032, 0.22255821,  
0.0778708 , 0.15431617, 0.05856061, 0.16185605, 0.15478414,  
0.20401475, 0.28853928, 0.08728807, 0.12185537, 0.08952966,  
0.04282257, 0.13686046, 0.04018358, 0.08625635, 0.26138657,  
0.21215499, 0.27301097, 0.16160784, 0.11679029, 0.188466 ,  
0.08751723, 0.21053173, 0.22068526, 0.03836254, 0.19379018,

```

0.04785559, 0.10438733, 0.05963426, 0.17697062, 0.27675415,
0.04058506, 0.05530025, 0.08519353, 0.15772399, 0.28630268,
0.046889 , 0.17008561, 0.27318586, 0.15515881, 0.19689971,
0.04508863, 0.08765144, 0.09149059, 0.14520886, 0.13206894,
0.20541906, 0.17121815, 0.08982819, 0.20700062, 0.0552408 ,
0.30092229, 0.03166527, 0.20172824, 0.1081384 , 0.1937389 ,
0.08317457, 0.10422403, 0.21013224, 0.13625495, 0.30456796,
0.10530653, 0.13249323, 0.20887183, 0.09351335, 0.05991567,
0.26306639, 0.28824196, 0.08193585, 0.22609382, 0.20213711,
0.05410628, 0.18841722, 0.15004198, 0.28776419, 0.13244161,
0.21227751, 0.04752324, 0.2557509 , 0.19790293, 0.23316148,
0.27015924, 0.13436908, 0.2267577 , 0.1097652 , 0.09702918,
0.30150563, 0.16237631, 0.07935192, 0.03878216, 0.05242865,
0.1071914 , 0.13436222, 0.27449374, 0.18084677, 0.12394095,
0.30647113, 0.16583244, 0.2090782 , 0.2021377 , 0.08162692,
0.15112986, 0.06050626, 0.28605945, 0.13007462, 0.06962309,
0.06715661])

```

```

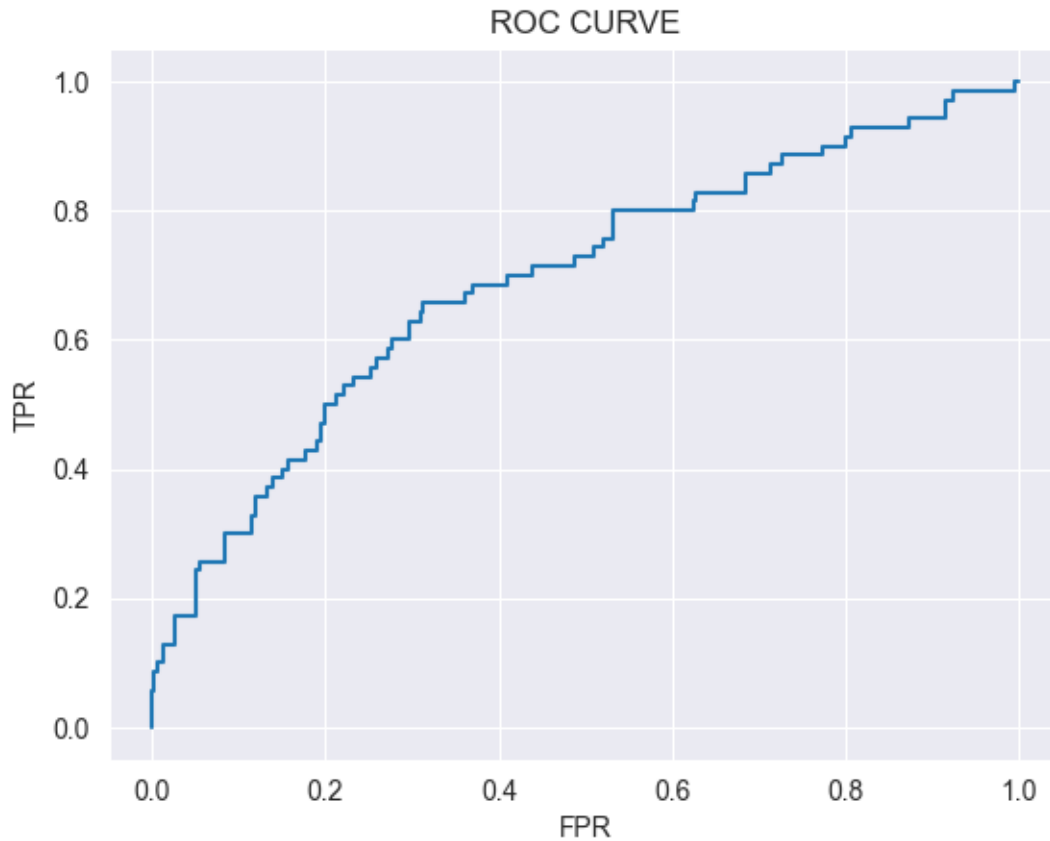
[82]: # roc_curve
fpr,tpr,threshholds = roc_curve(y_test,probability)

```

```

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

```



## 0.0.17 2.Decision tree

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

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

```
[85]: DecisionTreeClassifier()
```

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

```
[87]: pred
```

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

```

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

```

### 0.0.18 Classification

```

[88]: #Accuracy score
from sklearn.metrics import
    accuracy_score, confusion_matrix, classification_report, roc_auc_score, roc_curve

```

```

[89]: accuracy_score(y_test, pred)

```

```

[89]: 0.7324263038548753

```

```

[90]: confusion_matrix(y_test, pred)

```

```

[90]: array([[310,  61],
          [ 57,  13]], dtype=int64)

```

```

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

```

	precision	recall	f1-score	support
0	0.84	0.84	0.84	371
1	0.18	0.19	0.18	70
accuracy			0.73	441
macro avg	0.51	0.51	0.51	441
weighted avg	0.74	0.73	0.74	441

### 0.0.19 Roc-Curve

```

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

```

```

[93]: probability

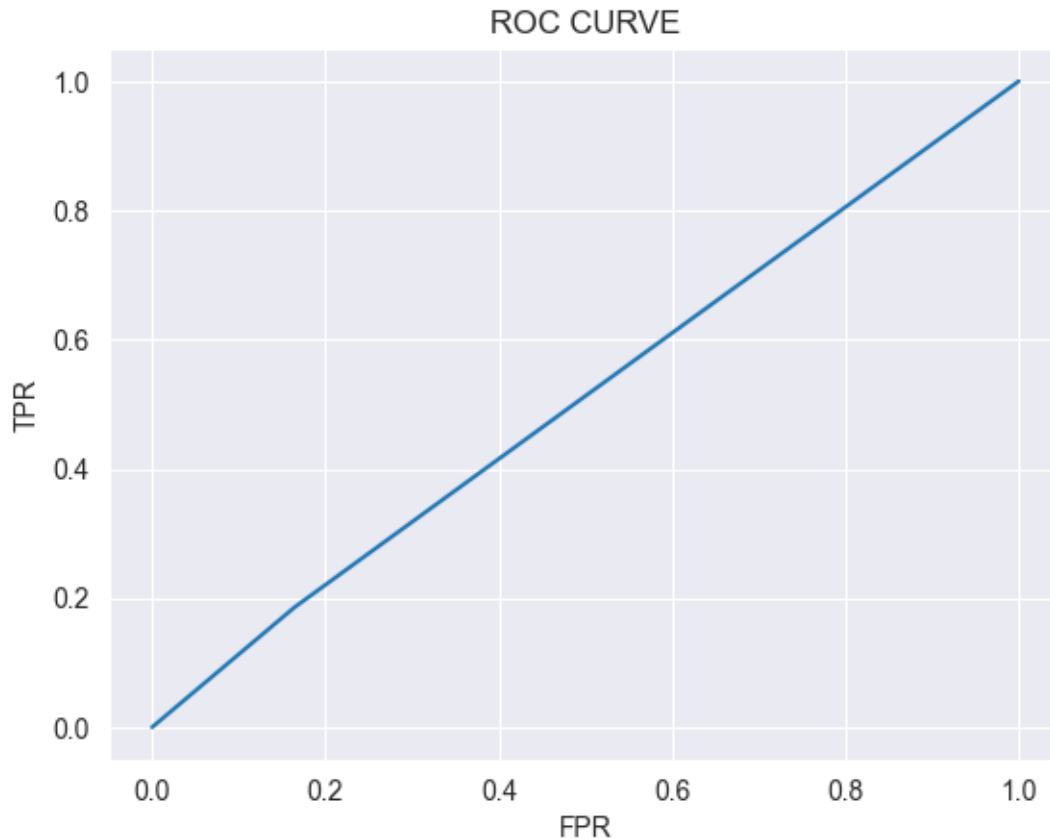
```

```
[93]: array([0., 0., 1., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
0., 0., 0., 0., 0., 1., 1., 1., 0., 0., 1., 1., 0., 0., 1., 0., 1.,
0., 1., 0., 0., 1., 1., 0., 0., 0., 0., 0., 0., 1., 1., 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., 1., 0.,
0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.,
0., 0., 0., 0., 1., 1., 0., 0., 0., 0., 0., 1., 1., 0., 0., 1., 1.,
0., 0., 0., 0., 1., 0., 0., 1., 0., 1., 0., 0., 0., 1., 0., 0., 0.,
0., 1., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
0., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0.,
0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 1., 0., 0.,
0., 0., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
1., 0., 0., 0., 0., 0., 0., 1., 0., 1., 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., 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., 1., 0., 0., 0., 0., 0., 0.,
1., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 1., 0., 1., 0., 0.,
0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 1., 0., 0., 0., 0.,
1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
0., 0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0.,
0., 0., 1., 0., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0.,
0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0.,
1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0.,
0., 0., 0., 0., 1., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.]
```

```
[94]: # roc_curve
fpr,tpr,threshholds = roc_curve(y_test,probability)
```

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





### 0.0.20 Hyper parameter tuning

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

```
[96]: [Text(0.2911364064856712, 0.9761904761904762, 'x[3] <= 0.038\ngini =
0.272\nsamples = 1029\nvalue = [862, 167]'),
Text(0.04487179487179487, 0.9285714285714286, 'x[2] <= 0.257\ngini =
0.5\nsamples = 65\nvalue = [33, 32]'),
Text(0.038838612368024134, 0.8809523809523809, 'x[2] <= 0.116\ngini =
0.499\nsamples = 61\nvalue = [29, 32]'),
Text(0.01809954751131222, 0.8333333333333334, 'x[6] <= 0.033\ngini =
0.463\nsamples = 11\nvalue = [7, 4]'),
Text(0.012066365007541479, 0.7857142857142857, 'x[4] <= 0.013\ngini =
0.346\nsamples = 9\nvalue = [7, 2]'),
Text(0.006033182503770739, 0.7380952380952381, 'gini = 0.0\nsamples = 3\nvalue
= [3, 0]'),
Text(0.01809954751131222, 0.7380952380952381, 'x[0] <= 0.5\ngini =
0.444\nsamples = 6\nvalue = [4, 2]'),
```

```

Text(0.012066365007541479, 0.6904761904761905, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.024132730015082957, 0.6904761904761905, 'x[2] <= 0.101\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.01809954751131222, 0.6428571428571429, 'x[2] <= 0.093\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.012066365007541479, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.024132730015082957, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.030165912518853696, 0.6428571428571429, 'gini = 0.0\nsamples = 3\nvalue
= [3, 0]'),
Text(0.024132730015082957, 0.7857142857142857, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
Text(0.05957767722473605, 0.8333333333333334, 'x[2] <= 0.141\ngini =
0.493\nsamples = 50\nvalue = [22, 28]'),
Text(0.03619909502262444, 0.7857142857142857, 'x[2] <= 0.127\ngini =
0.245\nsamples = 7\nvalue = [1, 6]'),
Text(0.030165912518853696, 0.7380952380952381, 'gini = 0.0\nsamples = 3\nvalue
= [0, 3]'),
Text(0.042232277526395176, 0.7380952380952381, 'x[2] <= 0.133\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.03619909502262444, 0.6904761904761905, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.048265460030165915, 0.6904761904761905, 'gini = 0.0\nsamples = 3\nvalue
= [0, 3]'),
Text(0.08295625942684766, 0.7857142857142857, 'x[2] <= 0.157\ngini =
0.5\nsamples = 43\nvalue = [21, 22]'),
Text(0.06636500754147813, 0.7380952380952381, 'x[2] <= 0.148\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
Text(0.06033182503770739, 0.6904761904761905, 'x[0] <= 0.5\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
Text(0.05429864253393665, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.06636500754147813, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.07239819004524888, 0.6904761904761905, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.09954751131221719, 0.7380952380952381, 'x[2] <= 0.235\ngini =
0.497\nsamples = 39\nvalue = [18, 21]'),
Text(0.08446455505279035, 0.6904761904761905, 'x[2] <= 0.226\ngini =
0.48\nsamples = 25\nvalue = [10, 15]'),
Text(0.0784313725490196, 0.6428571428571429, 'x[6] <= 0.033\ngini =
0.496\nsamples = 22\nvalue = [10, 12]'),
Text(0.07239819004524888, 0.5952380952380952, 'x[0] <= 0.5\ngini =
0.48\nsamples = 20\nvalue = [8, 12]'),
Text(0.05429864253393665, 0.5476190476190477, 'x[4] <= 0.013\ngini =

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0.469\nsamples = 8\nvalue = [5, 3]'),
Text(0.048265460030165915, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.06033182503770739, 0.5, 'x[2] <= 0.194\ngini = 0.408\nsamples = 7\nvalue
= [5, 2]'),
Text(0.05429864253393665, 0.4523809523809524, 'x[2] <= 0.181\ngini =
0.5\nsamples = 4\nvalue = [2, 2]'),
Text(0.048265460030165915, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.06033182503770739, 0.40476190476190477, 'x[2] <= 0.183\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.05429864253393665, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.06636500754147813, 0.35714285714285715, 'x[2] <= 0.189\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.06033182503770739, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.07239819004524888, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.06636500754147813, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.09049773755656108, 0.5476190476190477, 'x[2] <= 0.221\ngini =
0.375\nsamples = 12\nvalue = [3, 9]'),
Text(0.08446455505279035, 0.5, 'x[2] <= 0.186\ngini = 0.298\nsamples =
11\nvalue = [2, 9]'),
Text(0.0784313725490196, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.09049773755656108, 0.4523809523809524, 'x[2] <= 0.194\ngini =
0.375\nsamples = 8\nvalue = [2, 6]'),
Text(0.08446455505279035, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.09653092006033183, 0.40476190476190477, 'x[2] <= 0.209\ngini =
0.245\nsamples = 7\nvalue = [1, 6]'),
Text(0.09049773755656108, 0.35714285714285715, 'gini = 0.0\nsamples = 3\nvalue
= [0, 3]'),
Text(0.10256410256410256, 0.35714285714285715, 'x[2] <= 0.211\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.09653092006033183, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.1085972850678733, 0.30952380952380953, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.09653092006033183, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.08446455505279035, 0.5952380952380952, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.09049773755656108, 0.6428571428571429, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.11463046757164404, 0.6904761904761905, 'x[0] <= 0.5\ngini =
0.49\nsamples = 14\nvalue = [8, 6]'),

```

```

Text(0.10256410256410256, 0.6428571428571429, 'x[4] <= 0.013\ngini =
0.469\nsamples = 8\nvalue = [3, 5]'),
Text(0.09653092006033183, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.1085972850678733, 0.5952380952380952, 'x[2] <= 0.243\ngini =
0.408\nsamples = 7\nvalue = [2, 5]'),
Text(0.10256410256410256, 0.5476190476190477, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.11463046757164404, 0.5476190476190477, 'x[2] <= 0.25\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.1085972850678733, 0.5, 'x[2] <= 0.249\ngini = 0.444\nsamples = 3\nvalue
= [2, 1]'),
Text(0.10256410256410256, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.11463046757164404, 0.4523809523809524, 'x[2] <= 0.25\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.1085972850678733, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.12066365007541478, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.12066365007541478, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.12669683257918551, 0.6428571428571429, 'x[2] <= 0.248\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.12066365007541478, 0.5952380952380952, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.13273001508295626, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.05090497737556561, 0.8809523809523809, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.5374010180995475, 0.9285714285714286, 'x[1] <= 0.125\ngini =
0.241\nsamples = 964\nvalue = [829, 135]'),
Text(0.34723793363499245, 0.8809523809523809, 'x[2] <= 0.214\ngini =
0.347\nsamples = 322\nvalue = [250, 72]'),
Text(0.22850678733031674, 0.8333333333333334, 'x[2] <= 0.201\ngini =
0.431\nsamples = 102\nvalue = [70, 32]'),
Text(0.19155354449472098, 0.7857142857142857, 'x[2] <= 0.181\ngini =
0.339\nsamples = 60\nvalue = [47, 13]'),
Text(0.1794871794871795, 0.7380952380952381, 'x[2] <= 0.177\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.17345399698340874, 0.6904761904761905, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.18552036199095023, 0.6904761904761905, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.20361990950226244, 0.7380952380952381, 'x[6] <= 0.1\ngini =
0.298\nsamples = 55\nvalue = [45, 10]'),
Text(0.1975867269984917, 0.6904761904761905, 'x[5] <= 0.306\ngini =
0.369\nsamples = 41\nvalue = [31, 10]'),

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Text(0.19155354449472098, 0.6428571428571429, 'x[5] <= 0.139\ngini =
0.349\nsamples = 40\nvalue = [31, 9]'),
Text(0.18552036199095023, 0.5952380952380952, 'x[3] <= 0.188\ngini =
0.428\nsamples = 29\nvalue = [20, 9]'),
Text(0.15987933634992457, 0.5476190476190477, 'x[0] <= 0.5\ngini =
0.48\nsamples = 20\nvalue = [12, 8]'),
Text(0.14479638009049775, 0.5, 'x[3] <= 0.113\ngini = 0.444\nsamples = 6\nvalue
= [2, 4]'),
Text(0.138763197586727, 0.4523809523809524, 'x[5] <= 0.083\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.13273001508295626, 0.40476190476190477, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
Text(0.14479638009049775, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.15082956259426847, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.17496229260935142, 0.5, 'x[3] <= 0.1\ngini = 0.408\nsamples = 14\nvalue
= [10, 4]'),
Text(0.16289592760180996, 0.4523809523809524, 'x[3] <= 0.063\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.1568627450980392, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.1689291101055807, 0.40476190476190477, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.1870286576168929, 0.4523809523809524, 'x[2] <= 0.185\ngini =
0.298\nsamples = 11\nvalue = [9, 2]'),
Text(0.18099547511312217, 0.40476190476190477, 'x[4] <= 0.1\ngini =
0.48\nsamples = 5\nvalue = [3, 2]'),
Text(0.17496229260935142, 0.35714285714285715, 'x[6] <= 0.033\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.1689291101055807, 0.30952380952380953, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.18099547511312217, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.1870286576168929, 0.35714285714285715, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.19306184012066366, 0.40476190476190477, 'gini = 0.0\nsamples = 6\nvalue
= [6, 0]'),
Text(0.21116138763197587, 0.5476190476190477, 'x[4] <= 0.113\ngini =
0.198\nsamples = 9\nvalue = [8, 1]'),
Text(0.20512820512820512, 0.5, 'x[4] <= 0.088\ngini = 0.32\nsamples = 5\nvalue
= [4, 1]'),
Text(0.19909502262443438, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.21116138763197587, 0.4523809523809524, 'x[2] <= 0.186\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.20512820512820512, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue

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= [1, 0]'),
Text(0.2171945701357466, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.2171945701357466, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.1975867269984917, 0.5952380952380952, 'gini = 0.0\nsamples = 11\nvalue =
[11, 0]'),
Text(0.20361990950226244, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.2096530920060332, 0.6904761904761905, 'gini = 0.0\nsamples = 14\nvalue =
[14, 0]'),
Text(0.2654600301659125, 0.7857142857142857, 'x[2] <= 0.202\ngini =
0.495\nsamples = 42\nvalue = [23, 19]'),
Text(0.2594268476621418, 0.7380952380952381, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.27149321266968324, 0.7380952380952381, 'x[2] <= 0.206\ngini =
0.489\nsamples = 40\nvalue = [23, 17]'),
Text(0.25339366515837103, 0.6904761904761905, 'x[7] <= 0.441\ngini =
0.415\nsamples = 17\nvalue = [12, 5]'),
Text(0.2473604826546003, 0.6428571428571429, 'x[4] <= 0.088\ngini =
0.375\nsamples = 16\nvalue = [12, 4]'),
Text(0.24132730015082957, 0.5952380952380952, 'x[5] <= 0.083\ngini =
0.48\nsamples = 10\nvalue = [6, 4]'),
Text(0.23529411764705882, 0.5476190476190477, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.2473604826546003, 0.5476190476190477, 'x[3] <= 0.175\ngini =
0.49\nsamples = 7\nvalue = [3, 4]'),
Text(0.24132730015082957, 0.5, 'x[3] <= 0.088\ngini = 0.444\nsamples = 6\nvalue
= [2, 4]'),
Text(0.23529411764705882, 0.4523809523809524, 'x[6] <= 0.067\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.22926093514328807, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.24132730015082957, 0.40476190476190477, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
Text(0.2473604826546003, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.25339366515837103, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.25339366515837103, 0.5952380952380952, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.2594268476621418, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.2895927601809955, 0.6904761904761905, 'x[6] <= 0.1\ngini =
0.499\nsamples = 23\nvalue = [11, 12]'),
Text(0.277526395173454, 0.6428571428571429, 'x[3] <= 0.138\ngini =
0.457\nsamples = 17\nvalue = [6, 11]'),
Text(0.27149321266968324, 0.5952380952380952, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),

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Text(0.28355957767722473, 0.5952380952380952, 'x[2] <= 0.207\ngini =
0.5\nsamples = 12\nvalue = [6, 6]'),
Text(0.27149321266968324, 0.5476190476190477, 'x[2] <= 0.207\ngini =
0.32\nsamples = 5\nvalue = [1, 4]'),
Text(0.2654600301659125, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.277526395173454, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
Text(0.2956259426847662, 0.5476190476190477, 'x[2] <= 0.213\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),
Text(0.2895927601809955, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.30165912518853694, 0.5, 'x[6] <= 0.033\ngini = 0.444\nsamples = 3\nvalue
= [1, 2]'),
Text(0.2956259426847662, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.3076923076923077, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.30165912518853694, 0.6428571428571429, 'x[2] <= 0.21\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.2956259426847662, 0.5952380952380952, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.3076923076923077, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.4659690799396682, 0.8333333333333334, 'x[6] <= 0.367\ngini =
0.298\nsamples = 220\nvalue = [180, 40]'),
Text(0.39498491704374056, 0.7857142857142857, 'x[5] <= 0.028\ngini =
0.272\nsamples = 203\nvalue = [170, 33]'),
Text(0.3378582202111614, 0.7380952380952381, 'x[0] <= 0.5\ngini =
0.426\nsamples = 26\nvalue = [18, 8]'),
Text(0.33182503770739064, 0.6904761904761905, 'gini = 0.0\nsamples = 7\nvalue =
[7, 0]'),
Text(0.3438914027149321, 0.6904761904761905, 'x[2] <= 0.326\ngini =
0.488\nsamples = 19\nvalue = [11, 8]'),
Text(0.3378582202111614, 0.6428571428571429, 'x[2] <= 0.272\ngini =
0.498\nsamples = 15\nvalue = [7, 8]'),
Text(0.33182503770739064, 0.5952380952380952, 'x[3] <= 0.163\ngini =
0.463\nsamples = 11\nvalue = [7, 4]'),
Text(0.31975867269984914, 0.5476190476190477, 'x[3] <= 0.063\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.3137254901960784, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.3257918552036199, 0.5, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
Text(0.3438914027149321, 0.5476190476190477, 'x[2] <= 0.221\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.3378582202111614, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.34992458521870284, 0.5, 'x[4] <= 0.013\ngini = 0.444\nsamples = 3\nvalue
= [2, 1]'),
Text(0.3438914027149321, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.3559577677224736, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =

```

```

[2, 0]'),
Text(0.3438914027149321, 0.5952380952380952, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
Text(0.34992458521870284, 0.6428571428571429, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.45211161387631976, 0.7380952380952381, 'x[2] <= 0.223\ngini =
0.243\nsamples = 177\nvalue = [152, 25]'),
Text(0.44607843137254904, 0.6904761904761905, 'gini = 0.0\nsamples = 17\nvalue
= [17, 0]'),
Text(0.4581447963800905, 0.6904761904761905, 'x[2] <= 0.223\ngini =
0.264\nsamples = 160\nvalue = [135, 25]'),
Text(0.45211161387631976, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.46417797888386125, 0.6428571428571429, 'x[3] <= 0.212\ngini =
0.256\nsamples = 159\nvalue = [135, 24]'),
Text(0.4215686274509804, 0.5952380952380952, 'x[0] <= 0.5\ngini =
0.281\nsamples = 130\nvalue = [108, 22]'),
Text(0.3861236802413273, 0.5476190476190477, 'x[2] <= 0.24\ngini =
0.198\nsamples = 45\nvalue = [40, 5]'),
Text(0.3740573152337858, 0.5, 'x[2] <= 0.232\ngini = 0.469\nsamples = 8\nvalue
= [5, 3]'),
Text(0.3680241327300151, 0.4523809523809524, 'x[3] <= 0.088\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.36199095022624433, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.3740573152337858, 0.40476190476190477, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.38009049773755654, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.39819004524886875, 0.5, 'x[2] <= 0.281\ngini = 0.102\nsamples =
37\nvalue = [35, 2]'),
Text(0.39215686274509803, 0.4523809523809524, 'x[2] <= 0.28\ngini =
0.219\nsamples = 16\nvalue = [14, 2]'),
Text(0.3861236802413273, 0.40476190476190477, 'x[6] <= 0.033\ngini =
0.124\nsamples = 15\nvalue = [14, 1]'),
Text(0.38009049773755654, 0.35714285714285715, 'x[2] <= 0.249\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.3740573152337858, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.3861236802413273, 0.30952380952380953, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.39215686274509803, 0.35714285714285715, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
Text(0.39819004524886875, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.4042232277526395, 0.4523809523809524, 'gini = 0.0\nsamples = 21\nvalue =
[21, 0]'),

```



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Text(0.45701357466063347, 0.5476190476190477, 'x[2] <= 0.323\ngini =
0.32\nsamples = 85\nvalue = [68, 17]'),
Text(0.4374057315233786, 0.5, 'x[2] <= 0.305\ngini = 0.255\nsamples = 60\nvalue
= [51, 9]'),
Text(0.43137254901960786, 0.4523809523809524, 'x[2] <= 0.301\ngini =
0.286\nsamples = 52\nvalue = [43, 9]'),
Text(0.4193061840120664, 0.40476190476190477, 'x[2] <= 0.272\ngini =
0.245\nsamples = 49\nvalue = [42, 7]'),
Text(0.4132730015082956, 0.35714285714285715, 'x[2] <= 0.256\ngini =
0.301\nsamples = 38\nvalue = [31, 7]'),
Text(0.39819004524886875, 0.30952380952380953, 'x[7] <= 0.059\ngini =
0.185\nsamples = 29\nvalue = [26, 3]'),
Text(0.3861236802413273, 0.2619047619047619, 'x[4] <= 0.088\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.38009049773755654, 0.21428571428571427, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.39215686274509803, 0.21428571428571427, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.41025641025641024, 0.2619047619047619, 'x[4] <= 0.088\ngini =
0.137\nsamples = 27\nvalue = [25, 2]'),
Text(0.4042232277526395, 0.21428571428571427, 'x[2] <= 0.235\ngini =
0.231\nsamples = 15\nvalue = [13, 2]'),
Text(0.39819004524886875, 0.16666666666666666, 'gini = 0.0\nsamples = 6\nvalue
= [6, 0]'),
Text(0.41025641025641024, 0.16666666666666666, 'x[2] <= 0.236\ngini =
0.346\nsamples = 9\nvalue = [7, 2]'),
Text(0.4042232277526395, 0.11904761904761904, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.416289592760181, 0.11904761904761904, 'x[3] <= 0.163\ngini =
0.219\nsamples = 8\nvalue = [7, 1]'),
Text(0.41025641025641024, 0.07142857142857142, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
Text(0.42232277526395173, 0.07142857142857142, 'x[3] <= 0.188\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.416289592760181, 0.023809523809523808, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.42835595776772245, 0.023809523809523808, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
Text(0.416289592760181, 0.21428571428571427, 'gini = 0.0\nsamples = 12\nvalue =
[12, 0]'),
Text(0.42835595776772245, 0.30952380952380953, 'x[6] <= 0.033\ngini =
0.494\nsamples = 9\nvalue = [5, 4]'),
Text(0.42232277526395173, 0.2619047619047619, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.4343891402714932, 0.2619047619047619, 'x[2] <= 0.26\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.42835595776772245, 0.21428571428571427, 'gini = 0.0\nsamples = 1\nvalue

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= [0, 1]'),
  Text(0.44042232277526394, 0.21428571428571427, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
  Text(0.4253393665158371, 0.35714285714285715, 'gini = 0.0\nsamples = 11\nvalue
= [11, 0]'),
  Text(0.4434389140271493, 0.40476190476190477, 'x[6] <= 0.1\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
  Text(0.4374057315233786, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
  Text(0.4494720965309201, 0.35714285714285715, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
  Text(0.4434389140271493, 0.4523809523809524, 'gini = 0.0\nsamples = 8\nvalue =
[8, 0]'),
  Text(0.4766214177978884, 0.5, 'x[2] <= 0.327\ngini = 0.435\nsamples = 25\nvalue
= [17, 8]'),
  Text(0.47058823529411764, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
  Text(0.48265460030165913, 0.4523809523809524, 'x[4] <= 0.063\ngini =
0.351\nsamples = 22\nvalue = [17, 5]'),
  Text(0.4675716440422323, 0.40476190476190477, 'x[2] <= 0.346\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
  Text(0.46153846153846156, 0.35714285714285715, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
  Text(0.473604826546003, 0.35714285714285715, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
  Text(0.497737556561086, 0.40476190476190477, 'x[2] <= 0.331\ngini =
0.208\nsamples = 17\nvalue = [15, 2]'),
  Text(0.4856711915535445, 0.35714285714285715, 'x[3] <= 0.113\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
  Text(0.4796380090497738, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
  Text(0.4917043740573152, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
  Text(0.5098039215686274, 0.35714285714285715, 'x[5] <= 0.194\ngini =
0.124\nsamples = 15\nvalue = [14, 1]'),
  Text(0.5037707390648567, 0.30952380952380953, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
  Text(0.5158371040723982, 0.30952380952380953, 'x[3] <= 0.138\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
  Text(0.5098039215686274, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
  Text(0.521870286576169, 0.2619047619047619, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
  Text(0.5067873303167421, 0.5952380952380952, 'x[2] <= 0.238\ngini =
0.128\nsamples = 29\nvalue = [27, 2]'),
  Text(0.4947209653092006, 0.5476190476190477, 'x[0] <= 0.5\ngini = 0.32\nsamples
= 5\nvalue = [4, 1]'),

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Text(0.48868778280542985, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.5007541478129713, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.5188536953242836, 0.5476190476190477, 'x[5] <= 0.194\ngini =
0.08\nsamples = 24\nvalue = [23, 1]'),
Text(0.5128205128205128, 0.5, 'x[5] <= 0.139\ngini = 0.18\nsamples = 10\nvalue
= [9, 1]'),
Text(0.5067873303167421, 0.4523809523809524, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.5188536953242836, 0.4523809523809524, 'x[6] <= 0.033\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
Text(0.5128205128205128, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.5248868778280543, 0.40476190476190477, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.5248868778280543, 0.5, 'gini = 0.0\nsamples = 14\nvalue = [14, 0]'),
Text(0.5369532428355958, 0.7857142857142857, 'x[7] <= 0.382\ngini =
0.484\nsamples = 17\nvalue = [10, 7]'),
Text(0.530920060331825, 0.7380952380952381, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.5429864253393665, 0.7380952380952381, 'x[4] <= 0.188\ngini =
0.497\nsamples = 13\nvalue = [6, 7]'),
Text(0.5369532428355958, 0.6904761904761905, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.5490196078431373, 0.6904761904761905, 'x[4] <= 0.212\ngini =
0.496\nsamples = 11\nvalue = [6, 5]'),
Text(0.5429864253393665, 0.6428571428571429, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.555052790346908, 0.6428571428571429, 'x[2] <= 0.28\ngini =
0.494\nsamples = 9\nvalue = [4, 5]'),
Text(0.5490196078431373, 0.5952380952380952, 'x[2] <= 0.248\ngini =
0.49\nsamples = 7\nvalue = [4, 3]'),
Text(0.5429864253393665, 0.5476190476190477, 'x[3] <= 0.35\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.5369532428355958, 0.5, 'x[4] <= 0.237\ngini = 0.444\nsamples = 3\nvalue
= [2, 1]'),
Text(0.530920060331825, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.5429864253393665, 0.4523809523809524, 'x[2] <= 0.236\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.5369532428355958, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.5490196078431373, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.5490196078431373, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.555052790346908, 0.5476190476190477, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.5610859728506787, 0.5952380952380952, 'gini = 0.0\nsamples = 2\nvalue =

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[0, 2]'),
  Text(0.7275641025641025, 0.8809523809523809, 'x[3] <= 0.975\ngini =
0.177\nsamples = 642\nvalue = [579, 63]'),
  Text(0.7215309200603318, 0.8333333333333334, 'x[7] <= 0.029\ngini =
0.172\nsamples = 640\nvalue = [579, 61]'),
  Text(0.6229260935143288, 0.7857142857142857, 'x[2] <= 0.69\ngini =
0.344\nsamples = 77\nvalue = [60, 17]'),
  Text(0.6108597285067874, 0.7380952380952381, 'x[4] <= 0.163\ngini =
0.288\nsamples = 63\nvalue = [52, 11]'),
  Text(0.6048265460030166, 0.6904761904761905, 'x[2] <= 0.592\ngini =
0.324\nsamples = 54\nvalue = [43, 11]'),
  Text(0.5987933634992458, 0.6428571428571429, 'x[2] <= 0.586\ngini =
0.353\nsamples = 48\nvalue = [37, 11]'),
  Text(0.5927601809954751, 0.5952380952380952, 'x[4] <= 0.013\ngini =
0.335\nsamples = 47\nvalue = [37, 10]'),
  Text(0.5867269984917044, 0.5476190476190477, 'gini = 0.0\nsamples = 10\nvalue =
[10, 0]'),
  Text(0.5987933634992458, 0.5476190476190477, 'x[2] <= 0.566\ngini =
0.394\nsamples = 37\nvalue = [27, 10]'),
  Text(0.5927601809954751, 0.5, 'x[2] <= 0.468\ngini = 0.422\nsamples = 33\nvalue
= [23, 10]'),
  Text(0.579185520361991, 0.4523809523809524, 'x[4] <= 0.063\ngini =
0.375\nsamples = 28\nvalue = [21, 7]'),
  Text(0.5731523378582202, 0.40476190476190477, 'x[3] <= 0.388\ngini =
0.423\nsamples = 23\nvalue = [16, 7]'),
  Text(0.5520361990950227, 0.35714285714285715, 'x[3] <= 0.2\ngini = 0.5\nsamples
= 10\nvalue = [5, 5]'),
  Text(0.5399698340874811, 0.30952380952380953, 'x[5] <= 0.028\ngini =
0.444\nsamples = 6\nvalue = [4, 2]'),
  Text(0.5339366515837104, 0.2619047619047619, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
  Text(0.5460030165912518, 0.2619047619047619, 'x[0] <= 0.5\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
  Text(0.5399698340874811, 0.21428571428571427, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
  Text(0.5520361990950227, 0.21428571428571427, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
  Text(0.5641025641025641, 0.30952380952380953, 'x[2] <= 0.407\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
  Text(0.5580693815987934, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
  Text(0.5701357466063348, 0.2619047619047619, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
  Text(0.5942684766214178, 0.35714285714285715, 'x[2] <= 0.195\ngini =
0.26\nsamples = 13\nvalue = [11, 2]'),
  Text(0.5882352941176471, 0.30952380952380953, 'x[1] <= 0.5\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),

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Text(0.5822021116138764, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.5942684766214178, 0.2619047619047619, 'x[0] <= 0.5\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.5882352941176471, 0.21428571428571427, 'x[3] <= 0.475\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.5822021116138764, 0.16666666666666666, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.5942684766214178, 0.16666666666666666, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6003016591251885, 0.21428571428571427, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.6003016591251885, 0.30952380952380953, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.5852187028657617, 0.40476190476190477, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.6063348416289592, 0.4523809523809524, 'x[2] <= 0.507\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.6003016591251885, 0.40476190476190477, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.6123680241327301, 0.40476190476190477, 'x[5] <= 0.111\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.6063348416289592, 0.35714285714285715, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.6184012066365008, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6048265460030166, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.6048265460030166, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6108597285067874, 0.6428571428571429, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.6168929110105581, 0.6904761904761905, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
Text(0.6349924585218703, 0.7380952380952381, 'x[2] <= 0.799\ngini =
0.49\nsamples = 14\nvalue = [8, 6]'),
Text(0.6289592760180995, 0.6904761904761905, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.6410256410256411, 0.6904761904761905, 'x[5] <= 0.5\ngini =
0.444\nsamples = 12\nvalue = [8, 4]'),
Text(0.6349924585218703, 0.6428571428571429, 'x[4] <= 0.1\ngini =
0.397\nsamples = 11\nvalue = [8, 3]'),
Text(0.6289592760180995, 0.5952380952380952, 'x[2] <= 0.856\ngini =
0.469\nsamples = 8\nvalue = [5, 3]'),
Text(0.6229260935143288, 0.5476190476190477, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.6349924585218703, 0.5476190476190477, 'x[3] <= 0.438\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),

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```

Text(0.6289592760180995, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.6410256410256411, 0.5, 'x[4] <= 0.05\ngini = 0.444\nsamples = 3\nvalue =
[2, 1]'),
Text(0.6349924585218703, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.6470588235294118, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6410256410256411, 0.5952380952380952, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.6470588235294118, 0.6428571428571429, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8201357466063348, 0.7857142857142857, 'x[2] <= 0.64\ngini =
0.144\nsamples = 563\nvalue = [519, 44]'),
Text(0.7375565610859729, 0.7380952380952381, 'x[3] <= 0.237\ngini =
0.105\nsamples = 432\nvalue = [408, 24]'),
Text(0.6923076923076923, 0.6904761904761905, 'x[2] <= 0.464\ngini =
0.174\nsamples = 135\nvalue = [122, 13]'),
Text(0.6772247360482655, 0.6428571428571429, 'x[5] <= 0.139\ngini =
0.071\nsamples = 81\nvalue = [78, 3]'),
Text(0.6711915535444947, 0.5952380952380952, 'x[2] <= 0.398\ngini =
0.149\nsamples = 37\nvalue = [34, 3]'),
Text(0.665158371040724, 0.5476190476190477, 'gini = 0.0\nsamples = 21\nvalue =
[21, 0]'),
Text(0.6772247360482655, 0.5476190476190477, 'x[2] <= 0.414\ngini =
0.305\nsamples = 16\nvalue = [13, 3]'),
Text(0.665158371040724, 0.5, 'x[7] <= 0.088\ngini = 0.444\nsamples = 3\nvalue =
[1, 2]'),
Text(0.6591251885369532, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.6711915535444947, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.6892911010558069, 0.5, 'x[7] <= 0.206\ngini = 0.142\nsamples = 13\nvalue
= [12, 1]'),
Text(0.6832579185520362, 0.4523809523809524, 'gini = 0.0\nsamples = 12\nvalue =
[12, 0]'),
Text(0.6953242835595776, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6832579185520362, 0.5952380952380952, 'gini = 0.0\nsamples = 44\nvalue =
[44, 0]'),
Text(0.7073906485671192, 0.6428571428571429, 'x[2] <= 0.469\ngini =
0.302\nsamples = 54\nvalue = [44, 10]'),
Text(0.7013574660633484, 0.5952380952380952, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
Text(0.7134238310708899, 0.5952380952380952, 'x[3] <= 0.163\ngini =
0.211\nsamples = 50\nvalue = [44, 6]'),
Text(0.7073906485671192, 0.5476190476190477, 'gini = 0.0\nsamples = 14\nvalue =
[14, 0]'),

```

```

Text(0.7194570135746606, 0.5476190476190477, 'x[7] <= 0.382\ngini =
0.278\nsamples = 36\nvalue = [30, 6]'),
Text(0.7134238310708899, 0.5, 'x[7] <= 0.265\ngini = 0.375\nsamples = 24\nvalue
= [18, 6]'),
Text(0.7073906485671192, 0.4523809523809524, 'x[6] <= 0.367\ngini =
0.298\nsamples = 22\nvalue = [18, 4]'),
Text(0.6892911010558069, 0.40476190476190477, 'x[0] <= 0.5\ngini =
0.255\nsamples = 20\nvalue = [17, 3]'),
Text(0.6711915535444947, 0.35714285714285715, 'x[7] <= 0.088\ngini =
0.375\nsamples = 8\nvalue = [6, 2]'),
Text(0.665158371040724, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6772247360482655, 0.30952380952380953, 'x[2] <= 0.531\ngini =
0.245\nsamples = 7\nvalue = [6, 1]'),
Text(0.6711915535444947, 0.2619047619047619, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.6832579185520362, 0.2619047619047619, 'x[2] <= 0.563\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
Text(0.6772247360482655, 0.21428571428571427, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6892911010558069, 0.21428571428571427, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.7073906485671192, 0.35714285714285715, 'x[3] <= 0.188\ngini =
0.153\nsamples = 12\nvalue = [11, 1]'),
Text(0.7013574660633484, 0.30952380952380953, 'x[6] <= 0.067\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.6953242835595776, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.7073906485671192, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7134238310708899, 0.30952380952380953, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
Text(0.7254901960784313, 0.40476190476190477, 'x[2] <= 0.495\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.7194570135746606, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.7315233785822021, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7194570135746606, 0.4523809523809524, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.7254901960784313, 0.5, 'gini = 0.0\nsamples = 12\nvalue = [12, 0]'),
Text(0.7828054298642534, 0.6904761904761905, 'x[0] <= 0.5\ngini =
0.071\nsamples = 297\nvalue = [286, 11]'),
Text(0.7616892911010558, 0.6428571428571429, 'x[4] <= 0.738\ngini =
0.016\nsamples = 126\nvalue = [125, 1]'),
Text(0.755656108597285, 0.5952380952380952, 'gini = 0.0\nsamples = 125\nvalue =
[125, 0]'),

```

```

Text(0.7677224736048266, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.803921568627451, 0.6428571428571429, 'x[5] <= 0.417\ngini =
0.11\nsamples = 171\nvalue = [161, 10]'),
Text(0.779788838612368, 0.5952380952380952, 'x[4] <= 0.237\ngini =
0.148\nsamples = 112\nvalue = [103, 9]'),
Text(0.7616892911010558, 0.5476190476190477, 'x[2] <= 0.468\ngini =
0.081\nsamples = 71\nvalue = [68, 3]'),
Text(0.755656108597285, 0.5, 'x[2] <= 0.468\ngini = 0.127\nsamples = 44\nvalue
= [41, 3]'),
Text(0.7496229260935143, 0.4523809523809524, 'x[5] <= 0.139\ngini =
0.089\nsamples = 43\nvalue = [41, 2]'),
Text(0.7435897435897436, 0.40476190476190477, 'gini = 0.0\nsamples = 23\nvalue
= [23, 0]'),
Text(0.755656108597285, 0.40476190476190477, 'x[4] <= 0.113\ngini =
0.18\nsamples = 20\nvalue = [18, 2]'),
Text(0.7435897435897436, 0.35714285714285715, 'x[2] <= 0.364\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.7375565610859729, 0.30952380952380953, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.7496229260935143, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7677224736048266, 0.35714285714285715, 'x[3] <= 0.388\ngini =
0.111\nsamples = 17\nvalue = [16, 1]'),
Text(0.7616892911010558, 0.30952380952380953, 'x[3] <= 0.362\ngini =
0.245\nsamples = 7\nvalue = [6, 1]'),
Text(0.755656108597285, 0.2619047619047619, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.7677224736048266, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7737556561085973, 0.30952380952380953, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
Text(0.7616892911010558, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7677224736048266, 0.5, 'gini = 0.0\nsamples = 27\nvalue = [27, 0]'),
Text(0.7978883861236803, 0.5476190476190477, 'x[7] <= 0.088\ngini =
0.25\nsamples = 41\nvalue = [35, 6]'),
Text(0.7918552036199095, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.803921568627451, 0.5, 'x[4] <= 0.487\ngini = 0.219\nsamples = 40\nvalue
= [35, 5]'),
Text(0.7978883861236803, 0.4523809523809524, 'x[2] <= 0.374\ngini =
0.33\nsamples = 24\nvalue = [19, 5]'),
Text(0.7858220211161387, 0.40476190476190477, 'x[6] <= 0.233\ngini =
0.49\nsamples = 7\nvalue = [3, 4]'),
Text(0.779788838612368, 0.35714285714285715, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.7918552036199095, 0.35714285714285715, 'x[6] <= 0.467\ngini =

```



```

0.48\nsamples = 5\nvalue = [3, 2]'),
Text(0.7858220211161387, 0.30952380952380953, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.7978883861236803, 0.30952380952380953, 'x[3] <= 0.537\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.7918552036199095, 0.2619047619047619, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.803921568627451, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.8099547511312217, 0.40476190476190477, 'x[6] <= 0.4\ngini =
0.111\nsamples = 17\nvalue = [16, 1]'),
Text(0.803921568627451, 0.35714285714285715, 'gini = 0.0\nsamples = 14\nvalue =
[14, 0]'),
Text(0.8159879336349924, 0.35714285714285715, 'x[7] <= 0.471\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.8099547511312217, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8220211161387632, 0.30952380952380953, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.8099547511312217, 0.4523809523809524, 'gini = 0.0\nsamples = 16\nvalue =
[16, 0]'),
Text(0.8280542986425339, 0.5952380952380952, 'x[3] <= 0.337\ngini =
0.033\nsamples = 59\nvalue = [58, 1]'),
Text(0.8220211161387632, 0.5476190476190477, 'x[3] <= 0.312\ngini =
0.111\nsamples = 17\nvalue = [16, 1]'),
Text(0.8159879336349924, 0.5, 'gini = 0.0\nsamples = 13\nvalue = [13, 0]'),
Text(0.8280542986425339, 0.5, 'x[2] <= 0.415\ngini = 0.375\nsamples = 4\nvalue
= [3, 1]'),
Text(0.8220211161387632, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8340874811463047, 0.4523809523809524, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.8340874811463047, 0.5476190476190477, 'gini = 0.0\nsamples = 42\nvalue =
[42, 0]'),
Text(0.9027149321266968, 0.7380952380952381, 'x[2] <= 0.644\ngini =
0.259\nsamples = 131\nvalue = [111, 20]'),
Text(0.8966817496229261, 0.6904761904761905, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.9087481146304676, 0.6904761904761905, 'x[3] <= 0.263\ngini =
0.24\nsamples = 129\nvalue = [111, 18]'),
Text(0.8687782805429864, 0.6428571428571429, 'x[2] <= 0.671\ngini =
0.348\nsamples = 58\nvalue = [45, 13]'),
Text(0.8521870286576169, 0.5952380952380952, 'x[0] <= 0.5\ngini = 0.49\nsamples
= 7\nvalue = [3, 4]'),
Text(0.8461538461538461, 0.5476190476190477, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
Text(0.8582202111613876, 0.5476190476190477, 'gini = 0.0\nsamples = 3\nvalue =

```

```

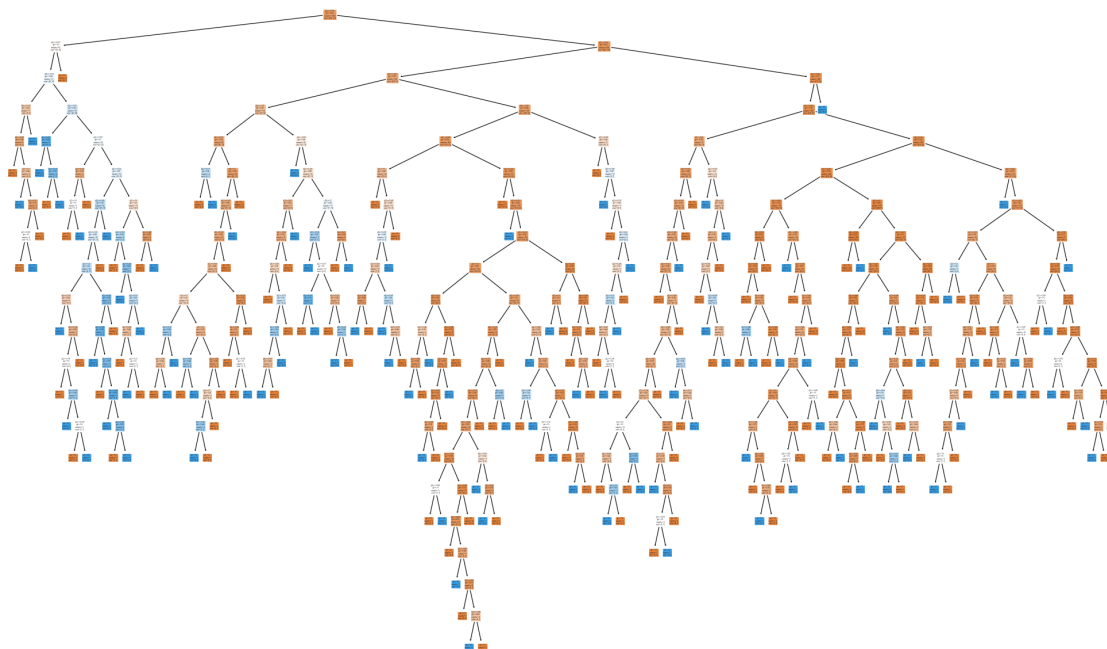
[3, 0]'),
Text(0.8853695324283559, 0.5952380952380952, 'x[6] <= 0.1\ngini =
0.291\nsamples = 51\nvalue = [42, 9]'),
Text(0.8702865761689291, 0.5476190476190477, 'x[2] <= 0.764\ngini =
0.175\nsamples = 31\nvalue = [28, 3]'),
Text(0.8642533936651584, 0.5, 'x[2] <= 0.76\ngini = 0.337\nsamples = 14\nvalue
= [11, 3]'),
Text(0.8582202111613876, 0.4523809523809524, 'x[7] <= 0.324\ngini =
0.26\nsamples = 13\nvalue = [11, 2]'),
Text(0.8521870286576169, 0.40476190476190477, 'x[7] <= 0.265\ngini =
0.444\nsamples = 6\nvalue = [4, 2]'),
Text(0.8461538461538461, 0.35714285714285715, 'x[3] <= 0.188\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.8401206636500754, 0.30952380952380953, 'x[0] <= 0.5\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
Text(0.8340874811463047, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8461538461538461, 0.2619047619047619, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.8521870286576169, 0.30952380952380953, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.8582202111613876, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8642533936651584, 0.40476190476190477, 'gini = 0.0\nsamples = 7\nvalue =
[7, 0]'),
Text(0.8702865761689291, 0.4523809523809524, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8763197586726998, 0.5, 'gini = 0.0\nsamples = 17\nvalue = [17, 0]'),
Text(0.9004524886877828, 0.5476190476190477, 'x[2] <= 0.804\ngini =
0.42\nsamples = 20\nvalue = [14, 6]'),
Text(0.8883861236802413, 0.5, 'x[3] <= 0.237\ngini = 0.18\nsamples = 10\nvalue
= [9, 1]'),
Text(0.8823529411764706, 0.4523809523809524, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.8944193061840121, 0.4523809523809524, 'x[4] <= 0.212\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
Text(0.8883861236802413, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.9004524886877828, 0.40476190476190477, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.9125188536953243, 0.5, 'x[3] <= 0.237\ngini = 0.5\nsamples = 10\nvalue =
[5, 5]'),
Text(0.9064856711915535, 0.4523809523809524, 'gini = 0.0\nsamples = 4\nvalue =
[0, 4]'),
Text(0.918552036199095, 0.4523809523809524, 'x[2] <= 0.852\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.9125188536953243, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =

```

```

[0, 1]'),
Text(0.9245852187028658, 0.40476190476190477, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.9487179487179487, 0.6428571428571429, 'x[4] <= 0.787\ngini =
0.131\nsamples = 71\nvalue = [66, 5]'),
Text(0.942684766214178, 0.5952380952380952, 'x[5] <= 0.083\ngini =
0.108\nsamples = 70\nvalue = [66, 4]'),
Text(0.9306184012066365, 0.5476190476190477, 'x[7] <= 0.324\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.9245852187028658, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.9366515837104072, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.9547511312217195, 0.5476190476190477, 'x[2] <= 0.875\ngini =
0.084\nsamples = 68\nvalue = [65, 3]'),
Text(0.9487179487179487, 0.5, 'gini = 0.0\nsamples = 31\nvalue = [31, 0]'),
Text(0.9607843137254902, 0.5, 'x[2] <= 0.889\ngini = 0.149\nsamples = 37\nvalue
= [34, 3]'),
Text(0.9457013574660633, 0.4523809523809524, 'x[6] <= 0.533\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.9396681749622926, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.951734539969834, 0.40476190476190477, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.975867269984917, 0.4523809523809524, 'x[4] <= 0.113\ngini =
0.108\nsamples = 35\nvalue = [33, 2]'),
Text(0.9638009049773756, 0.40476190476190477, 'x[2] <= 0.931\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
Text(0.9577677224736049, 0.35714285714285715, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.9698340874811463, 0.35714285714285715, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.9879336349924586, 0.40476190476190477, 'x[3] <= 0.362\ngini =
0.062\nsamples = 31\nvalue = [30, 1]'),
Text(0.9819004524886877, 0.35714285714285715, 'x[2] <= 0.912\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.975867269984917, 0.30952380952380953, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.9879336349924586, 0.30952380952380953, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.9939668174962293, 0.35714285714285715, 'gini = 0.0\nsamples = 26\nvalue
= [26, 0]'),
Text(0.9547511312217195, 0.5952380952380952, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7335972850678733, 0.8333333333333334, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]')

```



```
[97]: 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']
}
```

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

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

c:\Users\sivar\AppData\Local\Programs\Python\Python311\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\sivar\AppData\Local\Programs\Python\Python311\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\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\base.py", line 1144, in wrapper
    estimator._validate_params()
File "c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\base.py", line 637, in _validate_params
    validate_parameter_constraints(
File "c:\Users\sivar\AppData\Local\Programs\Python\Python311\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 {'sqrt', 'log2'} or None. Got 'auto'
instead.

```

```

warnings.warn(some_fits_failed_message, FitFailedWarning)
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [      nan      nan 0.83185413 0.83770779
0.83770779 0.83770779
      nan      nan 0.8338243  0.83770779 0.83185413 0.83770779
      nan      nan 0.82992186 0.83867866 0.82507696 0.83770779
      nan      nan 0.82700924 0.83770779 0.83478096 0.83673692
      nan      nan 0.82699976 0.83185887 0.81339806 0.82896993
      nan      nan 0.83770779 0.83770779 0.83770779 0.83770779
      nan      nan 0.83185413 0.83770779 0.83770779 0.83770779
      nan      nan 0.83087379 0.83673218 0.83086905 0.83673692
      nan      nan 0.81631542 0.83576604 0.82989344 0.83770779
      nan      nan 0.81924224 0.82991712 0.82601942 0.83089273]
warnings.warn(

```

```

[99]: GridSearchCV(cv=5, estimator=DecisionTreeClassifier(),
    param_grid={'criterion': ['gini', 'entropy'],
                'max_depth': [1, 2, 3, 4, 5],
                'max_features': ['auto', 'sqrt', 'log2'],
                'splitter': ['best', 'random']},
    scoring='accuracy')

```

```

[100]: grid_search.best_params_

```

```

[100]: {'criterion': 'gini',
        'max_depth': 3,
        'max_features': 'sqrt',
        'splitter': 'random'}

```

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

```
[101]: DecisionTreeClassifier(criterion='entropy', max_depth=3, max_features='sqrt')
```

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

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

	precision	recall	f1-score	support
0	0.84	1.00	0.91	371
1	0.00	0.00	0.00	70
accuracy			0.84	441
macro avg	0.42	0.50	0.46	441
weighted avg	0.71	0.84	0.77	441

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\metrics\_classification.py:1469: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
```

### 0.0.21 3.Random Forest

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

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

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

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

```
c:\Users\sivar\AppData\Local\Programs\Python\Python311\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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    return fit_method(estimator, *args, **kwargs)
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was
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```

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(n_samples,), for example using ravel().
    return fit_method(estimator, *args, **kwargs)
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
50 fits failed out of a total of 700.
The score on these train-test partitions for these parameters will be set to
nan.
If these failures are not expected, you can try to debug them by setting
error_score='raise'.

```

Below are more details about the failures:

-----

50 fits failed with the following error:

```

Traceback (most recent call last):
  File "c:\Users\sivar\AppData\Local\Programs\Python\Python311\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\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\base.py", line 1144, in wrapper
    estimator._validate_params()
  File "c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\base.py", line 637, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\utils\_param_validation.py", line 95, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features'
parameter of RandomForestClassifier must be an int in the range [1, inf), a
float in the range (0.0, 1.0], a str among {'sqrt', 'log2'} or None. Got 0
instead.

    warnings.warn(some_fits_failed_message, FitFailedWarning)
c:\Users\sivar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [      nan 0.82604226 0.8202075  0.82117837
0.8231106  0.81631449
0.81632401 0.81242147 0.81922711 0.81631449 0.81533409 0.80853798
0.80952789 0.8114506      nan 0.82117837 0.81825623 0.81825623
0.81923663 0.81340187 0.81341138 0.81048924 0.81048924 0.80563488
0.80757662 0.80757662 0.804664   0.80852846      nan 0.81923663
0.81923663 0.81534361 0.81340187 0.81048924 0.8114506  0.80465448
0.80272225 0.80562536 0.81047973 0.81048924 0.79980963 0.81048924
      nan 0.81728536 0.81534361 0.81243099 0.81340187 0.81146012
0.80562536 0.80467352 0.804664   0.804664   0.80078051 0.80272225
0.81048924 0.8075671      nan 0.81923663 0.81825623 0.80855702
0.80951837 0.80855702 0.80757662 0.81146012 0.80853798 0.804664
0.80757662 0.80077099 0.81243099 0.80563488]
    warnings.warn(
c:\Users\sivar\AppData\Local\Programs\Python\Python311\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)

```

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

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

```
[109]: pred
```

[illegible]

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

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

[111]: 0.8231292517006803

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

```
[112]: array([[358, 13],
              [ 65,  5]], dtype=int64)
```

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

	precision	recall	f1-score	support
0	0.85	0.96	0.90	371
1	0.28	0.07	0.11	70
accuracy			0.82	441

macro avg	0.56	0.52	0.51	441
weighted avg	0.76	0.82	0.78	441

```
[114]: rfc_cv.best_params_
```

```
[114]: {'max_depth': 10, 'max_features': 1}
```

```
[ ]:
```