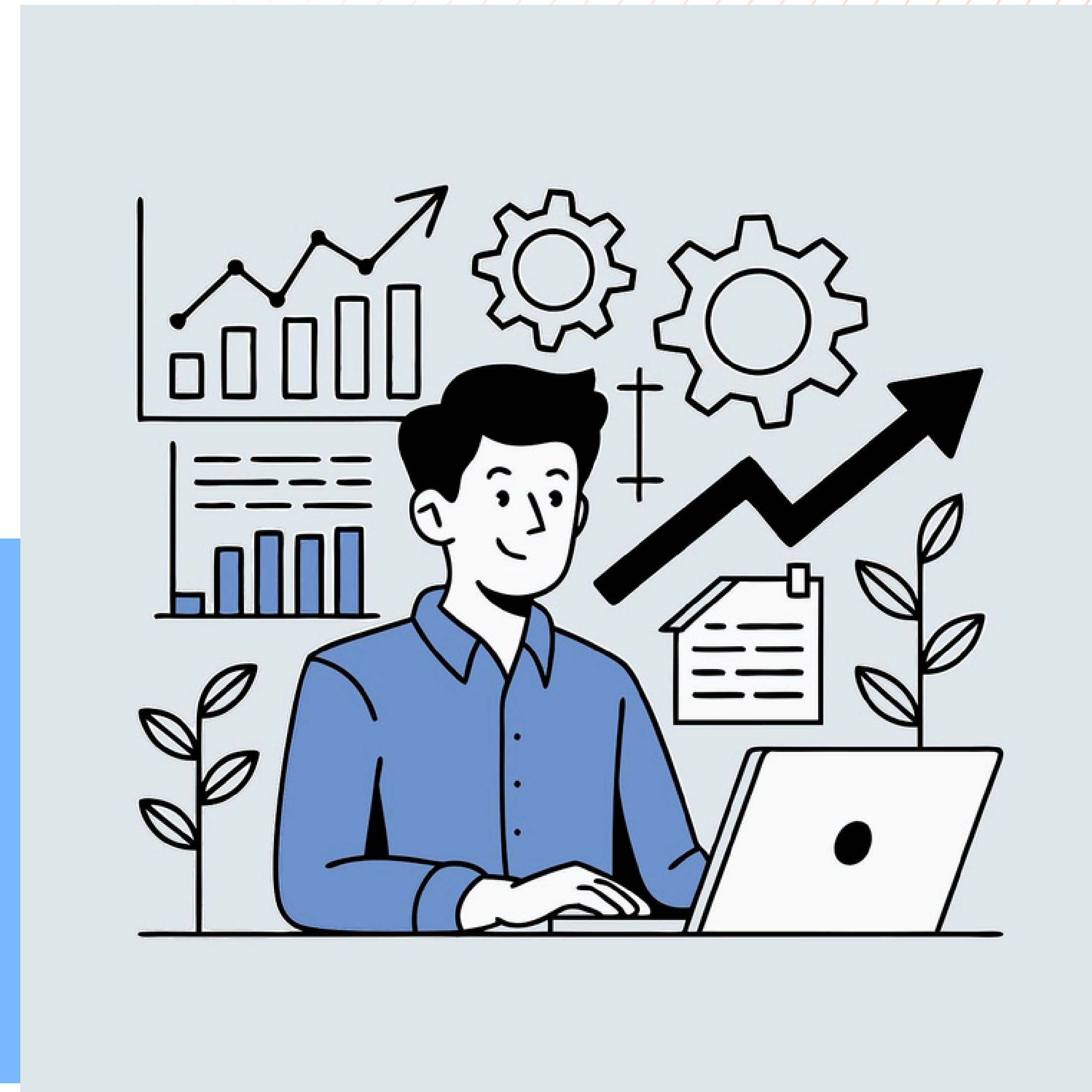

LABS

Data Mining

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Lab 8 => Decision tree Classifier By: Eng/Malek A.Almosanif

Load Lib

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_selection import SelectKBest,f_classif
from sklearn.model_selection import train_test_split as tts
from sklearn.preprocessing import MinMaxScaler
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import
accuracy_score,recall_score,f1_score,confusion_matrix,precision_score
from sklearn.tree import plot_tree,export_text
import numpy as np
import pickle as pk
```

Load Dataset

```
data=pd.read_csv('Hr_report.csv')
```

Know Your Data

```
data.shape
```

```
(14999, 12)
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14999 entries, 0 to 14998
Data columns (total 12 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   Unnamed: 0.1           14999 non-null  int64  
 1   Unnamed: 0             14999 non-null  int64  
 2   satisfaction_level     14999 non-null  float64
 3   last_evaluation        14999 non-null  float64
 4   number_project         14999 non-null  int64  
 5   average_montly_hours   14999 non-null  int64  
 6   time_spend_company     14999 non-null  int64  
 7   Work_accident          14999 non-null  int64  
 8   promotion_last_5years  14999 non-null  int64  
 9   dept                   14999 non-null  int64  
 10  salary                 14999 non-null  int64  
```

```
 11  left                   14999 non-null  int64
dtypes: float64(2), int64(10)
memory usage: 1.4 MB
```

```
data.describe()
```

```
       Unnamed: 0.1    Unnamed: 0  satisfaction_level  last_evaluation
\
count  14999.000000  14999.000000        14999.000000     14999.000000

mean    7499.000000   7499.000000            0.612834         0.716102

std     4329.982679   4329.982679            0.248631         0.171169

min        0.000000      0.000000            0.090000         0.360000

25%     3749.500000   3749.500000            0.440000         0.560000

50%     7499.000000   7499.000000            0.640000         0.720000

75%    11248.500000  11248.500000            0.820000         0.870000

max    14998.000000  14998.000000            1.000000         1.000000


       number_project  average_montly_hours  time_spend_company  \
count    14999.000000          14999.000000        14999.000000
mean         3.803054            201.050337            3.498233
std          1.232592             49.943099            1.460136
min          2.000000             96.000000            2.000000
25%          3.000000            156.000000            3.000000
50%          4.000000            200.000000            3.000000
75%          5.000000            245.000000            4.000000
max          7.000000            310.000000           10.000000

       Work_accident  promotion_last_5years          dept
salary  \
count   14999.000000           14999.000000  14999.000000
14999.000000
mean        0.144610               0.021268      5.870525
0.594706
std         0.351719               0.144281      2.868786
0.637183
min         0.000000               0.000000      0.000000
0.000000
25%         0.000000               0.000000      4.000000
0.000000
50%         0.000000               0.000000      7.000000
1.000000
75%         0.000000               0.000000      8.000000
1.000000
```

```
max        1.000000               1.000000     9.000000
2.000000

                left
count  14999.000000
mean       0.238083
std        0.425924
min        0.000000
25%        0.000000
50%        0.000000
75%        0.000000
max        1.000000
```

```
data.head()
```

```
   Unnamed: 0.1  Unnamed: 0  satisfaction_level  last_evaluation  \
0             0           0                0.38             0.53
1             1           1                0.80             0.86
2             2           2                0.11             0.88
3             3           3                0.72             0.87
4             4           4                0.37             0.52

   number_project  average_montly_hours  time_spend_company
Work_accident  \
0               2                   157                   3
0
1               5                   262                   6
0
2               7                   272                   4
0
3               5                   223                   5
0
4               2                   159                   3
0

   promotion_last_5years  dept  salary  left
0                      0     7       0     1
1                      0     7       1     1
2                      0     7       1     1
3                      0     7       0     1
4                      0     7       0     1
```

```
data.tail()
```

```
       Unnamed: 0.1  Unnamed: 0  satisfaction_level
last_evaluation  \
14994         14994       14994                0.40             0.57

14995         14995       14995                0.37             0.48

14996         14996       14996                0.37             0.53
```

```
14997          14997       14997                     0.11             0.96
14998          14998       14998                     0.37             0.52

       number_project  average_montly_hours  time_spend_company  \
14994               2                   151                   3
14995               2                   160                   3
14996               2                   143                   3
14997               6                   280                   4
14998               2                   158                   3

       Work_accident  promotion_last_5years  dept  salary  left
14994              0                      0     8       0     1
14995              0                      0     8       0     1
14996              0                      0     8       0     1
14997              0                      0     8       0     1
14998              0                      0     8       0     1
```

Clean Data

```
data.drop(columns=['Unnamed: 0.1','Unnamed: 0'],inplace=True)

data.duplicated().sum()

3008

data.isna().sum()

satisfaction_level       0
last_evaluation          0
number_project           0
average_montly_hours     0
time_spend_company       0
Work_accident            0
promotion_last_5years    0
dept                     0
salary                   0
left                     0
dtype: int64

data.drop_duplicates(inplace=True)
```

For Improve The Re_call and Presion

```
#For Improve The Re_call and Presion
# data_class_0 = data[data.iloc[:, -1] == 0]
# data_class_1 = data[data.iloc[:, -1] == 1]
# new_class_0=data_class_0.iloc[:2000,:]
```

```
# balanced_data = pd.concat([new_class_0, data_class_1])
# X=balanced_data.iloc[:,:-1]
# y=balanced_data.iloc[:,-1]
```

Split Data To Features And Target

```
X=data.iloc[:,:-1]
y=data.iloc[:,-1]
```

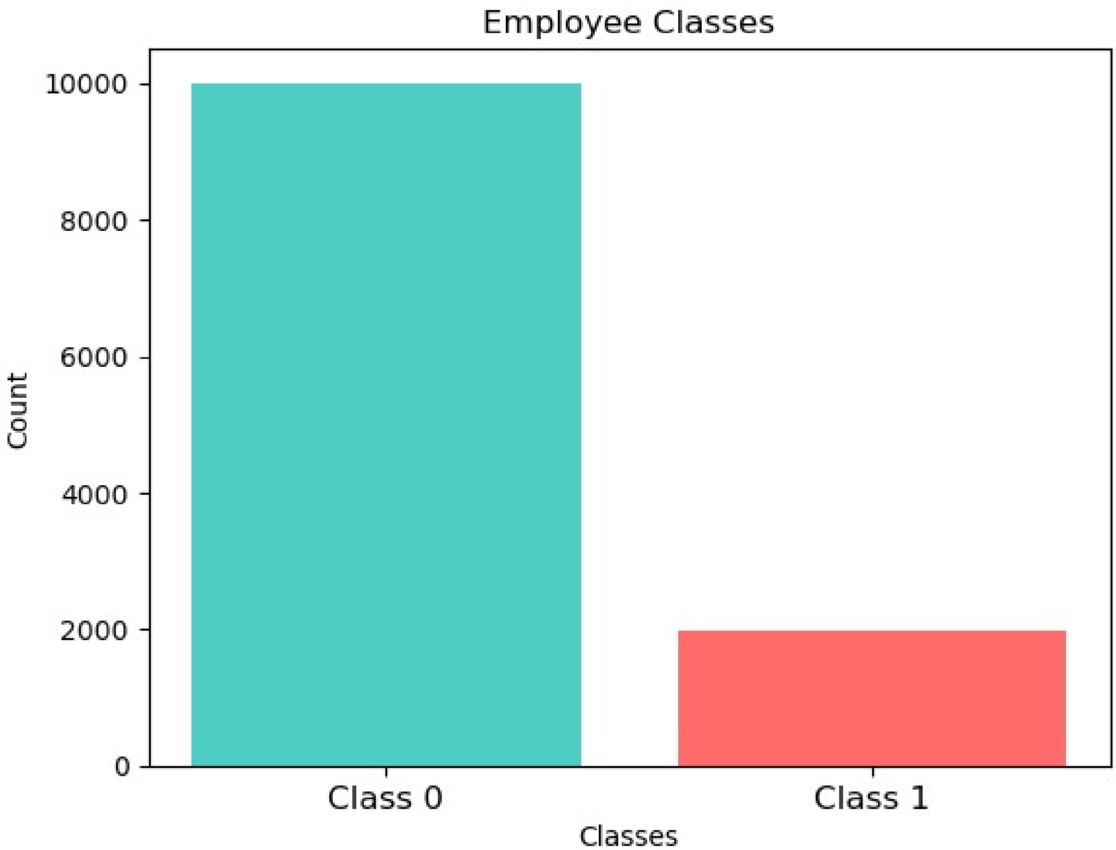
```
y.unique()
```

```
array([1, 0], dtype=int64)
```

```
value_counts=y.value_counts()
value_counts
```

```
left
0    10000
1     1991
Name: count, dtype: int64
```

```
colors = ['#4ECDC4','#FF6B6B']
plt.bar(value_counts.index,value_counts.values,color=colors)
plt.title('Employee Classes')
plt.xlabel('Classes')
plt.xticks(ticks=[0, 1],labels=['Class 0', 'Class 1'],fontsize=12)
plt.ylabel('Count')
plt.show()
```



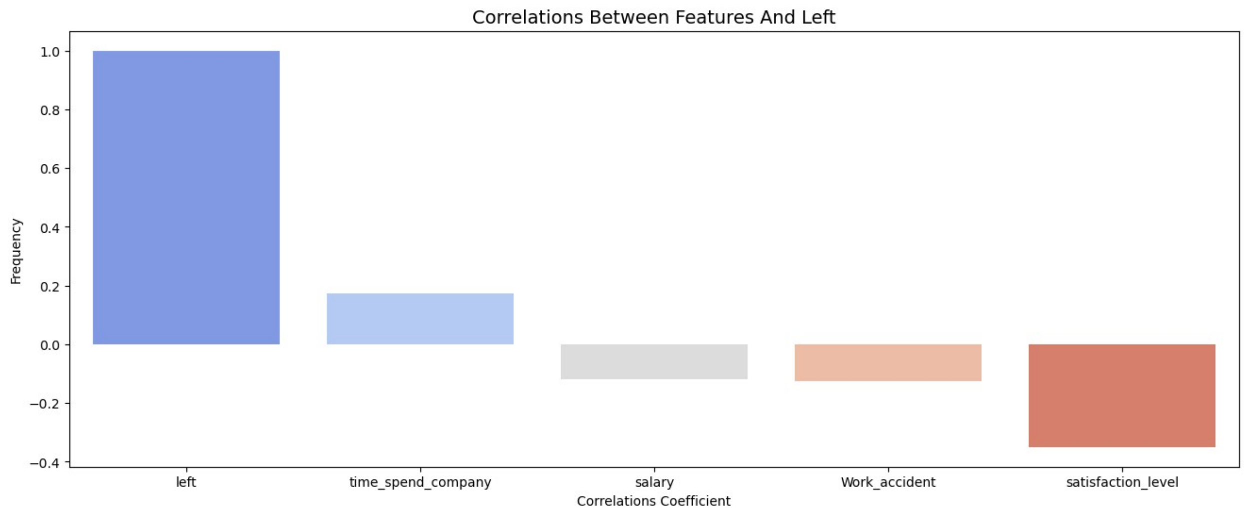
Feature Selection

```
select=SelectKBest(score_func=f_classif,k=4)
best_features=select.fit_transform(X,y)
best_features=pd.DataFrame(best_features,columns=X.columns[select.get_
support()])
best_features.head()
```

	satisfaction_level	time_spend_company	Work_accident	salary
0	0.38	3.0	0.0	0.0
1	0.80	6.0	0.0	1.0
2	0.11	4.0	0.0	1.0
3	0.72	5.0	0.0	0.0
4	0.37	3.0	0.0	0.0

```
mydata=best_features.copy()
mydata['left']=y
corrleation_matrix=mydata.corr()
corrleation_matrix_left=corrleation_matrix.left.sort_values(ascending=
False)
plt.figure(figsize=(16,6))
sns.barplot(x=corrleation_matrix_left.index,y=corrleation_matrix_left.
values,palette='coolwarm',hue=corrleation_matrix_left.index,legend=Fal
```

```
se)
plt.title('Correlations Between Features And Left',fontsize=14)
plt.xlabel("Correlations Coefficient")
plt.ylabel('Frequency')
plt.show()
```



Split DataSet Train and Test

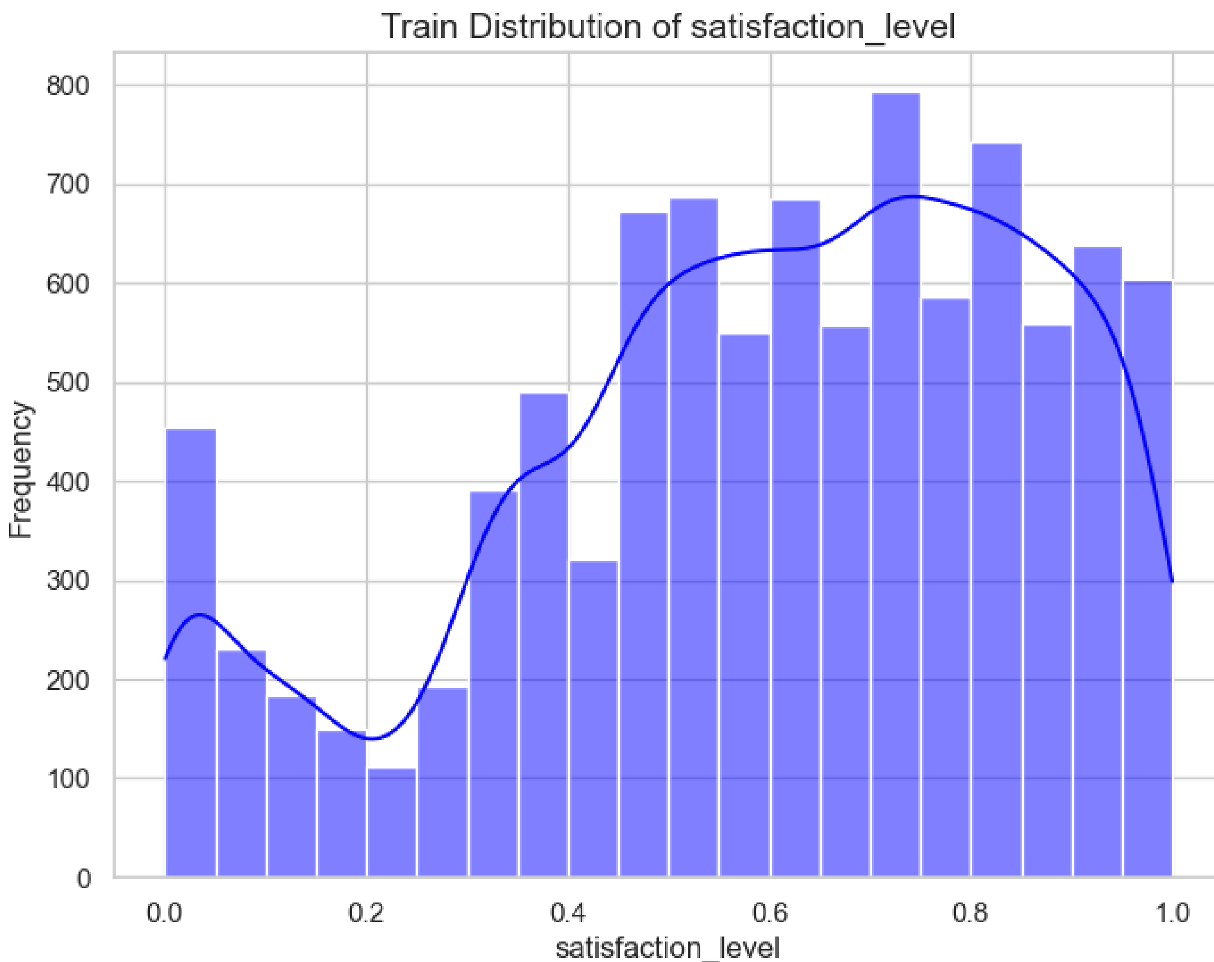
```
x_train,x_test,y_train,y_test=tts(best_features,y,test_size=.20,random
_state=30,shuffle=True)
```

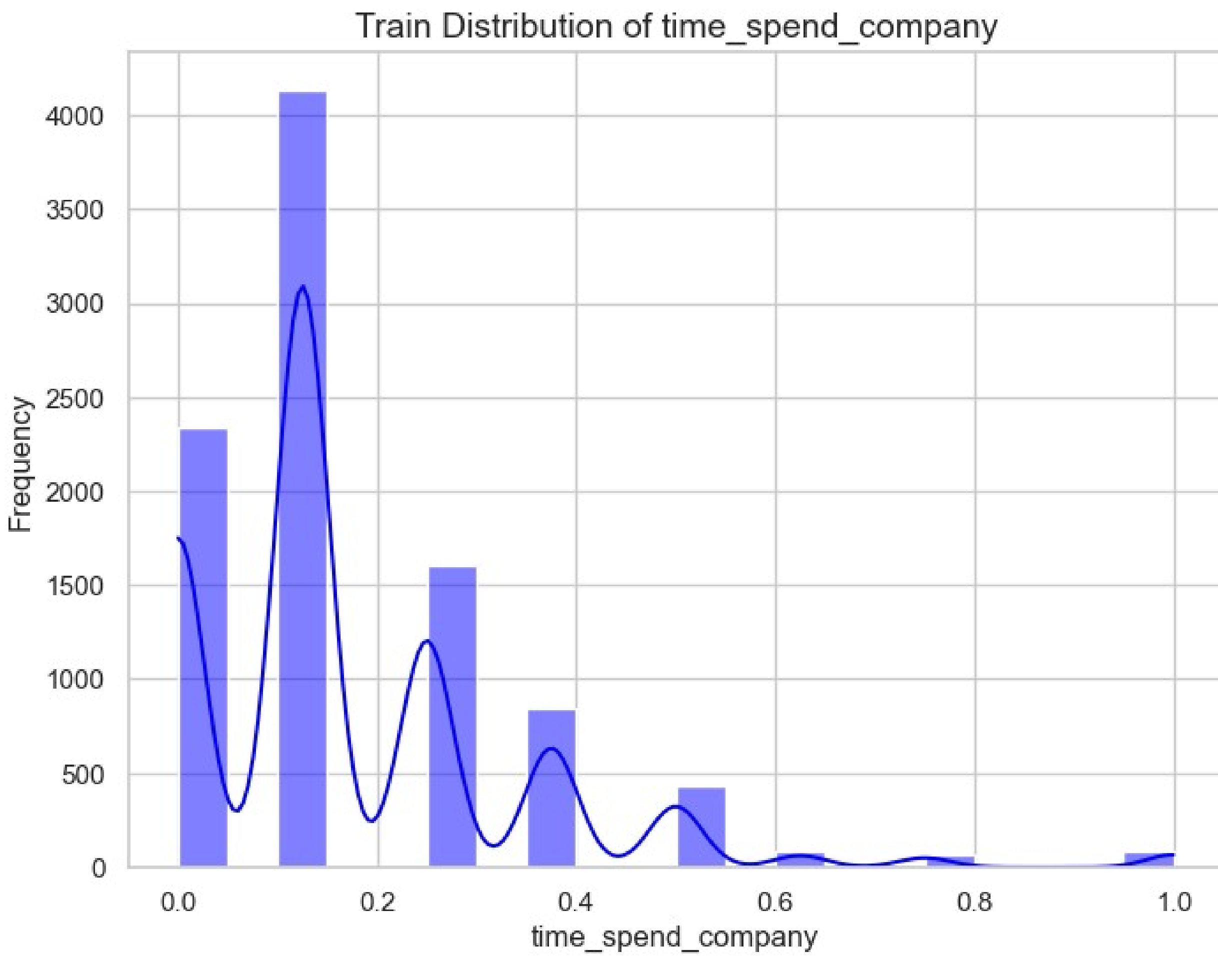
Feature Scaling

```
scaler=MinMaxScaler(feature_range=(0,1))
x_train_scalled=scaler.fit_transform(x_train)
x_test_scalled=scaler.fit_transform(x_test)
x_train_scalled=pd.DataFrame(x_train_scalled,columns=X.columns[select.
get_support()])
x_test_scalled=pd.DataFrame(x_test_scalled,columns=X.columns[select.ge
t_support()])
```

Data Column Visualization

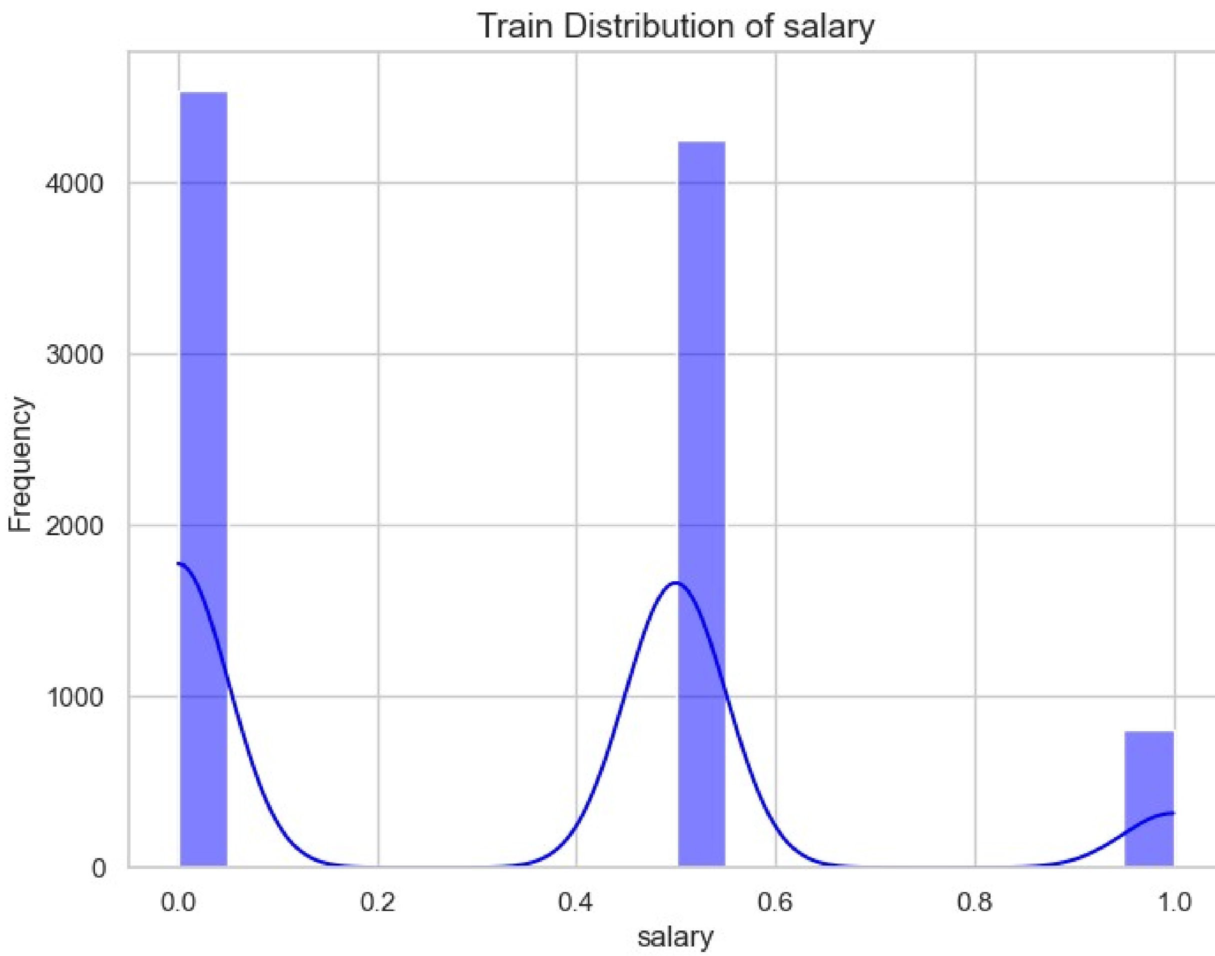
```
sns.set(style='whitegrid')
for column in x_train_scalled.columns:
    plt.figure(figsize=(8,6))

sns.histplot(x_train_scalled[column],kde=True,bins=20,color='blue')
    plt.title(f'Train Distribution of {column}',fontsize=14)
    plt.xlabel(column)
    plt.ylabel('Frequency')
    plt.show()
```


Train Distribution of satisfaction_level
Frequency
satisfaction_level
0
100
200
300
400
500
600
700
800
0.0
0.2
0.4
0.6
0.8
1.0

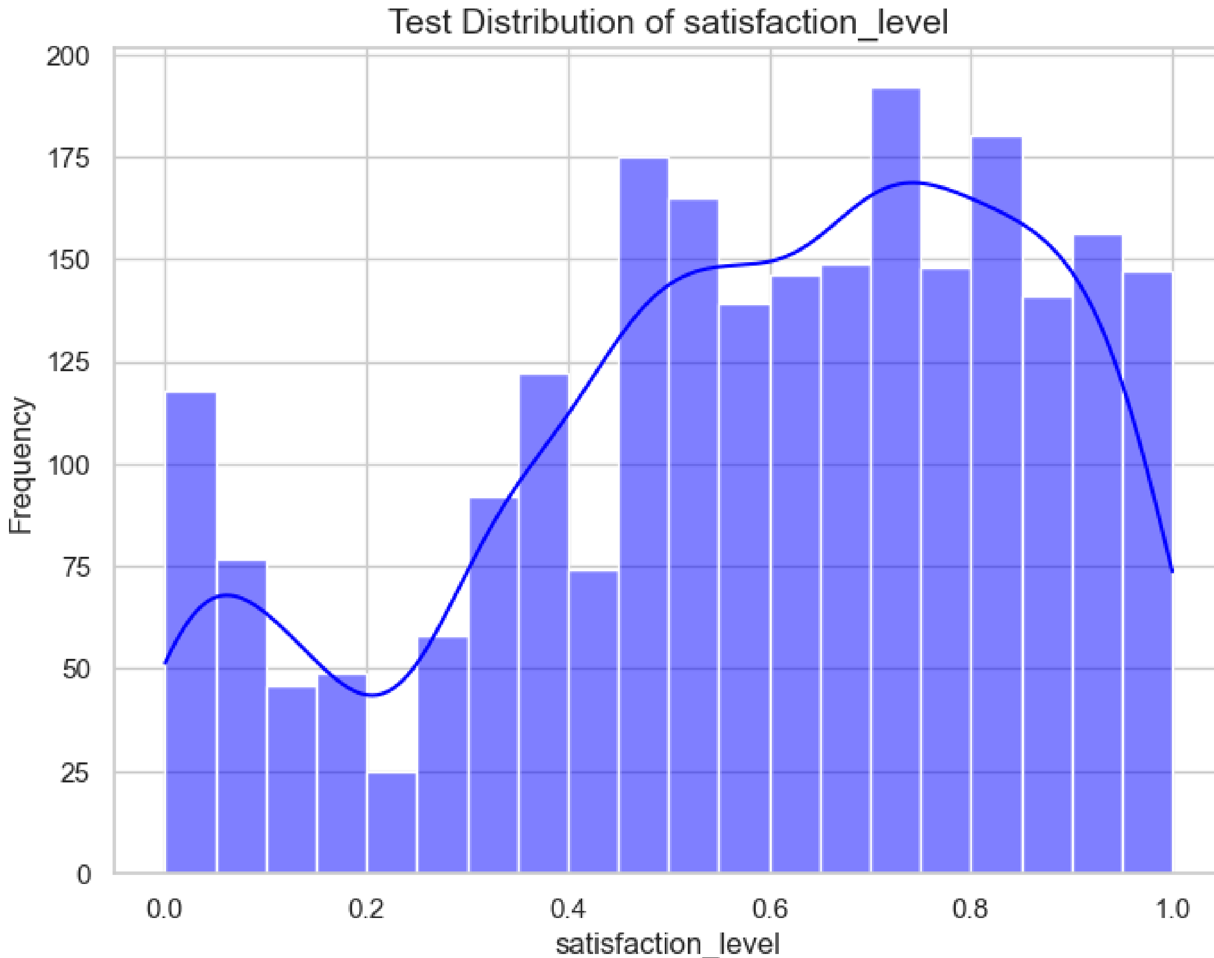


Train Distribution of time_spend_company
Frequency
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
time_spend_company

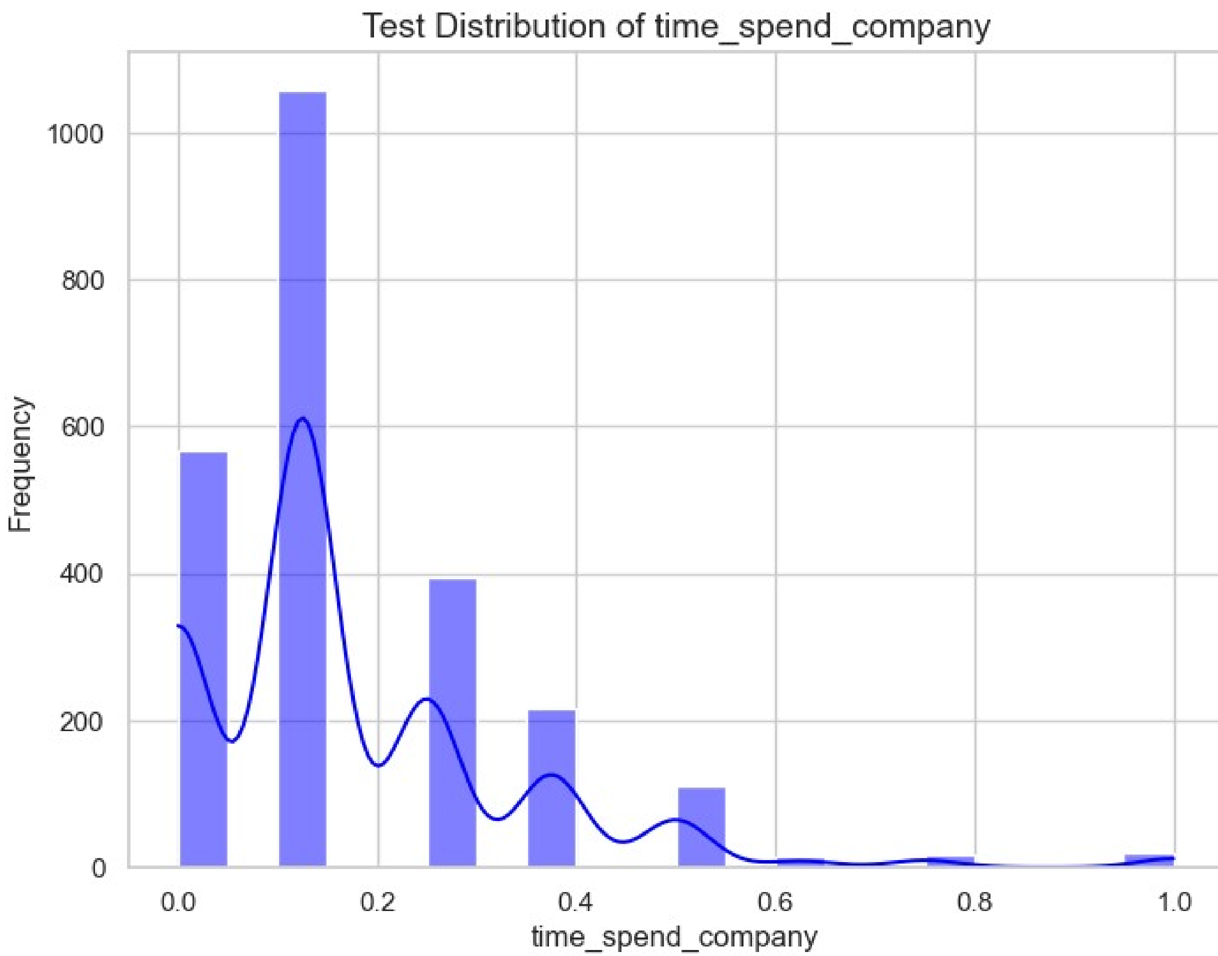

Train Distribution of Work_accident
Frequency
8000
7000
6000
5000
4000
3000
2000
1000
0
0.0
0.2
0.4
0.6
0.8
1.0
Work_accident

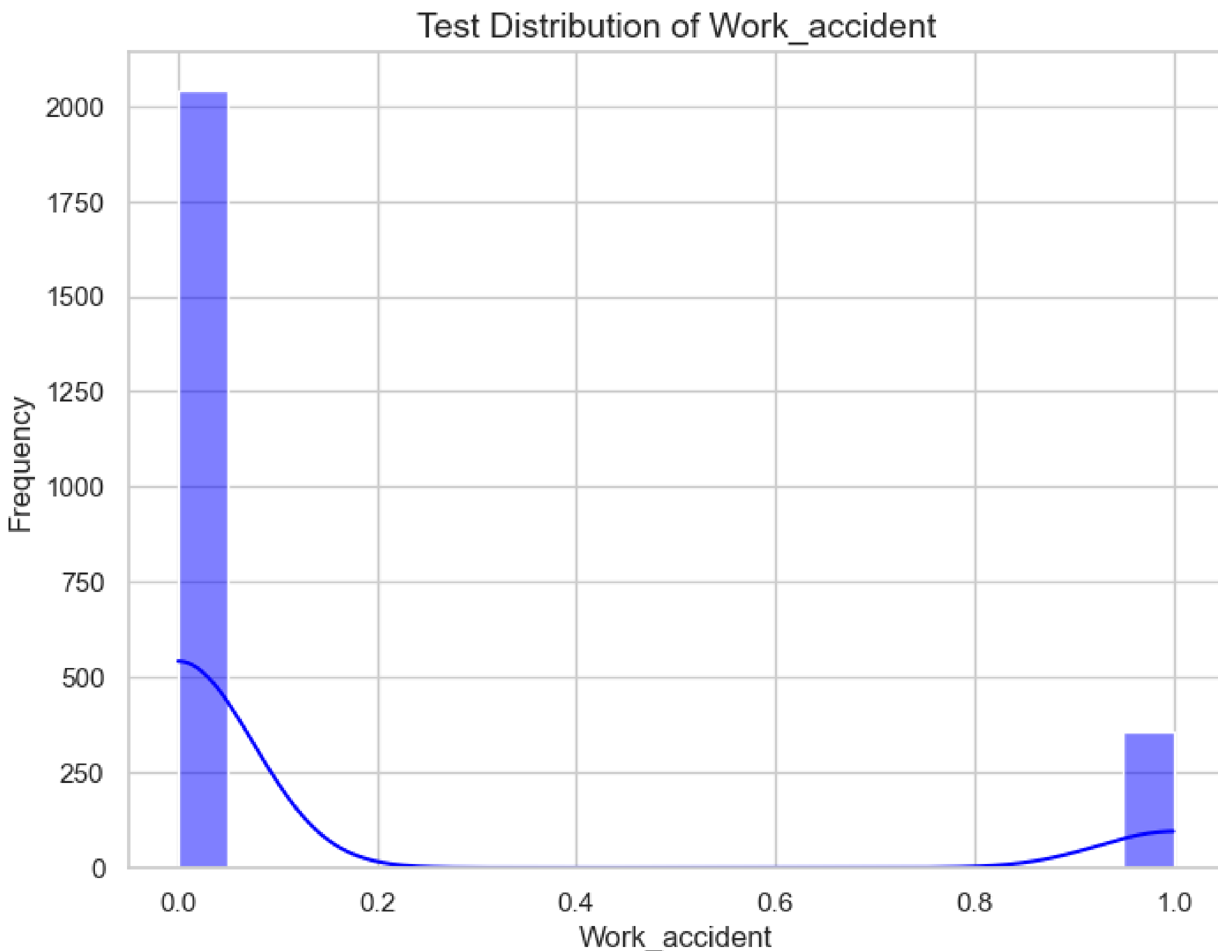



```
sns.set(style='whitegrid')
for column in x_test_scalled.columns:
    plt.figure(figsize=(8,6))
    sns.histplot(x_test_scalled[column],kde=True,bins=20,color='blue')
    plt.title(f'Test Distribution of {column}',fontsize=14)
    plt.xlabel(column)
    plt.ylabel('Frequency')
    plt.show()
```

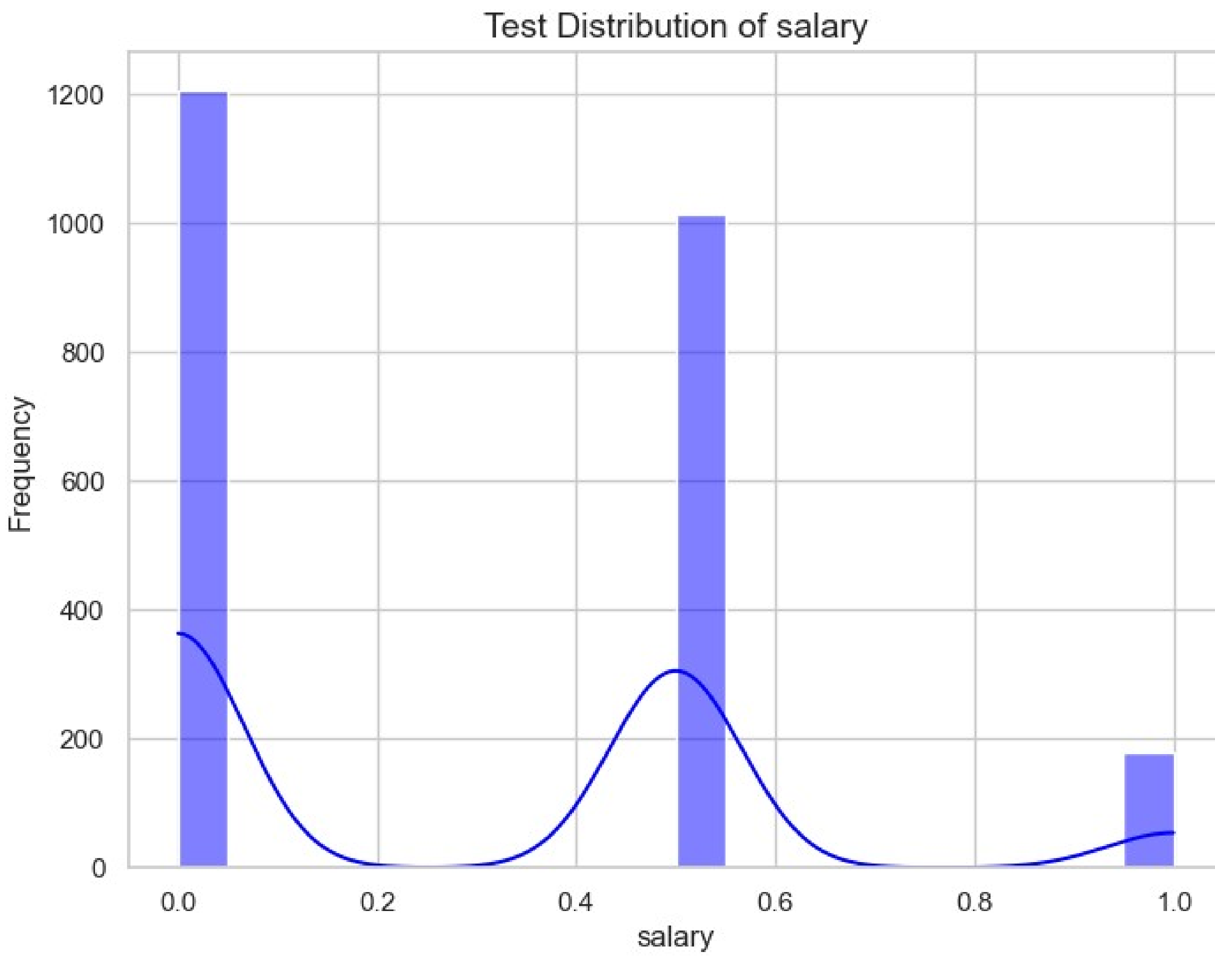


Test Distribution of satisfaction_level
Frequency
200
175
150
125
100
75
50
25
0
0.0
0.2
0.4
0.6
0.8
1.0
satisfaction_level


Test Distribution of time_spend_company
Frequency
time_spend_company
0
200
400
600
800
1000
0.0
0.2
0.4
0.6
0.8
1.0



Test Distribution of Work_accident
Frequency
Work_accident
2000
1750
1500
1250
1000
750
500
250
0
0.0
0.2
0.4
0.6
0.8
1.0



DecisionTree Train

```
# tree_classifier=DecisionTreeClassifier(criterion = 'gini', max_depth
= 2)
tree_classifier=DecisionTreeClassifier()
tree_classifier.fit(x_train_scalled,y_train)

DecisionTreeClassifier()

y_pred=tree_classifier.predict(x_test_scalled)

text_representation = export_text(tree_classifier)
print(text_representation)

|--- feature_0 <= 0.41
|   |--- feature_0 <= 0.03
|   |   |--- class: 1
|   |--- feature_0 >  0.03
|   |   |--- feature_0 <= 0.29
|   |   |   |--- feature_1 <= 0.44
|   |   |   |   |--- feature_3 <= 0.25
```

```
|   |   |   |   |   |--- feature_0 <= 0.24
|   |   |   |   |   |   |--- feature_1 <= 0.31
|   |   |   |   |   |   |   |--- feature_0 <= 0.07
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.05
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.05
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.05
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.05
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |--- feature_0 >  0.07
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.18
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 8
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.18
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.20
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.20
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |--- feature_1 >  0.31
|   |   |   |   |   |   |   |--- feature_0 <= 0.06
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.05
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.05
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.06
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.24
|   |   |   |   |   |   |--- feature_1 <= 0.31
|   |   |   |   |   |   |   |--- feature_0 <= 0.28
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.25
|   |   |   |   |   |   |   |   |   |   |--- class: 0
```

```
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.25
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.26
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.19
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.19
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.26
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.28
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.31
|   |   |   |   |   |   |   |--- feature_0 <= 0.25
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.25
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.26
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.26
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |--- feature_0 <= 0.06
|   |   |   |   |   |   |--- feature_0 <= 0.05
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.05
|   |   |   |   |   |   |   |--- feature_1 <= 0.31
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.19
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.19
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_1 >  0.31
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.06
|   |   |   |   |   |   |--- feature_1 <= 0.19
```

```
|   |   |   |   |   |   |   |--- feature_0 <= 0.24
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.24
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.25
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.25
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.19
|   |   |   |   |   |   |   |--- feature_0 <= 0.28
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.09
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.09
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.23
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 8
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.23
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.28
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.44
|   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |--- feature_0 <= 0.12
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.12
|   |   |   |   |   |   |--- feature_0 <= 0.13
|   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |--- class: 0
```

```
|   |   |   |   |   |   |--- feature_0 >  0.13
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |--- class: 0
|   |   |--- feature_0 >  0.29
|   |   |   |--- feature_1 <= 0.19
|   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |--- feature_0 <= 0.30
|   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.30
|   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |--- feature_0 <= 0.38
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.38
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |--- feature_0 <= 0.40
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.35
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.35
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.36
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.36
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.34
```

```
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.32
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.32
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.34
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |--- feature_0 >  0.40
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |--- feature_0 <= 0.39
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.32
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.30
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.30
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |--- feature_0 >  0.32
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.34
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.34
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |--- feature_0 >  0.39
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |--- feature_0 <= 0.32
|   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.30
```

```
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.30
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.32
|   |   |   |   |   |   |   |--- feature_0 <= 0.40
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.38
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.35
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.35
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_0 >  0.38
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.39
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.39
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_0 >  0.40
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.19
|   |   |   |   |--- feature_1 <= 0.31
|   |   |   |   |   |--- feature_0 <= 0.40
|   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |--- feature_0 <= 0.36
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.30
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.30
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.34
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.34
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.36
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
```

```
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.39
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.39
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |--- feature_0 <= 0.36
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.36
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.40
|   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_1 >  0.31
|   |   |   |   |   |--- feature_0 <= 0.35
|   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.56
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.32
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.32
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.32
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.32
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |--- feature_1 >  0.56
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.35
|   |   |   |   |   |   |--- class: 0
|--- feature_0 >  0.41
```

```
|   |--- feature_1 <= 0.31
|   |   |--- feature_0 <= 0.42
|   |   |   |--- feature_3 <= 0.25
|   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |--- feature_1 <= 0.19
|   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_1 >  0.19
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |--- class: 0
|   |   |   |--- feature_3 >  0.25
|   |   |   |   |--- class: 0
|   |   |--- feature_0 >  0.42
|   |   |   |--- feature_1 <= 0.19
|   |   |   |   |--- feature_0 <= 0.54
|   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |--- feature_0 <= 0.45
|   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.43
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.43
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.43
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.43
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.45
|   |   |   |   |   |   |   |--- feature_0 <= 0.49
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.47
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
```

```
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.47
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.49
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.52
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.51
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.51
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.51
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.51
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |--- feature_0 >  0.52
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_0 >  0.54
|   |   |   |   |   |--- feature_0 <= 0.90
|   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.79
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.72
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 9
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.72
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.76
```

```
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.76
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |--- feature_0 >  0.79
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.88
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.88
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.83
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.63
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.59
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.59
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 5
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.63
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.73
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.73
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.83
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.06
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.85
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.85
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.06
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.19
|   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |--- feature_0 <= 0.60
|   |   |   |   |   |   |--- feature_0 <= 0.57
|   |   |   |   |   |   |   |--- feature_0 <= 0.43
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.43
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.54
```

```
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.49
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.49
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.54
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.55
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.55
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.57
|   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.58
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.58
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.59
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.59
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.60
|   |   |   |   |   |   |--- feature_0 <= 0.90
|   |   |   |   |   |   |   |--- feature_0 <= 0.88
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.66
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.66
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.68
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.68
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.83
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 7
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.83
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.88
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |--- feature_0 <= 0.88
|   |   |   |   |   |   |--- feature_0 <= 0.87
|   |   |   |   |   |   |   |--- feature_0 <= 0.68
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.51
```

```
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.51
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.68
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.69
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.69
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.79
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.79
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.80
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.80
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.87
|   |   |   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- feature_0 >  0.88
|   |   |   |   |   |   |--- class: 0
|   |--- feature_1 >  0.31
|   |   |--- feature_0 <= 0.69
|   |   |   |--- feature_1 <= 0.56
|   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |--- feature_0 <= 0.57
|   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |--- feature_0 <= 0.54
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.49
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.47
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.47
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.49
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.44
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.53
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.42
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.42
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
```

```
depth 5
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.53
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.54
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_1 >  0.44
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |--- feature_0 <= 0.46
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.46
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.53
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.52
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.49
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 5
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.49
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.52
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.44
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.53
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.57
|   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |--- feature_0 <= 0.62
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.62
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.64
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.63
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.63
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_0 >  0.64
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.68
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.68
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.44
```

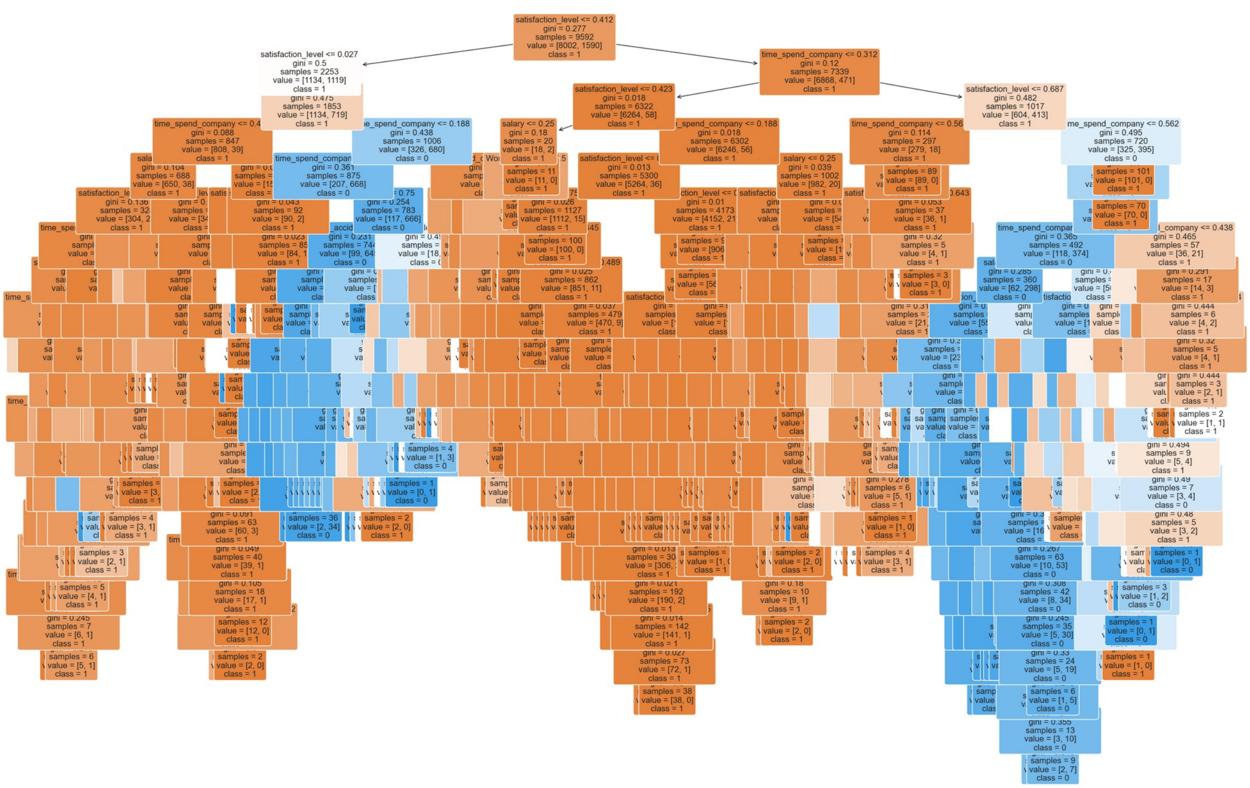
```
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |--- feature_0 <= 0.64
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  0.64
|   |   |   |   |   |   |--- feature_0 <= 0.65
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  0.65
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.56
|   |   |   |   |--- class: 0
|   |   |--- feature_0 >  0.69
|   |   |   |--- feature_1 <= 0.56
|   |   |   |   |--- feature_0 <= 0.92
|   |   |   |   |   |--- feature_2 <= 0.50
|   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.75
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.71
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.70
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.70
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.71
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.73
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.73
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |--- feature_0 >  0.75
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.76
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.76
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.91
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 11
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.91
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.86
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.72
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.72
```

```
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.82
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.82
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |--- feature_0 >  0.86
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.88
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.88
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.90
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.44
|   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.85
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.76
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.70
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.76
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.81
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.81
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 3
|   |   |   |   |   |   |   |   |--- feature_0 >  0.85
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.90
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.91
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.91
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.74
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.70
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 4
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.74
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.76
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
```

```
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.76
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 8
|   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_2 >  0.50
|   |   |   |   |   |   |--- feature_1 <= 0.44
|   |   |   |   |   |   |   |--- feature_0 <= 0.84
|   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.79
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.79
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.81
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.81
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.75
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.73
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.73
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of
depth 5
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.84
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.88
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_0 >  0.88
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.90
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.91
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.91
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  0.44
|   |   |   |   |   |   |   |--- feature_0 <= 0.86
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.71
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  0.71
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  0.86
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.87
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_0 >  0.87
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.90
```

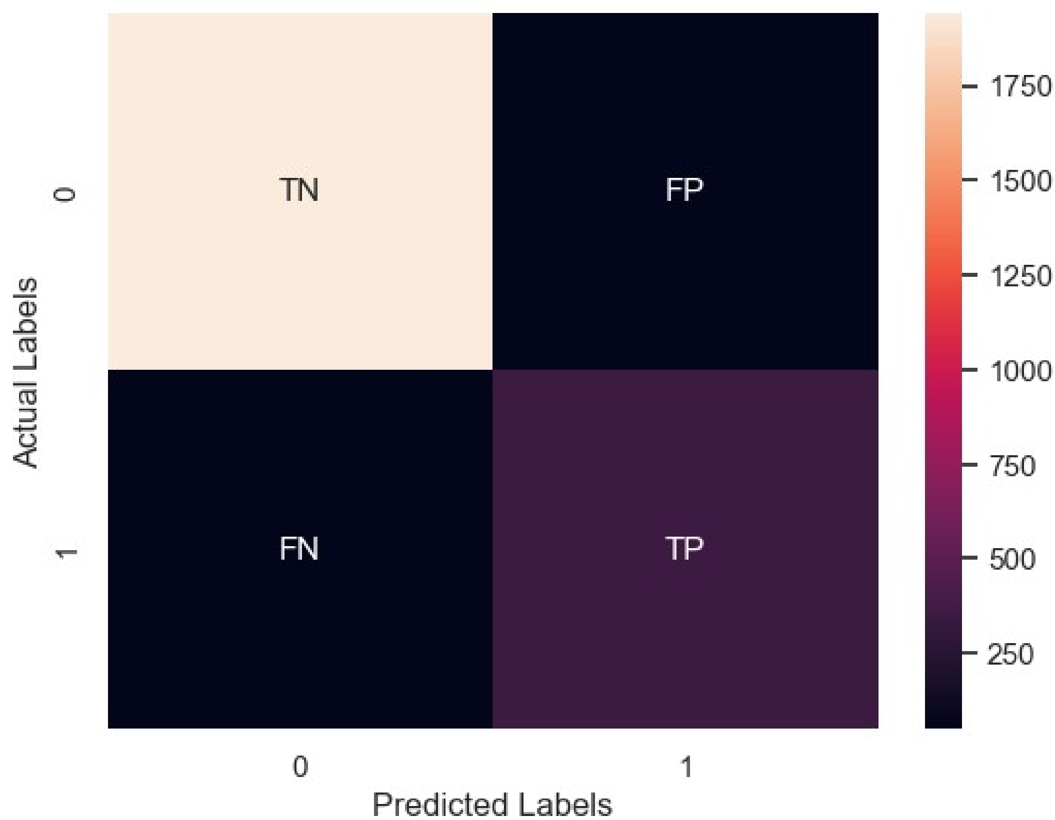
```
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  0.90
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_0 >  0.92
|   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.56
|   |   |   |   |--- class: 0
```

```
feature_names = best_features.columns.tolist()
target_names = [str(name) for name in y.unique().tolist()]
plt.figure(figsize=(30, 20))
plot_tree(tree_classifier,
          feature_names = feature_names,
          class_names = target_names,
          filled = True,
          rounded = True,
         fontsize=12)

plt.savefig('tree_visualization.png')
```



Model Evaluation

```
matrix=confusion_matrix(y_pred,y_test)
matrix

array([[1944,   50],
       [  54,  351]], dtype=int64)

labels = np.array([["TN", "FP"], ["FN", "TP"]])
sns.heatmap(matrix, annot=labels, fmt="", cbar=True)
plt.xlabel("Predicted Labels")
plt.ylabel("Actual Labels")
plt.savefig('Conf_matrix.png')
```



Accuracy_Score

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

```
accuracy_score(y_pred,y_test)
```

```
0.9566486035848271
```

Precision Score:

$$\text{Precision} = \frac{tp}{tp + fp}$$

```
precision_score(y_pred,y_test)
```

```
0.8753117206982544
```

Recall Score:

$$\textbf{Recall} = \frac{\textbf{TP}}{\textbf{TP + FN}}$$

```
recall_score(y_pred,y_test)
```

```
0.8666666666666667
```

```
f1_score(y_pred,y_test)
```

```
0.8709677419354839
```

```
input_data = pd.DataFrame([[0.01,0.04,0.5,0.02]],
columns=best_features.columns)
```

```
prediction = tree_classifier.predict(input_data)
print("Prediction:", prediction)

Prediction: [1]
```

Save The Model

```
pk.dump(tree_classifier , open('tree_classifier_model.pkl','wb'))

savedmodel = pk.load(open('tree_classifier_model.pkl','rb'))

input_data = pd.DataFrame([[0.9,0.7,0.5,0.02]],
columns=best_features.columns)
prediction = savedmodel.predict(input_data)
print("Prediction:", prediction)

Prediction: [0]
```