Assignment 1: Data Analytics Laboratory EE4708

Linear Regression

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Reading the data into pandas dataframes

```
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns

#reading the dataset
dataset = pd.read_excel('merged_data.xlsx',index_col=0)

# Visualizing the data
dataset.head()
```

```
  State                            AreaName  All_Poverty  M_Poverty  \
0    AK      Aleutians East Borough, Alaska          553        334
1    AK  Aleutians West Census Area, Alaska          499        273
2    AK      Anchorage Municipality, Alaska        23914      10698
3    AK          Bethel Census Area, Alaska         4364       2199
4    AK         Bristol Bay Borough, Alaska           69         33

   F_Poverty  FIPS  Med_Income  Med_Income_White  Med_Income_Black  \
0        219  2013     61518.0           72639.0           31250.0
1        226  2016     84306.0           97321.0           93750.0
2      13216  2020     78326.0           87235.0           50535.0
3       2165  2050     51012.0           92647.0           73661.0
4         36  2060     79750.0           88000.0               NaN

   Med_Income_Nat_Am  ...  F_Without  All_With  All_Without  fips_x  \
0            54750.0  ...        540      1442         1857    2013
1            48750.0  ...        564      4177         1333    2016
2            53935.0  ...      21393    243173        44638    2020
3            41594.0  ...       1774     13023         4482    2050
4            63333.0  ...         67       768          191    2060

   Incidence_Rate  Avg_Ann_Incidence  recent_trend  fips_y
```

```
Mortality_Rate  \
0                *          3 or fewer            *    2013
*
1                *          3 or fewer            *    2016
*
2             61.5                 131       stable    2020
47.3
3             62.7                   6       stable    2050
58.3
4                *          3 or fewer            *    2060
*

  Avg_Ann_Deaths
0              *
1              *
2             96
3              5
4              *

[5 rows x 25 columns]
```

Preprocessing and Data Cleaning

```
dataset.columns

Index(['State', 'AreaName', 'All_Poverty', 'M_Poverty', 'F_Poverty',
'FIPS',
       'Med_Income', 'Med_Income_White', 'Med_Income_Black',
       'Med_Income_Nat_Am', 'Med_Income_Asian', 'Hispanic', 'M_With',
       'M_Without', 'F_With', 'F_Without', 'All_With', 'All_Without',
'fips_x',
       'Incidence_Rate', 'Avg_Ann_Incidence', 'recent_trend',
'fips_y',
       'Mortality_Rate', 'Avg_Ann_Deaths'],
      dtype='object')

# Dropping unwanted columns
dataset.drop(['fips_x', 'fips_y'], axis = 1, inplace=True)

dataset.columns

Index(['State', 'AreaName', 'All_Poverty', 'M_Poverty', 'F_Poverty',
'FIPS',
       'Med_Income', 'Med_Income_White', 'Med_Income_Black',
       'Med_Income_Nat_Am', 'Med_Income_Asian', 'Hispanic', 'M_With',
       'M_Without', 'F_With', 'F_Without', 'All_With', 'All_Without',
       'Incidence_Rate', 'Avg_Ann_Incidence', 'recent_trend',
'Mortality_Rate',
       'Avg_Ann_Deaths'],
      dtype='object')
```

```
dataset.shape
```

```
(3134, 23)
```

```
#checking the number of null values in each of the features
dataset.isnull().sum()
```

```
State                    0
AreaName                 0
All_Poverty              0
M_Poverty                0
F_Poverty                0
FIPS                     0
Med_Income               1
Med_Income_White         2
Med_Income_Black      1210
Med_Income_Nat_Am     1660
Med_Income_Asian      1757
Hispanic               681
M_With                   0
M_Without                0
F_With                   0
F_Without                0
All_With                 0
All_Without              0
Incidence_Rate           0
Avg_Ann_Incidence        0
recent_trend             0
Mortality_Rate           0
Avg_Ann_Deaths           0
dtype: int64
```

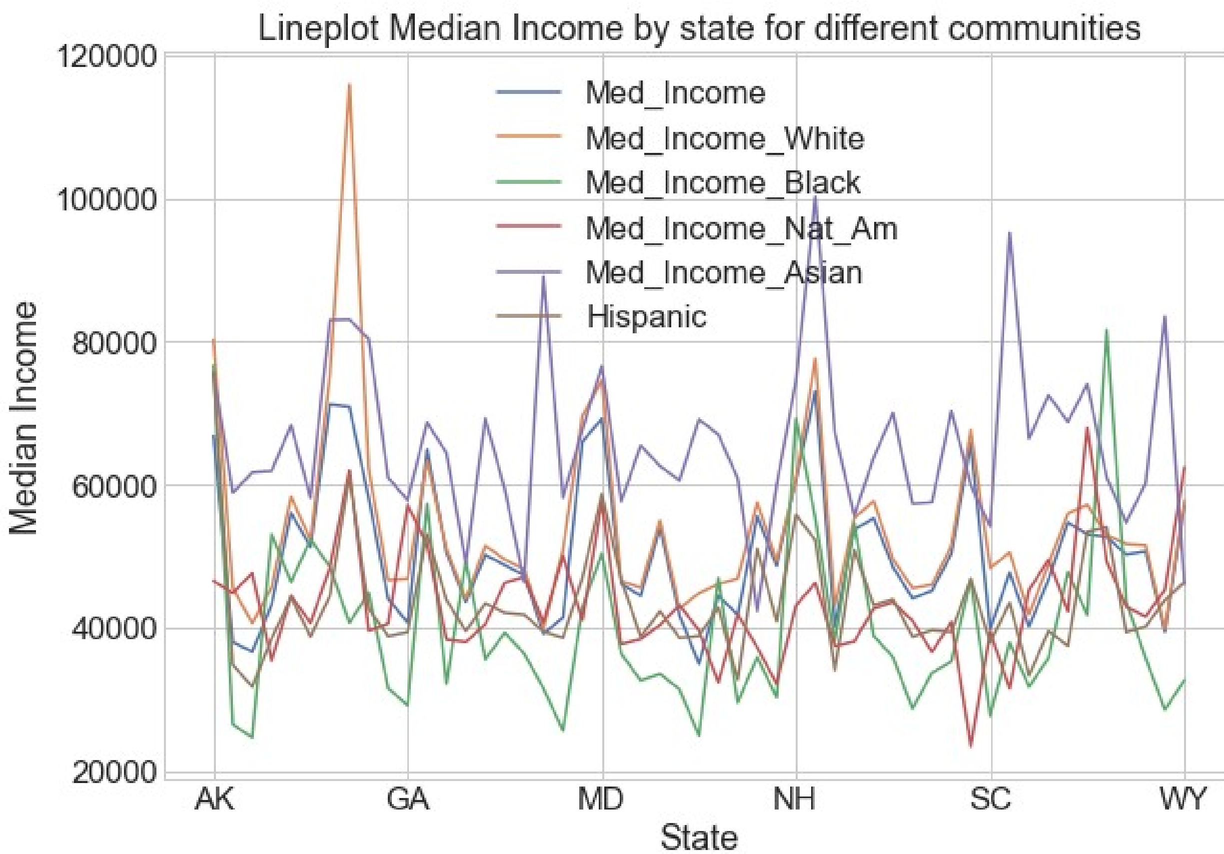
We see the columns with Med Income Black, Native american, Asian have too many missing values hence we tend to remove these columns.

```
fin_df = dataset.copy()

# Total Mean of the Median income for different communities
fin_df[['Med_Income', 'Med_Income_White', 'Med_Income_Black',
       'Med_Income_Nat_Am', 'Med_Income_Asian', 'Hispanic']].mean()
```

```
Med_Income           46819.837855
Med_Income_White     49490.181992
Med_Income_Black     34750.214137
Med_Income_Nat_Am    43309.998643
Med_Income_Asian     65412.969499
Hispanic             41118.231553
dtype: float64
```

```
# A lineplot of the mean of the median incomes of the different communities grouped by state
grpb = fin_df.groupby('State')[['Med_Income', 'Med_Income_White',
'Med_Income_Black',
       'Med_Income_Nat_Am', 'Med_Income_Asian', 'Hispanic']].mean()
grpb.plot.line(ylabel = 'Median Income', title = 'Lineplot Median Income by state for different communities', figsize = (10, 7))
```

```
<AxesSubplot:title={'center':'Lineplot Median Income by state for different communities'}, xlabel='State', ylabel='Median Income'>
```



We can see that the different social group have different mean incomes for different states, hence if we can prove that the median income is a valid factor determining the Avg Ann Incidence or Deaths, then we can also assume that social status would also be a valid factor !

```
#Dropping the following columns
fin_df.drop(['Med_Income_White', 'Med_Income_Black',
'Med_Income_Nat_Am',
             'Med_Income_Asian', 'Hispanic'], axis=1, inplace=True)

# Checks what all columns in the dataframe contain only numeric values
fin_df.apply(lambda s: pd.to_numeric(s,
errors='coerce').notnull().all())
```

```
State                 False
AreaName              False
All_Poverty            True
M_Poverty              True
F_Poverty              True
FIPS                   True
Med_Income            False
M_With                 True
M_Without              True
F_With                 True
F_Without              True
All_With               True
All_Without            True
Incidence_Rate        False
Avg_Ann_Incidence     False
recent_trend          False
Mortality_Rate        False
Avg_Ann_Deaths        False
dtype: bool
```

```
#this will give us info about the columns that only contain numeric of
null values
fin_df.describe()
```

```
        All_Poverty      M_Poverty      F_Poverty          FIPS  \
count  3.134000e+03    3134.000000    3134.000000   3134.000000
mean   1.522966e+04    6828.800893    8400.855775  30426.019145
std    5.457122e+04   24719.078097   29865.855831  15124.491165
min    1.000000e+01       5.000000       5.000000   1001.000000
25%    1.731250e+03     758.750000     957.000000  19001.500000
50%    4.294000e+03    1925.000000    2372.000000  29180.000000
75%    1.034550e+04    4697.500000    5812.500000  45080.500000
max    1.800265e+06  823612.000000  976653.000000  56045.000000

          Med_Income        M_With      M_Without         F_With  \
count    3133.000000  3.134000e+03    3134.000000   3.134000e+03
mean    46819.837855  4.158963e+04    6930.955329   4.487357e+04
std     12246.380184  1.293894e+05   28686.089548   1.406455e+05
min     19328.000000  3.200000e+01       4.000000   3.300000e+01
25%     38826.000000  4.506750e+03     750.000000   4.657500e+03
50%     45075.000000  1.040450e+04    1763.000000   1.110800e+04
75%     52224.000000  2.788775e+04    4407.250000   2.976475e+04
max    123453.000000  3.904322e+06  997326.000000   4.230137e+06

           F_Without      All_With   All_Without
count    3134.000000  3.134000e+03  3.134000e+03
mean     5968.701021  8.646320e+04  1.289966e+04
std     24657.276997  2.699985e+05  5.331494e+04
min         4.000000  6.700000e+01  8.000000e+00
25%       633.000000  9.173500e+03  1.388250e+03
```

```
50%      1529.000000  2.144800e+04  3.323500e+03
75%      3834.000000  5.756150e+04  8.240000e+03
max    837175.000000  8.134459e+06  1.834501e+06
```

Thus we can see we have to treat the columns [Incidence_Rate, Avg_Ann_Incidence, recent_trend, Mortality_Rate, Avg_Ann_Deaths] for values that are not numeric.

Here as we can see, all the independent columns are not normalized by population and we also do not have population data, it is better to delete the Mortality rate and Incidence rate columns as these are just the average values normalized by population and hence can be dropped !!

```
fin_df.drop(['Mortality_Rate', 'Incidence_Rate'], axis = 1, inplace =
True)

# checking for other data than numeric.
[i for i in fin_df['Avg_Ann_Incidence'].unique() if type(i)==str]
```

```
['3 or fewer', '_', '__']
```

On examining, we can see values with '3 or fewer' , _ and '__'

```
[i for i in fin_df['recent_trend'].unique() if type(i)==str]
```

```
['*', 'stable', 'falling', 'rising', '_', '__']
```

```
[i for i in fin_df['Avg_Ann_Deaths'].unique() if type(i)==str]
```

```
['*']
```

```
# Checks for the number of datapoints without numeric data
def f_(x):
    strs = []
    for _, i in enumerate(x):
        try:
            pd.to_numeric(i)
        except:
            strs.append(i)
    print(pd.Series(strs).value_counts())

f_(fin_df['Avg_Ann_Deaths'])
```

```
*    325
dtype: int64
```

We can see 325 datapoints with an asterisk. We can see from the explanation csv that it represents data that has been suppressed due to confidentiality when fewer than 16 cases were reported. So we have two options here, either to delete these row or impute them with the means of each of states they correspond to ! But as this data is not a large fraction of the data we can just delete it !!

```
# which states are associated with the "*"
fin_df.loc[fin_df.Avg_Ann_Deaths=='*', 'State'].value_counts()
```

```
TX    56
NE    37
KS    36
SD    31
ND    30
CO    24
MT    21
ID    15
UT    12
AK    11
GA     8
NM     7
MN     5
OK     5
NV     5
VA     3
OR     3
CA     3
IA     2
WA     2
WY     2
KY     1
MO     1
PA     1
HI     1
MI     1
MS     1
WI     1
Name: State, dtype: int64
```

```
f_(fin_df['Avg_Ann_Incidence'])
```

```
3 or fewer    211
_             192
__             17
dtype: int64
```

Here we convert the '3 or fewer' to 3 and the others to Nan values

```
f_(fin_df['Med_Income'])
```

```
Series([], dtype: int64)
```

```
C:\Users\hp\Anaconda3\lib\site-packages\ipykernel_launcher.py:9:
DeprecationWarning: The default dtype for empty Series will be
'object' instead of 'float64' in a future version. Specify a dtype
```

```
explicitly to silence this warning.
  if __name__ == '__main__':

# we create a filter to convert the non-numeric data to either numeric
or to replace by NULL
def filter_(x):
    try:
        return float(str(x).split(' ')[0])
    except ValueError:
        return float('NaN')

# Using the filter on different columns
fin_df['Avg_Ann_Incidence'] = fin_df['Avg_Ann_Incidence'].map(filter_)

fin_df['Avg_Ann_Deaths'] = fin_df['Avg_Ann_Deaths'].map(filter_)
fin_df['Med_Income'] = fin_df['Med_Income'].map(filter_)

print([i for i in fin_df['Avg_Ann_Incidence'].unique() if
type(i)==str])
print([i for i in fin_df['Avg_Ann_Deaths'].unique() if type(i)==str])
#print([i for i in fin_df['recent_trend'].unique() if type(i)==str])

[]
[]

# creating columns with Rising and falling !!

def boo(col, chck):
    if col == chck:
        return 1
    return 0

fin_df['Rising'] = fin_df['recent_trend'].apply(lambda x: boo(x,
'rising'))
fin_df['Falling'] = fin_df['recent_trend'].apply(lambda x: boo(x,
'falling'))

fin_df.select_dtypes(include=np.number)

      All_Poverty  M_Poverty  F_Poverty   FIPS  Med_Income  M_With
M_Without  \
0             553        334        219   2013     61518.0     876
1317
1             499        273        226   2016     84306.0    2470
769
2           23914      10698      13216   2020     78326.0  120747
23245
3            4364       2199       2165   2050     51012.0    6396
2708
4              69         33         36   2060     79750.0     419
124
```

```
...            ...        ...        ...    ...         ...     ...
...
3129          5058       2177       2881  56037     69022.0   19891
3318
3130          1638       1026        612  56039     75325.0    8948
2558
3131          2845       1453       1392  56041     56569.0    9132
1413
3132          1137        489        648  56043     47652.0    3349
691
3133           958        354        604  56045     57738.0    2927
454

      F_With  F_Without  All_With  All_Without  Avg_Ann_Incidence  \
0        566        540      1442         1857                3.0
1       1707        564      4177         1333                3.0
2     122426      21393    243173        44638              131.0
3       6627       1774     13023         4482                6.0
4        349         67       768          191                3.0
...      ...        ...       ...          ...                ...
3129   18600       2683     38491         6001               14.0
3130    9555       1192     18503         3750                5.0
3131    8711       1503     17843         2916                6.0
3132    3490        703      6839         1394                6.0
3133    3087        314      6014          768                4.0

      Avg_Ann_Deaths  Rising  Falling
0                NaN       0        0
1                NaN       0        0
2               96.0       0        0
3                5.0       0        0
4                NaN       0        0
...              ...     ...      ...
3129             9.0       0        0
3130             5.0       0        0
3131             4.0       0        0
3132             5.0       0        0
3133             4.0       0        0

[3134 rows x 15 columns]
```

```
#checking for null values post the pre-processing
fin_df.isnull().sum()
```

```
State                  0
AreaName               0
All_Poverty            0
M_Poverty              0
F_Poverty              0
FIPS                   0
```

```
Med_Income            1
M_With                0
M_Without             0
F_With                0
F_Without             0
All_With              0
All_Without           0
Avg_Ann_Incidence   209
recent_trend          0
Avg_Ann_Deaths      325
Rising                0
Falling               0
dtype: int64
```

```
fin_df.head()
```

```
  State                            AreaName  All_Poverty  M_Poverty  \
0    AK      Aleutians East Borough, Alaska          553        334
1    AK  Aleutians West Census Area, Alaska          499        273
2    AK      Anchorage Municipality, Alaska        23914      10698
3    AK          Bethel Census Area, Alaska         4364       2199
4    AK         Bristol Bay Borough, Alaska           69         33

   F_Poverty  FIPS  Med_Income  M_With  M_Without  F_With
F_Without  \
0        219  2013     61518.0     876       1317     566         540

1        226  2016     84306.0    2470        769    1707         564

2      13216  2020     78326.0  120747      23245  122426       21393

3       2165  2050     51012.0    6396       2708    6627        1774

4         36  2060     79750.0     419        124     349          67


   All_With  All_Without  Avg_Ann_Incidence recent_trend
Avg_Ann_Deaths  \
0      1442         1857                3.0            *
NaN
1      4177         1333                3.0            *
NaN
2    243173        44638              131.0       stable
96.0
3     13023         4482                6.0       stable
5.0
4       768          191                3.0            *
NaN

   Rising  Falling
```

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

```
#Checking for mean values for different features, grouped by state
fin_df.groupby(['State']).mean()
```

```
         All_Poverty     M_Poverty     F_Poverty          FIPS
Med_Income  \
State

AK       2978.782609   1425.260870   1553.521739   2138.217391
66812.565217
AL      13242.686567   5740.791045   7501.895522   1067.000000
37973.134328
AR       7381.920000   3303.280000   4078.640000   5075.000000
36626.480000
AZ      78712.666667  36501.133333  42211.533333   4013.866667
43252.200000
CA     105778.310345  48712.758621  57065.551724   6058.000000
56013.155172
CO      10218.265625   4729.312500   5488.953125   8062.234375
51263.187500
CT      45793.875000  20125.000000  25668.875000   9008.000000
71184.125000
DC     110365.000000  48069.000000  62296.000000  11001.000000
70848.000000
DE      36105.000000  15373.000000  20732.000000  10003.000000
58067.666667
FL      47464.313433  21485.835821  25978.477612  12067.910448
44046.477612
GA      11251.238994   4968.270440   6282.968553  13161.490566
40704.911950
HI      30788.800000  14142.200000  16646.600000  15005.000000
64879.000000
IA       3776.595960   1693.616162   2082.979798  19099.000000
50483.121212
ID       5572.204545   2591.636364   2980.568182  16044.000000
43607.750000
IL      17658.019608   7873.049020   9784.970588  17102.000000
50163.441176
IN      10630.902174   4719.782609   5911.119565  18092.000000
48745.402174
KS       3631.933333   1651.476190   1980.457143  20105.000000
47322.209524
KY       6715.341667   3007.733333   3707.608333  21120.000000
39137.300000
LA      13879.375000   5932.671875   7946.703125  22064.000000
```

```
41411.781250
MA      53493.214286  23007.857143  30485.357143  25014.000000
65974.428571
MD      24033.541667  10270.708333  13762.833333  24044.958333
69200.375000
ME      11267.375000   5047.500000   6219.875000  23016.000000
46141.750000
MI      19480.361446   8863.554217  10616.807229  26083.000000
44464.987952
MN       6858.183908   3145.494253   3712.689655  27087.000000
53926.988506
MO       7964.973913   3553.165217   4411.808696  29117.713043
41755.400000
MS       7945.670732   3430.256098   4515.414634  28082.000000
34938.926829
MT       2689.035714   1246.785714   1442.250000  30056.000000
44497.017857
NC      16674.650000   7399.320000   9275.330000  37100.000000
41784.200000
ND       1504.867925    669.962264    834.905660  38053.000000
55574.867925
NE       2485.107527   1088.548387   1396.559140  31093.000000
48646.129032
NH      11384.000000   5107.000000   6277.000000  33010.000000
60648.900000
NJ      44992.714286  19710.857143  25281.857143  34021.000000
73014.095238
NM      13010.939394   6034.939394   6976.000000  35030.151515
40183.666667
NV      25078.647059  11705.352941  13373.294118  32045.529412
53689.705882
NY      48482.951613  21388.532258  27094.419355  36062.000000
55275.693548
OH      20179.954545   8994.931818  11185.022727  39088.000000
48446.409091
OK       8104.454545   3612.857143   4491.597403  40077.000000
44097.376623
OR      17692.972222   8237.222222   9455.750000  41036.000000
45171.222222
PA      24874.164179  11000.119403  13874.044776  42067.000000
50316.253731
RI      28844.600000  12603.400000  16241.200000  44005.000000
65783.400000
SC      18063.065217   7840.521739  10222.543478  45046.000000
39756.695652
SD       1652.692308    756.615385    896.076923  46067.430769
47679.738462
TN      11764.147368   5240.600000   6523.547368  47095.000000
40168.031579
```

```
TX      17608.074803   7883.543307   9724.531496  48254.000000
46745.778656
UT      12124.172414   5646.620690   6477.551724  49029.000000
54687.034483
VA       6927.651515   3028.363636   3899.287879  51265.848485
53059.212121
VT       4945.214286   2213.642857   2731.571429  50014.000000
52653.500000
WA      23295.179487  10715.025641  12580.153846  53039.000000
50217.076923
WI      10060.388889   4519.638889   5540.750000  55071.097222
50649.000000
WV       5879.709091   2635.436364   3244.272727  54055.000000
39411.818182
WY       2825.869565   1255.739130   1570.130435  56023.000000
57042.304348

              M_With     M_Without          F_With     F_Without  \
State
AK      12366.565217   2917.739130   12147.608696   2411.217391
AL      29389.671642   4678.328358   32530.134328   4294.194030
AR      16012.226667   2881.893333   17237.906667   2603.880000
AZ     178389.533333  35436.066667  191685.466667  30056.200000
CA     269831.241379  52388.275862  287728.534483  43712.500000
CO      34745.546875   5534.781250   36322.625000   4447.265625
CT     194827.125000  19867.500000  212544.125000  15086.125000
DC     276285.000000  22198.000000  323314.000000  14813.000000
DE     132112.666667  13828.000000  146781.000000  11207.666667
FL     112310.552239  27464.761194  124417.328358  24393.179104
GA      24288.446541   5449.440252   26859.364780   5116.691824
HI     123945.400000   8997.200000  130480.400000   7047.000000
IA      14020.090909   1243.060606   14529.464646   1006.444444
ID      15305.886364   2773.363636   15626.613636   2562.863636
IL      53124.647059   7664.294118   57616.421569   6047.813725
IN      29740.010870   4733.456522   31571.097826   4270.260870
KS      11722.238095   1594.009524   12237.314286   1435.695238
KY      15362.841667   2174.991667   16486.958333   1910.525000
LA      28475.515625   5594.515625   31249.015625   5339.109375
MA     218643.642857  10231.071429  237913.857143   6623.428571
MD     104805.500000  12109.708333  116597.083333   9684.958333
ME      35496.687500   4614.687500   38427.937500   3637.187500
MI      51325.879518   6328.108434   55251.277108   5036.240964
MN      28082.068966   2476.908046   29202.885057   1857.229885
MO      21828.939130   3295.878261   23439.895652   3021.800000
MS      14163.085366   2915.890244   15824.743902   2720.536585
MT       7459.232143   1468.642857    7611.232143   1303.982143
NC      39094.400000   7360.030000   43500.040000   6541.590000
ND       6080.886792    679.924528    6035.056604    530.679245
NE       8726.322581   1086.344086    9035.322581    947.000000
```

NH	57839.500000	6636.700000	60861.000000	5568.500000
NJ	176838.857143	26562.190476	193311.333333	22173.523810
NM	25007.909091	5452.000000	26911.939394	4740.333333
NV	65350.588235	15792.000000	67480.411765	13947.588235
NY	134038.258065	17297.806452	149030.435484	12977.209677
OH	56197.590909	6936.954545	60783.000000	5660.829545
OK	19749.077922	4244.116883	21039.896104	3907.480519
OR	46073.055556	7253.416667	48939.194444	6089.083333
PA	82057.477612	9146.940299	89112.880597	7370.582090
RI	89317.200000	10941.000000	99037.000000	8290.800000
SC	41092.608696	7752.934783	45848.934783	7033.695652
SD	5532.461538	709.692308	5630.861538	609.646154
TN	27868.221053	4724.884211	30850.915789	3897.357895
TX	39586.787402	10816.748031	41903.157480	10301.303150
UT	42691.068966	6939.689655	43393.172414	6177.206897
VA	25542.757576	3658.446970	27926.901515	3227.848485
VT	20227.000000	1575.571429	21508.642857	1007.142857
WA	76236.564103	11122.410256	79952.794872	9069.102564
WI	35358.930556	3563.430556	37140.777778	2664.125000
WV	14296.309091	1975.145455	15042.254545	1820.836364
WY	10802.956522	1764.608696	10670.782609	1552.869565

\	All_With	All_Without	Avg_Ann_Incidence	Avg_Ann_Deaths
State				
AK	24514.173913	5328.956522	15.130435	19.833333
AL	61919.805970	8972.522388	59.597015	47.552239
AR	33250.133333	5485.773333	35.733333	28.546667
AZ	370075.000000	65492.266667	252.600000	182.666667
CA	557559.775862	96100.775862	294.396552	231.818182
CO	71068.171875	9982.046875	35.281250	39.075000
CT	407371.250000	34953.625000	332.875000	216.875000
DC	599599.000000	37011.000000	351.000000	240.000000
DE	278893.666667	25035.666667	257.666667	188.333333
FL	236727.880597	51857.940299	245.462687	178.029851
GA	51147.811321	10566.132075	39.823899	29.841060
HI	254425.800000	16044.200000	155.800000	134.250000
IA	28549.555556	2249.505051	24.131313	18.051546

ID	30932.500000	5336.227273	19.500000	20.586207
IL	110741.068627	13712.107843	91.254902	64.990196
IN	61311.108696	9003.717391	57.771739	43.586957
KS	23959.552381	3029.704762	NaN	20.826087
KY	31849.800000	4085.516667	40.083333	29.008403
LA	59724.531250	10933.625000	54.453125	42.500000
MA	456557.500000	16854.500000	358.785714	247.500000
MD	221402.583333	21794.666667	152.458333	114.083333
ME	73924.625000	8251.875000	82.750000	59.750000
MI	106577.156627	11364.349398	95.012048	71.731707
MN	57284.954023	4334.137931	NaN	28.719512
MO	45268.834783	6317.678261	46.243478	34.333333
MS	29987.829268	5636.426829	30.487805	23.975309
MT	15070.464286	2772.625000	13.321429	13.485714
NC	82594.440000	13901.620000	75.580000	54.840000
ND	12115.943396	1210.603774	9.094340	12.000000
NE	17761.645161	2033.344086	13.473118	15.035714
NH	118700.500000	12205.200000	105.600000	73.600000
NJ	370150.190476	48735.714286	280.904762	195.095238
NM	51919.848485	10192.333333	29.424242	27.653846
NV	132831.000000	29739.588235	NaN	108.500000
NY	283068.693548	30275.016129	219.532258	146.677419
OH	116980.590909	12597.784091	109.670455	84.204545
OK	40788.974026	8151.597403	39.272727	33.791667
OR	95012.250000	13342.500000	74.694444	62.363636
PA	171170.358209	16517.522388	159.074627	116.621212

RI	188354.200000	19231.800000	172.800000	124.600000
SC	86941.543478	14786.630435	81.413043	60.826087
SD	11163.323077	1319.338462	8.969231	10.882353
TN	58719.136842	8622.242105	59.515789	45.873684
TX	81489.944882	21118.051181	51.480315	48.020202
UT	86084.241379	13116.896552	22.241379	24.764706
VA	53469.659091	6886.295455	39.659091	30.387597
VT	41735.642857	2582.714286	37.357143	26.500000
WA	156189.358974	20191.512821	110.282051	84.837838
WI	72499.708333	6227.555556	55.888889	41.732394
WV	29338.563636	3795.981818	36.436364	27.436364
WY	21473.739130	3317.478261	12.739130	10.857143

	Rising	Falling
State		
AK	0.000000	0.000000
AL	0.000000	0.074627
AR	0.000000	0.040000
AZ	0.066667	0.133333
CA	0.000000	0.258621
CO	0.015625	0.062500
CT	0.000000	0.375000
DC	0.000000	0.000000
DE	0.000000	0.000000
FL	0.000000	0.134328
GA	0.000000	0.050314
HI	0.000000	0.000000
IA	0.060606	0.030303
ID	0.000000	0.000000
IL	0.009804	0.127451
IN	0.032609	0.032609
KS	0.000000	0.000000
KY	0.016667	0.041667
LA	0.000000	0.031250
MA	0.000000	0.142857
MD	0.041667	0.125000
ME	0.000000	0.000000
MI	0.000000	0.072289

```
MN     0.000000  0.000000
MO     0.052174  0.034783
MS     0.012195  0.048780
MT     0.035714  0.017857
NC     0.010000  0.040000
ND     0.056604  0.037736
NE     0.010753  0.000000
NH     0.000000  0.100000
NJ     0.000000  0.666667
NM     0.000000  0.121212
NV     0.000000  0.000000
NY     0.032258  0.096774
OH     0.000000  0.113636
OK     0.000000  0.038961
OR     0.000000  0.055556
PA     0.029851  0.029851
RI     0.000000  0.000000
SC     0.043478  0.086957
SD     0.000000  0.030769
TN     0.010526  0.063158
TX     0.007874  0.031496
UT     0.000000  0.068966
VA     0.015152  0.106061
VT     0.000000  0.142857
WA     0.000000  0.282051
WI     0.027778  0.055556
WV     0.018182  0.018182
WY     0.000000  0.043478
```

```python
# Creating a correlation matrix to check for the correlation between
different columns
fin_df.corr()
```

```
                   All_Poverty  M_Poverty  F_Poverty      FIPS
Med_Income  \
All_Poverty           1.000000   0.999696   0.999792 -0.059265
0.121617
M_Poverty             0.999696   1.000000   0.998986 -0.060504
0.120250
F_Poverty             0.999792   0.998986   1.000000 -0.058212
0.122692
FIPS                 -0.059265  -0.060504  -0.058212  1.000000
0.069289
Med_Income            0.121617   0.120250   0.122692  0.069289
1.000000
M_With                0.957627   0.957438   0.957343 -0.057703
0.261679
M_Without             0.970175   0.971202   0.968879 -0.051458
0.141092
F_With                0.961131   0.960465   0.961240 -0.057880
```

```
0.255890
F_Without            0.959671   0.960657   0.958413 -0.048607
0.135189
All_With             0.959581   0.959144   0.959502 -0.057803
0.258699
All_Without          0.965834   0.966843   0.964556 -0.050167
0.138437
Avg_Ann_Incidence    0.901260   0.898099   0.903467 -0.071399
0.241756
Avg_Ann_Deaths       0.911911   0.909497   0.913488 -0.060881
0.235420
Rising              -0.019629  -0.019341  -0.019858  0.010595   -
0.010574
Falling              0.269978   0.269447   0.270294 -0.006330
0.145025

                      M_With  M_Without    F_With  F_Without  All_With
\
All_Poverty         0.957627   0.970175  0.961131   0.959671  0.959581

M_Poverty           0.957438   0.971202  0.960465   0.960657  0.959144

F_Poverty           0.957343   0.968879  0.961240   0.958413  0.959502

FIPS               -0.057703  -0.051458 -0.057880  -0.048607 -0.057803

Med_Income          0.261679   0.141092  0.255890   0.135189  0.258699

M_With              1.000000   0.942191  0.999459   0.928710  0.999853

M_Without           0.942191   1.000000  0.941427   0.997856  0.941920

F_With              0.999459   0.941427  1.000000   0.927356  0.999876

F_Without           0.928710   0.997856  0.927356   1.000000  0.928130

All_With            0.999853   0.941920  0.999876   0.928130  1.000000

All_Without         0.936459   0.999542  0.935421   0.999380  0.936045

Avg_Ann_Incidence   0.949095   0.858194  0.953351   0.842368  0.951440

Avg_Ann_Deaths      0.953423   0.871616  0.957293   0.856068  0.955570

Rising             -0.021823  -0.018979 -0.022058  -0.019055 -0.021948

Falling             0.307680   0.261397  0.307576   0.259156  0.307668


                   All_Without  Avg_Ann_Incidence  Avg_Ann_Deaths
Rising  \
```

```
All_Poverty              0.965834           0.901260          0.911911 -
0.019629
M_Poverty                0.966843           0.898099          0.909497 -
0.019341
F_Poverty                0.964556           0.903467          0.913488 -
0.019858
FIPS                    -0.050167          -0.071399         -0.060881
0.010595
Med_Income               0.138437           0.241756          0.235420 -
0.010574
M_With                   0.936459           0.949095          0.953423 -
0.021823
M_Without                0.999542           0.858194          0.871616 -
0.018979
F_With                   0.935421           0.953351          0.957293 -
0.022058
F_Without                0.999380           0.842368          0.856068 -
0.019055
All_With                 0.936045           0.951440          0.955570 -
0.021948
All_Without              1.000000           0.851338          0.864893 -
0.019024
Avg_Ann_Incidence        0.851338           1.000000          0.997726 -
0.027694
Avg_Ann_Deaths           0.864893           0.997726          1.000000 -
0.028952
Rising                  -0.019024          -0.027694         -0.028952
1.000000
Falling                  0.260500           0.314654          0.306145 -
0.030629

                    Falling
All_Poverty        0.269978
M_Poverty          0.269447
F_Poverty          0.270294
FIPS              -0.006330
Med_Income         0.145025
M_With             0.307680
M_Without          0.261397
F_With             0.307576
F_Without          0.259156
All_With           0.307668
All_Without        0.260500
Avg_Ann_Incidence  0.314654
Avg_Ann_Deaths     0.306145
Rising            -0.030629
Falling            1.000000

# Using the describe method for the dataframe
fin_df.describe()
```

```
        All_Poverty      M_Poverty      F_Poverty          FIPS  \
count  3.134000e+03    3134.000000    3134.000000   3134.000000
mean   1.522966e+04    6828.800893    8400.855775  30426.019145
std    5.457122e+04   24719.078097   29865.855831  15124.491165
min    1.000000e+01       5.000000       5.000000   1001.000000
25%    1.731250e+03     758.750000     957.000000  19001.500000
50%    4.294000e+03    1925.000000    2372.000000  29180.000000
75%    1.034550e+04    4697.500000    5812.500000  45080.500000
max    1.800265e+06  823612.000000  976653.000000  56045.000000

          Med_Income        M_With      M_Without        F_With  \
count    3133.000000  3.134000e+03    3134.000000  3.134000e+03
mean    46819.837855  4.158963e+04    6930.955329  4.487357e+04
std     12246.380184  1.293894e+05   28686.089548  1.406455e+05
min     19328.000000  3.200000e+01       4.000000  3.300000e+01
25%     38826.000000  4.506750e+03     750.000000  4.657500e+03
50%     45075.000000  1.040450e+04    1763.000000  1.110800e+04
75%     52224.000000  2.788775e+04    4407.250000  2.976475e+04
max    123453.000000  3.904322e+06  997326.000000  4.230137e+06

           F_Without      All_With    All_Without  Avg_Ann_Incidence  \
count    3134.000000  3.134000e+03   3.134000e+03        2925.000000
mean     5968.701021  8.646320e+04   1.289966e+04          71.079316
std     24657.276997  2.699985e+05   5.331494e+04         172.803924
min         4.000000  6.700000e+01   8.000000e+00           3.000000
25%       633.000000  9.173500e+03   1.388250e+03          11.000000
50%      1529.000000  2.144800e+04   3.323500e+03          25.000000
75%      3834.000000  5.756150e+04   8.240000e+03          60.000000
max    837175.000000  8.134459e+06   1.834501e+06        3701.000000

       Avg_Ann_Deaths       Rising      Falling
count     2809.000000  3134.000000  3134.000000
mean        55.822357     0.013720     0.063178
std        127.709719     0.116347     0.243322
min          3.000000     0.000000     0.000000
25%         10.000000     0.000000     0.000000
50%         21.000000     0.000000     0.000000
75%         48.000000     0.000000     0.000000
max       2876.000000     1.000000     1.000000
```

```python
#Converting the Median Income column to numeric type
fin_df['Med_Income'] = pd.to_numeric(fin_df.Med_Income)

# Checks what all columns in the dataframe contain only numeric values
fin_df.apply(lambda s: pd.to_numeric(s,
errors='coerce').notnull().all())
```

```
State                False
AreaName             False
All_Poverty           True
```

```
M_Poverty              True
F_Poverty              True
FIPS                   True
Med_Income            False
M_With                 True
M_Without              True
F_With                 True
F_Without              True
All_With               True
All_Without            True
Avg_Ann_Incidence     False
recent_trend          False
Avg_Ann_Deaths        False
Rising                 True
Falling                True
dtype: bool
```

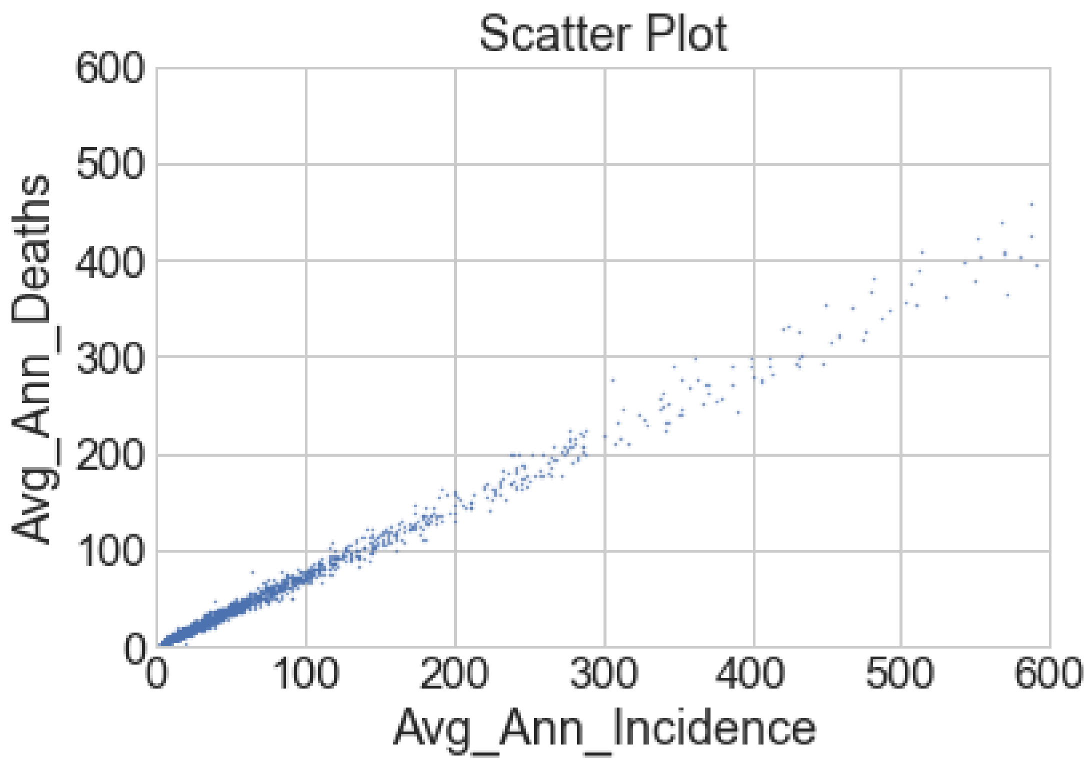
We wont be doing anything with the null values we have created as out library Statsmodels can handle missing data !

Visualization

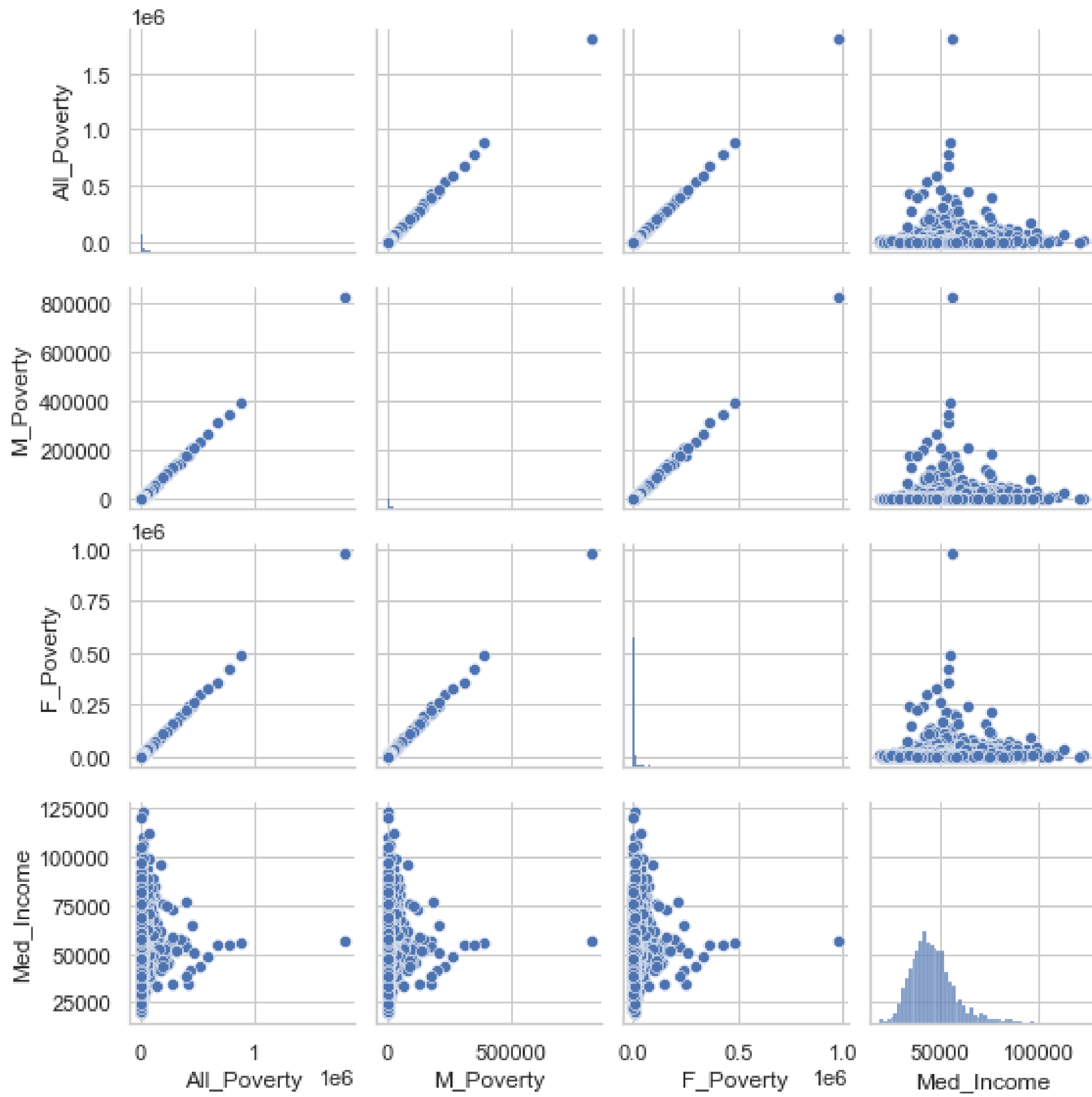
```
# Scatter plot Avg_Ann_Incidence vs Avg_Ann_Deaths
fin_df.plot(x = 'Avg_Ann_Incidence', y = 'Avg_Ann_Deaths', kind=
'scatter', s=0.1, xlim=[0, 600], ylim=[0, 600], title = 'Scatter
Plot')
```

```
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
```

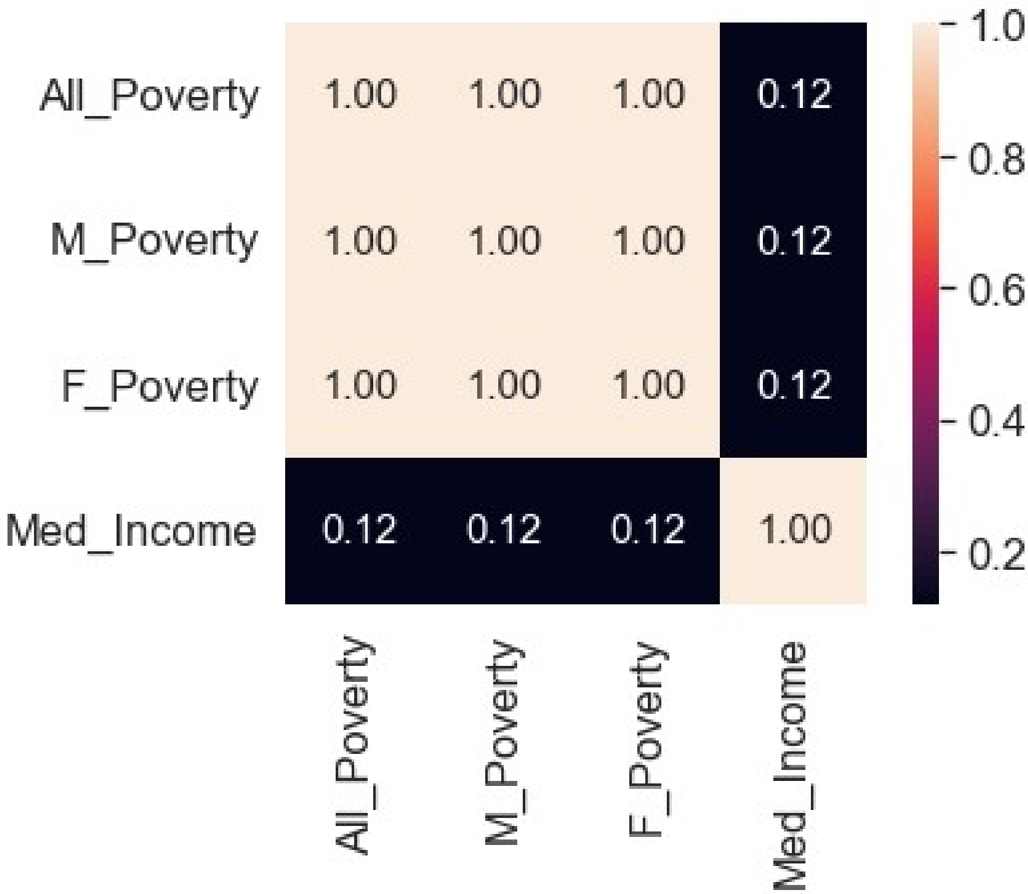
```
<AxesSubplot:title={'center':'Scatter Plot'},
xlabel='Avg_Ann_Incidence', ylabel='Avg_Ann_Deaths'>
```




```
# Pairplot
sns.set(style='whitegrid', context='notebook')
sns.pairplot(fin_df[['All_Poverty', 'M_Poverty', 'F_Poverty',
'Med_Income']], height=2)

<seaborn.axisgrid.PairGrid at 0x1b2f47ab688>
```

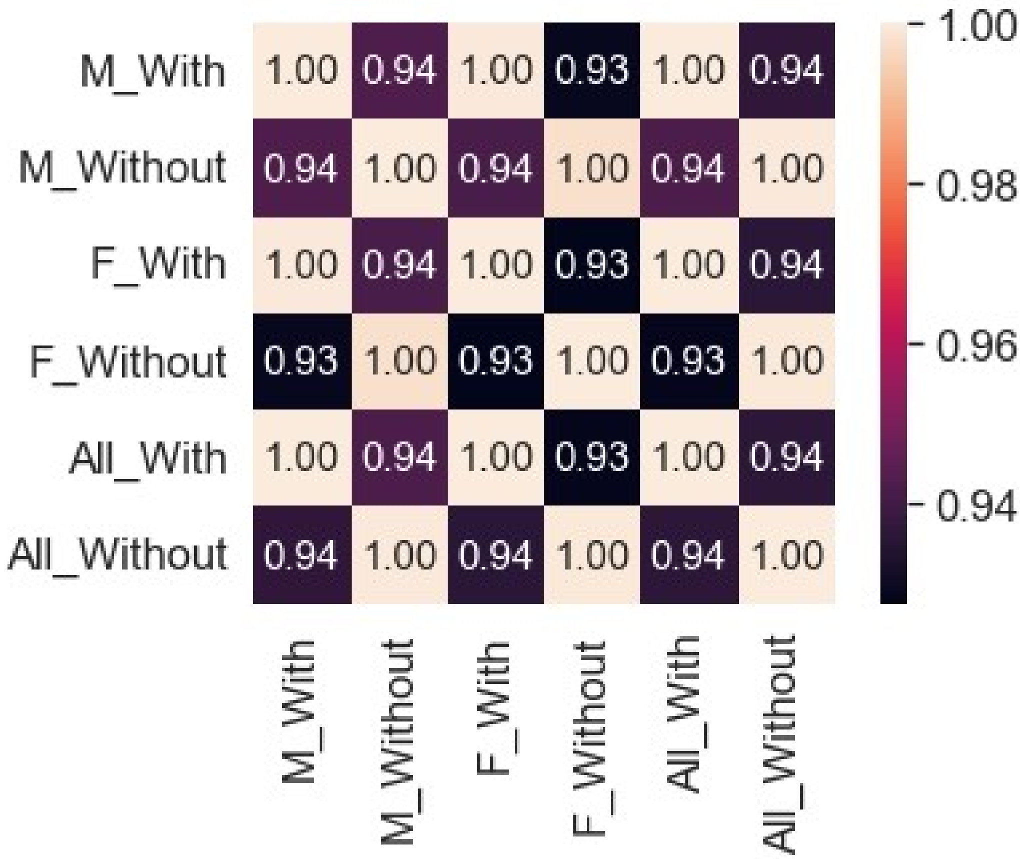



```
# Correlation Heatmap
cols = ['All_Poverty', 'M_Poverty', 'F_Poverty', 'Med_Income']
cm = fin_df[cols].corr()
sns.set(font_scale=1.5)
hm = sns.heatmap(cm, cbar=True, annot = True, square=True, fmt='.2f', annot_kws={'size':15},
                 yticklabels=cols, xticklabels=cols)
```

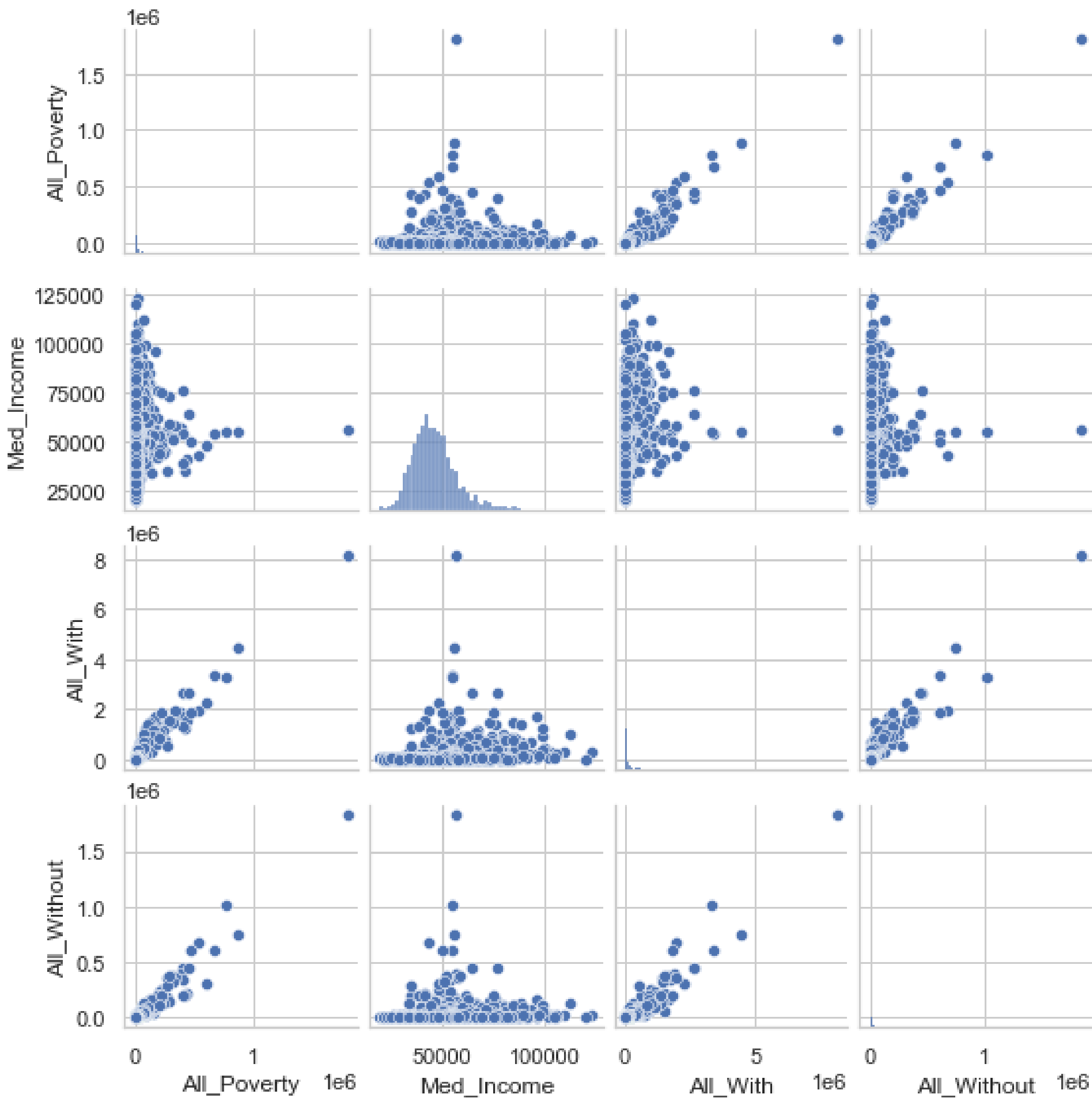


We see that the columns All_Poverty, M and F poverty are very correlated and hence we need to drop two from these !!

```
fin_df.drop(['M_Poverty', 'F_Poverty'], axis=1, inplace=True)

cols = ['M_With', 'M_Without', 'F_With', 'F_Without', 'All_With',
        'All_Without']
cm = fin_df[cols].corr()
sns.set(font_scale=1.5)
hm = sns.heatmap(cm, cbar=True, annot = True, square=True, fmt='.2f',
annot_kws={'size':15},
                yticklabels=cols, xticklabels=cols)
```




```
fin_df.drop(['M_With', 'M_Without', 'F_With', 'F_Without'], axis=1,
inplace=True)

sns.set(style='whitegrid', context='notebook')
sns.pairplot(fin_df[['All_Poverty', 'Med_Income', 'All_With',
        'All_Without']], height=2)

<seaborn.axisgrid.PairGrid at 0x1b2f7688488>
```

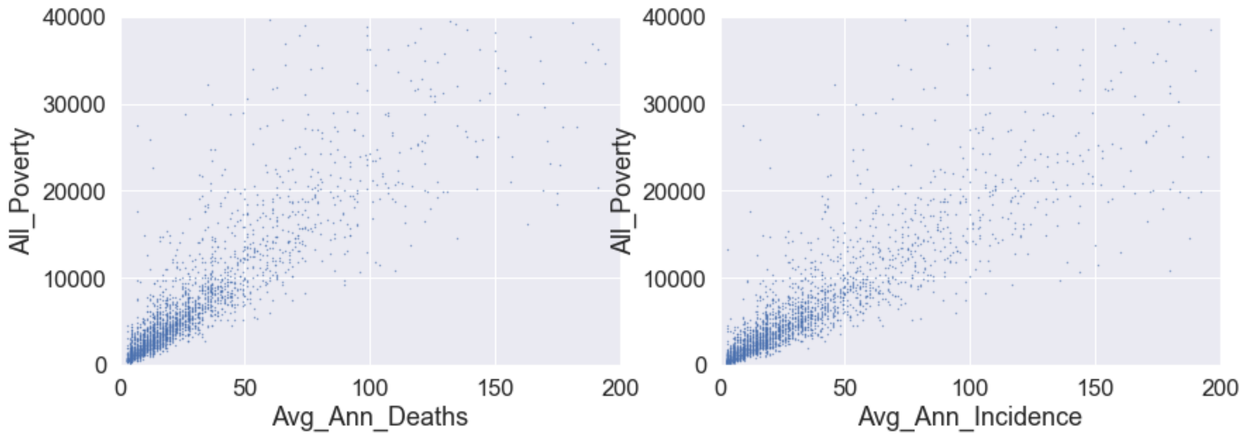



```
cols = ['All_Poverty', 'Med_Income', 'All_With','All_Without']
cm = fin_df[cols].corr()
sns.set(font_scale=1.5)
hm = sns.heatmap(cm, cbar=True, annot = True, square=True, fmt='.2f',
annot_kws={'size':15},
                 yticklabels=cols, xticklabels=cols)
```


```
# Scatter Plot
def visualize_scatter_pov(col):
    fig1 = plt.figure(figsize = (14,10))

    ax3 = fig1.add_subplot(223)
    fin_df.plot(x = 'Avg_Ann_Deaths', y = col, kind= 'scatter', s=0.1,
xlim = [0, 200], ylim = [0, 40000], ax = ax3)
    ax4 = fig1.add_subplot(224)
    fin_df.plot(x = 'Avg_Ann_Incidence', y = col, kind= 'scatter',
s=0.1,xlim = [0, 200], ylim = [0, 40000], ax = ax4)

visualize_scatter_pov('All_Poverty')
```

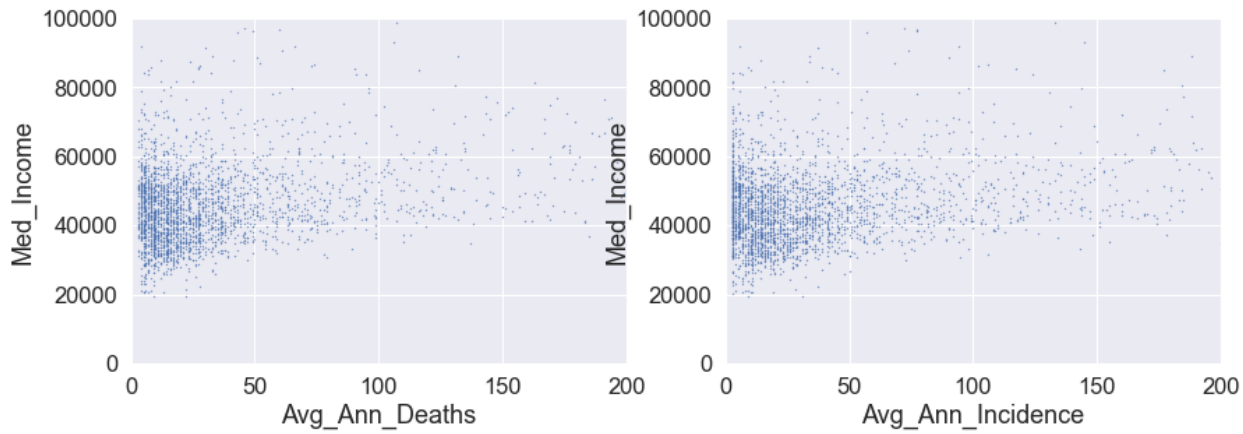
```
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
```

```
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
```

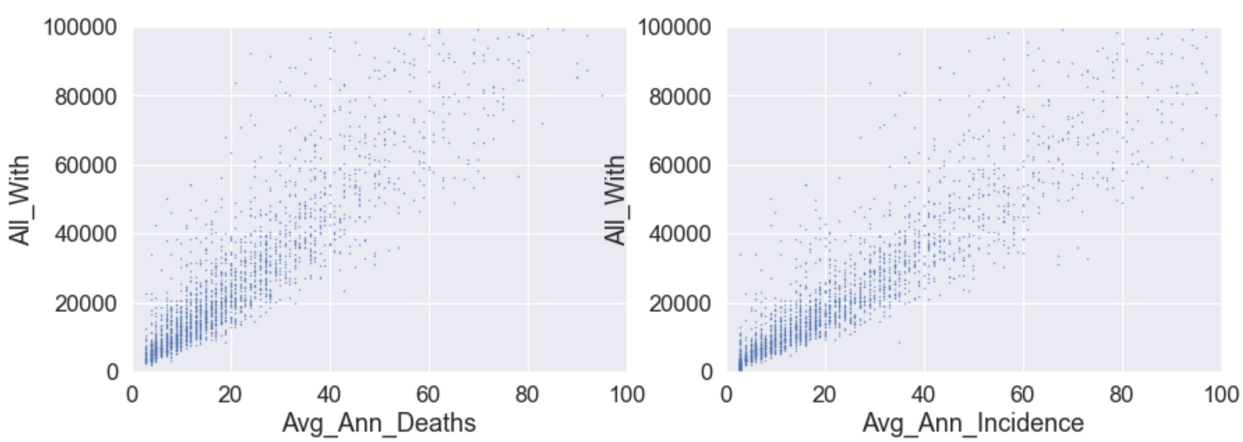



```
def visualize_scatter_inc(col):
    fig1 = plt.figure(figsize = (14,10))
    ax3 = fig1.add_subplot(223)
    fin_df.plot(x = 'Avg_Ann_Deaths', y = col, kind= 'scatter',xlim =
[0, 200], ylim = [0, 100000], s=0.1, ax = ax3)
    ax4 = fig1.add_subplot(224)
    fin_df.plot(x = 'Avg_Ann_Incidence', y = col, kind= 'scatter',
s=0.1,xlim = [0, 200], ylim = [0, 100000], ax = ax4)

visualize_scatter_inc('Med_Income')
```

```
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
```

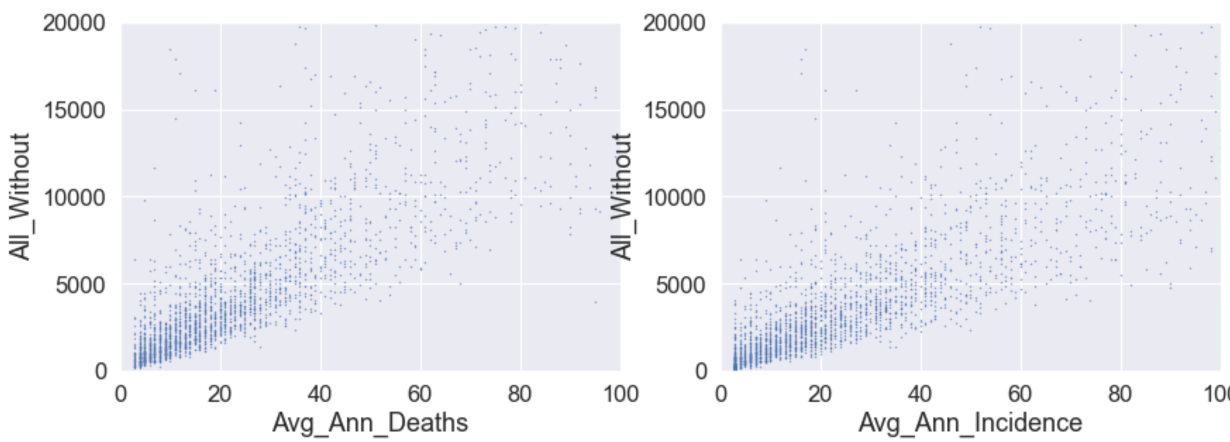



```
def visualize_scatter_with(col):
    fig1 = plt.figure(figsize = (14,10))
    ax3 = fig1.add_subplot(223)
    fin_df.plot(x = 'Avg_Ann_Deaths', y = col, kind= 'scatter',xlim =
[0, 100], ylim = [0, 100000], s=0.1, ax = ax3)
    ax4 = fig1.add_subplot(224)
    fin_df.plot(x = 'Avg_Ann_Incidence', y = col, kind= 'scatter',
s=0.1,xlim = [0, 100], ylim = [0, 100000], ax = ax4)

visualize_scatter_with('All_With')

*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
```



```
def visualize_scatter_without(col):
    fig1 = plt.figure(figsize = (14,10))
    ax3 = fig1.add_subplot(223)
    fin_df.plot(x = 'Avg_Ann_Deaths', y = col, kind= 'scatter',xlim =
[0, 100], ylim = [0, 20000], s=0.1, ax = ax3)
    ax4 = fig1.add_subplot(224)
    fin_df.plot(x = 'Avg_Ann_Incidence', y = col, kind= 'scatter',
s=0.1,xlim = [0, 100], ylim = [0, 20000], ax = ax4)

visualize_scatter_without('All_Without')
```

```
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
*c* argument looks like a single numeric RGB or RGBA sequence, which
should be avoided as value-mapping will have precedence in case its
length matches with *x* & *y*.  Please use the *color* keyword-
argument or provide a 2D array with a single row if you intend to
specify the same RGB or RGBA value for all points.
```



Statistical Linear Regression Modelling using Statsmodel Library

Unlike SKLearn, statsmodels doesn't automatically fit a constant, so you need to use the method sm.add_constant(X) in order to add a constant. Adding a constant, while not necessary, makes your line fit much better. For example, if you have a line with an intercept of -2000 and you try to fit the same line through the origin, you're going to get an inferior line. Once we add a constant (or an intercept if you're thinking in line terms), you'll see that the coefficients are the same in SKLearn and statsmodels.

```
fin_df.columns
```

```
Index(['State', 'AreaName', 'All_Poverty', 'FIPS', 'Med_Income',
'All_With',
       'All_Without', 'Avg_Ann_Incidence', 'recent_trend',
'Avg_Ann_Deaths',
       'Rising', 'Falling'],
      dtype='object')
```

```
res = ''
for i in fin_df.columns:
    res += str(i) + ' + '
print(res)
```

```
State + AreaName + All_Poverty + FIPS + Med_Income + All_With +
All_Without + Avg_Ann_Incidence + recent_trend + Avg_Ann_Deaths +
Rising + Falling +
```

```
import statsmodels.formula.api as smf
```

```
# Using statmodels library for Linear Regression Modelling
model1 = smf.ols(formula='Avg_Ann_Incidence ~ All_Poverty + Med_Income
+ All_With + All_Without + Rising + Falling', data=fin_df).fit()
print(model1.summary())
```

```
                            OLS Regression Results

======================================================================
========
Dep. Variable:      Avg_Ann_Incidence   R-squared:
0.922
Model:                            OLS   Adj. R-squared:
0.921
Method:                 Least Squares   F-statistic:
5707.
Date:                Mon, 06 Dec 2021   Prob (F-statistic):
0.00
Time:                        23:09:39   Log-Likelihood:
-15493.
No. Observations:                2924   AIC:
3.100e+04
Df Residuals:                    2917   BIC:
3.104e+04
Df Model:                           6

Covariance Type:            nonrobust

======================================================================
=========
                  coef    std err          t      P>|t|      [0.025
0.975]
----------------------------------------------------------------------
---------
```

```
Intercept       36.8125      3.931      9.365      0.000      29.105
44.520
All_Poverty      0.0005   8.38e-05      6.497      0.000       0.000
0.001
Med_Income      -0.0005   8.48e-05     -5.914      0.000      -0.001
-0.000
All_With         0.0008   1.36e-05     55.181      0.000       0.001
0.001
All_Without     -0.0014   6.39e-05    -22.047      0.000      -0.002
-0.001
Rising          -6.5225      7.452     -0.875      0.381     -21.134
8.089
Falling         11.5051      3.775      3.047      0.002       4.102
18.908
======================================================================
========
Omnibus:                     1643.837   Durbin-Watson:
1.614
Prob(Omnibus):                  0.000   Jarque-Bera (JB):
599626.270
Skew:                           1.406   Prob(JB):
0.00
Kurtosis:                      73.098   Cond. No.
2.50e+06
======================================================================
========

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is
correctly specified.
[2] The condition number is large, 2.5e+06. This might indicate that
there are
strong multicollinearity or other numerical problems.

# Fitting to Average Deaths
model2 = smf.ols(formula='Avg_Ann_Deaths ~ All_Poverty + Med_Income  +
All_With + All_Without + Rising + Falling', data=fin_df).fit()
print(model2.summary())

                            OLS Regression Results

======================================================================
========
Dep. Variable:         Avg_Ann_Deaths   R-squared:
0.925
Model:                            OLS   Adj. R-squared:
0.924
Method:                 Least Squares   F-statistic:
5728.
Date:                Mon, 06 Dec 2021   Prob (F-statistic):
```

```
0.00
Time:                            23:09:39   Log-Likelihood:
-13977.
No. Observations:                    2809   AIC:
2.797e+04
Df Residuals:                        2802   BIC:
2.801e+04
Df Model:                               6

Covariance Type:            nonrobust

======================================================================
=========
                 coef    std err          t      P>|t|      [0.025
0.975]
----------------------------------------------------------------------
---------
Intercept      32.1884      2.948     10.919      0.000      26.408
37.969
All_Poverty     0.0004   6.07e-05      7.192      0.000       0.000
0.001
Med_Income     -0.0004   6.35e-05     -6.973      0.000      -0.001
-0.000
All_With        0.0005   9.89e-06     51.334      0.000       0.000
0.001
All_Without    -0.0009   4.58e-05    -18.761      0.000      -0.001
-0.001
Rising         -6.4509      5.664     -1.139      0.255     -17.557
4.655
Falling         8.1574      2.736      2.982      0.003       2.793
13.522
======================================================================
========
Omnibus:                     1667.512   Durbin-Watson:
1.612
Prob(Omnibus):                  0.000   Jarque-Bera (JB):
293161.245
Skew:                           1.752   Prob(JB):
0.00
Kurtosis:                      52.925   Cond. No.
2.65e+06
======================================================================
========

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is
correctly specified.
[2] The condition number is large, 2.65e+06. This might indicate that
there are
strong multicollinearity or other numerical problems.
```

Multicollinearity

```
# Importing VIF to check for multicollinearity
from statsmodels.stats.outliers_influence import
variance_inflation_factor

X = fin_df[[ 'All_Poverty',  'Med_Income', 'All_With', 'All_Without',
'Rising', 'Falling', 'Avg_Ann_Incidence']]

X.columns
```

```
Index(['All_Poverty', 'Med_Income', 'All_With', 'All_Without',
'Rising',
       'Falling', 'Avg_Ann_Incidence'],
      dtype='object')
```

```
X.dropna(inplace=True)
```

```
C:\Users\hp\Anaconda3\lib\site-packages\pandas\util\
_decorators.py:311: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  return func(*args, **kwargs)
```

```
X1 = X[['All_Poverty', 'Med_Income', 'All_With', 'All_Without',
'Rising',
       'Falling']]

# Getting the VIFs corresponding to each of the features and then
treating the one with the highest value
pd.DataFrame([[var, variance_inflation_factor(X1.values,
X1.columns.get_loc(var))] for var in X1.columns],
                   index=range(X1.shape[1]), columns=['Variable',
'VIF'])
```

	Variable	VIF
0	All_Poverty	25.654166
1	Med_Income	1.271954
2	All_With	15.627624
3	All_Without	16.031002
4	Rising	1.015347
5	Falling	1.201154

We can see that the model suffers from high multicollinearity as the VIF is high for the variable and thus might lead to coefficients that are statistically insignificant !!

```
X.drop('All_Poverty', axis = 1, inplace=True)
X1.drop('All_Poverty', axis = 1, inplace=True)
```

```
C:\Users\hp\Anaconda3\lib\site-packages\pandas\core\frame.py:4913:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  errors=errors,
```

```
pd.DataFrame([[var, variance_inflation_factor(X1.values,
X1.columns.get_loc(var))] for var in X1.columns],
                   index=range(X1.shape[1]), columns=['Variable',
'VIF'])
```

```
      Variable       VIF
0   Med_Income  1.265045
1     All_With  9.776656
2  All_Without  8.926300
3       Rising  1.015175
4      Falling  1.199055
```

```
X.drop('All_Without', axis = 1, inplace=True)
X1.drop('All_Without', axis = 1, inplace=True)
```

```
C:\Users\hp\Anaconda3\lib\site-packages\pandas\core\frame.py:4913:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  errors=errors,
```

```
pd.DataFrame([[var, variance_inflation_factor(X1.values,
X1.columns.get_loc(var))] for var in X1.columns],
                   index=range(X1.shape[1]), columns=['Variable',
'VIF'])
```

```
     Variable       VIF
0  Med_Income  1.207631
1    All_With  1.257105
2      Rising  1.015051
3     Falling  1.193283
```

```
# Final model after treating for multicollinearity
model1 = smf.ols(formula='Avg_Ann_Incidence ~Med_Income  + All_With +
Rising + Falling', data=fin_df).fit()
print(model1.summary())
```

```
                            OLS Regression Results
```

```
==============================================================================
========
Dep. Variable:      Avg_Ann_Incidence   R-squared:
0.906
Model:                            OLS   Adj. R-squared:
0.906
Method:                 Least Squares   F-statistic:
7020.
Date:                Mon, 06 Dec 2021   Prob (F-statistic):
0.00
Time:                        23:09:39   Log-Likelihood:
-15759.
No. Observations:                2924   AIC:
3.153e+04
Df Residuals:                    2919   BIC:
3.156e+04
Df Model:                           4

Covariance Type:            nonrobust

==============================================================================
========
                 coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
--------
Intercept     24.4731      3.875      6.315      0.000      16.874
32.072
Med_Income    -0.0002   8.23e-05     -1.898      0.058      -0.000
5.17e-06
All_With       0.0006   3.84e-06    154.332      0.000       0.001
0.001
Rising        -6.8821      8.159     -0.844      0.399     -22.879
9.115
Falling       16.1143      4.122      3.909      0.000       8.032
24.196
==============================================================================
========
Omnibus:                     1260.365   Durbin-Watson:
1.646
Prob(Omnibus):                  0.000   Jarque-Bera (JB):
1570186.457
Skew:                           0.370   Prob(JB):
0.00
Kurtosis:                     116.523   Cond. No.
2.42e+06
==============================================================================
========

Notes:
```

```
[1] Standard Errors assume that the covariance matrix of the errors is
correctly specified.
[2] The condition number is large, 2.42e+06. This might indicate that
there are
strong multicollinearity or other numerical problems.
```

Detecting Outliers

```
fin_df.columns
```

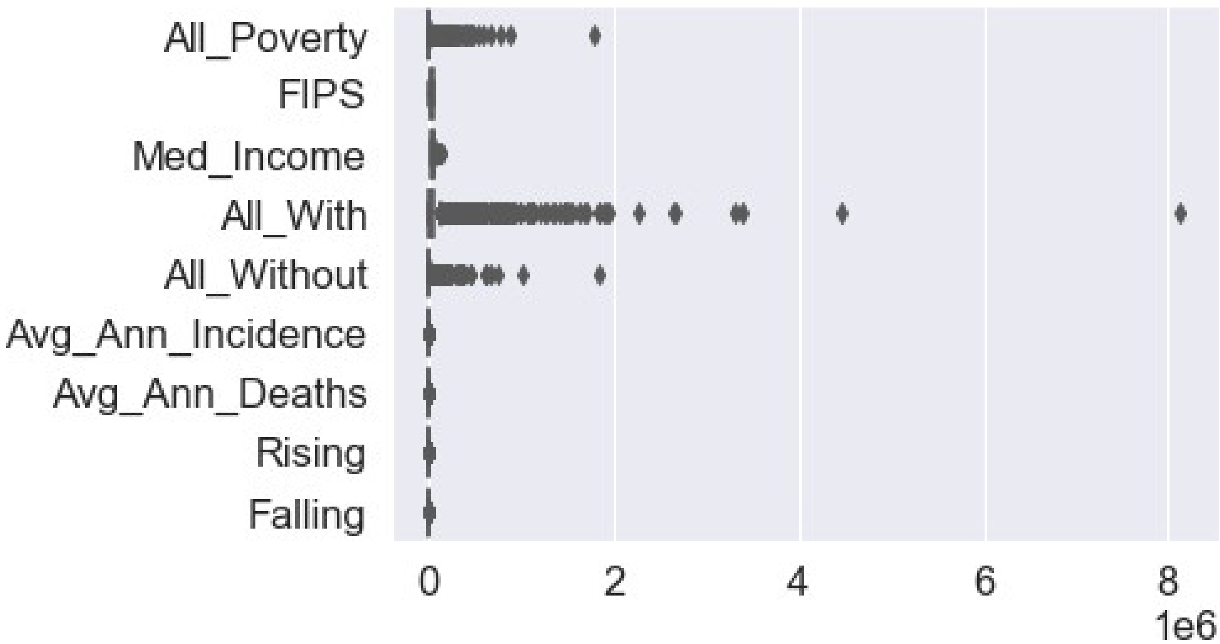
```
Index(['State', 'AreaName', 'All_Poverty', 'FIPS', 'Med_Income',
'All_With',
       'All_Without', 'Avg_Ann_Incidence', 'recent_trend',
'Avg_Ann_Deaths',
       'Rising', 'Falling'],
      dtype='object')
```

```
fin_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3134 entries, 0 to 3133
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   State              3134 non-null   object
 1   AreaName           3134 non-null   object
 2   All_Poverty        3134 non-null   int64
 3   FIPS               3134 non-null   int64
 4   Med_Income         3133 non-null   float64
 5   All_With           3134 non-null   int64
 6   All_Without        3134 non-null   int64
 7   Avg_Ann_Incidence  2925 non-null   float64
 8   recent_trend       3134 non-null   object
 9   Avg_Ann_Deaths     2809 non-null   float64
 10  Rising             3134 non-null   int64
 11  Falling            3134 non-null   int64
dtypes: float64(3), int64(6), object(3)
memory usage: 382.8+ KB
```

```
data_mod1 = fin_df.copy()
#using IQR method
dat = data_mod1['Med_Income']
Q1 = dat.quantile(0.25)
Q3 = dat.quantile(0.75)
IQR = Q3 - Q1    #IQR is interquartile range.

filter = (dat >= Q1 - 3 * IQR) & (dat <= Q3 + 3 *IQR)
data_mod1 = data_mod1.loc[filter]
print(data_mod1.shape)
```

```
(3112, 12)

# Boxplot for the initial data
ax = sns.boxplot(data=fin_df, orient="h", palette="Set2")
```




```
# Fitting to Average Deaths
model2 = smf.ols(formula='Avg_Ann_Deaths ~ All_Poverty + Med_Income  + 
All_With + All_Without + Rising + Falling', data=data_mod1).fit()
print(model2.summary())

                            OLS Regression Results                            

======================================================================
========
Dep. Variable:         Avg_Ann_Deaths   R-squared:                       
0.928
Model:                            OLS   Adj. R-squared:                  
0.927
Method:                 Least Squares   F-statistic:                     
5933.
Date:                Mon, 06 Dec 2021   Prob (F-statistic):              
0.00
Time:                        23:09:40   Log-Likelihood:                  
-13809.
No. Observations:                2788   AIC:                             
2.763e+04
Df Residuals:                    2781   BIC:                             
2.767e+04
Df Model:                           6
```

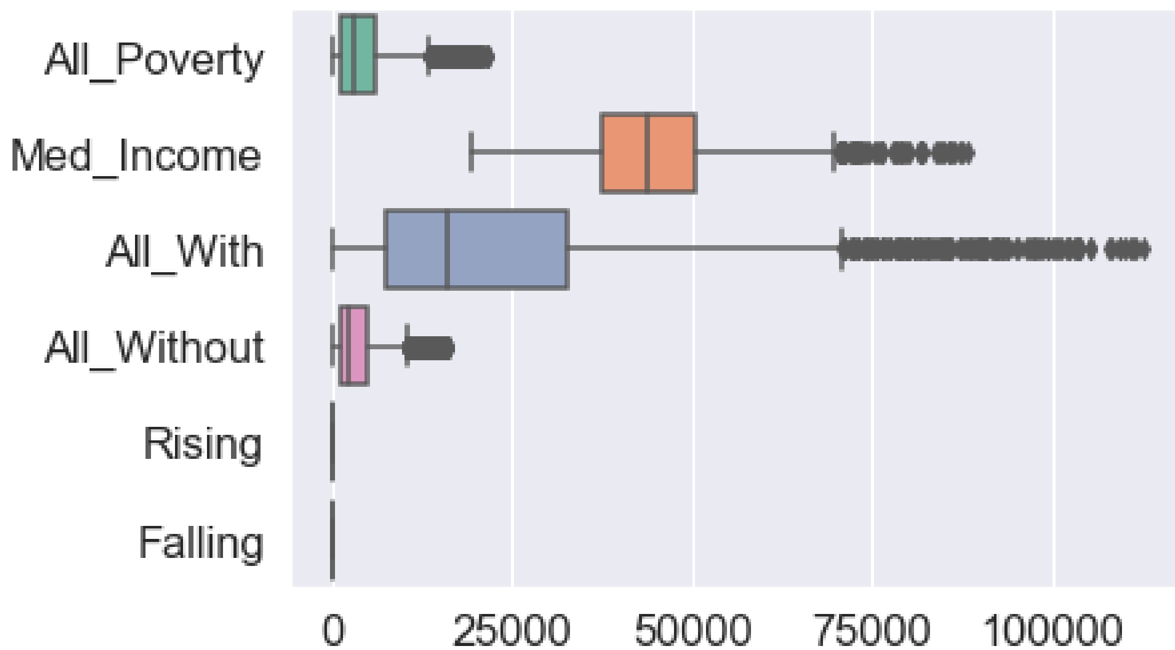
```
Covariance Type:            nonrobust

==============================================================================
=========
                 coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
---------
Intercept      30.6782      3.056     10.040      0.000      24.687
36.670
All_Poverty     0.0003   6.18e-05      4.587      0.000       0.000
0.000
Med_Income     -0.0004   6.63e-05     -6.240      0.000      -0.001
-0.000
All_With        0.0005   1.03e-05     52.225      0.000       0.001
0.001
All_Without    -0.0008   4.49e-05    -18.758      0.000      -0.001
-0.001
Rising         -6.4949      5.536     -1.173      0.241     -17.349
4.360
Falling         7.2932      2.718      2.683      0.007       1.964
12.623
==============================================================================
========
Omnibus:                     1780.288   Durbin-Watson:
1.606
Prob(Omnibus):                  0.000   Jarque-Bera (JB):
313764.257
Skew:                           1.992   Prob(JB):
0.00
Kurtosis:                      54.818   Cond. No.
2.62e+06
==============================================================================
========

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is
correctly specified.
[2] The condition number is large, 2.62e+06. This might indicate that
there are
strong multicollinearity or other numerical problems.
```

```
data_mod1 = fin_df.copy()
for i in ['All_Poverty', 'Med_Income', 'All_With', 'All_Without',
'Rising', 'Falling']:
    #using IQR method
    dat = data_mod1[i]
    Q1 = dat.quantile(0.25)
    Q3 = dat.quantile(0.75)
```

```
    IQR = Q3 - Q1    #IQR is interquartile range.

    filter = (dat >= Q1 - 3 * IQR) & (dat <= Q3 + 3 *IQR)
    data_mod1 = data_mod1.loc[filter]
    print(data_mod1.shape)
```

```
(2563, 12)
(2563, 12)
(2559, 12)
(2553, 12)
(2553, 12)
(2455, 12)
```

```
# Boxplot for the filtered data
ax = sns.boxplot(data=data_mod1[['All_Poverty', 'Med_Income',
'All_With', 'All_Without', 'Rising', 'Falling']], orient="h",
palette="Set2")
```

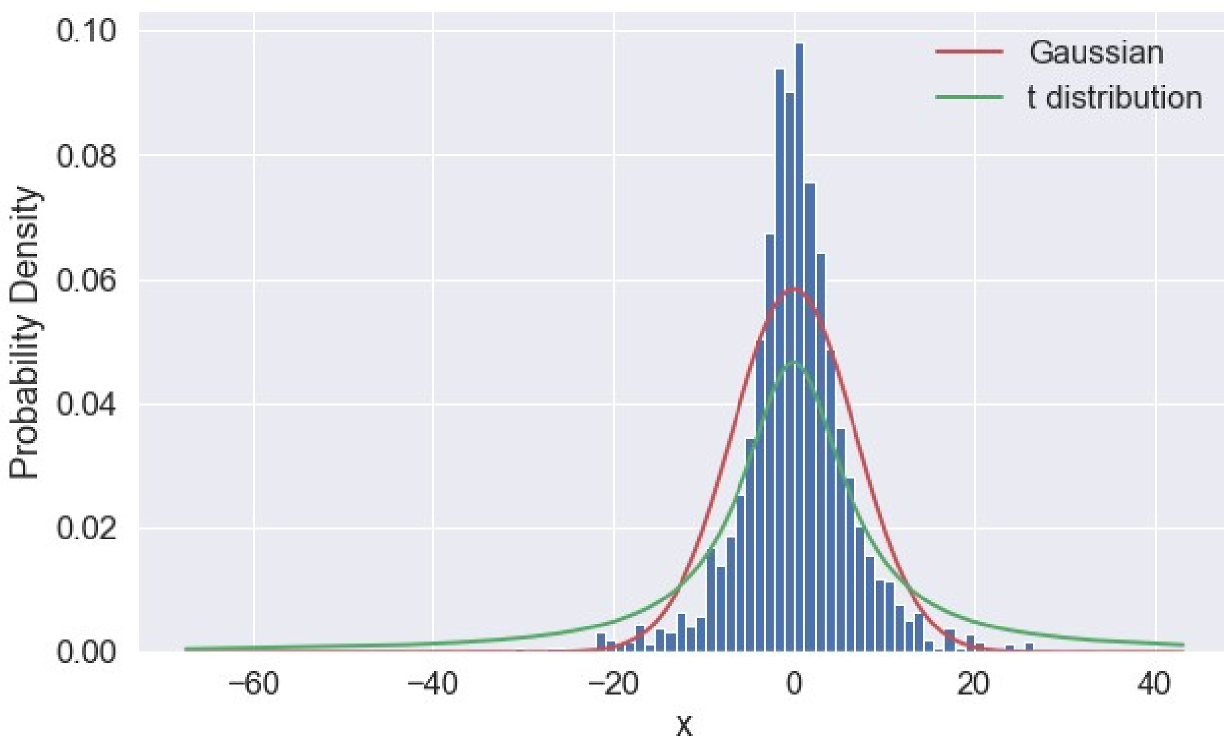



```
fin_df = data_mod1

# Fitting to Average Deaths
model1 = smf.ols(formula='Avg_Ann_Deaths ~ All_Poverty + Med_Income  +
All_With + All_Without + Rising + Falling', data=data_mod1).fit()
```

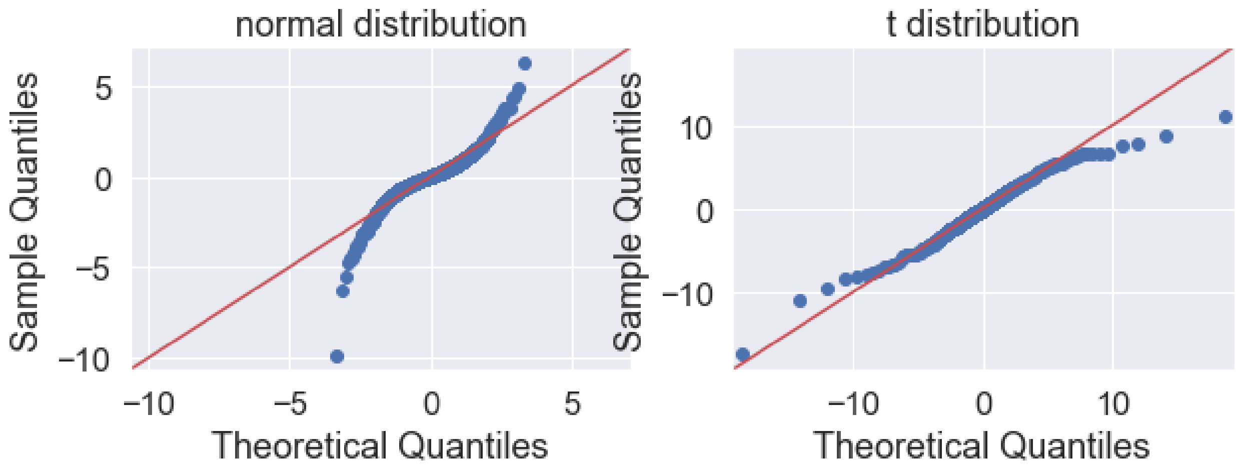
Normality of Errors

```
# histogram superimposed by normal curve
plt.figure(figsize=(10,6))
```

```
import scipy.stats as stats
mu = np.mean(model1.resid)
sigma = np.std(model1.resid)
pdf = stats.norm.pdf(sorted(model1.resid), mu, sigma)
pdf2 = stats.t.pdf(sorted(model1.resid), df = 1, loc = mu,
scale=sigma,)
plt.xlabel('x')
plt.ylabel('Probability Density')
plt.hist(model1.resid, bins=100, density= True)
plt.plot(sorted(model1.resid), pdf, color='r', linewidth=2, label =
'Gaussian')
plt.plot(sorted(model1.resid), pdf2, color='g', linewidth=2, label =
't distribution')
plt.legend()
plt.show()
```




```
import statsmodels.graphics.gofplots as sm

# QQplot
fig, [ax1, ax2] = plt.subplots(1,2, figsize=(10,3))
sm.qqplot(model1.resid, stats.norm, fit=True, line='45', ax=ax1)
ax1.set_title("normal distribution")
sm.qqplot(model1.resid, stats.t, fit=True, line='45', ax = ax2)
ax2.set_title("t distribution")

plt.show()
```



As we can see that the QQ plot for the normal distribution is not close to the straight line at the ends and it deviates to the top at the right and to the bottom at the left, we can say that the tails for the residuals are heavier than a normal distribution, hence on following that I tried using a t distribution, which gives a much better QQ plot and hence we can confirm that the residuals come from the t distribution !! Fatter tails suggest we have more number of outliers !

```
result = model1

# plot actual values versus residuals
plt.figure(figsize=(14,7))
plt.title('Scatter plot of Residuals vs Fitted Values')
plt.scatter(y=result.resid, x=result.fittedvalues, alpha=0.5, s=22)
plt.axhline(y=0, color='r', linestyle="--", alpha=0.5)
plt.xlabel("Fitted Values")
plt.ylabel("Residuals")
plt.xlim(-10, 100)
plt.ylim(-200, 200)
plt.show()
```

We can see a cone shaped residual plot which is common in cases of heteroscadasticity wherein when the fitted value increases, the variance also increases. Hence our model suffers from high heteroscadasticity.

Heteroscedasticity is a systematic change in the spread of the residuals over the range of measured values. Heteroscedasticity is a problem because ordinary least squares (OLS) regression assumes that all residuals are drawn from a population that has a constant variance (homoscedasticity). Heteroscedasticity, also spelled heteroskedasticity, occurs more often in datasets that have a large range between the largest and smallest observed values. While there are numerous reasons why heteroscedasticity can exist, a common explanation is that the error variance changes proportionally with a factor. This factor might be a variable in the model.

While heteroscedasticity does not cause bias in the coefficient estimates, it does make them less precise. Lower precision increases the likelihood that the coefficient estimates are further from the correct population value. Heteroscedasticity tends to produce p-values that are smaller than they should be. This effect occurs because heteroscedasticity increases the variance of the coefficient estimates but the OLS procedure does not detect this increase. Consequently, OLS calculates the t-values and F-values using an underestimated amount of variance. This problem can lead you to conclude that a model term is statistically significant when it is actually not significant.

```python
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns

# Reading the data
df = pd.read_csv('train.csv')

df_test = pd.read_csv('test.csv')

df.head()
```

```
   PassengerId  Survived  Pclass  \
0            1         0       3
1            2         1       1
2            3         1       3
3            4         1       1
4            5         0       3

                                                Name     Sex   Age
SibSp  \
0                            Braund, Mr. Owen Harris    male  22.0
1
1  Cumings, Mrs. John Bradley (Florence Briggs Th...  female  38.0
1
2                             Heikkinen, Miss. Laina  female  26.0
0
3       Futrelle, Mrs. Jacques Heath (Lily May Peel)  female  35.0
1
4                           Allen, Mr. William Henry    male  35.0
0

   Parch            Ticket     Fare Cabin Embarked
0      0         A/5 21171   7.2500   NaN        S
1      0          PC 17599  71.2833   C85        C
2      0  STON/O2. 3101282   7.9250   NaN        S
3      0            113803  53.1000  C123        S
4      0            373450   8.0500   NaN        S
```

```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   PassengerId  891 non-null    int64
```

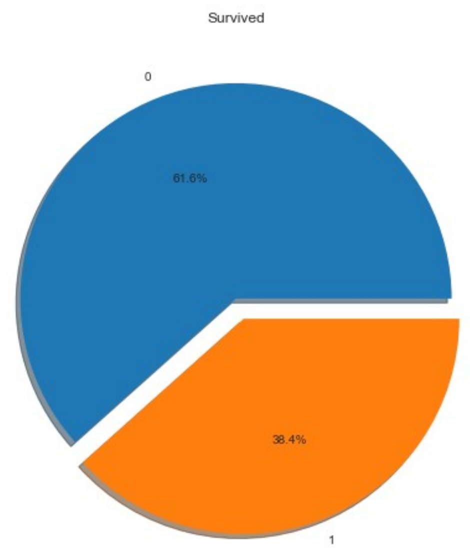
```
 1   Survived     891 non-null    int64
 2   Pclass       891 non-null    int64
 3   Name         891 non-null    object
 4   Sex          891 non-null    object
 5   Age          714 non-null    float64
 6   SibSp        891 non-null    int64
 7   Parch        891 non-null    int64
 8   Ticket       891 non-null    object
 9   Fare         891 non-null    float64
 10  Cabin        204 non-null    object
 11  Embarked     889 non-null    object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.7+ KB
```

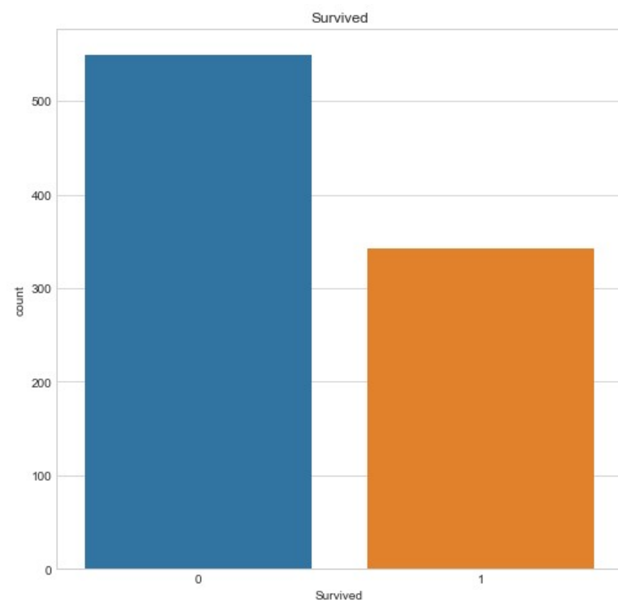
```
df.describe().transpose()
```

```
             count        mean         std   min       25%       50%
75%  \
PassengerId  891.0  446.000000  257.353842  1.00  223.5000  446.0000
668.5
Survived     891.0    0.383838    0.486592  0.00    0.0000    0.0000
1.0
Pclass       891.0    2.308642    0.836071  1.00    2.0000    3.0000
3.0
Age          714.0   29.699118   14.526497  0.42   20.1250   28.0000
38.0
SibSp        891.0    0.523008    1.102743  0.00    0.0000    0.0000
1.0
Parch        891.0    0.381594    0.806057  0.00    0.0000    0.0000
0.0
Fare         891.0   32.204208   49.693429  0.00    7.9104   14.4542
31.0

                  max
PassengerId  891.0000
Survived       1.0000
Pclass         3.0000
Age           80.0000
SibSp          8.0000
Parch          6.0000
Fare         512.3292
```

```
f,ax=plt.subplots(1,2,figsize=(18,8))
df['Survived'].value_counts().plot.pie(ax = ax[0],
explode=[0,0.1],autopct='%1.1f%%',shadow=True)
ax[0].set_title('Survived')
ax[0].set_ylabel('')
sns.countplot('Survived',data=df,ax=ax[1])
ax[1].set_title('Survived')
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning

Text(0.5, 1.0, 'Survived')
```





Overall Probability of Survival ~ 38%

Pre-processing, EDA and Feature Generation

Handling Missing Values

Handling Age First

```
df['Age'].describe()

count    714.000000
mean      29.699118
std       14.526497
min        0.420000
25%       20.125000
50%       28.000000
75%       38.000000
max       80.000000
Name: Age, dtype: float64

df.corr()
```

```
             PassengerId  Survived    Pclass        Age     SibSp
Parch  \
PassengerId     1.000000 -0.005007 -0.035144  0.036847 -0.057527 -
0.001652
Survived       -0.005007  1.000000 -0.338481 -0.077221 -0.035322
0.081629
Pclass         -0.035144 -0.338481  1.000000 -0.369226  0.083081
0.018443
Age             0.036847 -0.077221 -0.369226  1.000000 -0.308247 -
0.189119
SibSp          -0.057527 -0.035322  0.083081 -0.308247  1.000000
0.414838
Parch          -0.001652  0.081629  0.018443 -0.189119  0.414838
1.000000
Fare            0.012658  0.257307 -0.549500  0.096067  0.159651
0.216225

                 Fare
PassengerId  0.012658
Survived     0.257307
Pclass      -0.549500
Age          0.096067
SibSp        0.159651
Parch        0.216225
Fare         1.000000
```

We see that the Pclass column has the maximum absolute correlation with our target class Survived.

```
df.corr()['Pclass'].sort_values()

Fare          -0.549500
Age           -0.369226
Survived      -0.338481
PassengerId   -0.035144
Parch          0.018443
SibSp          0.083081
Pclass         1.000000
Name: Pclass, dtype: float64

age_by_pclass_sex= df.groupby(['Sex','Pclass']).median()['Age']

age_by_pclass_sex

Sex     Pclass
female  1         35.0
        2         28.0
        3         21.5
male    1         40.0
        2         30.0
```

```
        3         25.0
Name: Age, dtype: float64
```

```
median_all = df['Age'].median()
median_all
```

```
28.0
```

```
df['Age'] = df.groupby(['Sex', 'Pclass'])['Age'].apply(lambda
x:x.fillna(x.median()))
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   PassengerId  891 non-null    int64
 1   Survived     891 non-null    int64
 2   Pclass       891 non-null    int64
 3   Name         891 non-null    object
 4   Sex          891 non-null    object
 5   Age          891 non-null    float64
 6   SibSp        891 non-null    int64
 7   Parch        891 non-null    int64
 8   Ticket       891 non-null    object
 9   Fare         891 non-null    float64
 10  Cabin        204 non-null    object
 11  Embarked     889 non-null    object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.7+ KB
```

Let's jump to Embarked

```
df['Embarked'].describe()
```

```
count     889
unique      3
top         S
freq      644
Name: Embarked, dtype: object
```

only two values are missing!

```
df[df['Embarked'].isnull()]
```

```
     PassengerId  Survived  Pclass
Name  \
61            62         1       1                        Icard, Miss.
```

```
Amelie
829           830         1        1  Stone, Mrs. George Nelson (Martha
Evelyn)

        Sex   Age  SibSp  Parch  Ticket  Fare Cabin Embarked
61   female  38.0      0      0  113572  80.0   B28      NaN
829  female  62.0      0      0  113572  80.0   B28      NaN
```

Let's Handle Cabin

We have (891-204) = 687 missing Cabin values

```
df['Cabin'].unique()
```

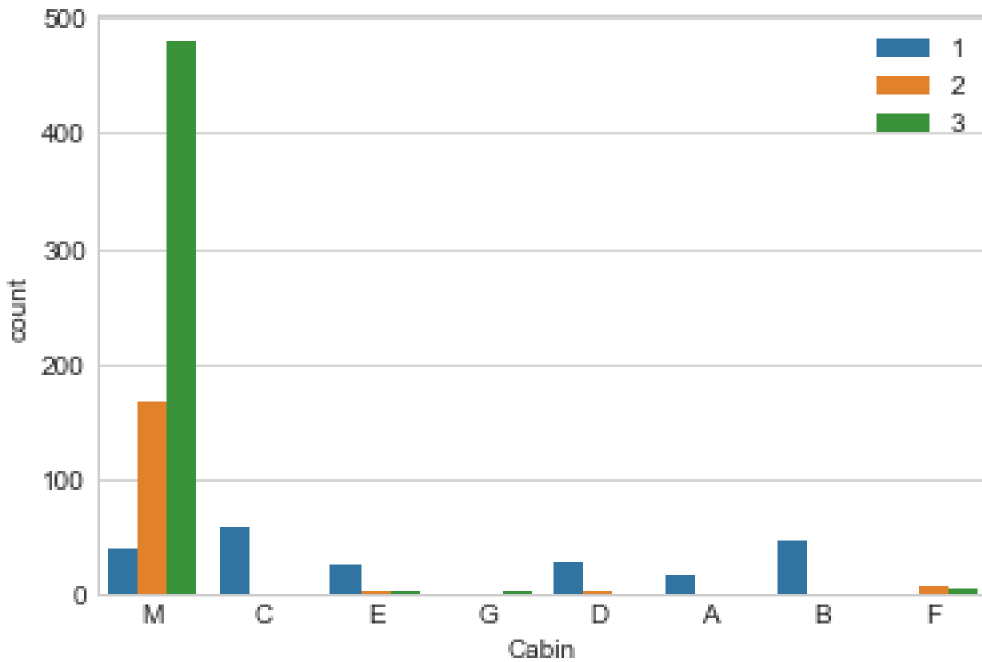
```
array([nan, 'C85', 'C123', 'E46', 'G6', 'C103', 'D56', 'A6',
       'C23 C25 C27', 'B78', 'D33', 'B30', 'C52', 'B28', 'C83', 'F33',
       'F G73', 'E31', 'A5', 'D10 D12', 'D26', 'C110', 'B58 B60',
'E101',
       'F E69', 'D47', 'B86', 'F2', 'C2', 'E33', 'B19', 'A7', 'C49',
'F4',
       'A32', 'B4', 'B80', 'A31', 'D36', 'D15', 'C93', 'C78', 'D35',
       'C87', 'B77', 'E67', 'B94', 'C125', 'C99', 'C118', 'D7', 'A19',
       'B49', 'D', 'C22 C26', 'C106', 'C65', 'E36', 'C54',
       'B57 B59 B63 B66', 'C7', 'E34', 'C32', 'B18', 'C124', 'C91',
'E40',
       'T', 'C128', 'D37', 'B35', 'E50', 'C82', 'B96 B98', 'E10',
'E44',
       'A34', 'C104', 'C111', 'C92', 'E38', 'D21', 'E12', 'E63',
'A14',
       'B37', 'C30', 'D20', 'B79', 'E25', 'D46', 'B73', 'C95', 'B38',
       'B39', 'B22', 'C86', 'C70', 'A16', 'C101', 'C68', 'A10', 'E68',
       'B41', 'A20', 'D19', 'D50', 'D9', 'A23', 'B50', 'A26', 'D48',
       'E58', 'C126', 'B71', 'B51 B53 B55', 'D49', 'B5', 'B20', 'F
G63',
       'C62 C64', 'E24', 'C90', 'C45', 'E8', 'B101', 'D45', 'C46',
'D30',
       'E121', 'D11', 'E77', 'F38', 'B3', 'D6', 'B82 B84', 'D17',
'A36',
       'B102', 'B69', 'E49', 'C47', 'D28', 'E17', 'A24', 'C50', 'B42',
       'C148'], dtype=object)
```

We can see that there are many missing values thus we replace the missing values by a new class M (missing), plus we have cabins with different classes followed by numbers, thus we can just keep the classes.

```
df['Cabin']=df['Cabin'].fillna('M')

df['Cabin']=df['Cabin'].apply(lambda str: str[0])
```

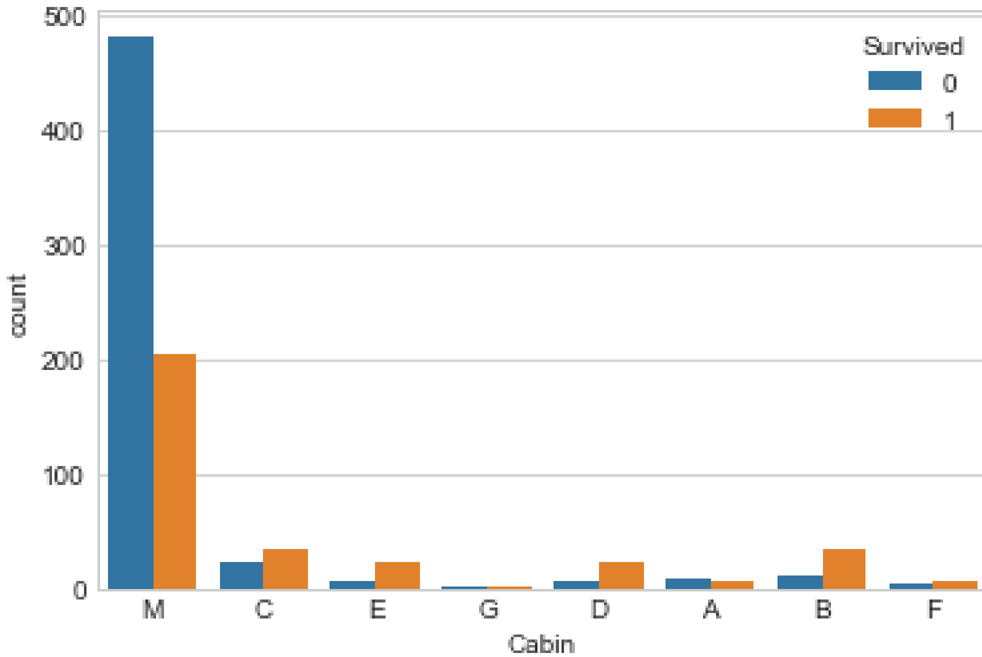
```python
df.loc[df[df['Cabin']=='T'].index,'Cabin']='A'

g = sns.countplot(x='Cabin',data=df,hue='Pclass', )
plt.legend(loc='upper right')
```

```
<matplotlib.legend.Legend at 0x1fb148e3848>
```




```python
sns.countplot(x='Cabin',data=df,hue='Survived')
```

```
<AxesSubplot:xlabel='Cabin', ylabel='count'>
```



On visualizing the final Cabin column we see that most of the people in the missing class belong to the Pclass 3 and have little chance of survival. We see a higher chance of survival in most of the other cabin classes, with the least being in cabin A and the highest chance being in the cabin class B. We also observe that most of the people in the classes C, E, G, D, A, B belong ot the Pclass 1, and have high chances of survival, thus indicating that Pclass might be a factor resulting in higher chances of survival.

```
df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   PassengerId  891 non-null    int64
 1   Survived     891 non-null    int64
 2   Pclass       891 non-null    int64
 3   Name         891 non-null    object
 4   Sex          891 non-null    object
 5   Age          891 non-null    float64
 6   SibSp        891 non-null    int64
 7   Parch        891 non-null    int64
 8   Ticket       891 non-null    object
 9   Fare         891 non-null    float64
 10  Cabin        891 non-null    object
 11  Embarked     889 non-null    object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.7+ KB
```

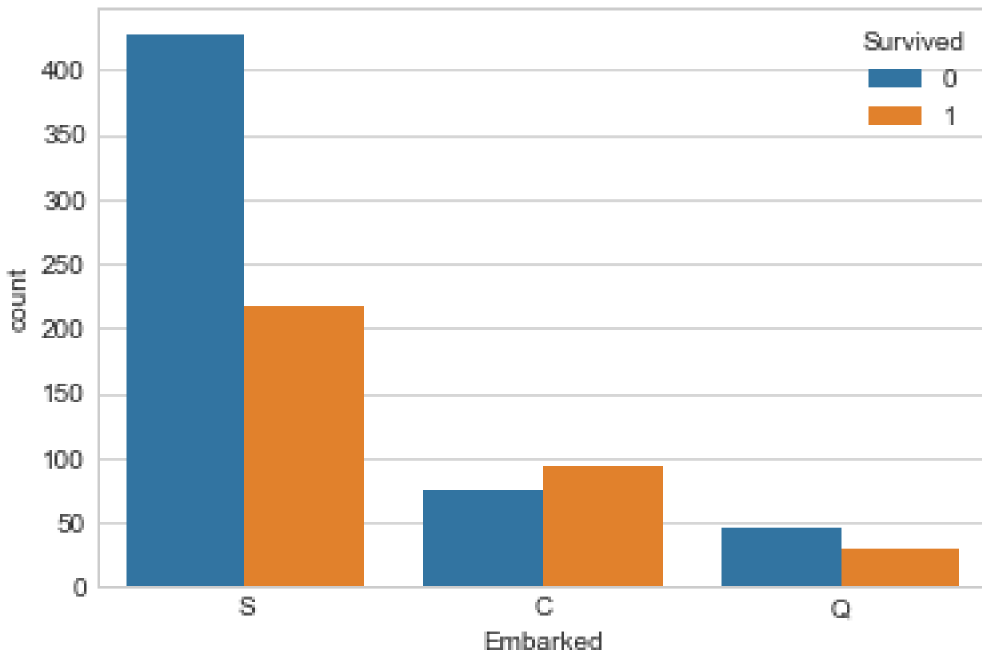
EDA and Feature Generation

```
df['Embarked'].unique()
```

```
array(['S', 'C', 'Q', nan], dtype=object)
```

```
sns.countplot(x='Embarked',data=df,hue='Survived')
```

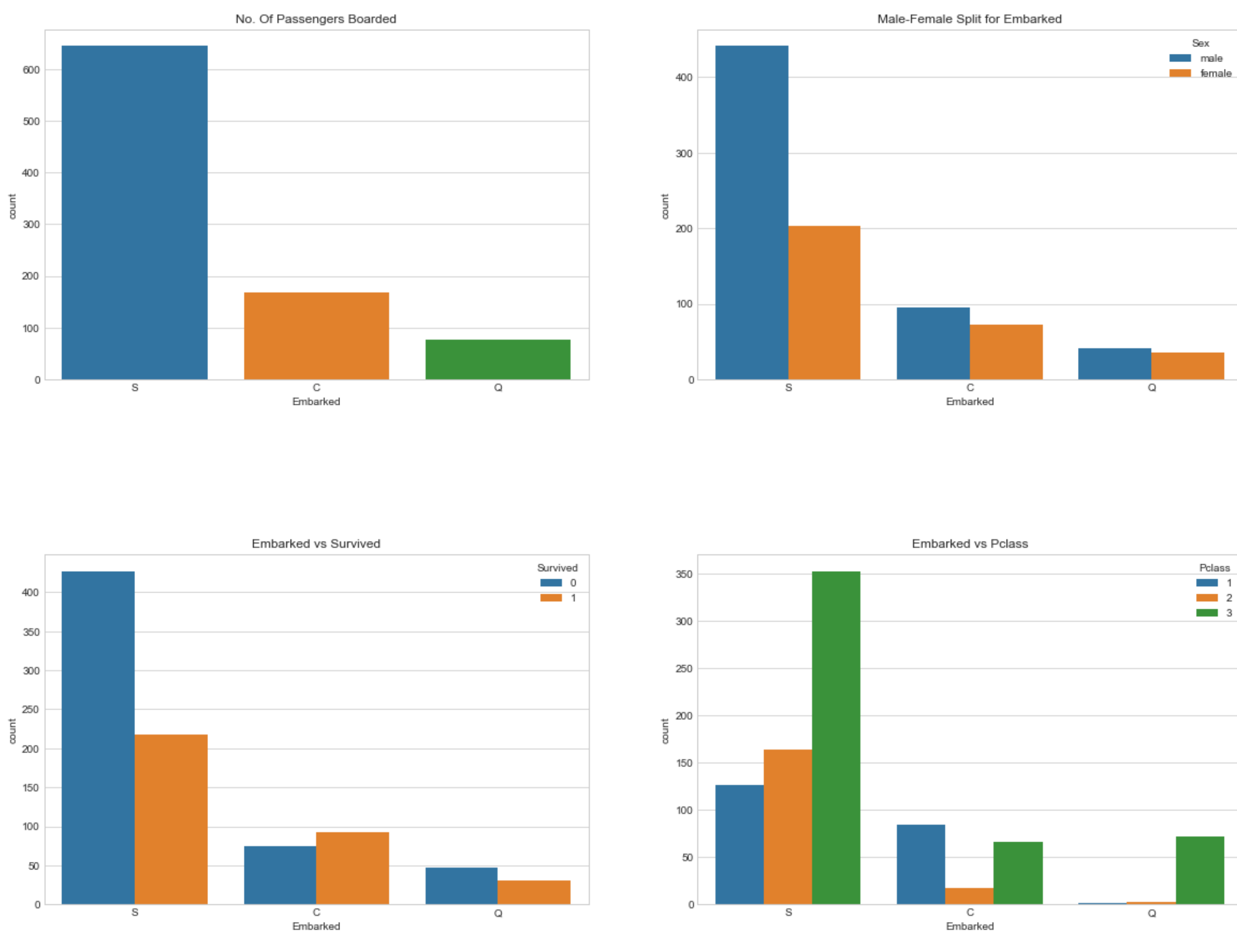
```
<AxesSubplot:xlabel='Embarked', ylabel='count'>
```




```
f,ax=plt.subplots(2,2,figsize=(20,15))
sns.countplot('Embarked',data=df,ax=ax[0,0])
ax[0,0].set_title('No. Of Passengers Boarded')
sns.countplot('Embarked',hue='Sex',data=df,ax=ax[0,1])
ax[0,1].set_title('Male-Female Split for Embarked')
sns.countplot('Embarked',hue='Survived',data=df,ax=ax[1,0])
ax[1,0].set_title('Embarked vs Survived')
sns.countplot('Embarked',hue='Pclass',data=df,ax=ax[1,1])
ax[1,1].set_title('Embarked vs Pclass')
plt.subplots_adjust(wspace=0.2,hspace=0.5)
plt.show()
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
```

```
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
```



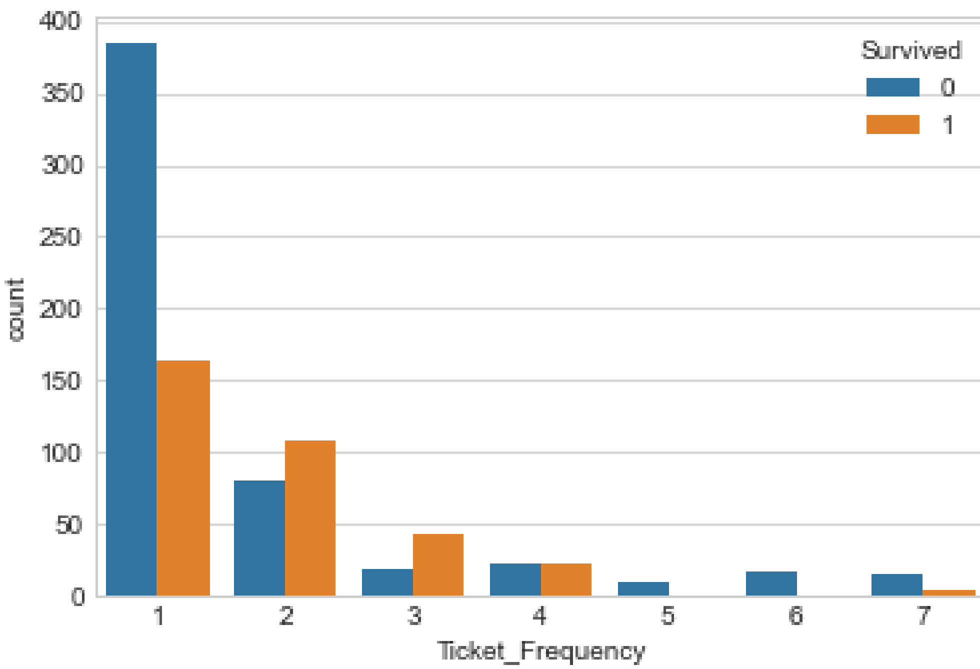
1)Maximum passenegers boarded from S. Majority of them being from Pclass3.

2)The Passengers from C look to be lucky as a good proportion of them survived. The reason for this maybe the rescue of all the Pclass1 and Pclass2 Passengers.

3)The Embark S looks to the port from where majority of the rich people boarded. Still the chances for survival is low here, that is because many passengers from Pclass3 around 81% didn't survive.

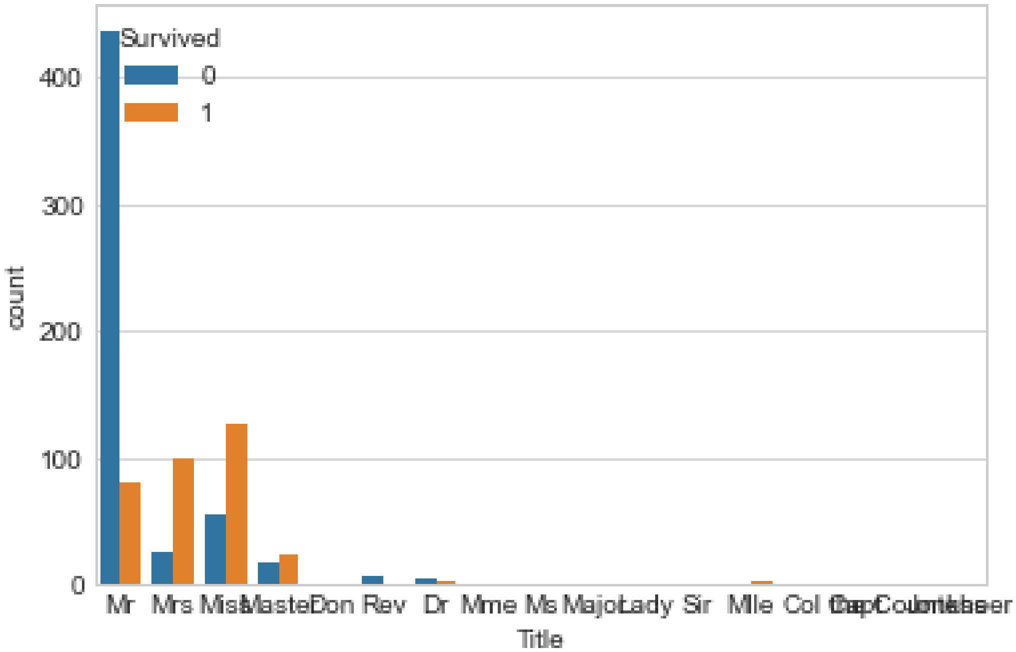
4)Port Q had almost 95% of the passengers were from Pclass3.

```
df['Ticket_Frequency']=df.groupby('Ticket')
['Ticket'].transform('count')

sns.countplot(x='Ticket_Frequency',data=df,hue='Survived')

<AxesSubplot:xlabel='Ticket_Frequency', ylabel='count'>
```

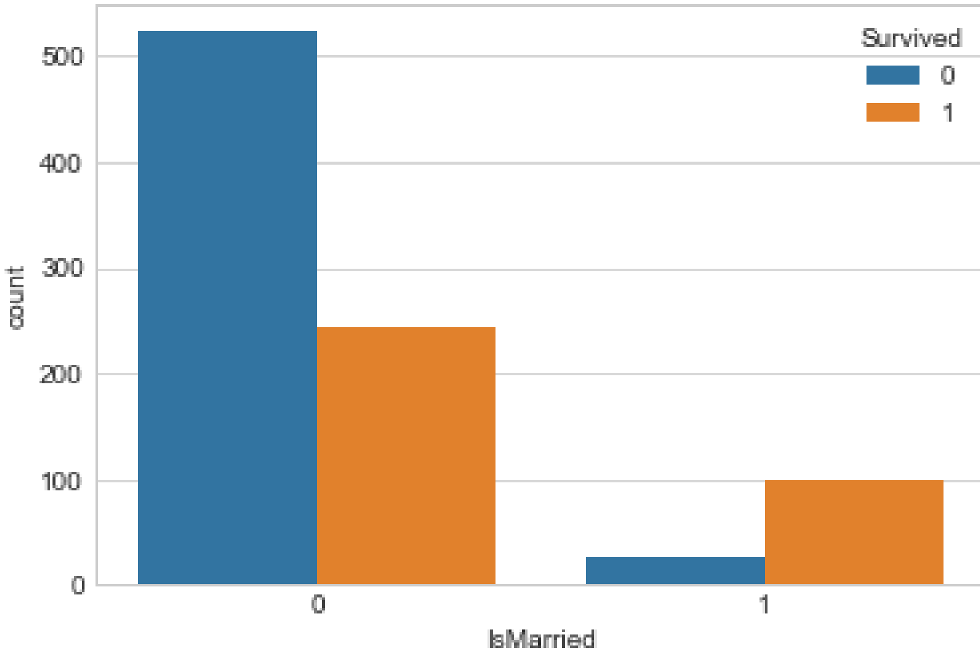


On careful observation we see that different ticket frequency has different rates of survival with the highest being for the group of two and the chance for groups of more than 4 being very less.

```
df['Title']=df['Name'].str.split(', ',expand=True)
[1].str.split('.',expand=True)[0]

df['Title'].unique()

array(['Mr', 'Mrs', 'Miss', 'Master', 'Don', 'Rev', 'Dr', 'Mme', 'Ms',
       'Major', 'Lady', 'Sir', 'Mlle', 'Col', 'Capt', 'the Countess',
       'Jonkheer'], dtype=object)

sns.countplot(x='Title',data=df,hue='Survived')

<AxesSubplot:xlabel='Title', ylabel='count'>
```

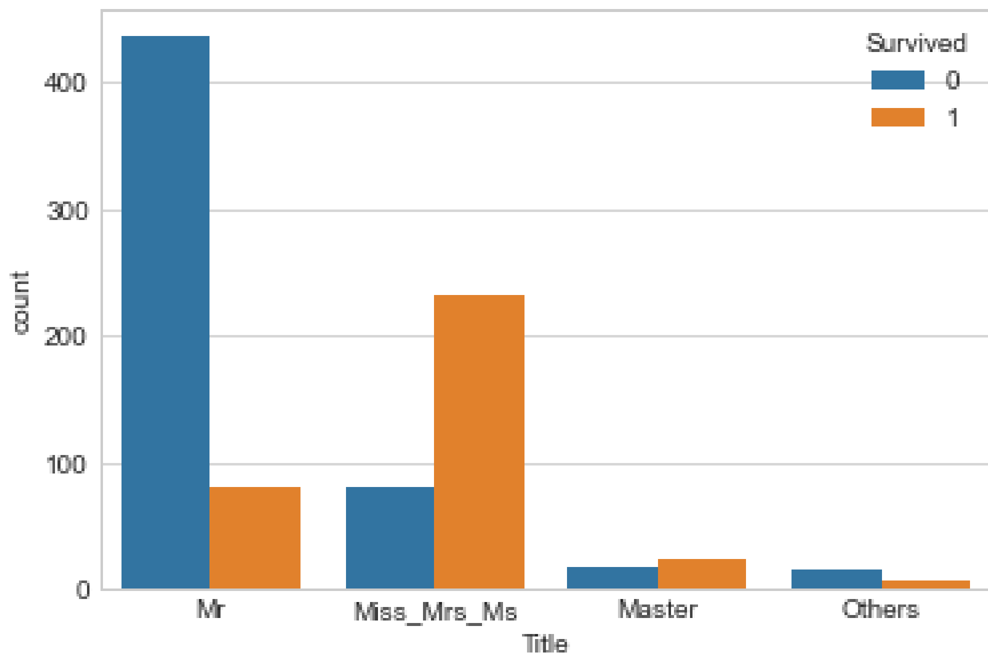



```
df['IsMarried']=0

df['IsMarried'].loc[df['Title']=='Mrs']=1

C:\Users\hp\Anaconda3\lib\site-packages\pandas\core\indexing.py:1732:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  self._setitem_single_block(indexer, value, name)

df['IsMarried'].unique()

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

sns.countplot(x='IsMarried',data=df,hue='Survived')

<AxesSubplot:xlabel='IsMarried', ylabel='count'>
```



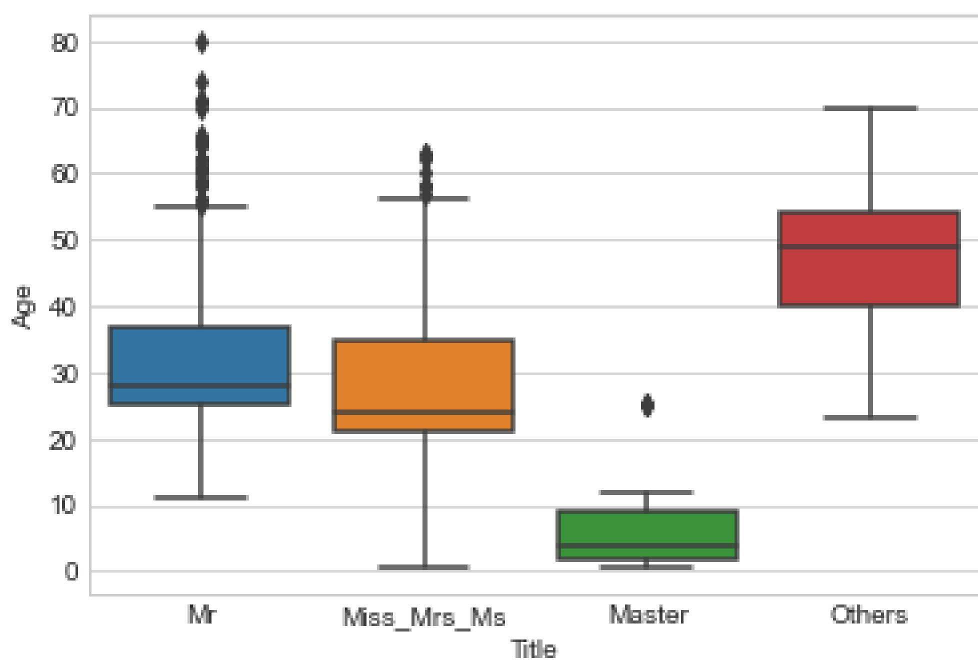
We created a new feature called IsMarried that is checked for title Mrs. We see that being married has a greater chance of survival !

```
df['Title'] = df['Title'].replace(['Miss', 'Mrs','Ms', 'Mlle', 'Lady',
'Mme', 'the Countess', 'Dona'], 'Miss_Mrs_Ms')

df['Title'] = df['Title'].replace(['Dr', 'Col', 'Major', 'Jonkheer',
'Capt', 'Sir', 'Don', 'Rev'], 'Others')

sns.countplot(x='Title',data=df,hue='Survived')

<AxesSubplot:xlabel='Title', ylabel='count'>
```



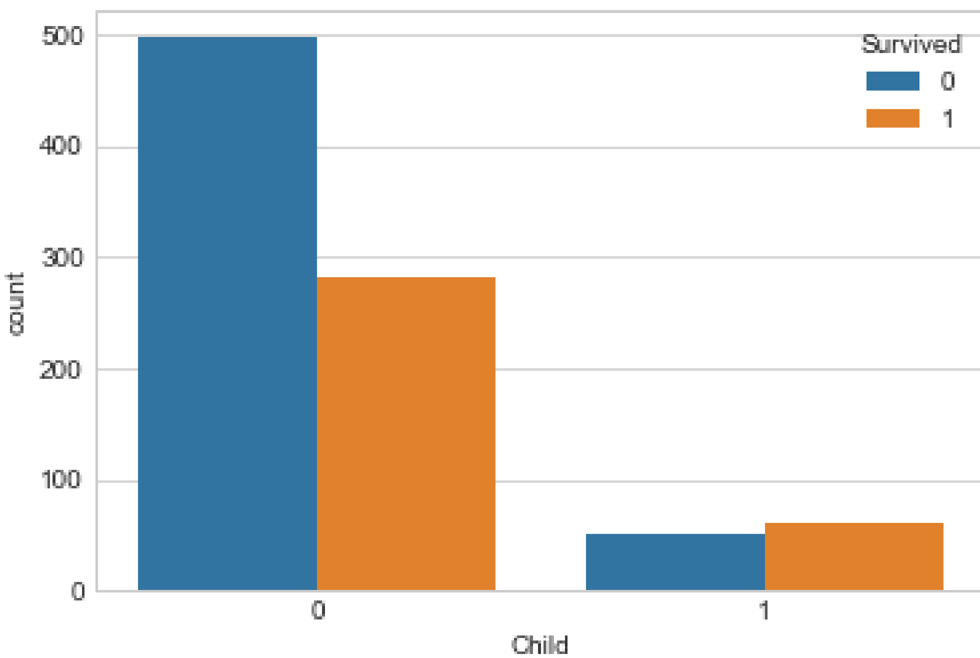

```
sns.boxplot(x='Title', y='Age', data=df)
```

```
<AxesSubplot:xlabel='Title', ylabel='Age'>
```



1. We converted Title into 4 groups.
2. We can see most of the people are from Mr. grp where the probability of surviving is low while the probability of Miss_Mrs_Ms and Master is higher for surviving.
3. We have very less people belonging to the other classes.

```
df['Child']=0

df['Child'].loc[df['Age']<18]=1

C:\Users\hp\Anaconda3\lib\site-packages\pandas\core\indexing.py:1732:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  self._setitem_single_block(indexer, value, name)

df['Child'].unique()

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

sns.countplot(x='Child',data=df,hue='Survived')

<AxesSubplot:xlabel='Child', ylabel='count'>
```

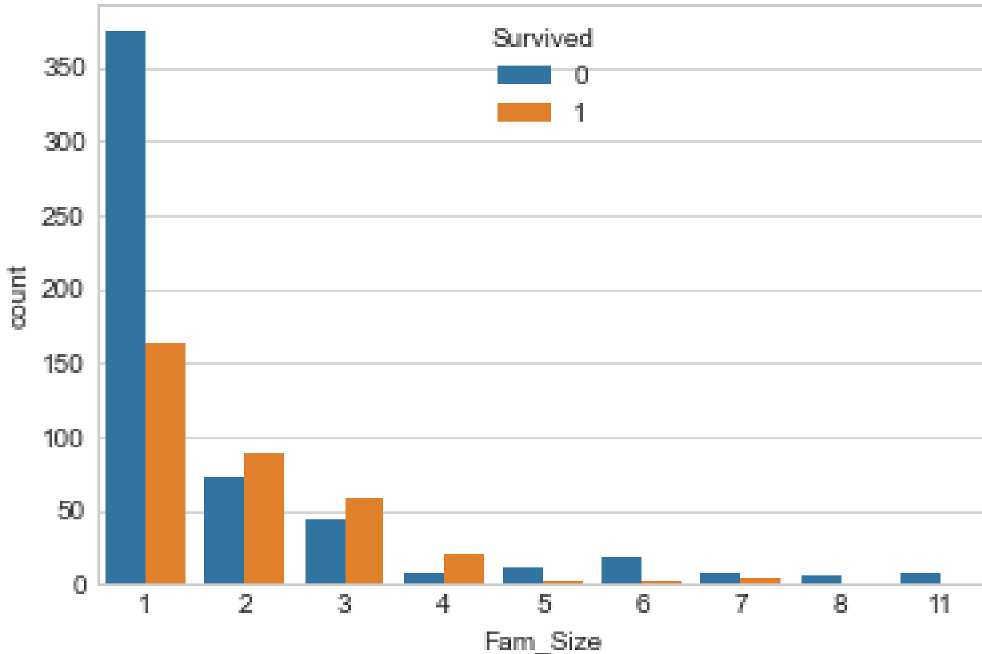


We created a Child feature for people below 18 years of age, now we can see that children have a higher chance of getting out !

We create a new feature Family size, which is essentialy No. of Parents + Chilren + Siblings + Spouse + 1

```
df['Fam_Size']=df['Parch']+df['SibSp']+1

sns.countplot(x='Fam_Size',data=df,hue='Survived')
```

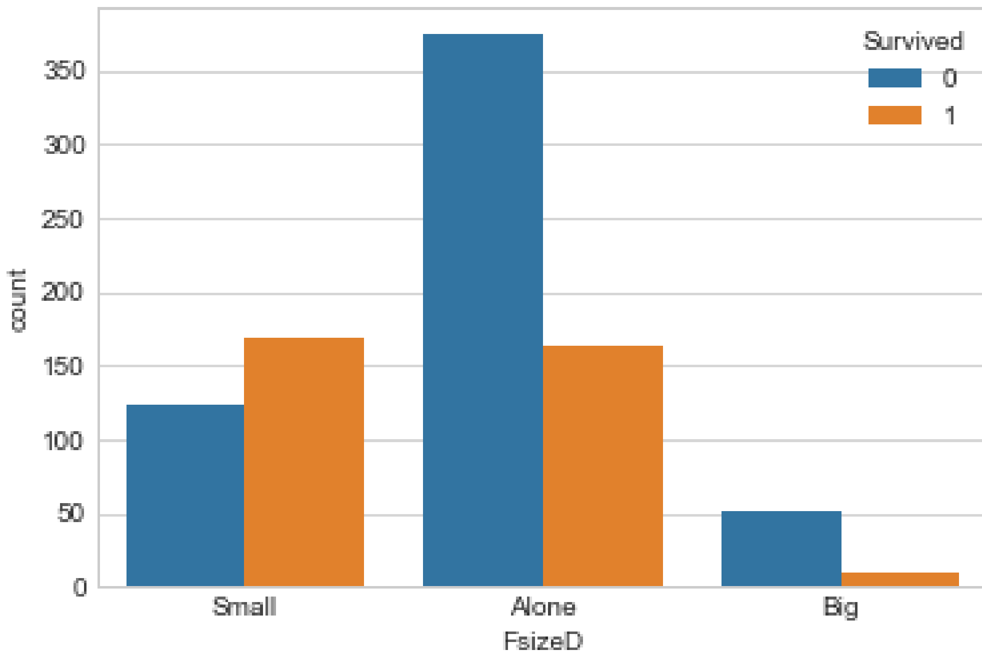
```
<AxesSubplot:xlabel='Fam_Size', ylabel='count'>
```




```
df.loc[:,'FsizeD']='Alone'

df.loc[(df['Fam_Size']>1),'FsizeD']='Small'

df.loc[(df['Fam_Size']>4),'FsizeD']='Big'
```

Now we create three different categories of Family Size

```
sns.countplot(x='FsizeD',data=df,hue='Survived')

<AxesSubplot:xlabel='FsizeD', ylabel='count'>
```

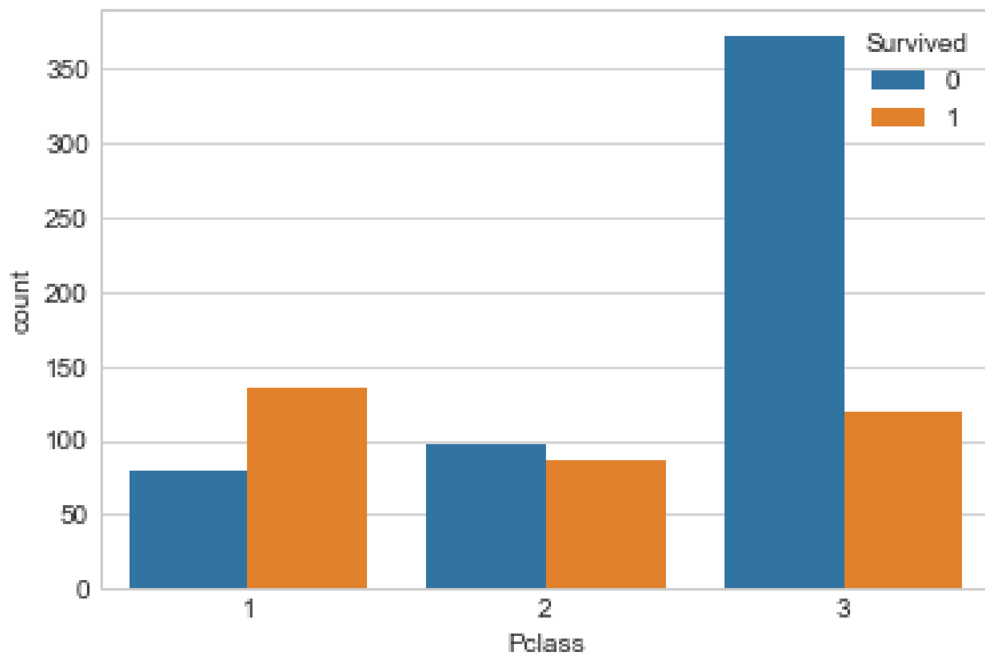


We see that people with small family size have the highest chance of Surviving, and the ones with a big family, which the lease chance !

```
df=df.drop(['Name','Ticket','Fam_Size'],axis=1)

df=df.drop(['PassengerId'],axis=1)
```

Visualization

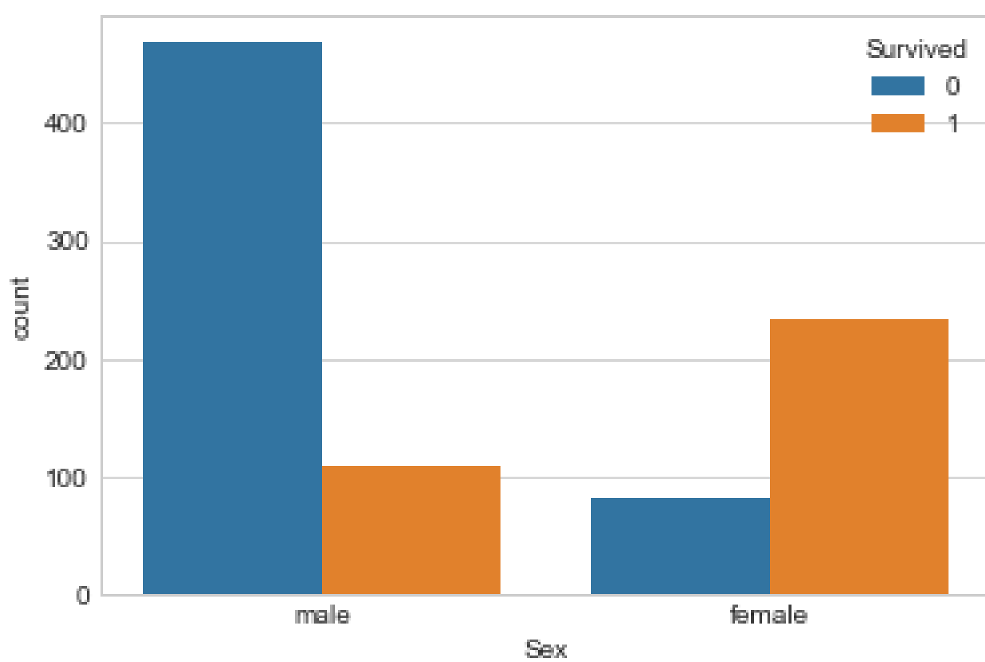
```
sns.countplot(x='Pclass',data=df,hue='Survived')

<AxesSubplot:xlabel='Pclass', ylabel='count'>
```



We see that the people belonging to the Pclass 1 have a higher chance of survival, which keeps on decreasing as we go down the classes !

```
sns.countplot(x='Sex',data=df,hue='Survived')
```

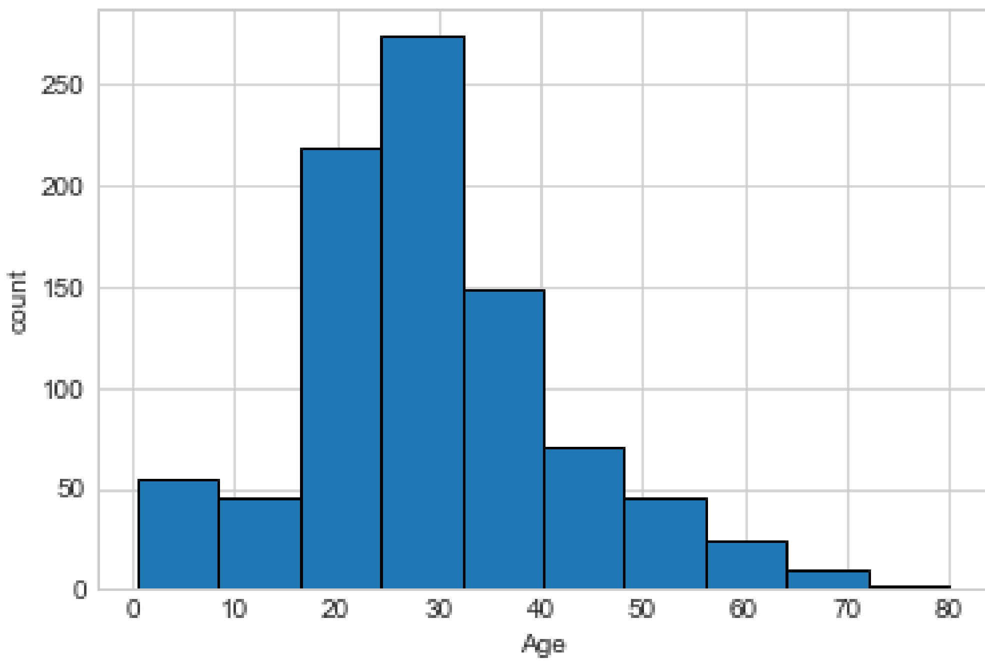
```
<AxesSubplot:xlabel='Sex', ylabel='count'>
```



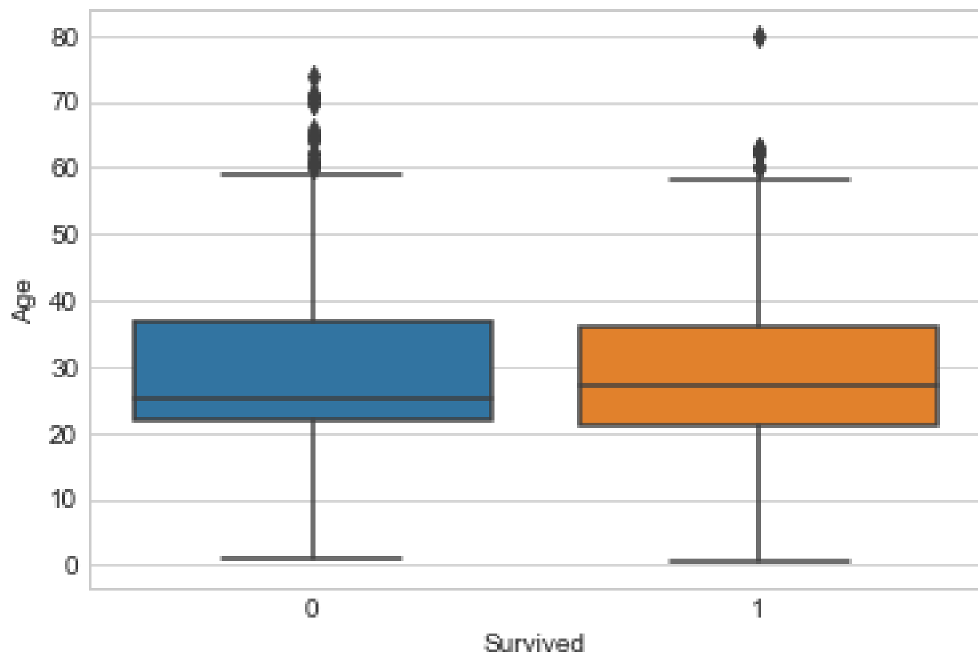
1. Proportion of male and female: ~2/3 vs ~1/3

2. Male is much less likely to survive, with only 20% chance of survival. For female, >70% chance of survival.
3. Obviously, Sex is an important feature to predict survival.

```
plt.hist(df.Age, edgecolor="black")
plt.xlabel('Age')
plt.ylabel('count')
plt.show()
```



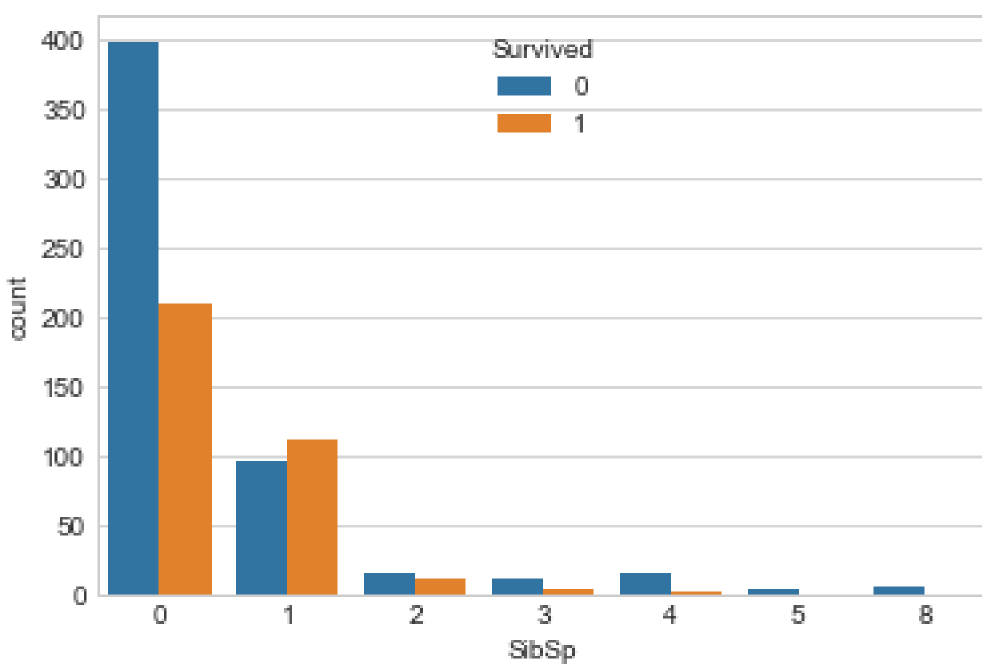

```
sns.boxplot(x='Survived', y='Age', data=df)
plt.show()
```



1. Passengers are mainly aged 20–40.
2. Younger passengers tends to survive.

```
sns.countplot(x='SibSp',data=df,hue='Survived')
```

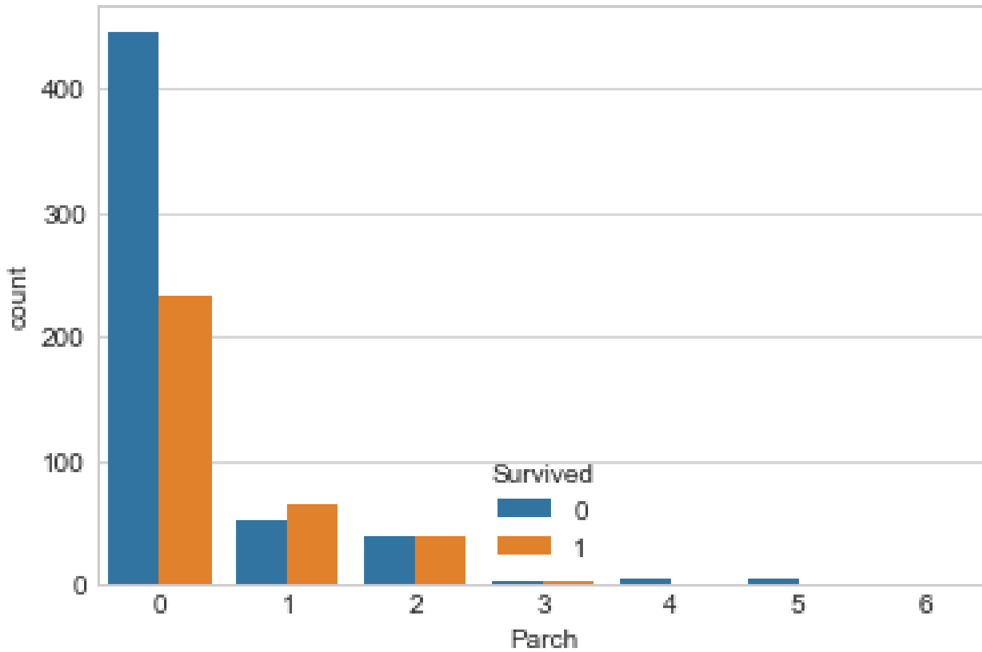
```
<AxesSubplot:xlabel='SibSp', ylabel='count'>
```



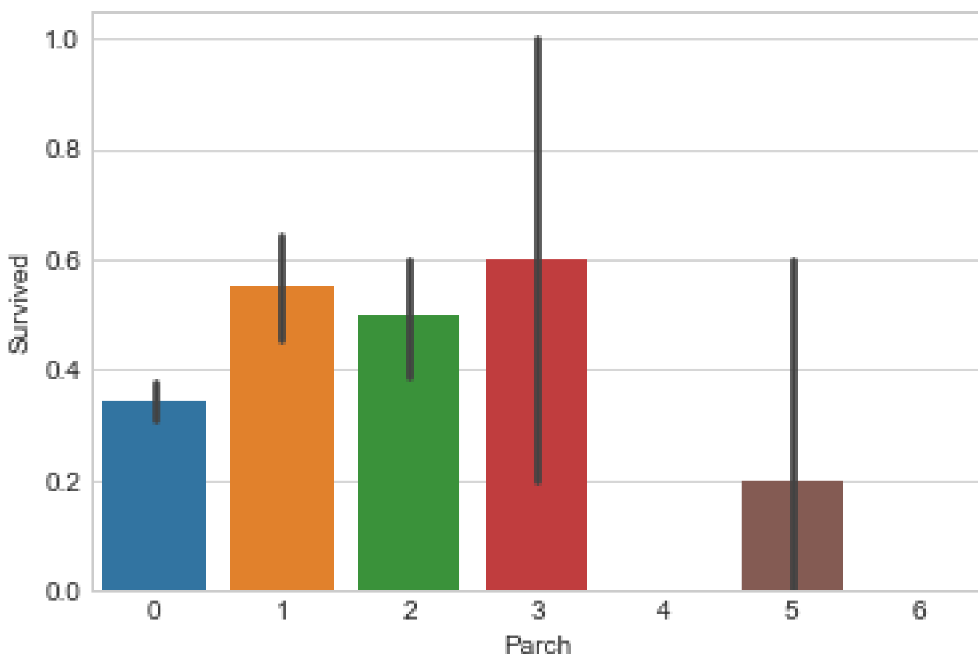
1. Most of the passengers are travelling alone
2. The ones with 1 sibling/spouse are more likely to survive

```
sns.countplot(x='Parch',data=df,hue='Survived')
```

```
<AxesSubplot:xlabel='Parch', ylabel='count'>
```




```
sns.barplot(x='Parch', y='Survived', data=df)
plt.show()
```

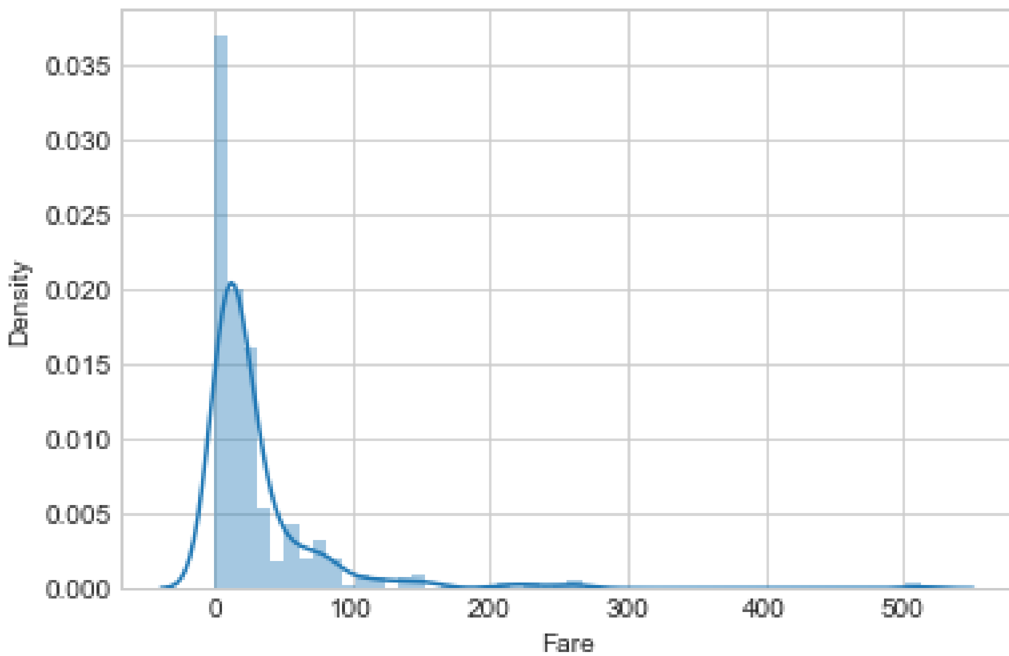


1. ~ >70% passengers travel without parents/children.

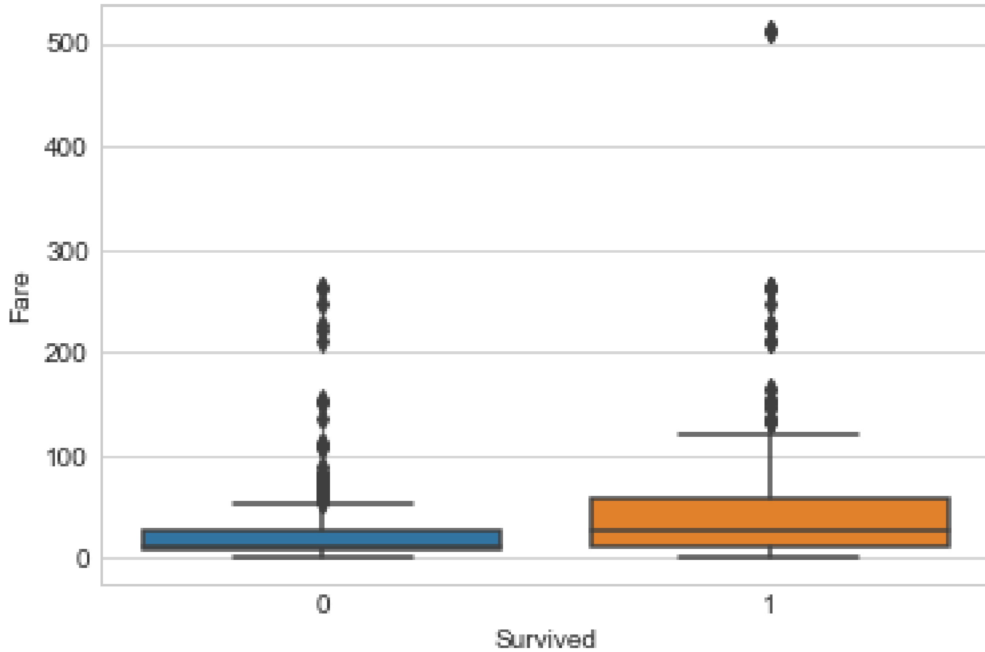
2. Passengers travelling with parents/children are more likely to survive than those not.

```
sns.distplot(df.Fare)
plt.show()
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\distributions.py:2619:
FutureWarning: `distplot` is a deprecated function and will be removed
in a future version. Please adapt your code to use either `displot` (a
figure-level function with similar flexibility) or `histplot` (an
axes-level function for histograms).
  warnings.warn(msg, FutureWarning)
```



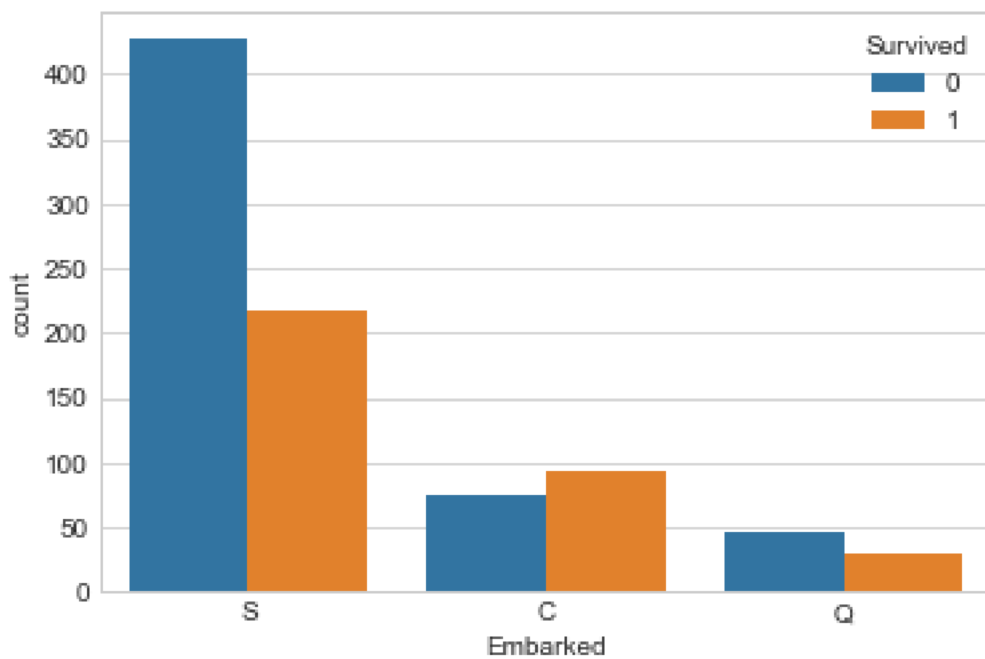

```
sns.boxplot(x='Survived', y='Fare', data=df)
plt.show()
```



1. We see that there are people paying too much for their tickets (outliers)
2. We see that people with higher fares are likely to survive !

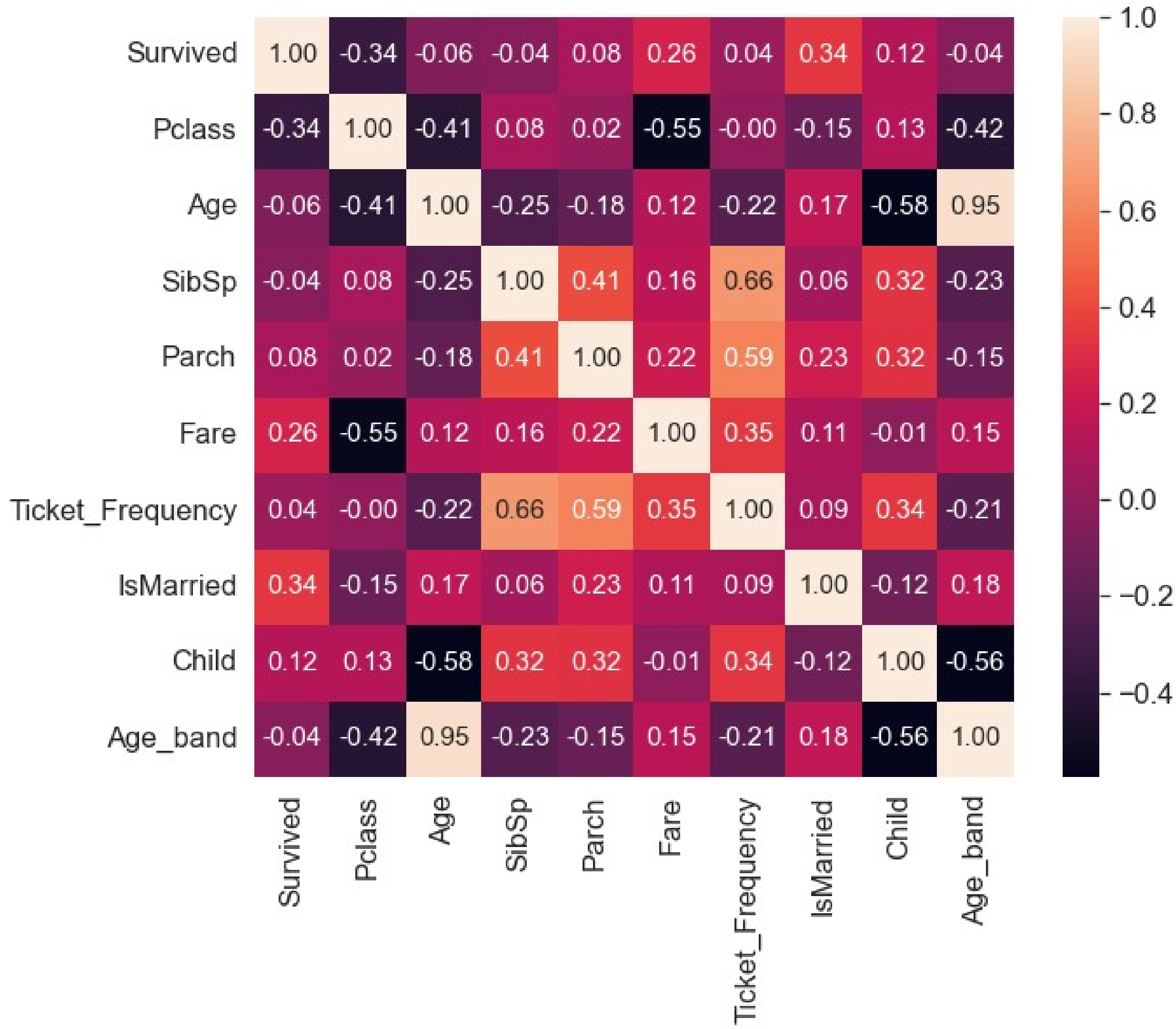
```
sns.countplot(x='Embarked',data=df,hue='Survived')
```

```
<AxesSubplot:xlabel='Embarked', ylabel='count'>
```



1. We see most of the people were embarked from the port S
2. People embarked from the C port are more likely to survive !

```
df['Age_band']=0
df.loc[df['Age']<=16,'Age_band']=0
df.loc[(df['Age']>16)&(df['Age']<=32),'Age_band']=1
df.loc[(df['Age']>32)&(df['Age']<=48),'Age_band']=2
df.loc[(df['Age']>48)&(df['Age']<=64),'Age_band']=3
df.loc[df['Age']>64,'Age_band']=4

df['Fare_Range']=pd.qcut(df['Fare'],4)

cm = df.corr()
sns.set(font_scale=1.5, )
hm = sns.heatmap(cm, cbar=True, annot = True, square=True, fmt='.2f',
annot_kws={'size':15})
      #           yticklabels=cols, xticklabels=cols)

fig = plt.gcf()
fig.set_size_inches(10,8)
```



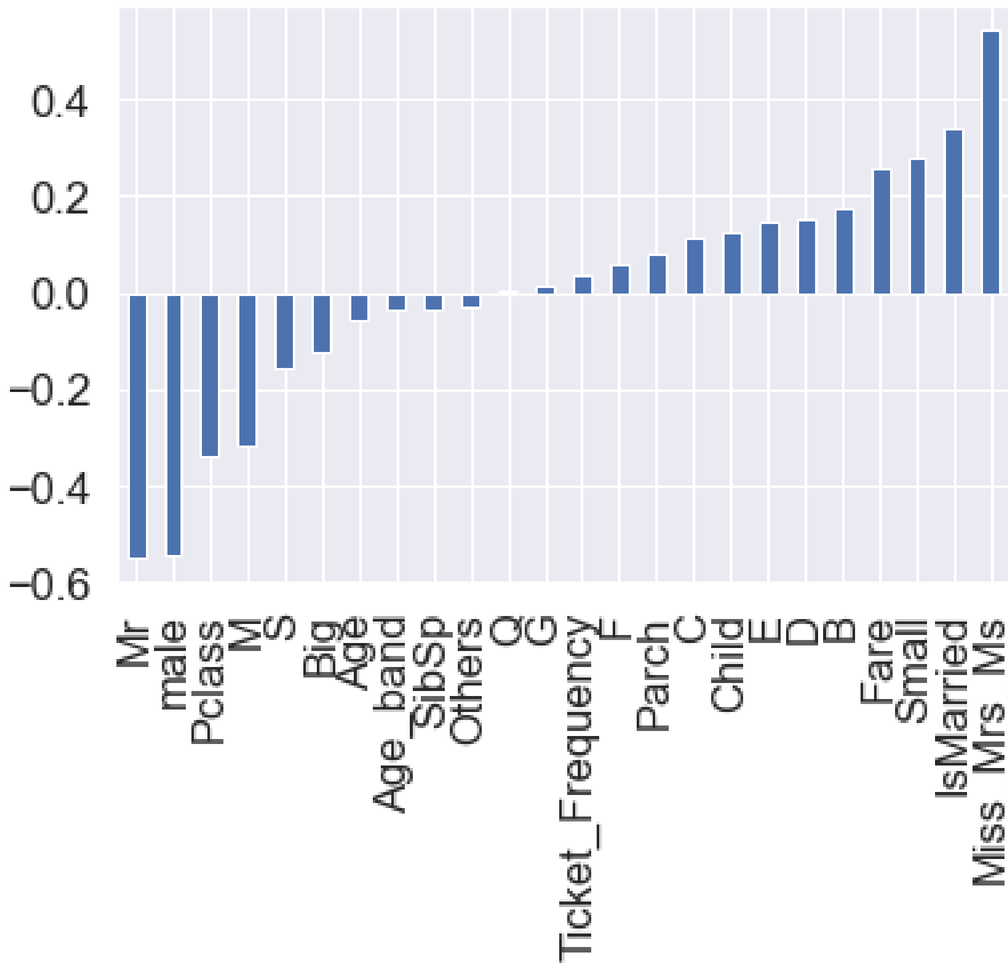
Converting into Dummies

```
dummies = pd.get_dummies(df['Embarked'],drop_first=True)

df = pd.concat([df.drop('Embarked',axis=1),dummies],axis=1)

dummies = pd.get_dummies(df['Cabin'],drop_first=True)

df = pd.concat([df.drop('Cabin',axis=1),dummies],axis=1)

dummies = pd.get_dummies(df['Sex'],drop_first=True)

df = pd.concat([df.drop('Sex',axis=1),dummies],axis=1)

dummies = pd.get_dummies(df['Title'],drop_first=True)

df = pd.concat([df.drop('Title',axis=1),dummies],axis=1)

dummies = pd.get_dummies(df['FsizeD'],drop_first=True)

df = pd.concat([df.drop('FsizeD',axis=1),dummies],axis=1)

df.head()
```

```
   Survived  Pclass   Age  SibSp  Parch     Fare  Ticket_Frequency
IsMarried  \
0         0       3  22.0      1      0   7.2500                 1
0
1         1       1  38.0      1      0  71.2833                 1
1
2         1       3  26.0      0      0   7.9250                 1
0
3         1       1  35.0      1      0  53.1000                 2
1
4         0       3  35.0      0      0   8.0500                 1
0

   Child  Age_band  ...  E  F  G  M  male  Miss_Mrs_Ms  Mr  Others
Big  Small
0      0         1  ...  0  0  0  1     1            0   1       0
0      1
1      0         2  ...  0  0  0  0     0            1   0       0
0      1
2      0         1  ...  0  0  0  1     0            1   0       0
0      0
3      0         2  ...  0  0  0  0     0            1   0       0
0      1
4      0         2  ...  0  0  0  1     1            0   1       0
0      0

[5 rows x 26 columns]
```

```python
df.corr()['Survived'].sort_values().drop('Survived').plot(kind='bar')
```

```
<AxesSubplot:>
```




```python
df.isnull().sum()
```

```
Survived            0
Pclass              0
Age                 0
SibSp               0
Parch               0
Fare                0
Ticket_Frequency    0
IsMarried           0
Child               0
Age_band            0
Fare_Range          0
Q                   0
S                   0
```

```
B                     0
C                     0
D                     0
E                     0
F                     0
G                     0
M                     0
male                  0
Miss_Mrs_Ms           0
Mr                    0
Others                0
Big                   0
Small                 0
dtype: int64
```

```
df.drop('Age', axis = 1, inplace=True)
```

Statistical Logistic Regression Modelling using Statsmodel Library

```
from sklearn.metrics import confusion_matrix, f1_score
```

```
df.columns
```

```
Index(['Survived', 'Pclass', 'SibSp', 'Parch', 'Fare',
'Ticket_Frequency',
       'IsMarried', 'Child', 'Age_band', 'Fare_Range', 'Q', 'S', 'B',
'C', 'D',
       'E', 'F', 'G', 'M', 'male', 'Miss_Mrs_Ms', 'Mr', 'Others',
'Big',
       'Small'],
      dtype='object')
```

```
res = ''
for i in df.columns:
    res += str(i) + ' + '
print(res)
```

```
Survived + Pclass + SibSp + Parch + Fare + Ticket_Frequency +
IsMarried + Child + Age_band + Fare_Range + Q + S + B + C + D + E + F
+ G + M + male + Miss_Mrs_Ms + Mr + Others + Big + Small +
```

```
df.head()
```

```
   Survived  Pclass  SibSp  Parch     Fare  Ticket_Frequency
IsMarried  \
0         0       3      1      0   7.2500                 1
0
1         1       1      1      0  71.2833                 1
1
```

```
2          1       3      0      0   7.9250                 1
0
3          1       1      1      0  53.1000                 2
1
4          0       3      0      0   8.0500                 1
0

   Child  Age_band       Fare_Range  ...  E  F  G  M  male
Miss_Mrs_Ms  Mr  \
0      0         1   (-0.001, 7.91]  ...  0  0  0  1     1
0   1
1      0         2  (31.0, 512.329]  ...  0  0  0  0     0
1   0
2      0         1   (7.91, 14.454]  ...  0  0  0  1     0
1   0
3      0         2  (31.0, 512.329]  ...  0  0  0  0     0
1   0
4      0         2   (7.91, 14.454]  ...  0  0  0  1     1
0   1

   Others  Big  Small
0       0    0      1
1       0    0      1
2       0    0      0
3       0    0      1
4       0    0      0

[5 rows x 25 columns]
```

```
import statsmodels.formula.api as smf

m1 = smf.logit(
  formula='Survived ~ Pclass + SibSp + Parch + Ticket_Frequency +
IsMarried + Child + Age_band + Fare_Range + Q + S + B + C + D + E + F
+ G + M + male + Mr + Others + Big + Small',
  data=df) \
.fit()

m1.summary()
```

```
Optimization terminated successfully.
         Current function value: 0.393608
         Iterations 7
```

```
<class 'statsmodels.iolib.summary.Summary'>
"""
                           Logit Regression Results

======================================================================
========
Dep. Variable:               Survived   No. Observations:
```

```
891
Model:                          Logit   Df Residuals:
866
Method:                           MLE   Df Model:
24
Date:                Wed, 01 Dec 2021   Pseudo R-squ.:
0.4089
Time:                        05:55:35   Log-Likelihood:
-350.70
converged:                       True   LL-Null:
-593.33
Covariance Type:            nonrobust   LLR p-value:
1.920e-87
==============================================================================
===================================================
                                                            coef
std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
---------------------------------------------------
Intercept                                                 3.9991
0.931      4.297      0.000       2.175       5.823
Fare_Range[T.Interval(7.91, 14.454, closed='right')]      0.1753
0.318      0.552      0.581      -0.448       0.798
Fare_Range[T.Interval(14.454, 31.0, closed='right')]      0.4089
0.393      1.041      0.298      -0.361       1.179
Fare_Range[T.Interval(31.0, 512.329, closed='right')]     0.5037
0.542      0.929      0.353      -0.559       1.567
Pclass                                                   -0.7701
0.229     -3.357      0.001      -1.220      -0.320
SibSp                                                    -0.1094
0.227     -0.483      0.629      -0.554       0.335
Parch                                                     0.0651
0.228      0.285      0.775      -0.382       0.512
Ticket_Frequency                                          0.0699
0.129      0.543      0.587      -0.182       0.322
IsMarried                                                 0.5934
0.378      1.569      0.117      -0.148       1.335
Child                                                     0.0872
0.417      0.209      0.834      -0.729       0.904
Age_band                                                 -0.4638
0.174     -2.671      0.008      -0.804      -0.124
Q                                                        -0.0446
0.420     -0.106      0.915      -0.868       0.779
S                                                        -0.3810
0.260     -1.467      0.142      -0.890       0.128
B                                                         0.3840
0.713      0.539      0.590      -1.014       1.782
C                                                        -0.0901
0.672     -0.134      0.893      -1.406       1.226
```

```
D                                                                 0.8875
0.751      1.181      0.238      -0.585      2.360
E                                                                 1.0669
0.752      1.418      0.156      -0.407      2.541
F                                                                 0.2211
1.102      0.201      0.841      -1.939      2.381
G                                                                -1.3949
1.255     -1.112      0.266      -3.854      1.064
M                                                                -0.4634
0.655     -0.707      0.479      -1.747      0.821
male                                                              0.2801
0.548      0.511      0.610      -0.795      1.355
Mr                                                               -3.2986
0.593     -5.566      0.000      -4.460     -2.137
Others                                                           -2.9690
0.775     -3.829      0.000      -4.489     -1.449
Big                                                              -3.1760
1.100     -2.889      0.004      -5.331     -1.021
Small                                                            -0.4798
0.397     -1.209      0.226      -1.257      0.298
======================================================================
===================================================
"""

X = df.drop(['Survived','Miss_Mrs_Ms', 'Fare'], axis = 1)

predictions = m1.predict(X)
thresholds = np.arange(0, 100)/100
best_thres = 0
best_score = 0
for thresh in thresholds:
    oofs_rounded = (predictions > thresh) * 1
    thresh_score = f1_score(df["Survived"], oofs_rounded)
    if thresh_score > best_score:
        best_score = thresh_score
        best_thres = thresh
print(f'Threshold {best_thres}: {best_score}')

Threshold 0.41: 0.7885714285714286

round_preds = (predictions > best_thres) * 1

print(confusion_matrix(df["Survived"], round_preds))

[[467  82]
 [ 66 276]]
```

Thus we have 492 True Negatives, 57 False Positives, 81 False Negatives, 261 True Positives

```
X.dtypes
```

```
Pclass                     int64
SibSp                      int64
Parch                      int64
Ticket_Frequency           int64
IsMarried                  int64
Child                      int64
Age_band                   int64
Fare_Range              category
Q                          uint8
S                          uint8
B                          uint8
C                          uint8
D                          uint8
E                          uint8
F                          uint8
G                          uint8
M                          uint8
male                       uint8
Mr                         uint8
Others                     uint8
Big                        uint8
Small                      uint8
dtype: object
```

Updates

```
# Create new feature Age_band*Pclass

df['Age_Class'] = df['Pclass']*df['Age_band']
```

Upsampling & Downsampling

```
# Using resample to upsample and downsample to the minority class

from sklearn.utils import resample

X_train = df.drop(['Survived','Miss_Mrs_Ms', 'Fare'], axis = 1)
y_train = df['Survived']
# Upsample minority class
X_train_u, y_train_u = resample(X_train[y_train == 1],
                                y_train[y_train == 1],
                                replace=True,
                                n_samples=X_train[y_train ==
0].shape[0],
                                random_state=1)

X_train_u = np.concatenate((X_train[y_train == 0], X_train_u))
y_train_u = np.concatenate((y_train[y_train == 0], y_train_u))
```

```
# Downsample majority class
X_train_d, y_train_d = resample(X_train[y_train == 0],
                                y_train[y_train == 0],
                                replace=True,
                                n_samples=X_train[y_train ==
1].shape[0],
                                random_state=1)
X_train_d = np.concatenate((X_train[y_train == 1], X_train_d))
y_train_d = np.concatenate((y_train[y_train == 1], y_train_d))


print("Original shape:", X_train.shape, y_train.shape)
print("Upsampled shape:", X_train_u.shape, y_train_u.shape)
#print ("SMOTE sample shape:", x_train_sm.shape, y_train_sm.shape)
print("Downsampled shape:", X_train_d.shape, y_train_d.shape)
```

```
Original shape: (891, 23) (891,)
Upsampled shape: (1098, 23) (1098,)
Downsampled shape: (684, 23) (684,)
```

```
# Creating the upsampled and downsampled dataframes

X_train_u = pd.DataFrame(X_train_u, columns=X.columns)
X_train_d = pd.DataFrame(X_train_d, columns=X.columns,
dtype=X.dtypes.values)
X_train_u['Survived'] = y_train_u
X_train_d['Survived'] = y_train_d
X_train_u['Fare_Range'] = X_train_u['Fare_Range'].astype('category')
X_train_d['Fare_Range'] = X_train_d['Fare_Range'].astype('category')
```

```
# Fitting on the upsampled data
m1 = smf.logit(
  formula='Survived ~ Pclass + SibSp + Parch + Ticket_Frequency +
IsMarried + Child + Age_band + Fare_Range + Q + S + B + C + D + E + F
+ G + M + male + Mr + Others + Big + Small + Age_Class',
  data=X_train_u) \
.fit()

m1.summary()
```

```
Warning: Maximum number of iterations has been exceeded.
         Current function value: 0.381698
         Iterations: 35

C:\Users\hp\Anaconda3\lib\site-packages\statsmodels\base\model.py:606:
ConvergenceWarning: Maximum Likelihood optimization failed to
converge. Check mle_retvals
  ConvergenceWarning)

<class 'statsmodels.iolib.summary.Summary'>
"""
```

```
                           Logit Regression Results

======================================================================
========
Dep. Variable:               Survived   No. Observations:
1098
Model:                          Logit   Df Residuals:
1047
Method:                           MLE   Df Model:
50
Date:                Thu, 02 Dec 2021   Pseudo R-squ.:
0.4493
Time:                        03:25:23   Log-Likelihood:
-419.10
converged:                      False   LL-Null:
-761.08
Covariance Type:            nonrobust   LLR p-value:
3.453e-112
======================================================================
===================================================
                                                                  coef
std err          z      P>|z|      [0.025      0.975]
----------------------------------------------------------------------
---------------------------------------------------
Intercept                                                       1.0938
1.500      0.729      0.466      -1.845       4.033
Pclass[T.2]                                                     1.2351
1.469      0.841      0.400      -1.644       4.114
Pclass[T.3]                                                    -0.5783
1.267     -0.456      0.648      -3.062       1.905
SibSp[T.1]                                                     -0.0156
0.478     -0.033      0.974      -0.953       0.922
SibSp[T.2]                                                      1.3456
0.720      1.868      0.062      -0.066       2.758
SibSp[T.3]                                                      0.7408
1.232      0.601      0.548      -1.674       3.155
SibSp[T.4]                                                      1.2711
1.297      0.980      0.327      -1.272       3.814
SibSp[T.5]                                                      0.9788
7766.329      0.000      1.000   -1.52e+04    1.52e+04
SibSp[T.8]                                                    -97.4643
1.04e+21  -9.39e-20      1.000   -2.04e+21    2.04e+21
Parch[T.1]                                                     -0.5896
0.428     -1.379      0.168      -1.428       0.249
Parch[T.2]                                                     -0.2703
0.590     -0.458      0.647      -1.427       0.887
Parch[T.3]                                                      2.6476
1.649      1.606      0.108      -0.584       5.879
Parch[T.4]                                                    -16.8059
```

```
1.17e+04     -0.001      0.999    -2.3e+04     2.3e+04
Parch[T.5]                                                  -20.1932
3.67e+04     -0.001      1.000   -7.19e+04    7.18e+04
Parch[T.6]                                                    1.0223
2.4e+04   4.27e-05      1.000    -4.7e+04     4.7e+04
Ticket_Frequency[T.2]                                        -0.0660
0.301     -0.219      0.826      -0.656      0.524
Ticket_Frequency[T.3]                                         0.2667
0.435      0.613      0.540      -0.587      1.120
Ticket_Frequency[T.4]                                         0.0999
0.590      0.169      0.866      -1.056      1.256
Ticket_Frequency[T.5]                                       -23.8209
4.38e+04     -0.001      1.000   -8.58e+04    8.57e+04
Ticket_Frequency[T.6]                                       -18.5631
4831.678     -0.004      0.997   -9488.477    9451.351
Ticket_Frequency[T.7]                                         1.7367
0.826      2.103      0.035       0.118      3.355
IsMarried[T.1]                                                0.6891
0.378      1.822      0.068      -0.052      1.430
Child[T.1]                                                    1.8920
0.686      2.760      0.006       0.548      3.236
Age_band[T.1]                                                 1.4812
nan        nan        nan         nan        nan
Age_band[T.2]                                                 3.1079
nan        nan        nan         nan        nan
Age_band[T.3]                                                 2.2155
nan        nan        nan         nan        nan
Age_band[T.4]                                               -16.7861
nan        nan        nan         nan        nan
Fare_Range[T.Interval(7.91, 14.454, closed='right')]          0.0299
0.293      0.102      0.919      -0.545      0.605
Fare_Range[T.Interval(14.454, 31.0, closed='right')]          0.0469
0.368      0.127      0.899      -0.675      0.769
Fare_Range[T.Interval(31.0, 512.329, closed='right')]        -0.0806
0.556     -0.145      0.885      -1.169      1.008
Q[T.1]                                                        0.2060
0.390      0.529      0.597      -0.558      0.970
S[T.1]                                                       -0.4811
0.246     -1.957      0.050      -0.963      0.001
B[T.1]                                                        0.3569
0.686      0.520      0.603      -0.988      1.701
C[T.1]                                                       -0.2542
0.618     -0.411      0.681      -1.465      0.957
D[T.1]                                                        0.9620
0.702      1.370      0.171      -0.414      2.338
E[T.1]                                                        1.0264
0.708      1.450      0.147      -0.361      2.414
F[T.1]                                                       -0.5310
1.126     -0.472      0.637      -2.737      1.675
```

```
G[T.1]                                                      -0.8528
1.172     -0.728      0.467      -3.149       1.444
M[T.1]                                                      -0.6323
0.623     -1.016      0.310      -1.853       0.588
male[T.1]                                                    1.7295
0.652      2.652      0.008       0.451       3.008
Mr[T.1]                                                     -4.7763
0.689     -6.931      0.000      -6.127      -3.426
Others[T.1]                                                 -4.5419
0.835     -5.440      0.000      -6.178      -2.906
Big[T.1]                                                    -3.6727
1.331     -2.759      0.006      -6.281      -1.064
Small[T.1]                                                  -0.2821
0.571     -0.494      0.621      -1.401       0.837
Age_Class[T.1]                                               1.1688
nan        nan        nan         nan         nan
Age_Class[T.2]                                              -0.8542
nan        nan        nan         nan         nan
Age_Class[T.3]                                              -0.0887
nan        nan        nan         nan         nan
Age_Class[T.4]                                              -2.5753
nan        nan        nan         nan         nan
Age_Class[T.6]                                              -2.0160
nan        nan        nan         nan         nan
Age_Class[T.8]                                              -2.5628
nan        nan        nan         nan         nan
Age_Class[T.9]                                              -1.6949
nan        nan        nan         nan         nan
Age_Class[T.12]                                             -1.3583
nan        nan        nan         nan         nan
======================================================================
===================================================
"""

# Fitting on the downsampled data
m1 = smf.logit(
  formula='Survived ~ Pclass + SibSp + Parch + Ticket_Frequency +
IsMarried + Child + Age_band + Fare_Range + Q + S + B + C + D + E + F
+ G + M + male + Mr + Others + Big + Small + Age_Class',
  data=X_train_d) \
.fit()

m1.summary()

Warning: Maximum number of iterations has been exceeded.
         Current function value: 0.382638
         Iterations: 35

C:\Users\hp\Anaconda3\lib\site-packages\statsmodels\base\model.py:606:
ConvergenceWarning: Maximum Likelihood optimization failed to
```

```
converge. Check mle_retvals
  ConvergenceWarning)

<class 'statsmodels.iolib.summary.Summary'>
"""
                           Logit Regression Results

======================================================================
========
Dep. Variable:               Survived   No. Observations:
684
Model:                          Logit   Df Residuals:
635
Method:                           MLE   Df Model:
48
Date:                Thu, 02 Dec 2021   Pseudo R-squ.:
0.4480
Time:                        03:25:25   Log-Likelihood:
-261.72
converged:                      False   LL-Null:
-474.11
Covariance Type:            nonrobust   LLR p-value:
8.355e-62
======================================================================
===================================================
                                                            coef
std err          z      P>|z|      [0.025      0.975]
----------------------------------------------------------------------
---------------------------------------------------
Intercept                                                29.1405
7.77e+05   3.75e-05      1.000   -1.52e+06    1.52e+06
Pclass[T.2]                                             -25.3053
7.77e+05  -3.26e-05      1.000   -1.52e+06    1.52e+06
Pclass[T.3]                                             -26.9066
7.77e+05  -3.46e-05      1.000   -1.52e+06    1.52e+06
SibSp[T.1]                                                0.4606
0.624      0.738      0.461      -0.763       1.684
SibSp[T.2]                                                1.3198
0.950      1.389      0.165      -0.543       3.182
SibSp[T.3]                                                0.7750
1.727      0.449      0.654      -2.609       4.159
SibSp[T.4]                                                0.8682
1.870      0.464      0.642      -2.797       4.534
SibSp[T.5]                                               -1.8573
1.35e+04     -0.000      1.000   -2.65e+04    2.65e+04
Parch[T.1]                                               -0.2422
0.560     -0.432      0.665      -1.340       0.856
Parch[T.2]                                               -0.4156
0.741     -0.561      0.575      -1.869       1.037
Parch[T.3]                                                0.6588
```

```
1.923      0.343      0.732      -3.110      4.428
Parch[T.4]                                                    -0.4481
8728.678  -5.13e-05      1.000   -1.71e+04    1.71e+04
Parch[T.5]                                                     0.2163
2.198      0.098      0.922      -4.092      4.524
Ticket_Frequency[T.2]                                          0.0590
0.402      0.147      0.883      -0.730      0.847
Ticket_Frequency[T.3]                                          0.2407
0.514      0.468      0.640      -0.767      1.248
Ticket_Frequency[T.4]                                          1.4789
0.821      1.801      0.072      -0.131      3.088
Ticket_Frequency[T.5]                                        -26.6842
4.25e+05  -6.27e-05      1.000   -8.34e+05    8.34e+05
Ticket_Frequency[T.6]                                        -15.0687
1930.224     -0.008      0.994   -3798.238    3768.101
Ticket_Frequency[T.7]                                          1.9985
0.984      2.031      0.042       0.070      3.927
IsMarried[T.1]                                                 1.1873
0.537      2.212      0.027       0.135      2.239
Child[T.1]                                                     0.1094
1.137      0.096      0.923      -2.119      2.337
Age_band[T.1]                                                 14.0224
nan        nan        nan         nan        nan
Age_band[T.2]                                                -11.4310
nan        nan        nan         nan        nan
Age_band[T.3]                                                -12.4506
nan        nan        nan         nan        nan
Age_band[T.4]                                                -36.3436
nan        nan        nan         nan        nan
Fare_Range[T.Interval(7.91, 14.454, closed='right')]           0.1495
0.366      0.409      0.683      -0.568      0.867
Fare_Range[T.Interval(14.454, 31.0, closed='right')]           0.1472
0.463      0.318      0.751      -0.760      1.055
Fare_Range[T.Interval(31.0, 512.329, closed='right')]         -0.0163
0.699     -0.023      0.981      -1.387      1.355
Q[T.1]                                                        -0.2188
0.503     -0.435      0.664      -1.205      0.767
S[T.1]                                                        -0.6832
0.324     -2.111      0.035      -1.317     -0.049
B[T.1]                                                         0.5338
0.822      0.650      0.516      -1.076      2.144
C[T.1]                                                         0.3623
0.762      0.475      0.635      -1.132      1.857
D[T.1]                                                         1.2846
0.878      1.462      0.144      -0.437      3.006
E[T.1]                                                         1.6220
0.880      1.843      0.065      -0.103      3.347
F[T.1]                                                        -0.6997
1.242     -0.564      0.573      -3.134      1.734
```

```
G[T.1]                                                            23.7863
2.4e+05    9.9e-05      1.000   -4.71e+05    4.71e+05
M[T.1]                                                            -0.5800
0.801     -0.724      0.469      -2.150       0.990
male[T.1]                                                          0.8889
0.791      1.124      0.261      -0.662       2.440
Mr[T.1]                                                           -3.7853
0.828     -4.570      0.000      -5.409      -2.162
Others[T.1]                                                       -3.4673
0.996     -3.481      0.001      -5.420      -1.515
Big[T.1]                                                          -4.3302
1.867     -2.320      0.020      -7.989      -0.671
Small[T.1]                                                        -0.5077
0.737     -0.689      0.491      -1.951       0.936
Age_Class[T.1]                                                   -39.0641
nan        nan        nan         nan         nan
Age_Class[T.2]                                                   -15.0088
nan        nan        nan         nan         nan
Age_Class[T.3]                                                   -14.2374
nan        nan        nan         nan         nan
Age_Class[T.4]                                                     9.8245
nan        nan        nan         nan         nan
Age_Class[T.6]                                                    10.4136
nan        nan        nan         nan         nan
Age_Class[T.8]                                                    -4.3162
5.2e+08  -8.29e-09      1.000   -1.02e+09    1.02e+09
Age_Class[T.9]                                                    11.0429
nan        nan        nan         nan         nan
Age_Class[T.12]                                                   -4.8573
1.84e+09  -2.64e-09      1.000    -3.6e+09     3.6e+09
======================================================================
===================================================
"""
```

```
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns

# Reading the data
df = pd.read_csv('adult.csv')

df.head()
```

```
   Age         Workclass  fnlwgt   education  education-num  \
0   39         State-gov   77516   Bachelors             13
1   50  Self-emp-not-inc   83311   Bachelors             13
2   38           Private  215646     HS-grad              9
3   53           Private  234721        11th              7
4   28           Private  338409   Bachelors             13

         maritalstatus         occupation    relationship    race
sex  \
0        Never-married       Adm-clerical   Not-in-family   White
Male
1   Married-civ-spouse    Exec-managerial         Husband   White
Male
2             Divorced  Handlers-cleaners   Not-in-family   White
Male
3   Married-civ-spouse  Handlers-cleaners         Husband   Black
Male
4   Married-civ-spouse     Prof-specialty            Wife   Black
Female

   capital-gain  capital-loss  hourspw   nativecountry  target
0          2174             0       40   United-States   <=50K
1             0             0       13   United-States   <=50K
2             0             0       40   United-States   <=50K
3             0             0       40   United-States   <=50K
4             0             0       40            Cuba   <=50K
```

```
#Checking for null values and data types
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 32561 entries, 0 to 32560
Data columns (total 15 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Age             32561 non-null  int64
 1   Workclass       32561 non-null  object
```

```
 2   fnlwgt          32561 non-null  int64
 3   education       32561 non-null  object
 4   education-num   32561 non-null  int64
 5   maritalstatus   32561 non-null  object
 6   occupation      32561 non-null  object
 7   relationship    32561 non-null  object
 8   race            32561 non-null  object
 9   sex             32561 non-null  object
 10  capital-gain    32561 non-null  int64
 11  capital-loss    32561 non-null  int64
 12  hourspw         32561 non-null  int64
 13  nativecountry   32561 non-null  object
 14  target          32561 non-null  object
dtypes: int64(6), object(9)
memory usage: 3.7+ MB
```

We do not have any null values!

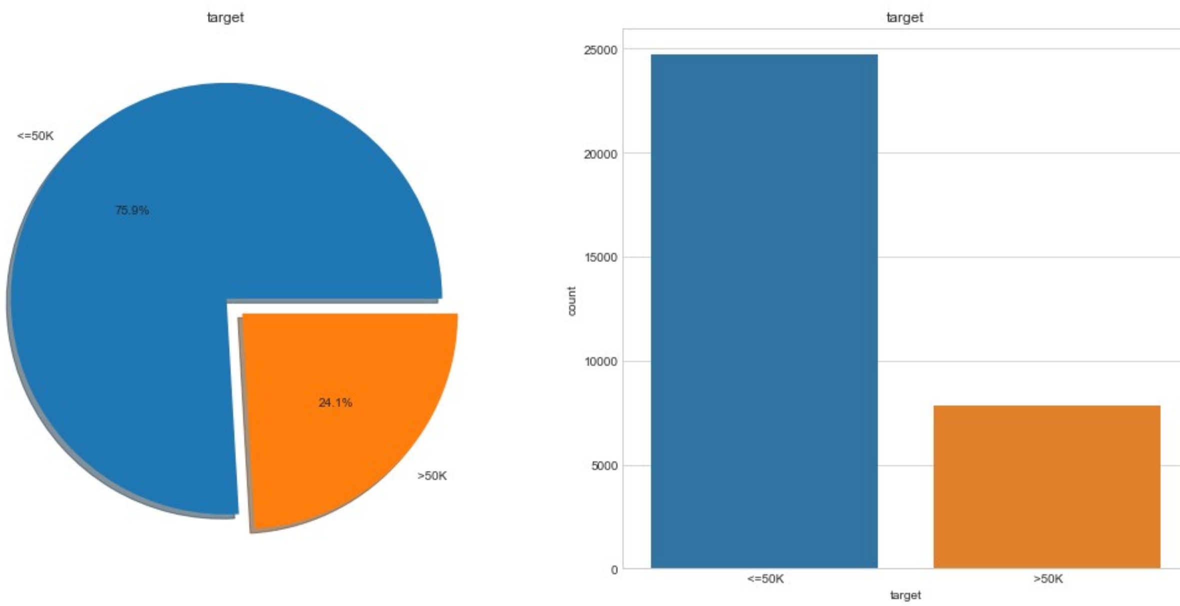
```
#description of numerical variales
df.describe().transpose()
```

```
                 count           mean            std      min
25%  \
Age            32561.0      38.581647      13.640433     17.0
28.0
fnlwgt         32561.0  189778.366512  105549.977697  12285.0
117827.0
education-num  32561.0      10.080679       2.572720      1.0
9.0
capital-gain   32561.0    1077.648844    7385.292085      0.0
0.0
capital-loss   32561.0      87.303830     402.960219      0.0
0.0
hourspw        32561.0      40.437456      12.347429      1.0
40.0

                    50%       75%        max
Age                37.0      48.0       90.0
fnlwgt         178356.0  237051.0  1484705.0
education-num      10.0      12.0       16.0
capital-gain        0.0       0.0    99999.0
capital-loss        0.0       0.0     4356.0
hourspw            40.0      45.0       99.0
```

```
#Plotting target distribution
f,ax=plt.subplots(1,2,figsize=(18,8))
df['target'].value_counts().plot.pie(ax = ax[0],
explode=[0,0.1],autopct='%1.1f%%',shadow=True)
ax[0].set_title('target')
```

```
ax[0].set_ylabel('')
sns.countplot('target',data=df,ax=ax[1])
ax[1].set_title('target')
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning

Text(0.5, 1.0, 'target')
```



Overall 24.1 % people have a higher income than 50K

EDA and Feature Generation

```
#Checking the Columns or features
df.columns
```

```
Index(['Age', 'Workclass', 'fnlwgt', 'education', 'education-num',
       'maritalstatus', 'occupation', 'relationship', 'race', 'sex',
       'capital-gain', 'capital-loss', 'hourspw', 'nativecountry',
'target'],
      dtype='object')
```

```
# find categorical variables

categorical = [var for var in df.columns if df[var].dtype=='O']
print(categorical)
```

```
['Workclass', 'education', 'maritalstatus', 'occupation',
'relationship', 'race', 'sex', 'nativecountry', 'target']

# Find numerical variables

numerical = [var for var in df.columns if df[var].dtype !='O']
print(numerical)

['Age', 'fnlwgt', 'education-num', 'capital-gain', 'capital-loss',
'hourspw']

# We check for values with '?'

for i in categorical:
    for j in df[i].value_counts().index:
        if j == ' ?':
            print(i)
            break

Workclass
occupation
nativecountry

#Unique classes in Workclass
df['Workclass'].unique()

array([' State-gov', ' Self-emp-not-inc', ' Private', ' Federal-gov',
       ' Local-gov', ' ?', ' Self-emp-inc', ' Without-pay',
       ' Never-worked'], dtype=object)

# Number of data points per unique value
df['Workclass'].value_counts()

 Private             22696
 Self-emp-not-inc     2541
 Local-gov            2093
 ?                    1836
 State-gov            1298
 Self-emp-inc         1116
 Federal-gov           960
 Without-pay            14
 Never-worked            7
Name: Workclass, dtype: int64
```

We see that there are 1836 '?' values, that are corrupt and should be treated.

```
#Replacing '?' with NaN values
df['Workclass'].replace(' ?', np.NaN, inplace= True)

df['Workclass'].value_counts()
```

```
 Private             22696
 Self-emp-not-inc     2541
 Local-gov            2093
 State-gov            1298
 Self-emp-inc         1116
 Federal-gov           960
 Without-pay            14
 Never-worked            7
Name: Workclass, dtype: int64
```

Checking Occupation Variable

```
# Repeating the same process with Occupation
df['occupation'].unique()

array([' Adm-clerical', ' Exec-managerial', ' Handlers-cleaners',
       ' Prof-specialty', ' Other-service', ' Sales', ' Craft-repair',
       ' Transport-moving', ' Farming-fishing', ' Machine-op-inspct',
       ' Tech-support', ' ?', ' Protective-serv', ' Armed-Forces',
       ' Priv-house-serv'], dtype=object)

df['occupation'].value_counts()

 Prof-specialty       4140
 Craft-repair         4099
 Exec-managerial      4066
 Adm-clerical         3770
 Sales                3650
 Other-service        3295
 Machine-op-inspct    2002
 ?                    1843
 Transport-moving     1597
 Handlers-cleaners    1370
 Farming-fishing       994
 Tech-support          928
 Protective-serv       649
 Priv-house-serv       149
 Armed-Forces            9
Name: occupation, dtype: int64
```

Again we see that there are 1843 '?' counts

```
df['occupation'].replace(' ?', np.NaN, inplace=True)

df['occupation'].value_counts()

 Prof-specialty       4140
 Craft-repair         4099
 Exec-managerial      4066
 Adm-clerical         3770
```

```
 Sales                 3650
 Other-service         3295
 Machine-op-inspct     2002
 Transport-moving      1597
 Handlers-cleaners     1370
 Farming-fishing        994
 Tech-support           928
 Protective-serv        649
 Priv-house-serv        149
 Armed-Forces             9
Name: occupation, dtype: int64
```

Checking native country

```
# Repeating the same process with Native Country
df['nativecountry'].unique()
```

```
array([' United-States', ' Cuba', ' Jamaica', ' India', ' ?', '
Mexico',
       ' South', ' Puerto-Rico', ' Honduras', ' England', ' Canada',
       ' Germany', ' Iran', ' Philippines', ' Italy', ' Poland',
       ' Columbia', ' Cambodia', ' Thailand', ' Ecuador', ' Laos',
       ' Taiwan', ' Haiti', ' Portugal', ' Dominican-Republic',
       ' El-Salvador', ' France', ' Guatemala', ' China', ' Japan',
       ' Yugoslavia', ' Peru', ' Outlying-US(Guam-USVI-etc)', '
Scotland',
       ' Trinadad&Tobago', ' Greece', ' Nicaragua', ' Vietnam', '
Hong',
       ' Ireland', ' Hungary', ' Holand-Netherlands'], dtype=object)
```

```
df['nativecountry'].value_counts()
```

```
 United-States                 29170
 Mexico                          643
 ?                               583
 Philippines                     198
 Germany                         137
 Canada                          121
 Puerto-Rico                     114
 El-Salvador                     106
 India                           100
 Cuba                             95
 England                          90
 Jamaica                          81
 South                            80
 China                            75
 Italy                            73
 Dominican-Republic               70
 Vietnam                          67
 Guatemala                        64
```

```
 Japan                              62
 Poland                             60
 Columbia                           59
 Taiwan                             51
 Haiti                              44
 Iran                               43
 Portugal                           37
 Nicaragua                          34
 Peru                               31
 France                             29
 Greece                             29
 Ecuador                            28
 Ireland                            24
 Hong                               20
 Cambodia                           19
 Trinadad&Tobago                    19
 Laos                               18
 Thailand                           18
 Yugoslavia                         16
 Outlying-US(Guam-USVI-etc)         14
 Honduras                           13
 Hungary                            13
 Scotland                           12
 Holand-Netherlands                  1
Name: nativecountry, dtype: int64
```

```
df['nativecountry'].replace(' ?', np.NaN, inplace=True)

for i in categorical:
    for j in df[i].value_counts().index:
        if j == ' ?':
            print(i)
            break
```

After careful observation, we donot observe any '?' in any other features

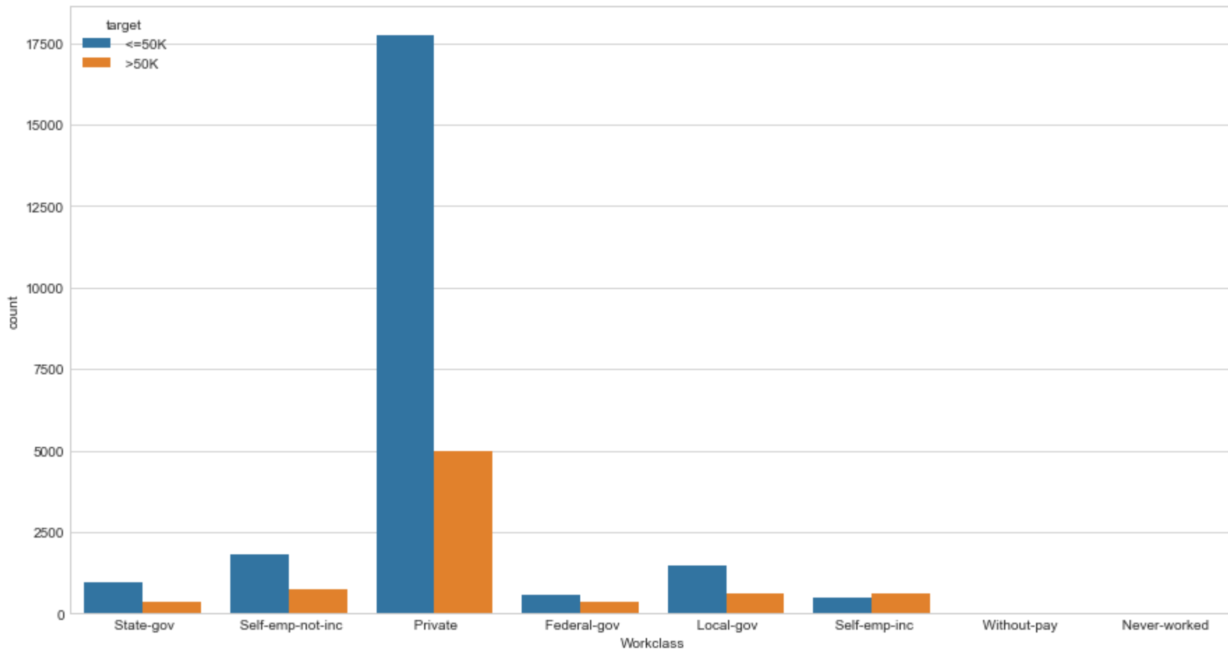
```
df[categorical].isnull().sum()
```

```
Workclass        1836
education           0
maritalstatus       0
occupation       1843
relationship        0
race                0
sex                 0
nativecountry     583
target              0
dtype: int64
```

EDA

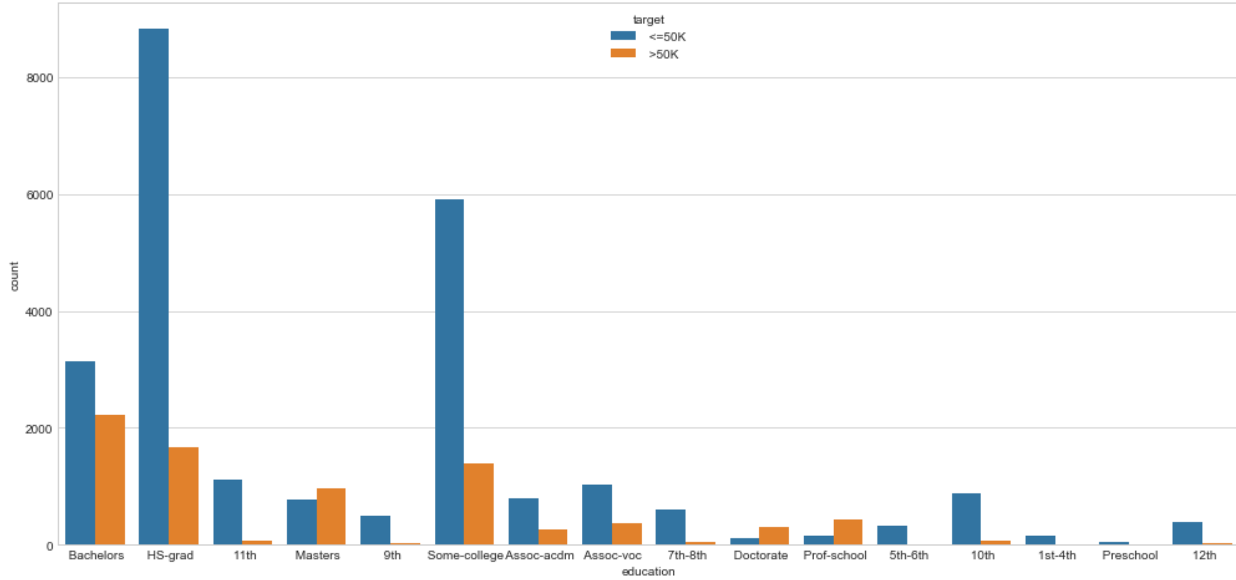
```
# Creating countplot for categorical variables with hue as target
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='Workclass',data=df,hue='target', ax = ax)
```

```
<AxesSubplot:xlabel='Workclass', ylabel='count'>
```

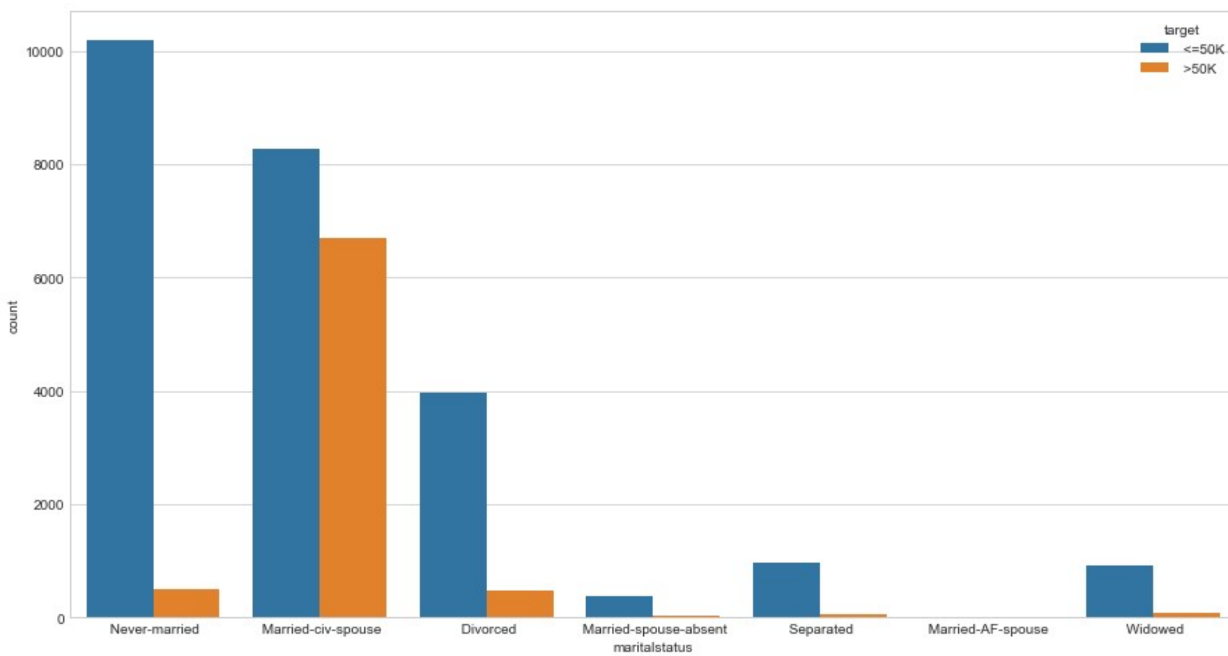



```
f,ax=plt.subplots(1,1,figsize=(17,8))
sns.countplot(x='education',data=df,hue='target', ax = ax)
```

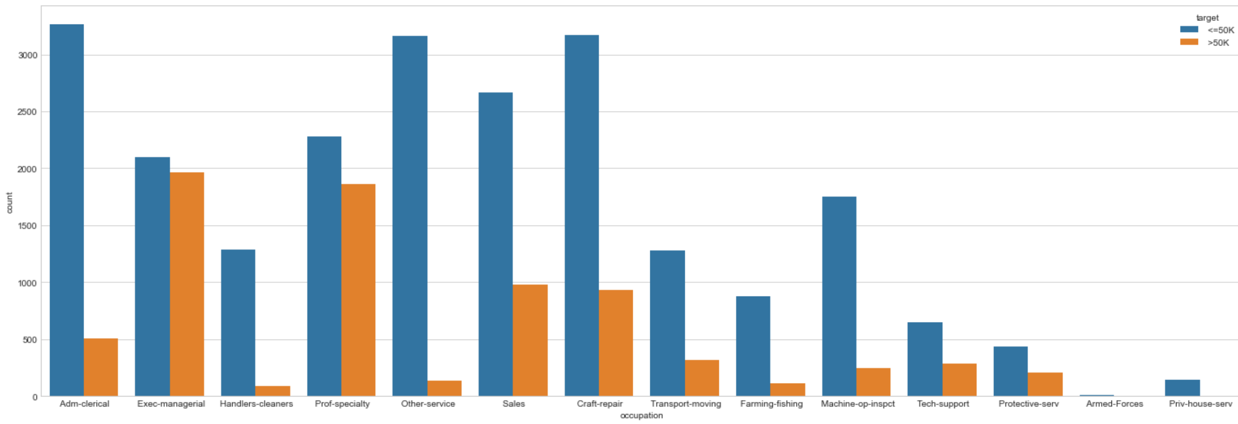
```
<AxesSubplot:xlabel='education', ylabel='count'>
```



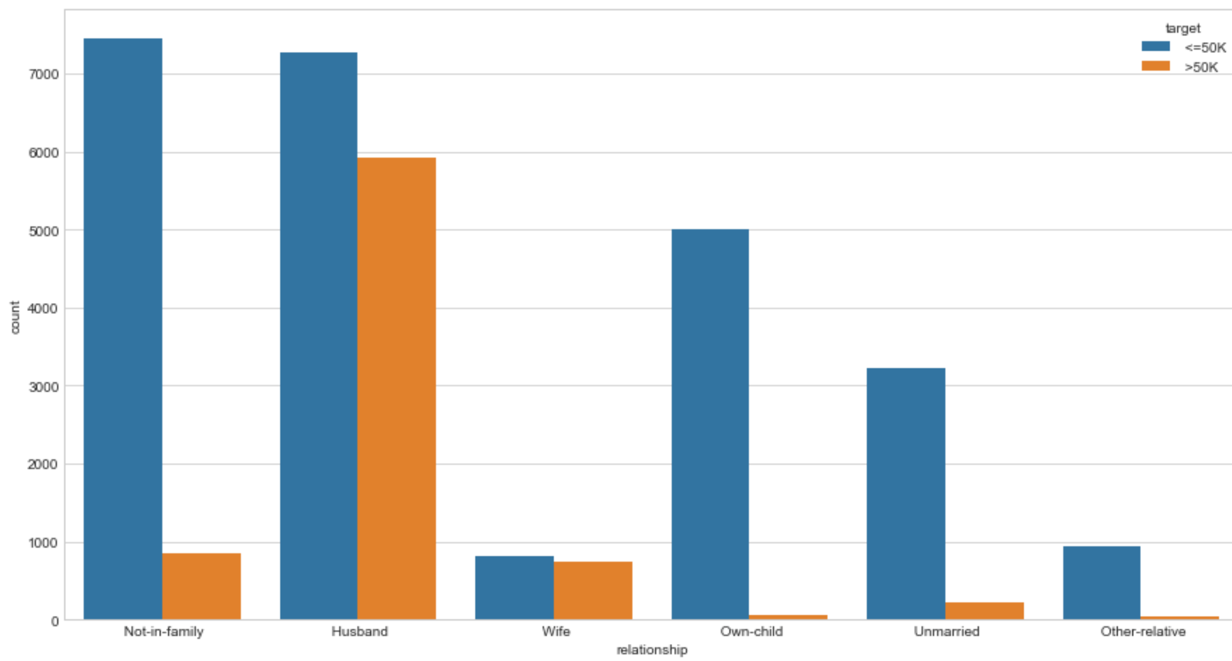

```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='maritalstatus',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='maritalstatus', ylabel='count'>
```



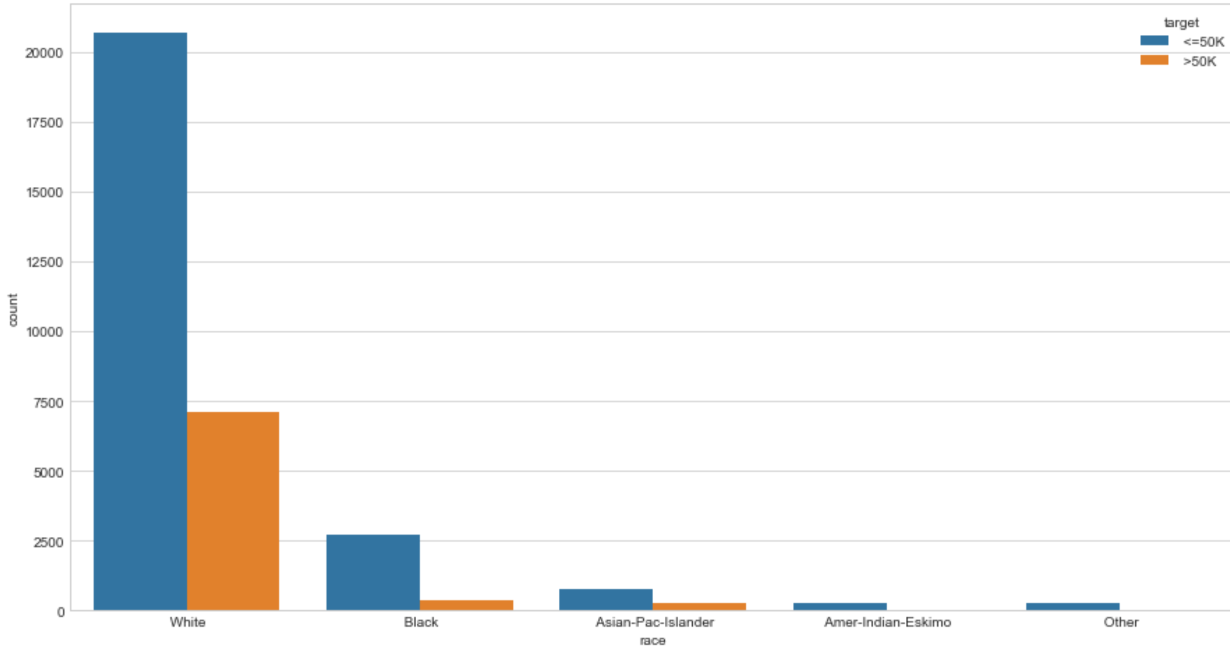

```
f,ax=plt.subplots(1,1,figsize=(24,8))
sns.countplot(x='occupation',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='occupation', ylabel='count'>
```



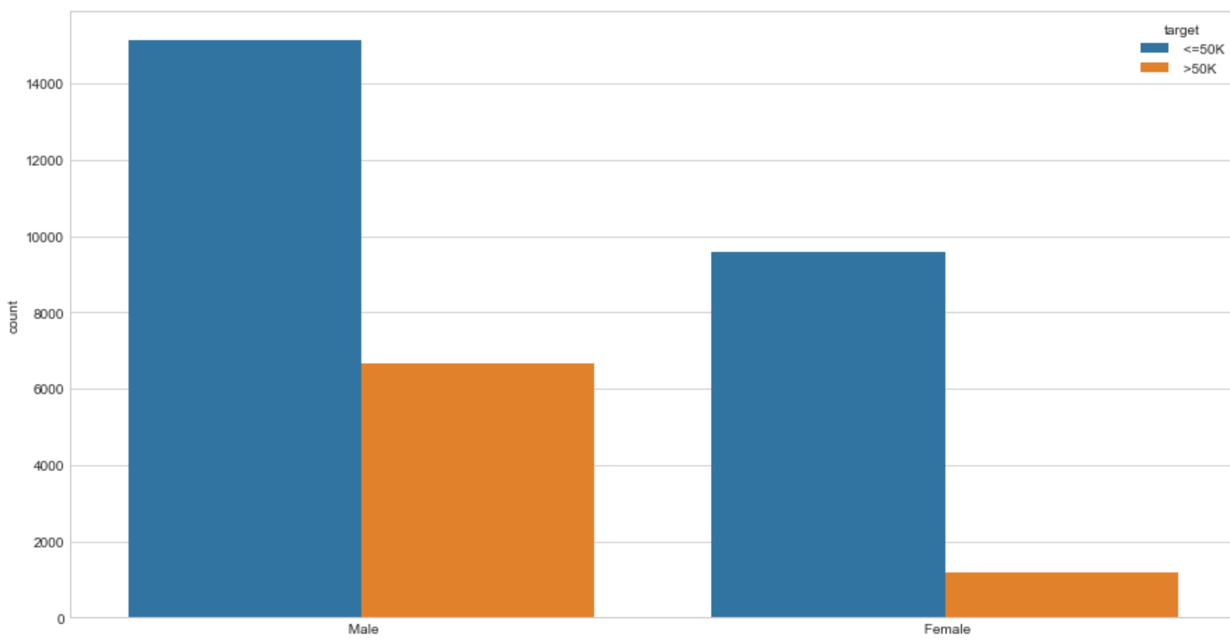

```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='relationship',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='relationship', ylabel='count'>
```




```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='race',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='race', ylabel='count'>
```

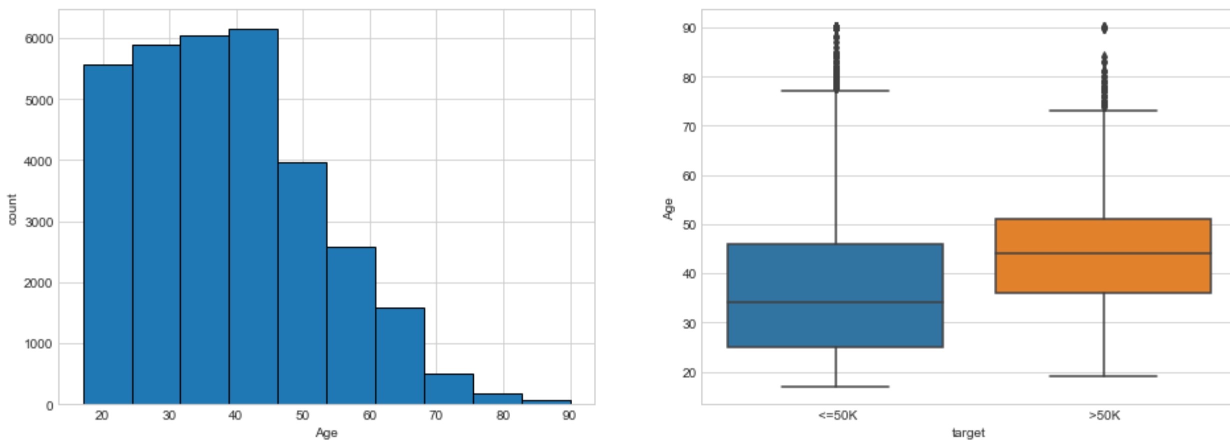



```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='sex',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='sex', ylabel='count'>
```




```
# Creating histograms and boxplot for numerical variables
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df.Age, edgecolor="black")
```

```
ax[0].set_xlabel('Age')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='Age', data=df, ax=ax[1])
plt.show()

(2,)
```




```
df.describe()

                Age        fnlwgt  education-num  capital-gain
capital-loss  \
count  32561.000000  3.256100e+04   32561.000000  32561.000000
32561.000000
mean      38.581647  1.897784e+05      10.080679   1077.648844
87.303830
std       13.640433  1.055500e+05       2.572720   7385.292085
402.960219
min       17.000000  1.228500e+04       1.000000      0.000000
0.000000
25%       28.000000  1.178270e+05       9.000000      0.000000
0.000000
50%       37.000000  1.783560e+05      10.000000      0.000000
0.000000
75%       48.000000  2.370510e+05      12.000000      0.000000
0.000000
max       90.000000  1.484705e+06      16.000000  99999.000000
4356.000000

            hourspw
count  32561.000000
mean      40.437456
std       12.347429
min        1.000000
25%       40.000000
50%       40.000000
```

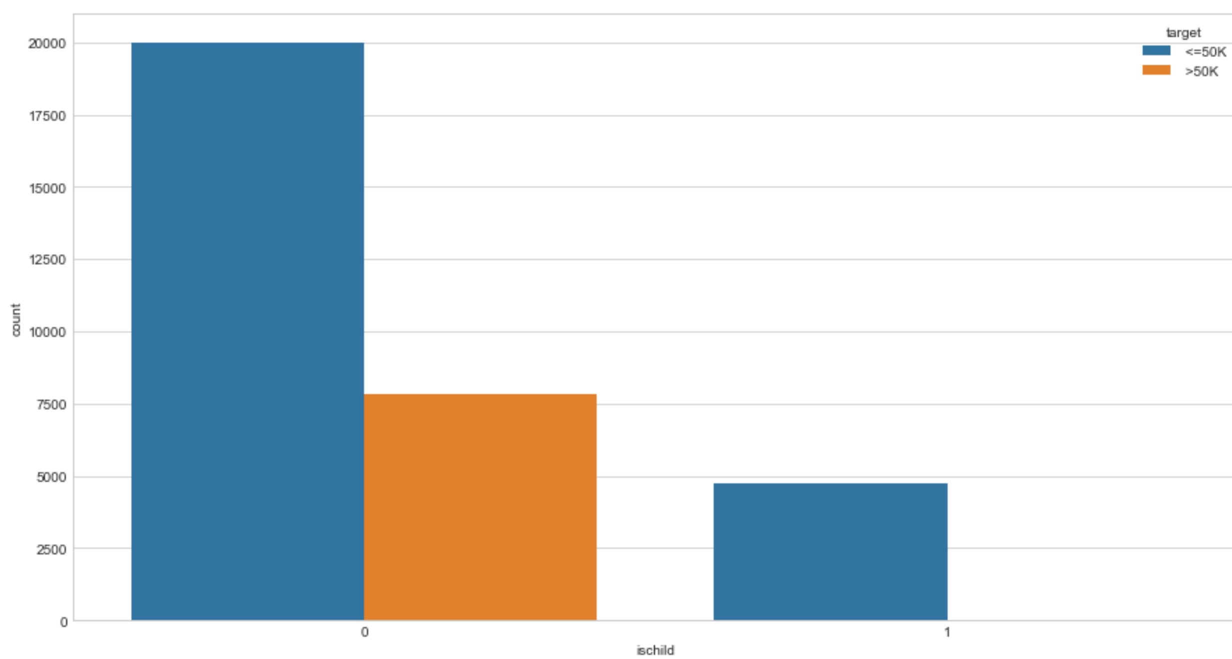
```
75%        45.000000
max        99.000000
```

```
# Creating a new variable isChild for age less than 24
df['ischild'] = 0
df['ischild'][df['Age'] < 24] = 1
```

```
C:\Users\hp\Anaconda3\lib\site-packages\ipykernel_launcher.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  This is separate from the ipykernel package so we can avoid doing
imports until
```

```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='ischild',data=df,hue='target', ax = ax)
```

```
<AxesSubplot:xlabel='ischild', ylabel='count'>
```



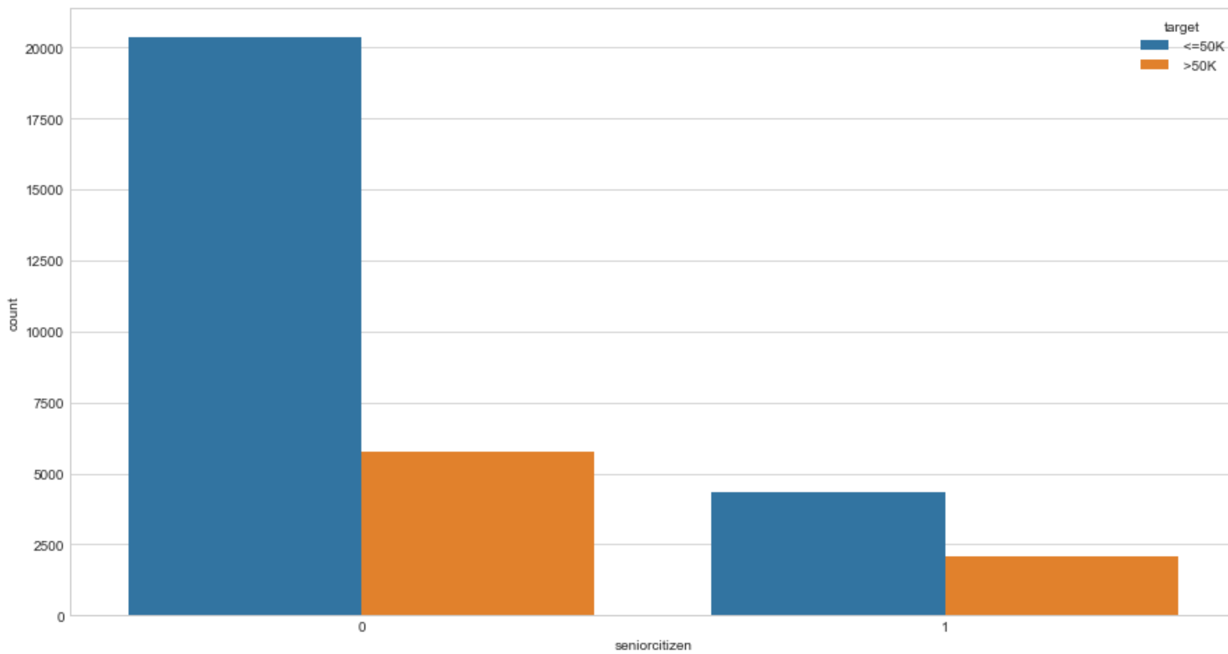

```
# Creating a new variable seniorcitizen for age more than 50
df['seniorcitizen'] = 0
df['seniorcitizen'][df['Age'] > 50] = 1
```

```
C:\Users\hp\Anaconda3\lib\site-packages\ipykernel_launcher.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  This is separate from the ipykernel package so we can avoid doing
imports until
```

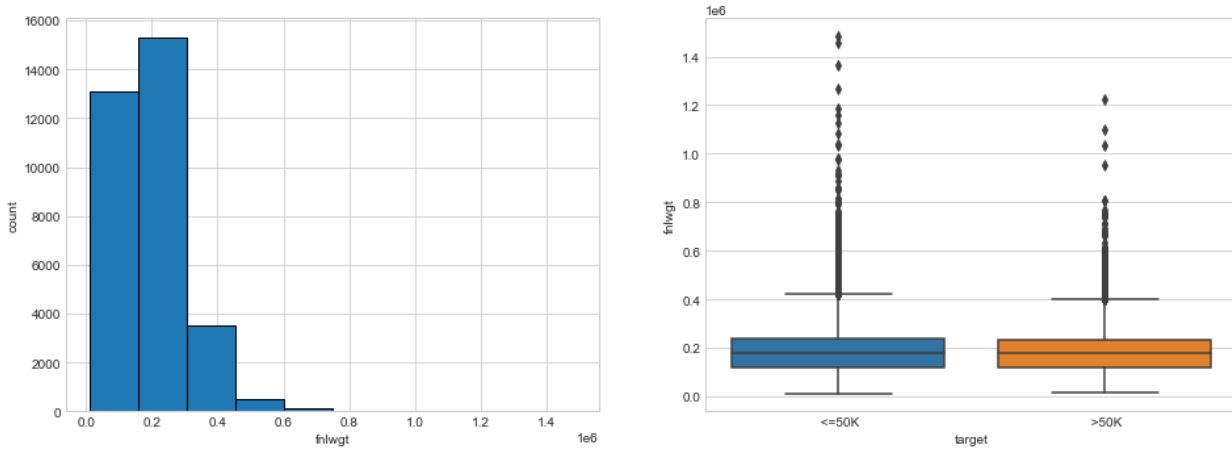
```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='seniorcitizen',data=df,hue='target', ax = ax)
```

```
<AxesSubplot:xlabel='seniorcitizen', ylabel='count'>
```




```
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df.fnlwgt, edgecolor="black")
ax[0].set_xlabel('fnlwgt')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='fnlwgt', data=df, ax=ax[1])
plt.show()
```

```
(2,)
```

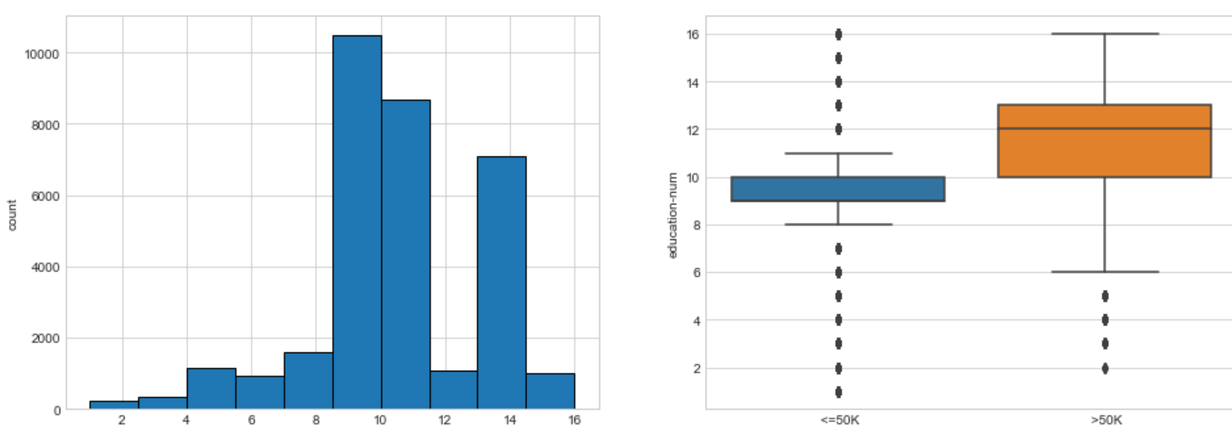



```
df['fnlwgt'].describe()
```

```
count    3.256100e+04
mean     1.897784e+05
std      1.055500e+05
min      1.228500e+04
25%      1.178270e+05
50%      1.783560e+05
75%      2.370510e+05
max      1.484705e+06
Name: fnlwgt, dtype: float64
```

```
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df['education-num'], edgecolor="black")
ax[0].set_xlabel('education-num')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='education-num', data=df, ax=ax[1])
plt.show()
```

```
(2,)
```

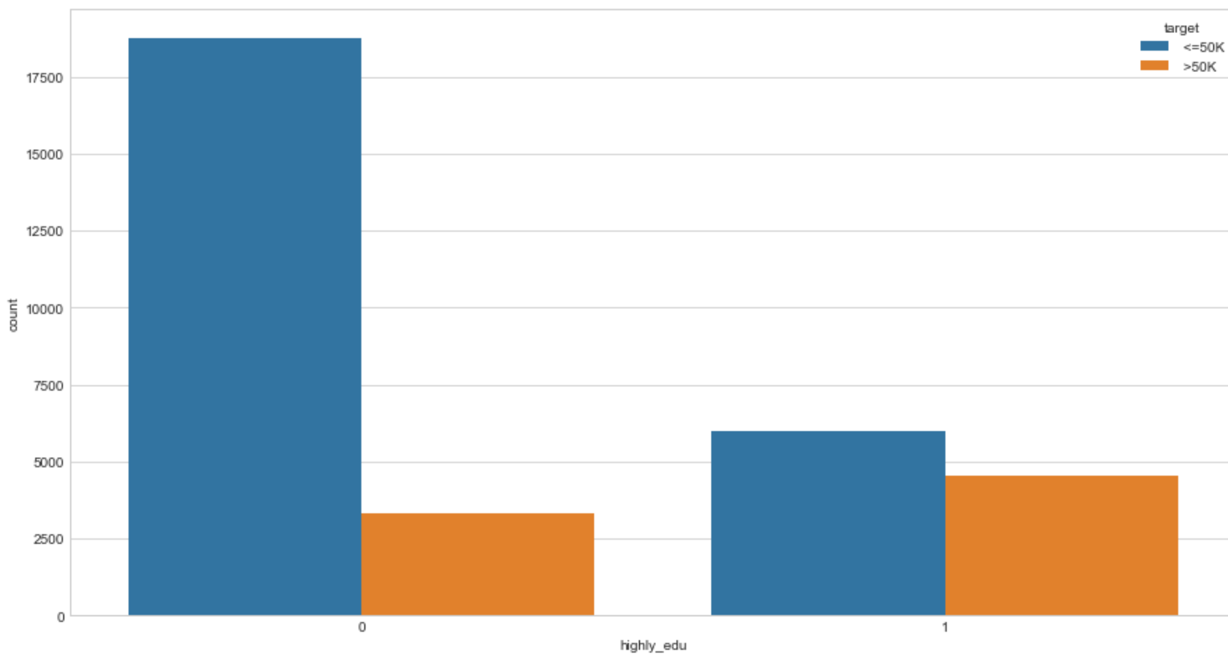


```
df['highly_edu'] = 0
df['highly_edu'][df['education-num'] > 10] = 1
```

```
C:\Users\hp\Anaconda3\lib\site-packages\ipykernel_launcher.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
```

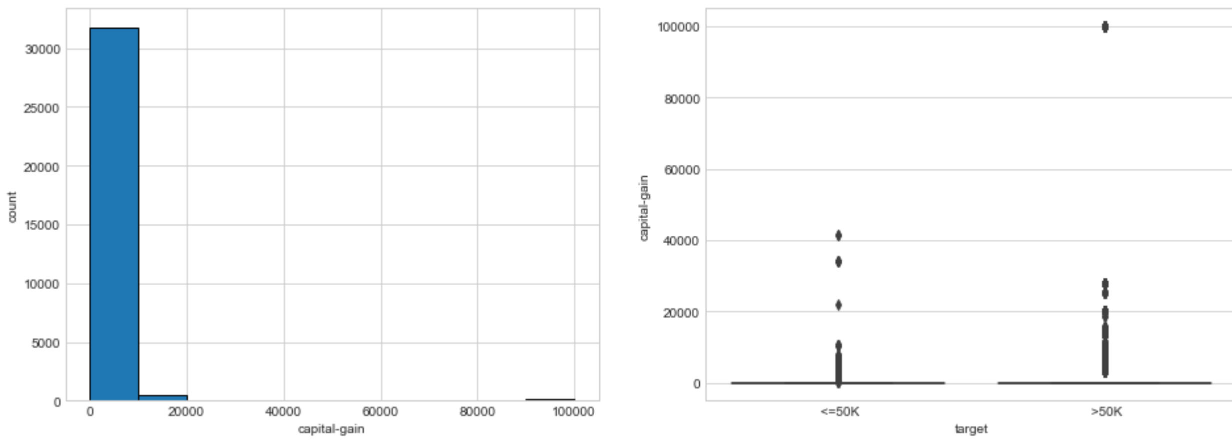
```
f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='highly_edu',data=df,hue='target', ax = ax)
```

```
<AxesSubplot:xlabel='highly_edu', ylabel='count'>
```



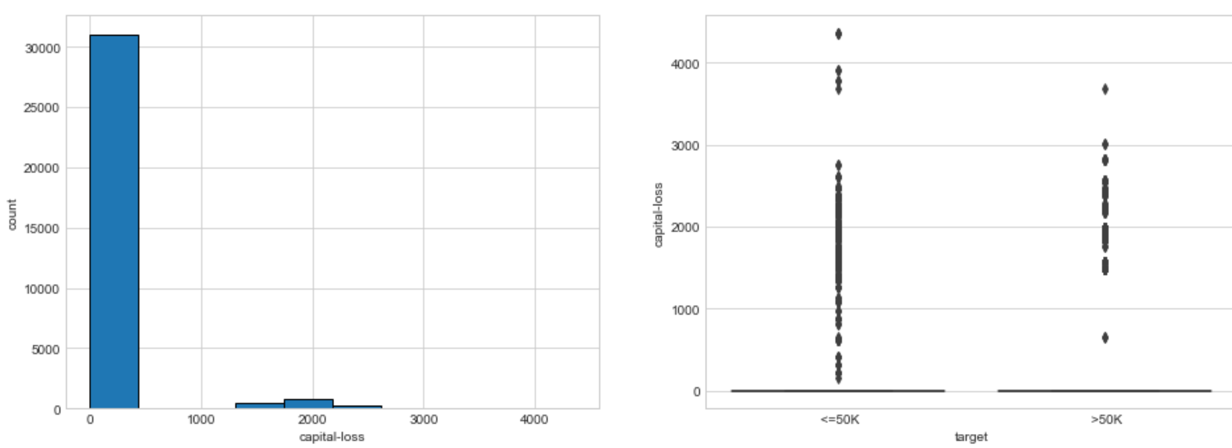

```
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df['capital-gain'], edgecolor="black")
ax[0].set_xlabel('capital-gain')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='capital-gain', data=df, ax=ax[1])
plt.show()
```

```
(2,)
```



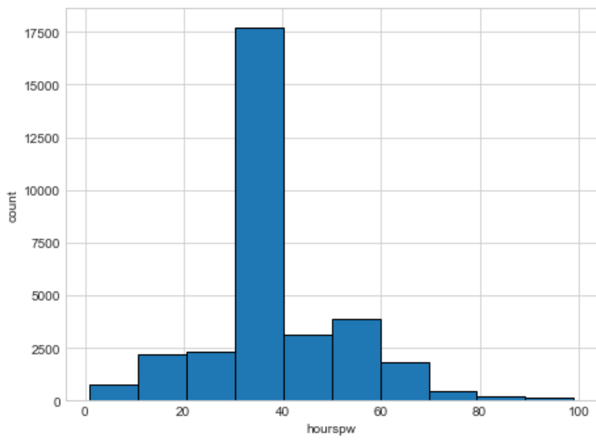

```
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df['capital-loss'], edgecolor="black")
ax[0].set_xlabel('capital-loss')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='capital-loss', data=df, ax=ax[1])
plt.show()
```

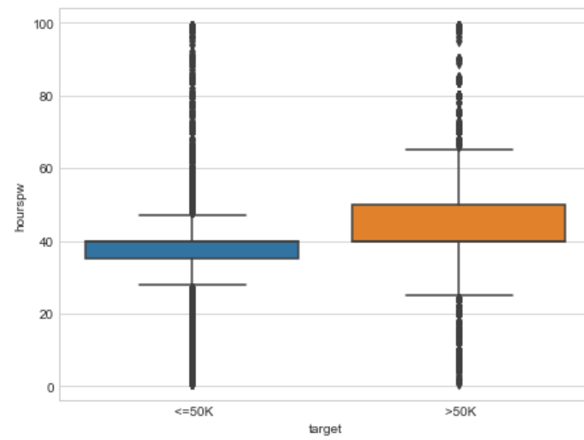
```
(2,)
```



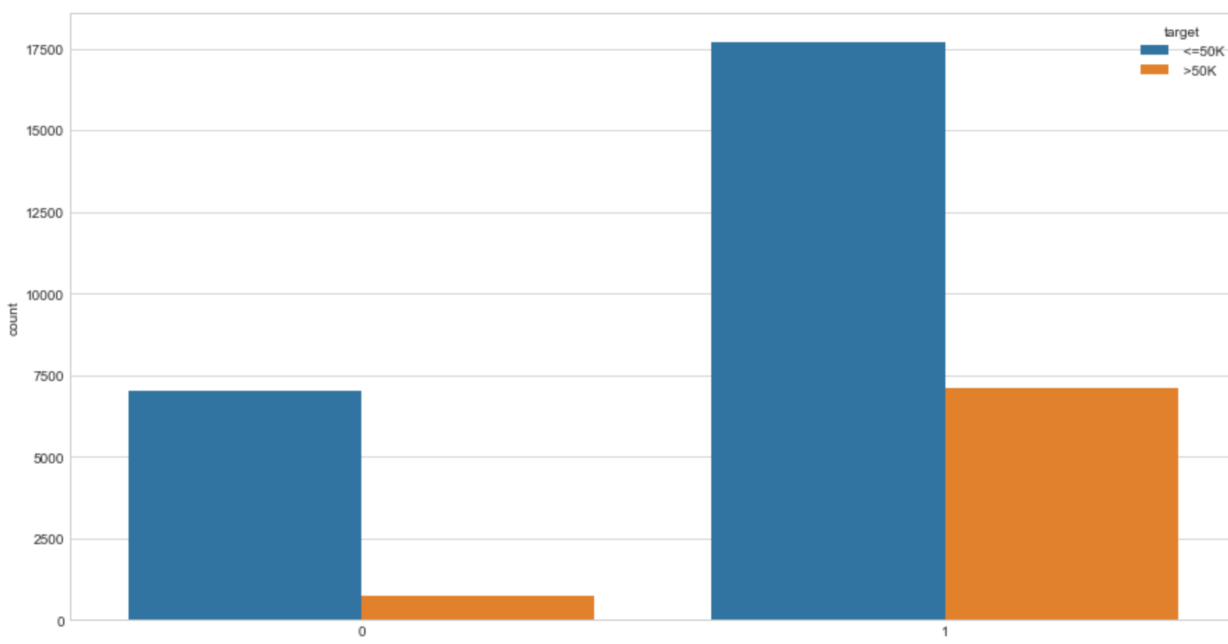

```
f,ax=plt.subplots(1,2,figsize=(16,5.5))
print(ax.shape)
ax[0].hist(df['hourspw'], edgecolor="black")
ax[0].set_xlabel('hourspw')
ax[0].set_ylabel('count')
sns.boxplot(x='target', y='hourspw', data=df, ax=ax[1])
plt.show()
```

```
(2,)
```






```
df['work_more'] = 0
df['work_more'][df['hourspw'] >= 40] = 1

C:\Users\hp\Anaconda3\lib\site-packages\ipykernel_launcher.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy


f,ax=plt.subplots(1,1,figsize=(15,8))
sns.countplot(x='work_more',data=df,hue='target', ax = ax)

<AxesSubplot:xlabel='work_more', ylabel='count'>
```



Handling Missing values

```
# print percentage of missing values in the categorical variables in
training set

df[categorical].isnull().mean()
```

```
Workclass        0.056386
education        0.000000
maritalstatus    0.000000
occupation       0.056601
relationship     0.000000
race             0.000000
sex              0.000000
nativecountry    0.017905
target           0.000000
dtype: float64
```

```
# imputing the missing values with the modes of each feature
df['Workclass'].fillna(df['Workclass'].mode()[0], inplace = True)
df['occupation'].fillna(df['occupation'].mode()[0], inplace = True)
df['nativecountry'].fillna(df['nativecountry'].mode()[0], inplace =
True)

# print percentage of missing values in the categorical variables in
training set

df[categorical].isnull().mean()
```

```
Workclass        0.0
education        0.0
maritalstatus    0.0
occupation       0.0
relationship     0.0
race             0.0
sex              0.0
nativecountry    0.0
target           0.0
dtype: float64
```

Updates

```
df.head()
```

```
   Age          Workclass  fnlwgt   education  education-num  \
0   39          State-gov   77516   Bachelors             13
1   50   Self-emp-not-inc   83311   Bachelors             13
2   38            Private  215646     HS-grad              9
3   53            Private  234721        11th              7
```

```
4   28             Private  338409   Bachelors             13

         maritalstatus          occupation    relationship    race
sex  \
0        Never-married        Adm-clerical   Not-in-family   White
Male
1   Married-civ-spouse     Exec-managerial         Husband   White
Male
2             Divorced   Handlers-cleaners   Not-in-family   White
Male
3   Married-civ-spouse   Handlers-cleaners         Husband   Black
Male
4   Married-civ-spouse      Prof-specialty            Wife   Black
Female

   capital-gain  capital-loss  hourspw   nativecountry  target
ischild  \
0          2174             0       40   United-States   <=50K
0
1             0             0       13   United-States   <=50K
0
2             0             0       40   United-States   <=50K
0
3             0             0       40   United-States   <=50K
0
4             0             0       40            Cuba   <=50K
0

   seniorcitizen  highly_edu  work_more
0              0           1          1
1              0           1          0
2              0           0          1
3              1           0          1
4              0           1          1

#data can be train or test
#var name is variable name: should be passed as strings within ('')
# bins is list of numeric values like [0,6,10,11]
# group names is list of groups you want to create in list form
def bin_var(data, var, bins, group_names):
    bin_value = bins
    group = group_names
    data[var+'Cat'] = pd.cut(df[var], bin_value, labels=group)

bin_var(df, 'education-num', [0,6,11,16], ['Low', 'Medium', 'High'])
```

Created a new variable grouping according to education numbers ar high, med or low

```
bin_var(df, 'hourspw', [0,35,40,60,100], ['Low', 'Medium',
'High','VeryHigh'])
```

Classifying the occupation into Highly Skilled and low Skilled

```
occu=pd.crosstab(df['occupation'],df['target'],
margins=True).reset_index()

occu
```

target	occupation	<=50K	>50K	All
0	Adm-clerical	3263	507	3770
1	Armed-Forces	8	1	9
2	Craft-repair	3170	929	4099
3	Exec-managerial	2098	1968	4066
4	Farming-fishing	879	115	994
5	Handlers-cleaners	1284	86	1370
6	Machine-op-inspct	1752	250	2002
7	Other-service	3158	137	3295
8	Priv-house-serv	148	1	149
9	Prof-specialty	3933	2050	5983
10	Protective-serv	438	211	649
11	Sales	2667	983	3650
12	Tech-support	645	283	928
13	Transport-moving	1277	320	1597
14	All	24720	7841	32561

```
#creating a function to categorize skill
import re
def occup(x):
    if re.search('managerial', x):
        return 'Highskill'
    elif re.search('specialty',x):
        return 'Highskill'
    else:
        return 'Lowskill'

# Creating the occupation category feature
df['Occupa_cat']=df.occupation.apply(lambda x: x.strip()).apply(lambda
x: occup(x))

df['Occupa_cat'].value_counts()
```

```
Lowskill     22512
Highskill    10049
Name: Occupa_cat, dtype: int64
```

Race has been binned into White and others

```
pd.crosstab(df['race'],df['target'], margins=True)
```

```
target                   <=50K   >50K    All
race
 Amer-Indian-Eskimo        275     36    311
 Asian-Pac-Islander        763    276   1039
 Black                    2737    387   3124
 Other                     246     25    271
 White                   20699   7117  27816
All                      24720   7841  32561
```

```
# Creating race category feature
df['Race_cat']=df['race'].apply(lambda x: x.strip())
df['Race_cat']=df['Race_cat'].apply(lambda x: 'White' if x=='White'
else 'Other')
```

Encoding the categorical variables

```
# find categorical variables

categorical = [var for var in df.columns if df[var].dtype=='O']
print(categorical)
```

```
['Workclass', 'education', 'maritalstatus', 'occupation',
'relationship', 'race', 'sex', 'nativecountry', 'target',
'Occupa_cat', 'Race_cat']
```

```
# Find numerical variables

numerical = [var for var in df.columns if df[var].dtype !='O']
print(numerical)
```

```
['Age', 'fnlwgt', 'education-num', 'capital-gain', 'capital-loss',
'hourspw', 'ischild', 'seniorcitizen', 'highly_edu', 'work_more',
'education-numCat', 'hourspwCat']
```

```
categorical
```

```
['Workclass',
 'education',
 'maritalstatus',
 'occupation',
 'relationship',
 'race',
 'sex',
 'nativecountry',
 'target',
 'Occupa_cat',
 'Race_cat']
```

```
df.head()
```

```
   Age          Workclass  fnlwgt   education  education-num  \
0   39          State-gov   77516   Bachelors             13
1   50   Self-emp-not-inc   83311   Bachelors             13
2   38            Private  215646     HS-grad              9
3   53            Private  234721        11th              7
4   28            Private  338409   Bachelors             13

         maritalstatus         occupation    relationship    race
sex  \
0        Never-married       Adm-clerical   Not-in-family   White
Male
1   Married-civ-spouse    Exec-managerial         Husband   White
Male
2             Divorced  Handlers-cleaners   Not-in-family   White
Male
3   Married-civ-spouse  Handlers-cleaners         Husband   Black
Male
4   Married-civ-spouse     Prof-specialty            Wife   Black
Female

   ...   nativecountry  target  ischild seniorcitizen highly_edu
work_more  \
0  ...   United-States   <=50K        0             0          1
1
1  ...   United-States   <=50K        0             0          1
0
2  ...   United-States   <=50K        0             0          0
1
3  ...   United-States   <=50K        0             1          0
1
4  ...            Cuba   <=50K        0             0          1
1

   education-numCat  hourspwCat  Occupa_cat Race_cat
0              High      Medium    Lowskill    White
1              High         Low   Highskill    White
2            Medium      Medium    Lowskill    White
3            Medium      Medium    Lowskill    Other
4              High      Medium   Highskill    Other

[5 rows x 23 columns]

# import category encoders

import category_encoders as ce
# encode remaining variables with one-hot encoding

encoder = ce.OneHotEncoder(cols=['Workclass',
 'education',
 'maritalstatus',
```

```
 'occupation',
 'relationship',
 'race',
 'sex',
 'nativecountry',
 'Occupa_cat',
 'Race_cat', 'education-numCat', "hourspwCat"])

df = encoder.fit_transform(df)
```

Feature Selection Using Variance Threshold

Variance Threshold is a univariate approach to feature selection. It removes all features whose variance doesn't meet some threshold. By default, it removes all zero-variance features, i.e. features that have the same value in all samples. As an example, suppose that we have a dataset with boolean features, and we want to remove all features that are either one or zero (on or off) in more than 80% of the samples. Boolean features are Bernoulli random variables, and the variance of such variables is given by The below approach removes variable which have more than 80% values are either 0 or 1

```
df.columns

Index(['Age', 'Workclass_1', 'Workclass_2', 'Workclass_3',
'Workclass_4',
       'Workclass_5', 'Workclass_6', 'Workclass_7', 'Workclass_8',
'fnlwgt',
       ...
       'education-numCat_2', 'education-numCat_3', 'hourspwCat_1',
       'hourspwCat_2', 'hourspwCat_3', 'hourspwCat_4', 'Occupa_cat_1',
       'Occupa_cat_2', 'Race_cat_1', 'Race_cat_2'],
      dtype='object', length=121)

# Using Variance Threshold for feature selection
from sklearn.feature_selection import VarianceThreshold
def variance_threshold_select(df, thresh=0.0, na_replacement=-999):
    df1 = df.copy(deep=True) # Make a deep copy of the dataframe
    selector = VarianceThreshold(thresh) # passing Threshold
    selector.fit(df1) # Fill NA values as VarianceThreshold cannot
deal with those
    df2 = df.loc[:,selector.get_support(indices=False)] # Get new
dataframe with columns deleted that have NA values
    return df2

# Setting a 80 percent threshold
df2=variance_threshold_select(df.drop('target', axis=1), thresh=.8* (1
- .8))

print(df2.columns)
```

```
Index(['Age', 'Workclass_3', 'fnlwgt', 'education_2', 'education_6',
       'education-num', 'maritalstatus_1', 'maritalstatus_2',
'relationship_1',
       'relationship_2', 'sex_1', 'sex_2', 'capital-gain', 'capital-
loss',
       'hourspw', 'highly_edu', 'work_more', 'education-numCat_2',
       'education-numCat_3', 'hourspwCat_1', 'hourspwCat_2',
'hourspwCat_3',
       'Occupa_cat_1', 'Occupa_cat_2'],
      dtype='object')
```

```
# Checking the final length of the selected features
len(df2.columns)
```

```
24
```

Modelling the Naive Bayes Classifier

```
df.head()
```

```
   Age  Workclass_1  Workclass_2  Workclass_3  Workclass_4
Workclass_5  \
0   39            1            0            0            0
0
1   50            0            1            0            0
0
2   38            0            0            1            0
0
3   53            0            0            1            0
0
4   28            0            0            1            0
0

   Workclass_6  Workclass_7  Workclass_8  fnlwgt  ...  education-
numCat_2  \
0            0            0            0   77516  ...
0
1            0            0            0   83311  ...
0
2            0            0            0  215646  ...
1
3            0            0            0  234721  ...
1
4            0            0            0  338409  ...
0

   education-numCat_3  hourspwCat_1  hourspwCat_2  hourspwCat_3
hourspwCat_4  \
0                   1             0             1             0
0
```

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

   Occupa_cat_1  Occupa_cat_2  Race_cat_1  Race_cat_2
0             1             0           1           0
1             0             1           1           0
2             1             0           1           0
3             1             0           0           1
4             0             1           0           1

[5 rows x 121 columns]
```

```python
# importing Gaussian Naive Bayes, Accuracy score and train test split
from sklearn
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score
from sklearn.model_selection import train_test_split

model = GaussianNB()

# Splitting data into test train, using a 0.3 split
X = df2
y = df['target']

X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)

# check the shape of X_train and X_test
X_train.shape, X_test.shape
```

```
((22792, 24), (9769, 24))
```

```python
# Scaling the training and test feature values
from sklearn.preprocessing import RobustScaler

scaler = RobustScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)

# Using Random Search method to find the best hyperparameters
from sklearn.model_selection import RandomizedSearchCV
gnb = GaussianNB()
param_grid = {
    'var_smoothing': np.logspace(0,-9, num=100)
}
```

```
CV_rfc = RandomizedSearchCV(estimator=gnb,
param_distributions=param_grid, cv= 5,random_state=1)
CV_rfc.fit(X_train, y_train)
print(CV_rfc.best_params_)
```

```
{'var_smoothing': 3.5111917342151273e-09}
```

```
#Defining the model with tuned hyperparameters
model = GaussianNB(var_smoothing=CV_rfc.best_params_['var_smoothing'])
```

```
# Fitting the model on to the train set
model.fit(X_train,y_train)
```

```
GaussianNB(var_smoothing=3.5111917342151273e-09)
```

```
predict_train = model.predict(X_train)
```

```
# Accuracy Score on train dataset
accuracy_train = accuracy_score(y_train,predict_train)
print('accuracy_score on train dataset : ', accuracy_train)
```

```
predict_test = model.predict(X_test)
```

```
# Accuracy Score on test dataset
accuracy_test = accuracy_score(y_test,predict_test)
print('accuracy_score on test dataset : ', accuracy_test)
```

```
accuracy_score on train dataset :  0.8292383292383292
accuracy_score on test dataset :  0.8334527587265841
```

We see that the accuracy values for test and train are close, and thus no overfitting!

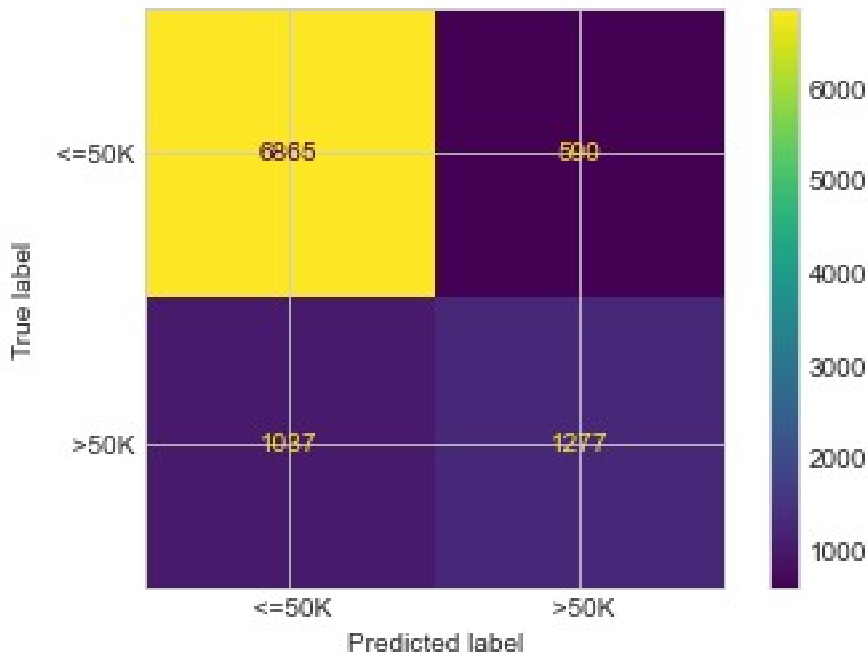
Confusion Matrix

```
# Print the Confusion Matrix and slice it into four pieces

from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

cm = confusion_matrix(y_test, predict_test)
print(cm)

plot_confusion_matrix(model, X_test, y_test)
```

```
[[6865  590]
 [1037 1277]]
```

```
C:\Users\hp\Anaconda3\lib\site-packages\sklearn\utils\
deprecation.py:87: FutureWarning: Function plot_confusion_matrix is
deprecated; Function `plot_confusion_matrix` is deprecated in 1.0 and
will be removed in 1.2. Use one of the class methods:
ConfusionMatrixDisplay.from_predictions or
```

```
ConfusionMatrixDisplay.from_estimator.
  warnings.warn(msg, category=FutureWarning)

<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
0x1e59e344948>
```




```
print('\nTrue Positives(TP) = ', cm[0,0])

print('\nTrue Negatives(TN) = ', cm[1,1])

print('\nFalse Positives(FP) = ', cm[0,1])

print('\nFalse Negatives(FN) = ', cm[1,0])


True Positives(TP) =  6865

True Negatives(TN) =  1277

False Positives(FP) =  590

False Negatives(FN) =  1037
```

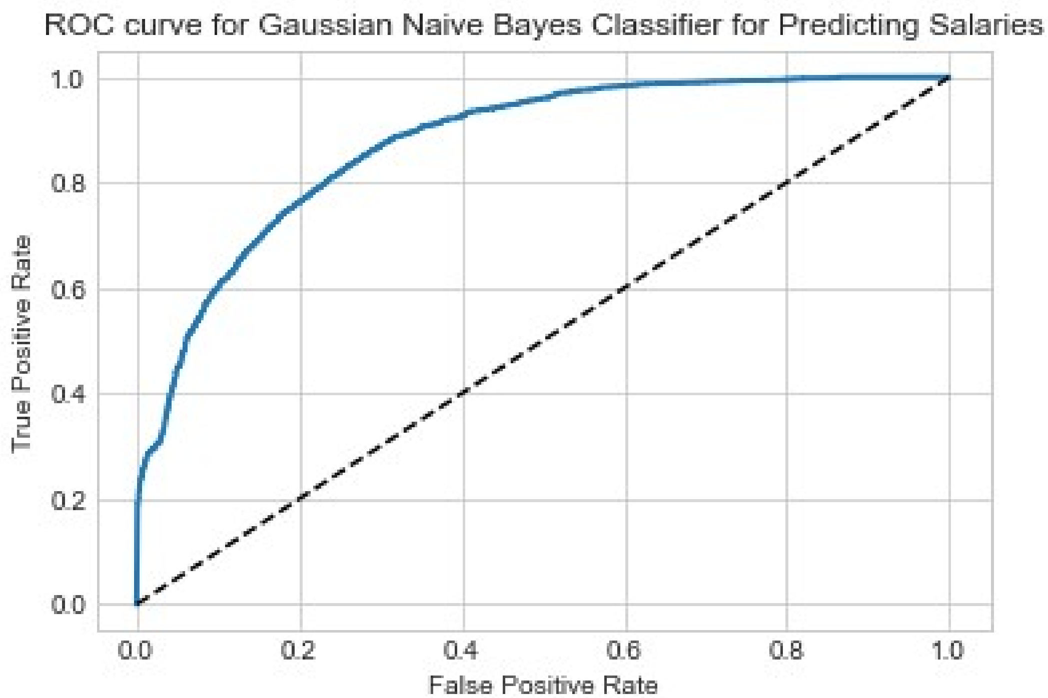
Classification Report

```
#Prinitng the classification report using the sklearn metrics library
from sklearn.metrics import classification_report

print(classification_report(y_test, predict_test))
```

```
              precision    recall  f1-score   support

       <=50K       0.87      0.92      0.89      7455
        >50K       0.68      0.55      0.61      2314

    accuracy                           0.83      9769
   macro avg       0.78      0.74      0.75      9769
weighted avg       0.82      0.83      0.83      9769
```

ROC - AUC

```
#Getting predicted probabilities
pred_proba = model.predict_proba(X_test)[:, 1]

# plot ROC Curve

from sklearn.metrics import roc_curve

fpr, tpr, thresholds = roc_curve(y_test, pred_proba, pos_label = '
>50K')

plt.figure(figsize=(6,4))

plt.plot(fpr, tpr, linewidth=2)

plt.plot([0,1], [0,1], 'k--' )

plt.title('ROC curve for Gaussian Naive Bayes Classifier for
Predicting Salaries')

plt.xlabel('False Positive Rate')

plt.ylabel('True Positive Rate')

plt.show()
```




```
# compute ROC AUC

from sklearn.metrics import roc_auc_score

ROC_AUC = roc_auc_score(y_test, pred_proba)

print('ROC AUC : {:.4f}'.format(ROC_AUC))

ROC AUC : 0.8733
```

As our ROC AUC value is close to 1, we can say that our classifer model is working well !

k-Fold Cross Validation

```
# Applying 10-Fold Cross Validation

from sklearn.model_selection import cross_val_score

scores = cross_val_score(model, X_train, y_train, cv = 10,
scoring='accuracy')

print('Cross-validation scores:{}'.format(scores))

print('Cross-validation mean accuracy:{}'.format(scores.mean()))

Cross-validation scores:[0.82807018 0.82675439 0.83369899 0.8174638
0.82974989 0.8372093
 0.82448442 0.825362   0.82229048 0.84422993]
Cross-validation mean accuracy:0.8289313372285475
```

We see that the mean accuracy is close to the original one, and also there is not much deviation from the average for all the folds, thus we can say our model is not much reliant on the data on which it is being trained.

Using different threshold values

```
#Transforming the test set in 0 and 1
y_testing = np.zeros(y_test.shape)
y_testing[y_test == ' >50K'] = 1

#Computing accuracy for different thresholds and finding the best one.
from sklearn.metrics import accuracy_score, f1_score

thresholds = np.arange(0, 100)/100
best_thres = 0
best_score = 0
for thresh in thresholds:
    oofs_rounded = (pred_proba > thresh) * 1
    thresh_score = accuracy_score(y_testing, oofs_rounded)
    if thresh_score > best_score:
        best_score = thresh_score
        best_thres = thresh
print(f'Threshold {best_thres}: {best_score}')
```

```
Threshold 0.74: 0.8361142389190296
```

Thus using 0.8 as thershold and predicting salary to be >50K for probability greater than 0.8 gives us the best accuracy score of 0.835

As you can see below the number of columns have been reduced to 24 because of the the variance threshold. The removed columns have the same value in 80% of the observations

```python
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns

# Reading the data
df = pd.read_csv('car_evaluation.csv', names=['buying', 'maint',
'doors', 'persons', 'lug_boot', 'safety', 'target'])

# Visualizing the dataframe
df.head()
```

```
  buying  maint doors persons lug_boot safety target
0  vhigh  vhigh     2       2    small    low  unacc
1  vhigh  vhigh     2       2    small    med  unacc
2  vhigh  vhigh     2       2    small   high  unacc
3  vhigh  vhigh     2       2      med    low  unacc
4  vhigh  vhigh     2       2      med    med  unacc
```

```python
# Checking the shape of the data
df.shape
```

```
(1728, 7)
```

```python
#Checking for null values and data types
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1728 entries, 0 to 1727
Data columns (total 7 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   buying    1728 non-null   object
 1   maint     1728 non-null   object
 2   doors     1728 non-null   object
 3   persons   1728 non-null   object
 4   lug_boot  1728 non-null   object
 5   safety    1728 non-null   object
 6   target    1728 non-null   object
dtypes: object(7)
memory usage: 94.6+ KB
```

```python
# Null alues
df.isnull().sum()
```

```
buying      0
maint       0
```

```
doors       0
persons     0
lug_boot    0
safety      0
target      0
dtype: int64
```

We do not have any null values!

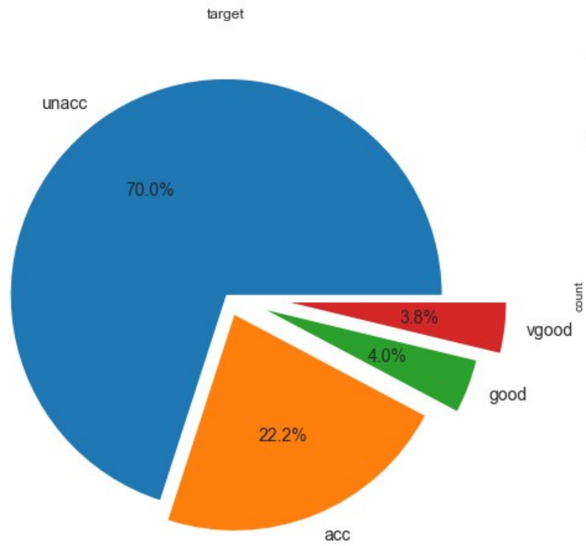
```
#description
df.describe().transpose()
```

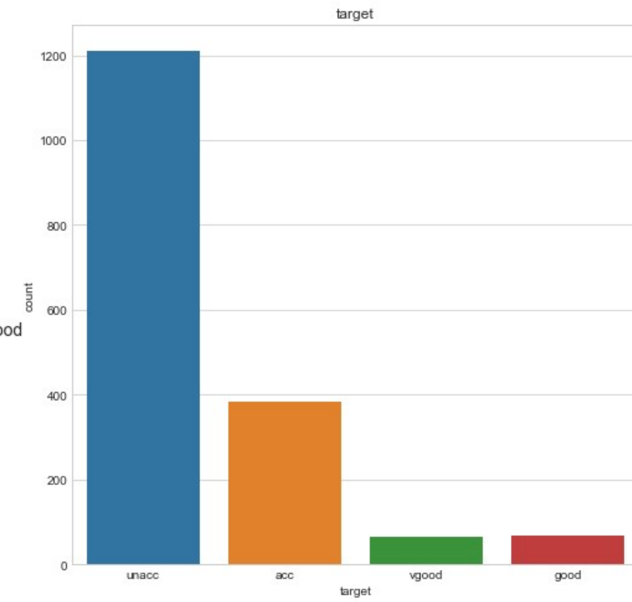
```
         count unique    top  freq
buying    1728      4  vhigh   432
maint     1728      4  vhigh   432
doors     1728      4      2   432
persons   1728      3      2   576
lug_boot  1728      3  small   576
safety    1728      3    low   576
target    1728      4  unacc  1210
```

```
#Plotting target distribution
f,ax=plt.subplots(1,2,figsize=(18,8))
df['target'].value_counts().plot.pie(ax = ax[0], explode=[0,0.1, 0.2,
0.3],autopct='%1.1f%%',shadow=False, textprops={'fontsize': 14})
ax[0].set_title('target')
ax[0].set_ylabel('')
sns.countplot('target',data=df,ax=ax[1])
ax[1].set_title('target')
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
```

```
Text(0.5, 1.0, 'target')
```





Pre-processing

```
#Checking the Columns or features
df.columns
```

```
Index(['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety',
'target'], dtype='object')
```

```
# find categorical variables

categorical = [var for var in df.columns if df[var].dtype=='O']
print(categorical)
```

```
['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety',
'target']
```

```
# Find numerical variables

numerical = [var for var in df.columns if df[var].dtype !='O']
print(numerical)
```

```
[]
```

```
# Printing all the unique classes in the features.
for col in categorical:
    print(df[col].value_counts())
```

```
vhigh    432
high     432
med      432
low      432
```

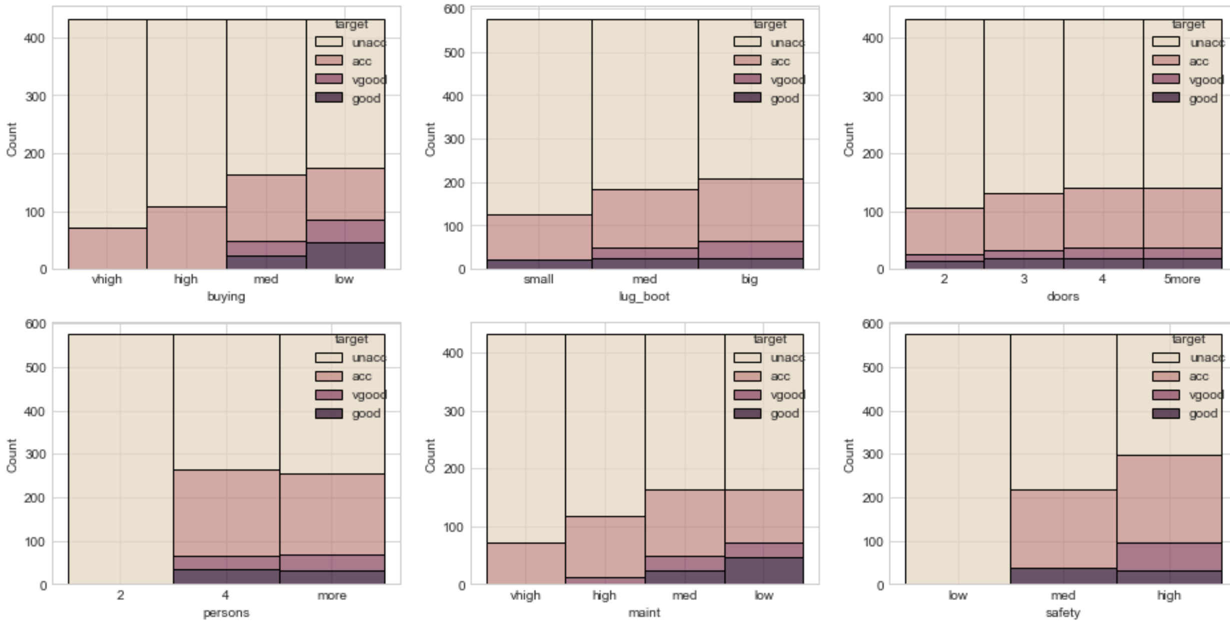
```
Name: buying, dtype: int64
vhigh     432
high      432
med       432
low       432
Name: maint, dtype: int64
2         432
3         432
4         432
5more     432
Name: doors, dtype: int64
2        576
4        576
more     576
Name: persons, dtype: int64
small     576
med       576
big       576
Name: lug_boot, dtype: int64
low      576
med      576
high     576
Name: safety, dtype: int64
unacc     1210
acc        384
good        69
vgood       65
Name: target, dtype: int64
```

EDA

```
# Creating pairwise list
cols = df.drop('target', axis = 1).columns
paircols = []
for i in range(len(cols)-1):
    for j in range(i+1, len(cols)):
        paircols.append([cols[i], cols[j]])
```

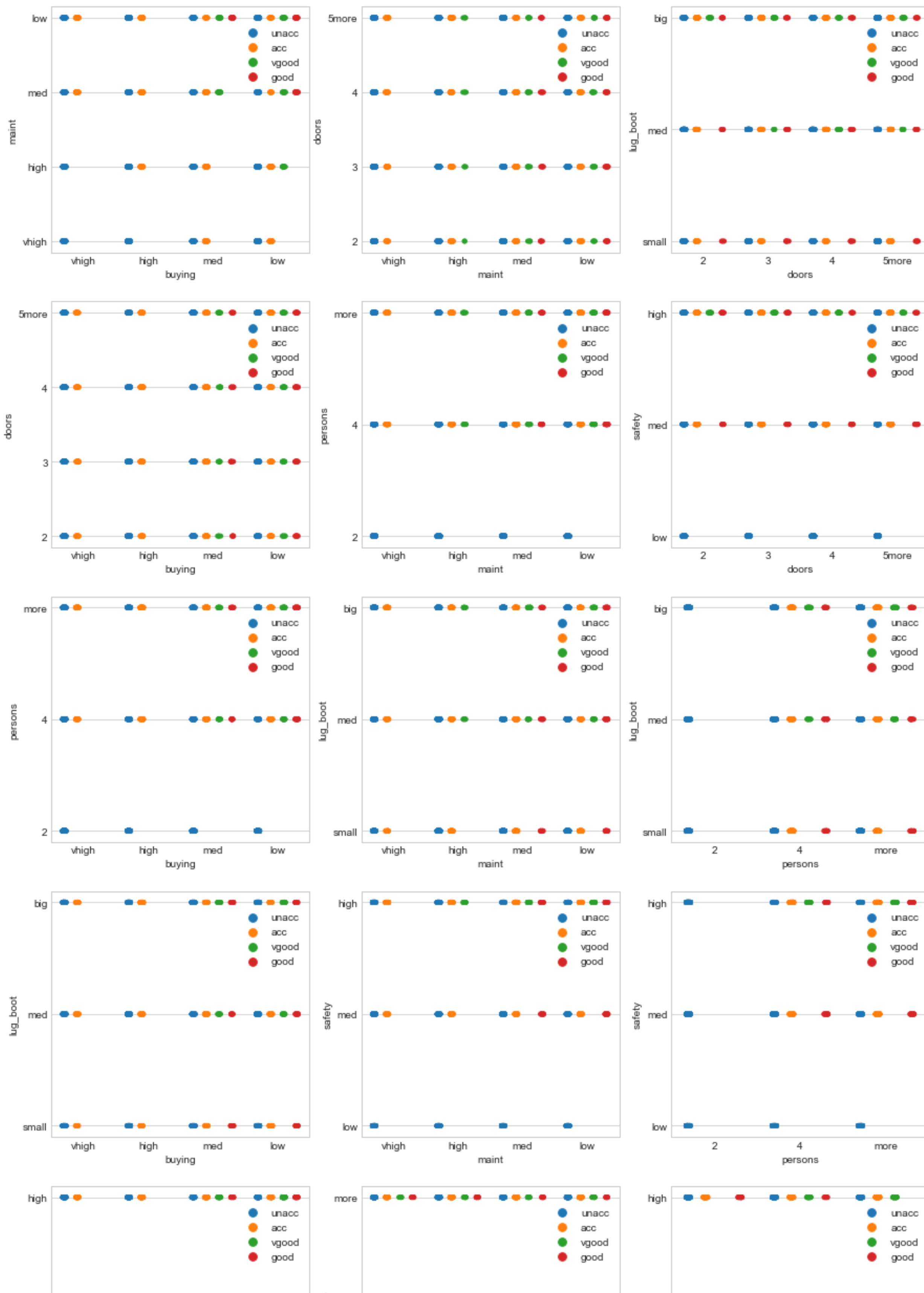
Univariate Analysis

```
# Histplots for each feature
f,ax=plt.subplots(2,3,figsize=(16,8))
for i, col in enumerate(cols):
    sns.histplot(binwidth=0.5, x=col, hue="target", data=df,
stat="count", multiple="stack", palette="ch:0.25", ax=ax[i%2, i%3])
```



Multivariate analysis

```python
# Stripplot for each feature
f,ax=plt.subplots(5,3,figsize=(15,25))
j = -1
for i, col in enumerate(paircols):
    if i%5 == 0: j = j+1
    sns.stripplot(x =col[0], y =col[1], data = df,jitter = True, hue
='target', dodge = True, ax=ax[i%5, j],)
    ax[i%5, j].legend(bbox_to_anchor=(0.7, 0.95), loc=2)
```



maint
buying
doors
lug_boot
persons
safety
unacc
acc
vgood
good
low
med
high
vhigh
5more
4
3
2
more
big
small

Modelling the Decision Tree models

As the dataset has categorical features and hence they needs to be encoded in the appropriate form. There are two main method of encodig:

1. One hot encoding
2. Label encoding

As we have categorial features that are ordinal in nature i.e that can be ranked (ordered) hence label encoding will solve our purpose.Had there been nominal features we could have preferred one hot encoding.

```
# Getting X and y
X = df.drop('target', axis = 1)
y = df['target']

# importing necessary package for encoding our categorial features
import category_encoders as ce

encoder = ce.OrdinalEncoder(cols=cols)
x= encoder.fit_transform(X)

x.head()
```

	buying	maint	doors	persons	lug_boot	safety
0	1	1	1	1	1	1
1	1	1	1	1	1	2
2	1	1	1	1	1	3
3	1	1	1	1	2	1
4	1	1	1	1	2	2

```
# importing necessary packages
from sklearn.metrics import
accuracy_score,confusion_matrix,classification_report
from sklearn.tree import DecisionTreeClassifier
import scikitplot.metrics as skplt
from sklearn import tree
from sklearn.model_selection import train_test_split

# Splitting data into test train, using a 0.3 split
X_train, X_test, y_train, y_test = train_test_split(x, y,
test_size=0.3, random_state=42)

# Exploring class distribution under train ,crossvalidation dataset
print('Training Dataset',X_train.shape,y_train.shape)
print('\n Class label distribution in Training Set\
n',y_train.value_counts())
print('\n**********')
print("\n CrossValidation Dataset",X_test.shape,y_test.shape)
print('\nClass label distribution in Cross Validation Set\
```

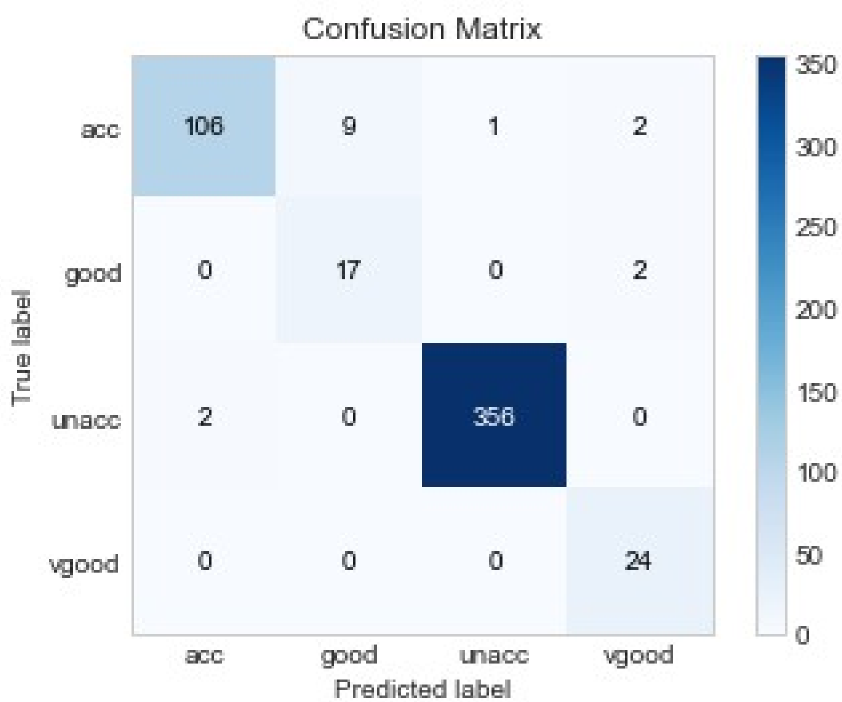
```
n',y_test.value_counts())
print('\n***********')
```

```
Training Dataset (1209, 6) (1209,)

 Class label distribution in Training Set
 unacc    852
acc      266
good      50
vgood     41
Name: target, dtype: int64

***********

 CrossValidation Dataset (519, 6) (519,)

Class label distribution in Cross Validation Set
 unacc    358
acc      118
vgood     24
good      19
Name: target, dtype: int64

***********
```

```
# Using Grid search to find the best decision tree classifier with the
given set of parameters.
from sklearn.model_selection import GridSearchCV

parameters={'max_depth': list(range(1,10)),
            'min_samples_leaf' : list(range(2,10,1)),
            'min_samples_split': list(range(5,10,10)),
            }
model=GridSearchCV(DecisionTreeClassifier(class_weight='balanced'),par
ameters,n_jobs=-1,cv=10,scoring='accuracy', )
model.fit(X_train,y_train)
print('The best model is ', model.best_estimator_)
print("\n The best model parameters are ",model.best_params_)
print("\n The model accuracy on train set
is",model.score(X_train,y_train))
print("\n The model accuracy on test set
is",model.score(X_test,y_test))

y_predict=model.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  DecisionTreeClassifier(class_weight='balanced',
max_depth=9, min_samples_leaf=2,
```

```
                       min_samples_split=5)

 The best model parameters are  {'max_depth': 9, 'min_samples_leaf': 2, 'min_samples_split': 5}

 The model accuracy on train set is 0.9834574028122415

 The model accuracy on test set is 0.9691714836223507


 Classification Report
              precision    recall  f1-score   support

         acc       0.98      0.90      0.94       118
        good       0.65      0.89      0.76        19
       unacc       1.00      0.99      1.00       358
       vgood       0.86      1.00      0.92        24

    accuracy                           0.97       519
   macro avg       0.87      0.95      0.90       519
weighted avg       0.97      0.97      0.97       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted label', ylabel='True label'>
```




```python
# Visualising Decision Tree
clf =
```

```
tree.DecisionTreeClassifier(class_weight='balanced',max_depth=9,min_sa
mples_leaf=2,min_samples_split=5)
clf.fit(X_train, y_train)
trgt=[' acc','unacc ','good',' vgood']

fig, axes = plt.subplots(nrows = 1,ncols = 1,figsize = (20,20),
dpi=300)
tree.plot_tree(clf,feature_names = cols, class_names=trgt,filled =
True, fontsize=25);
```

```
# Visualize the trained Decision Tree by export_graphviz() method

from sklearn.tree import export_graphviz
from sklearn import tree
from IPython.display import SVG
```

```python
from graphviz import Source
from IPython.display import display

graph = Source(tree.export_graphviz(clf ,feature_names = cols,
class_names = trgt, max_depth = 9, filled = True, ))
display(SVG(graph.pipe(format='svg')))
```

Random Forest Classifier

```python
# Importing and defining the random search feature space.
from sklearn.ensemble import RandomForestClassifier

from sklearn.model_selection import RandomizedSearchCV

# Number of trees in random forest
n_estimators = [int(x) for x in range(200,2000,200)]
# Number of features to consider at every split
max_features = ['auto', 'sqrt']
# Maximum number of levels in tree
max_depth = [int(x) for x in np.linspace(2, 30, num = 1)]
max_depth.append(None)
# Minimum number of samples required to split a node
min_samples_split = [ 2,3, 4, 5, 7,10]
# Minimum number of samples required at each leaf node
min_samples_leaf = [1, 2, 4, 5]
# Method of selecting samples for training each tree
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
print(random_grid)
```

```
{'n_estimators': [200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800],
'max_features': ['auto', 'sqrt'], 'max_depth': [2, None],
'min_samples_split': [2, 3, 4, 5, 7, 10], 'min_samples_leaf': [1, 2,
4, 5], 'bootstrap': [True, False]}
```

```python
# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestClassifier()
```

```
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available
cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions =
random_grid, n_iter = 100, cv = 3, verbose=2, random_state=42, n_jobs
= -1)
# Fit the random search model
rf_random.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
```

```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(),
n_iter=100,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [2, None],
                                        'max_features': ['auto',
'sqrt'],
                                        'min_samples_leaf': [1, 2, 4,
5],
                                        'min_samples_split': [2, 3, 4,
5, 7,
                                                              10],
                                        'n_estimators': [200, 400,
600, 800,
                                                         1000, 1200,
1400, 1600,
                                                         1800]},
                   random_state=42, verbose=2)
```

```
# Printing the best hyperparameters

rf_random.best_params_
```

```
{'n_estimators': 800,
 'min_samples_split': 3,
 'min_samples_leaf': 1,
 'max_features': 'auto',
 'max_depth': None,
 'bootstrap': False}
```

```
# Checking accuracies on the train and test data, predicting on the
test data.

print('The best model is ', rf_random.best_estimator_)
print("\n The best model parameters are ",rf_random.best_params_)
print("\n The model accuracy on train set
is",rf_random.score(X_train,y_train))
print("\n The model accuracy on test set
is",rf_random.score(X_test,y_test))
```

```
y_predict=rf_random.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  RandomForestClassifier(bootstrap=False,
min_samples_split=3, n_estimators=800)

 The best model parameters are  {'n_estimators': 800,
'min_samples_split': 3, 'min_samples_leaf': 1, 'max_features': 'auto',
'max_depth': None, 'bootstrap': False}

 The model accuracy on train set is 1.0

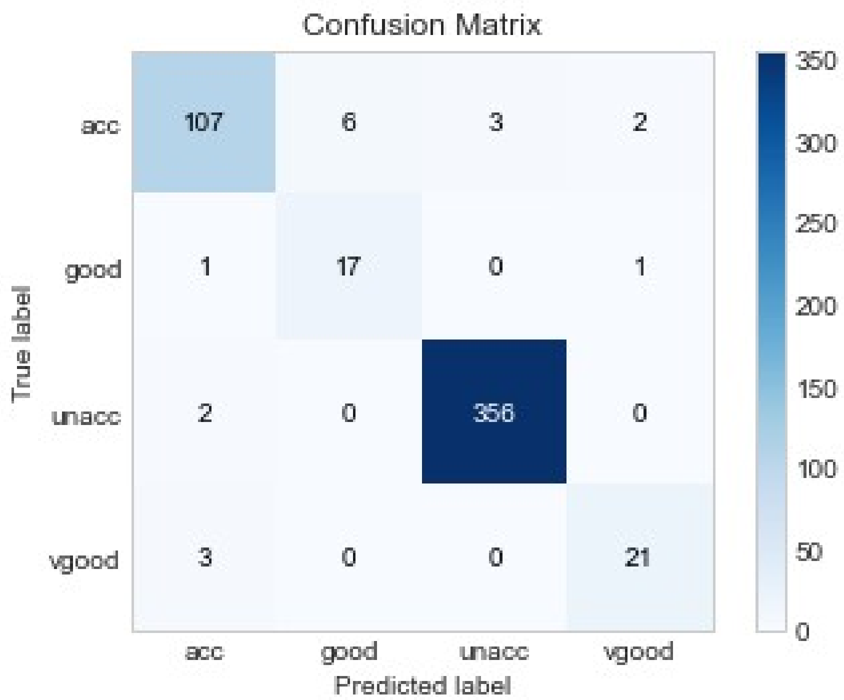
 The model accuracy on test set is 0.9653179190751445


 Classification Report
              precision    recall  f1-score   support

         acc       0.95      0.91      0.93       118
        good       0.74      0.89      0.81        19
       unacc       0.99      0.99      0.99       358
       vgood       0.88      0.88      0.88        24

    accuracy                           0.97       519
   macro avg       0.89      0.92      0.90       519
weighted avg       0.97      0.97      0.97       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```




```
# Defining the model with the best parameters
clf = RandomForestClassifier(bootstrap=True, max_depth=None,
max_features='auto', min_samples_leaf=1, min_samples_split=3,
n_estimators = 1000)
clf.fit(X_train, y_train)

RandomForestClassifier(min_samples_split=3, n_estimators=1000)

print("\n The model accuracy on train set
is",clf.score(X_train,y_train))
print("\n The model accuracy on test set is",clf.score(X_test,y_test))

y_predict=clf.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)


 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9653179190751445

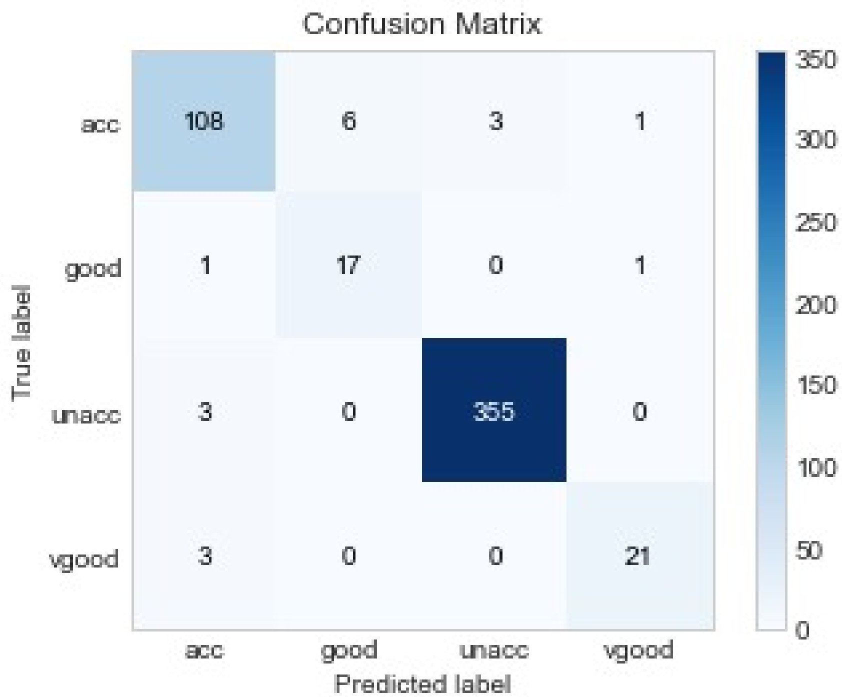

 Classification Report
              precision    recall  f1-score   support

         acc       0.94      0.92      0.93       118
        good       0.74      0.89      0.81        19
```

```
       unacc       0.99      0.99      0.99       358
       vgood       0.91      0.88      0.89        24

    accuracy                           0.97       519
   macro avg       0.90      0.92      0.91       519
weighted avg       0.97      0.97      0.97       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```




```
# view the feature scores

feature_scores = pd.Series(clf.feature_importances_,
index=X_train.columns).sort_values(ascending=False)

feature_scores

safety      0.303113
persons     0.244645
maint       0.155830
buying      0.150934
lug_boot    0.086554
doors       0.058924
dtype: float64

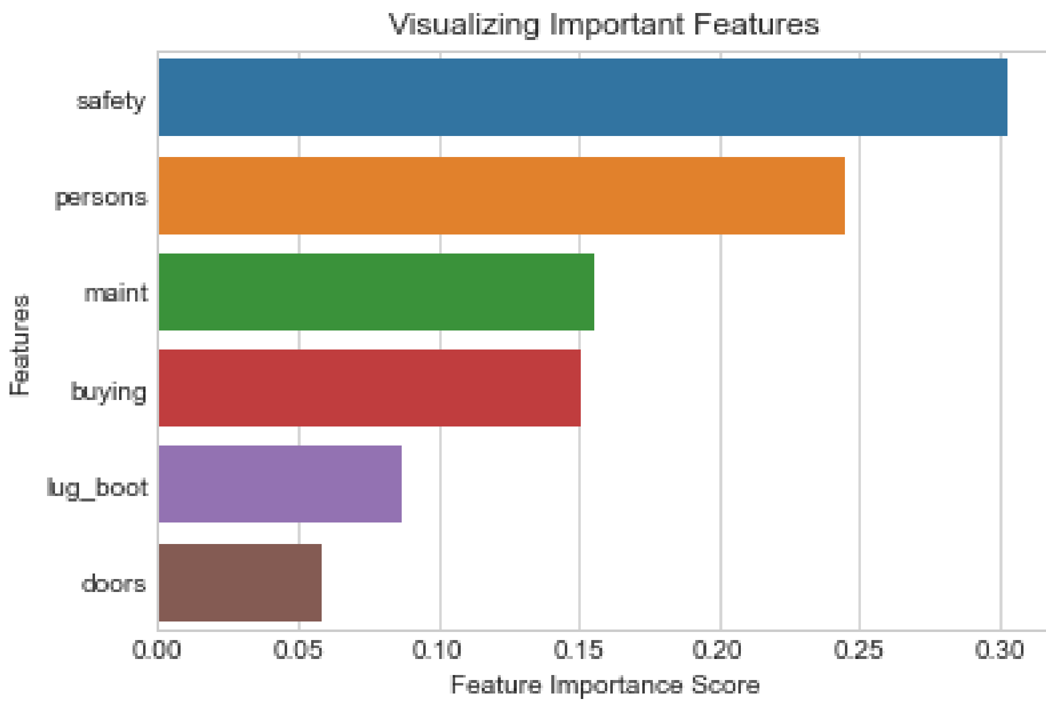
# Creating a seaborn bar plot
```

```
sns.barplot(x=feature_scores, y=feature_scores.index)
# Add labels to the graph

plt.xlabel('Feature Importance Score')
plt.ylabel('Features')

# Add title to the graph
plt.title("Visualizing Important Features")

# Visualize the graph
plt.show()
```



Building a model on selected features without the least important feature

```
# declare feature vector and target variable, without the least
important feature

X1 = df.drop(['target', 'doors'], axis=1)

y1 = df['target']

# split data into training and testing sets

from sklearn.model_selection import train_test_split

X_train1, X_test1, y_train1, y_test1 = train_test_split(X1, y1,
test_size = 0.33, random_state = 42)
```

```
# encode categorical variables with ordinal encoding

encoder = ce.OrdinalEncoder(cols=['buying', 'maint', 'persons',
'lug_boot', 'safety'])


X_train1 = encoder.fit_transform(X_train1)

X_test1 = encoder.transform(X_test1)

# modelling without the least important feature
clf = RandomForestClassifier(bootstrap=True, max_depth=None,
max_features='auto', min_samples_leaf=1, min_samples_split=3,
n_estimators = 1000)
clf.fit(X_train1, y_train1)
```

```
RandomForestClassifier(min_samples_split=3, n_estimators=1000)
```

```
print("\n The model accuracy on train set
is",clf.score(X_train1,y_train1))
print("\n The model accuracy on test set
is",clf.score(X_test1,y_test1))

y_predict1=clf.predict(X_test1)
accuracy=accuracy_score(y_test1,y_predict1,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test1,y_predict1))
skplt.plot_confusion_matrix(y_test1,y_predict1)
```

```
 The model accuracy on train set is 0.9688850475367329

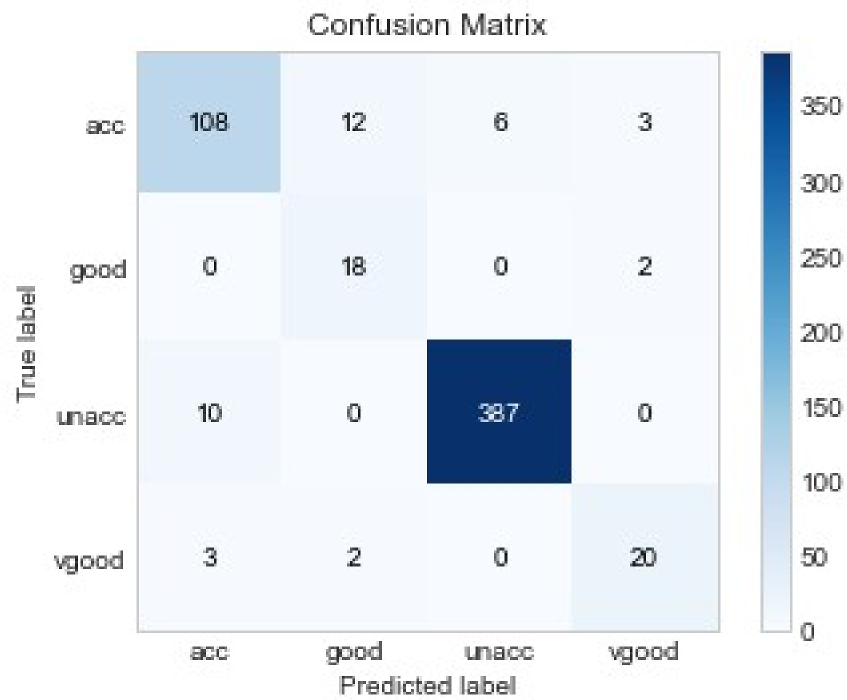
 The model accuracy on test set is 0.9334500875656743


 Classification Report
              precision    recall  f1-score   support

         acc       0.89      0.84      0.86       129
        good       0.56      0.90      0.69        20
       unacc       0.98      0.97      0.98       397
       vgood       0.80      0.80      0.80        25

    accuracy                           0.93       571
   macro avg       0.81      0.88      0.83       571
weighted avg       0.94      0.93      0.94       571
```

```
<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Xgboost

```
# import machine learning libraries
import xgboost as xgb

# import packages for hyperparameters tuning
from hyperopt import STATUS_OK, Trials, fmin, hp, tpe

# Defining the feature space for search
space={'max_depth': hp.quniform("max_depth", 3, 18, 1),
        'gamma': hp.uniform ('gamma', 1,9),
        'reg_alpha' : hp.quniform('reg_alpha', 40,180,1),
        'reg_lambda' : hp.uniform('reg_lambda', 0,1),
        'colsample_bytree' : hp.uniform('colsample_bytree', 0.5,1),
        'min_child_weight' : hp.quniform('min_child_weight', 0, 10,
1),
        'n_estimators': 180,
        'seed': 42
    }

# Deifning the objective function to minimize as this is required by
hyperopt library
def objective(space):
    clf=xgb.XGBClassifier(
                    n_estimators =space['n_estimators'], max_depth =
int(space['max_depth']), gamma = space['gamma'],
                    reg_alpha =
int(space['reg_alpha']),min_child_weight=int(space['min_child_weight']
```

```
),
                    colsample_bytree=int(space['colsample_bytree']))

    evaluation = [( X_train, y_train), ( X_test, y_test)]

    clf.fit(X_train, y_train,
            eval_set=evaluation, eval_metric = 'merror',
            early_stopping_rounds=10,verbose=2)


    pred = clf.predict(X_test)
    accuracy = accuracy_score(y_test, pred)
    print ("SCORE:", accuracy)
    return {'loss': -accuracy, 'status': STATUS_OK }

# Getting the optimum
trials = Trials()

best_hyperparams = fmin(fn = objective,
                        space = space,
                        algo = tpe.suggest,
                        max_evals = 100,
                        trials = trials)
```

```
   0%|
| 0/100 [00:00<?, ?trial/s, best loss=?]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
SCORE:
0.6897880539499036
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
  2%|█                                              | 2/100
[00:00<00:35,  2.76trial/s, best loss: -0.6897880539499036]
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021
SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

  4%|█                                              | 4/100
[00:01<00:19,  4.86trial/s, best loss: -0.6897880539499036]

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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

  6%|███                                             | 6/100
[00:01<00:15,  5.92trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

  8%|████                                               | 8/100
[00:01<00:14,  6.42trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:
0.6897880539499036
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
[9]	validation_0-merror:0.29529	validation_1-merror:0.31021
SCORE:
0.6897880539499036
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
SCORE:
0.6897880539499036
 11%|█████                                         | 11/100
[00:01<00:10,  8.27trial/s, best loss: -0.6897880539499036]
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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```

```
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[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

 12%|█████▌                                        | 12/100
[00:02<00:10,  8.61trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
```

```
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 14%|██████                                       | 14/100
[00:02<00:09,  8.95trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 15%|███████                                        | 15/100
[00:03<00:28,  3.01trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

 16%|███████▌                                       | 16/100
[00:03<00:29,  2.84trial/s, best loss: -0.6897880539499036]
```

```
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 18%|████████                                      | 18/100
[00:03<00:21,  3.78trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]   validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 20%|█████████                                     | 20/100
[00:04<00:19,  4.16trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 22%|██████████                                    | 22/100
[00:04<00:18,  4.17trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 24%|                                    | 24/100
[00:05<00:15,  5.02trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 26%|                                    | 26/100
[00:05<00:15,  4.71trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 27%|██████████                           | 27/100
[00:05<00:14,  4.95trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 29%|█████████████                                 | 29/100
[00:06<00:13,  5.18trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

 30%|██████████████                                | 30/100
[00:06<00:13,  5.28trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

 31%|██████████████                                | 31/100
[00:07<00:24,  2.83trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[9]   validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 32%|███████████████                               | 32/100
[00:07<00:26,  2.60trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 34%|████████████████                              | 34/100
[00:08<00:22,  2.96trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
```

```
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 35%|████████████████                              | 35/100
[00:08<00:18,  3.45trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 39%|██████████████████                             | 39/100
[00:09<00:12,  4.96trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 41%|███████████████████                            | 41/100
[00:09<00:11,  5.32trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 45%|████████████████████                         | 45/100
[00:10<00:10,  5.48trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 46%|█████████████████████                         | 46/100
[00:10<00:10,  5.18trial/s, best loss: -0.6897880539499036]


C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
 48%|██████████████████████                        | 48/100
[00:11<00:20,  2.51trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

 48%|██████████████████████                        | 48/100
[00:11<00:20,  2.51trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

 50%|███████████████████████                       | 50/100
[00:12<00:16,  3.12trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 51%|███████████████████████▍                      | 51/100
[00:12<00:13,  3.62trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 53%|█████████████████████████                      | 53/100
[00:12<00:10,  4.43trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 55%|█████████████████████████                     | 55/100
[00:13<00:09,  4.88trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

 57%|█████████████████████████████████                    | 57/100
[00:13<00:07,  5.66trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
```

```
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 59%|██████████████████████████▌                  | 59/100
[00:13<00:06,  6.06trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
```

```
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 61%|████████████████████████████                  | 61/100
[00:14<00:06,  6.16trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
```

```
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 62%|████████████████████████████                  | 62/100
[00:14<00:06,  6.11trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[9]   validation_0-merror:0.29529 validation_1-merror:0.31021
SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

 64%|█████████████████████████████                 | 64/100
[00:16<00:16,  2.22trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 66%|██████████████████████████████                | 66/100
[00:16<00:11,  3.08trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 68%|███████████████████████████████               | 68/100
[00:16<00:08,  3.94trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 70%|█████████████████████████████████              | 70/100
[00:17<00:06,  4.75trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[6]	validation_0-merror:0.29529	validation_1-merror:0.31021
[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 74%|██████████████████████████████████            | 74/100
[00:17<00:04,  5.97trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 75%|███████████████████████████████████             | 75/100
[00:17<00:04,  6.18trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 76%|███████████████████████████████████▌            | 76/100
[00:18<00:07,  3.33trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 78%|██████████████████████████████████▎         | 78/100
[00:19<00:11,  1.93trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 79%|██████████████████████████████████▊         | 79/100
[00:20<00:08,  2.36trial/s, best loss: -0.6897880539499036]
```

```
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 80%|█████████████████████████████████████         | 80/100
[00:20<00:06,  2.89trial/s, best loss: -0.6897880539499036]


C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

 82%|██████████████████████████████████████        | 82/100
[00:20<00:04,  4.08trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

 84%|████████████████████████████████████████        | 84/100
[00:21<00:03,  5.27trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
```

```
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the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
```

```
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[10]  validation_0-merror:0.29529 validation_1-merror:0.31021
SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[9]   validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

 88%|████████████████████████████████████████      | 88/100
[00:21<00:01,  6.58trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021



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```
[6]   validation_0-merror:0.29529 validation_1-merror:0.31021
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[9]   validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

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[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 92%|███████████████████████████████████████████    | 92/100
[00:22<00:01,  6.61trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

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[4]   validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 94%|███████████████████████████████████████████   | 94/100
[00:23<00:01,  3.04trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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the following: 1) Pass option use_label_encoder=False when
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[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

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SCORE:

0.6897880539499036

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[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 96%|█████████████████████████████████████████████  | 96/100
[00:23<00:00,  4.14trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

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SCORE:

0.6897880539499036

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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 98%|█████████████████████████████████████████████ | 98/100
[00:23<00:00,  5.14trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

100%|██████████████████████████████████████████████| 100/100
[00:24<00:00,  4.14trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```python
# Getting the best model
print("The best hyperparameters are : ","\n")
print(best_hyperparams)
```

```
The best hyperparameters are :

{'colsample_bytree': 0.8735300604984144, 'gamma': 4.042605283938188, 'max_depth': 15.0, 'min_child_weight': 3.0, 'reg_alpha': 95.0, 'reg_lambda': 0.4425426723169459}
```

```python
# Best model
clf=xgb.XGBClassifier(best_hyperparams)
```

```
evaluation = [( X_train, y_train), ( X_test, y_test)]
clf.fit(X_train, y_train,
            eval_set=evaluation,
            early_stopping_rounds=10,verbose=2)
```

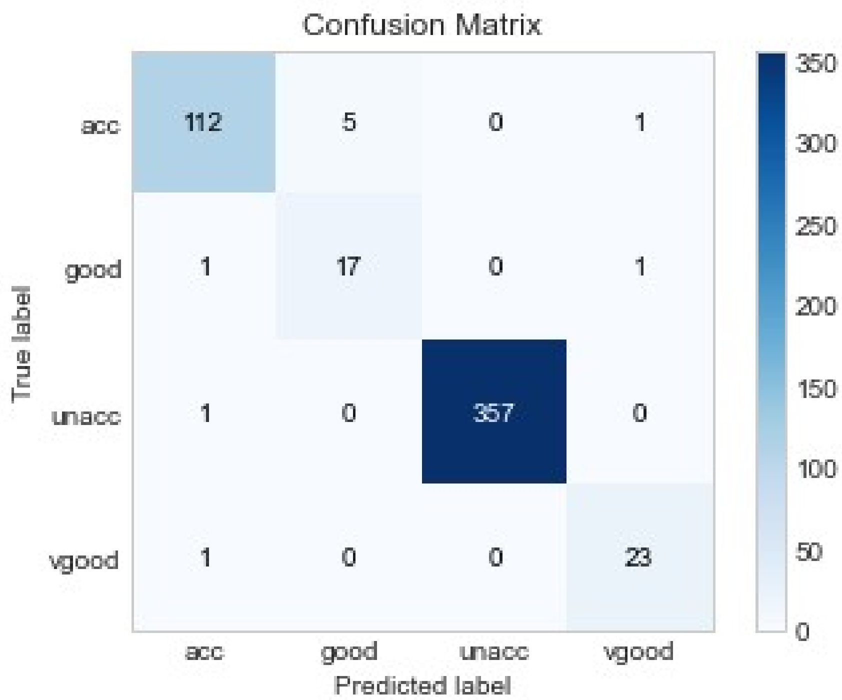
```
[05:21:31] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.5.0/src/learner.cc:1115: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[0]	validation_0-mlogloss:0.94153	validation_1-mlogloss:0.94379
[2]	validation_0-mlogloss:0.53773	validation_1-mlogloss:0.55620
[4]	validation_0-mlogloss:0.34786	validation_1-mlogloss:0.37244
[6]	validation_0-mlogloss:0.23741	validation_1-mlogloss:0.26699

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\core.py:502: FutureWarning: Pass `objective` as keyword args.  Passing these as positional arguments will be considered as error in future releases.
  format(", ".join(args_msg)), FutureWarning
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[8]	validation_0-mlogloss:0.17458	validation_1-mlogloss:0.21000
[10]	validation_0-mlogloss:0.13339	validation_1-mlogloss:0.17272
[12]	validation_0-mlogloss:0.10732	validation_1-mlogloss:0.14942
[14]	validation_0-mlogloss:0.08744	validation_1-mlogloss:0.12898
[16]	validation_0-mlogloss:0.07224	validation_1-mlogloss:0.11262
[18]	validation_0-mlogloss:0.06176	validation_1-mlogloss:0.10467
[20]	validation_0-mlogloss:0.05197	validation_1-mlogloss:0.09462
[22]	validation_0-mlogloss:0.04259	validation_1-mlogloss:0.08466
[24]	validation_0-mlogloss:0.03656	validation_1-mlogloss:0.08024
[26]	validation_0-mlogloss:0.03204	validation_1-mlogloss:0.07596
[28]	validation_0-mlogloss:0.02850	validation_1-mlogloss:0.07431
[30]	validation_0-mlogloss:0.02557	validation_1-mlogloss:0.07131
[32]	validation_0-mlogloss:0.02324	validation_1-mlogloss:0.07019
[34]	validation_0-mlogloss:0.02097	validation_1-mlogloss:0.06757
[36]	validation_0-mlogloss:0.01961	validation_1-mlogloss:0.06629
[38]	validation_0-mlogloss:0.01840	validation_1-mlogloss:0.06548
[40]	validation_0-mlogloss:0.01672	validation_1-mlogloss:0.06358
[42]	validation_0-mlogloss:0.01589	validation_1-mlogloss:0.06396
[44]	validation_0-mlogloss:0.01541	validation_1-mlogloss:0.06414
[46]	validation_0-mlogloss:0.01478	validation_1-mlogloss:0.06455
[48]	validation_0-mlogloss:0.01420	validation_1-mlogloss:0.06383
[50]	validation_0-mlogloss:0.01369	validation_1-mlogloss:0.06387
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1,
enable_categorical=False,
              gamma=0, gpu_id=-1, importance_type=None,
              interaction_constraints='', learning_rate=0.300000012,
              max_delta_step=0, max_depth=6, min_child_weight=1,
missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=4,
              num_parallel_tree=1, objective='multi:softprob',
predictor='auto',
              random_state=0, reg_alpha=0, reg_lambda=1,
scale_pos_weight=None,
              subsample=1, tree_method='exact', validate_parameters=1,
              verbosity=None)
```

```
print("\n The model accuracy on train set
is",clf.score(X_train,y_train))
print("\n The model accuracy on test set is",clf.score(X_test,y_test))

y_predict=clf.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9807321772639692


 Classification Report
              precision    recall  f1-score   support

         acc       0.97      0.95      0.96       118
        good       0.77      0.89      0.83        19
       unacc       1.00      1.00      1.00       358
       vgood       0.92      0.96      0.94        24

    accuracy                           0.98       519
   macro avg       0.92      0.95      0.93       519
weighted avg       0.98      0.98      0.98       519
```

```
<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Updates

```
import category_encoders as ce
encoder = ce.OrdinalEncoder(cols=['buying', 'maint', 'doors',
'persons', 'lug_boot', 'safety'])
df = encoder.fit_transform(df)

from sklearn.preprocessing import PolynomialFeatures

# summarize the shape of the dataset
print(df.shape)
# summarize each variable
display(df.head(2))

# perform a polynomial features transform of the dataset
trans = PolynomialFeatures(degree=4)
data = trans.fit_transform(df.iloc[:,:-1])

# convert the array back to a dataframe
dataset = pd.DataFrame(data)

# summarize
display(dataset.head(2))
```

```
(1728, 7)
```

	buying	maint	doors	persons	lug_boot	safety	target
0	1	1	1	1	1	1	unacc
1	1	1	1	1	1	2	unacc

```
   0    1    2    3    4    5    6    7    8    9    ...  200  201  
202  203  \
0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  ...  1.0  1.0  
1.0  1.0   
1  1.0  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  ...  4.0  1.0  
2.0  4.0   

   204  205  206  207  208   209  
0  1.0  1.0  1.0  1.0  1.0   1.0  
1  8.0  1.0  2.0  4.0  8.0  16.0  

[2 rows x 210 columns]
```

```
# Getting X and y
X = dataset
y = df['target']

X.head()
```

```
   0    1    2    3    4    5    6    7    8    9    ...  200  201  
202  203  \
0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  ...  1.0  1.0  
1.0  1.0   
1  1.0  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  ...  4.0  1.0  
2.0  4.0   
2  1.0  1.0  1.0  1.0  1.0  1.0  3.0  1.0  1.0  1.0  ...  9.0  1.0  
3.0  9.0   
3  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  1.0  ...  1.0  8.0  
4.0  2.0   
4  1.0  1.0  1.0  1.0  1.0  2.0  2.0  1.0  1.0  1.0  ...  4.0  8.0  
8.0  8.0   

    204   205   206   207   208   209  
0   1.0   1.0   1.0   1.0   1.0   1.0  
1   8.0   1.0   2.0   4.0   8.0  16.0  
2  27.0   1.0   3.0   9.0  27.0  81.0  
3   1.0  16.0   8.0   4.0   2.0   1.0  
4   8.0  16.0  16.0  16.0  16.0  16.0  

[5 rows x 210 columns]
```

```
# importing necessary packages
from sklearn.metrics import 
accuracy_score,confusion_matrix,classification_report
from sklearn.tree import DecisionTreeClassifier
import scikitplot.metrics as skplt
from sklearn import tree
from sklearn.model_selection import train_test_split
```

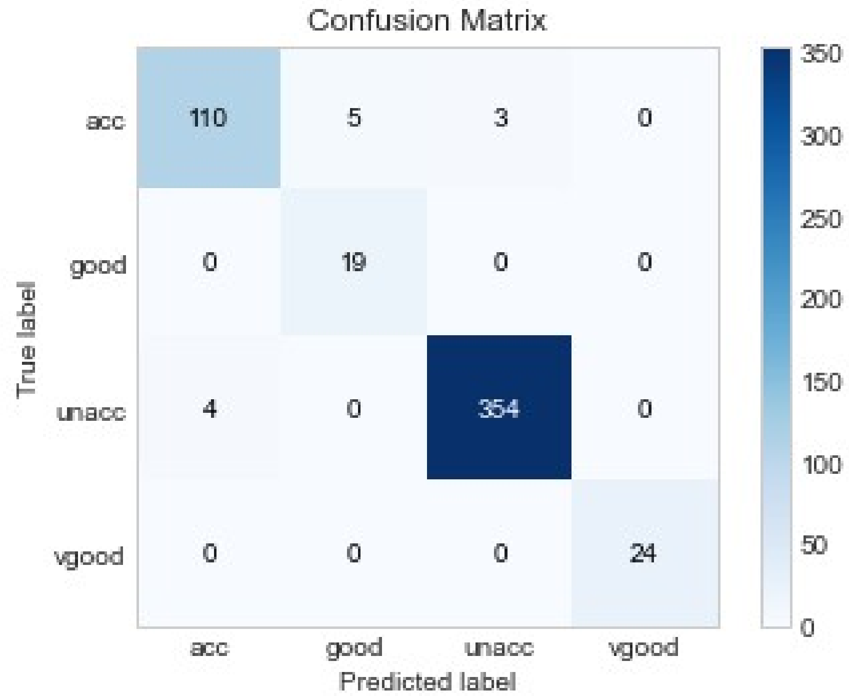
```
# Splitting data into test train, using a 0.3 split
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)

# Exploring class distribution under train ,crossvalidation dataset
print('Training Dataset',X_train.shape,y_train.shape)
print('\n Class label distribution in Training Set\
n',y_train.value_counts())
print('\n***********')
print("\n CrossValidation Dataset",X_test.shape,y_test.shape)
print('\nClass label distribution in Cross Validation Set\
n',y_test.value_counts())
print('\n***********')
```

```
Training Dataset (1209, 210) (1209,)

 Class label distribution in Training Set
 unacc    852
acc      266
good      50
vgood     41
Name: target, dtype: int64

***********

 CrossValidation Dataset (519, 210) (519,)

Class label distribution in Cross Validation Set
 unacc    358
acc      118
vgood     24
good      19
Name: target, dtype: int64

***********
```

```
# Using Grid search to find the best decision tree classifier with the
given set of parameters.
from sklearn.model_selection import GridSearchCV

parameters={'max_depth': list(range(1,10)),
            'min_samples_leaf' : list(range(2,10,1)),
            'min_samples_split': list(range(5,10,10)),
            }
model=GridSearchCV(DecisionTreeClassifier(class_weight='balanced'),par
ameters,n_jobs=-1,cv=10,scoring='accuracy', )
model.fit(X_train,y_train)
print('The best model is ', model.best_estimator_)
print("\n The best model parameters are ",model.best_params_)
print("\n The model accuracy on train set
is",model.score(X_train,y_train))
```

```python
print("\n The model accuracy on test set
is",model.score(X_test,y_test))

y_predict=model.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  DecisionTreeClassifier(class_weight='balanced',
max_depth=9, min_samples_leaf=2,
                       min_samples_split=5)

 The best model parameters are  {'max_depth': 9, 'min_samples_leaf':
2, 'min_samples_split': 5}

 The model accuracy on train set is 0.9867659222497932

 The model accuracy on test set is 0.976878612716763


 Classification Report
              precision    recall  f1-score   support

         acc       0.96      0.93      0.95       118
        good       0.79      1.00      0.88        19
       unacc       0.99      0.99      0.99       358
       vgood       1.00      1.00      1.00        24

    accuracy                           0.98       519
   macro avg       0.94      0.98      0.96       519
weighted avg       0.98      0.98      0.98       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Using SMOTE for Upsampling

```
X_train
```

```
        0    1    2    3    4    5    6     7     8     9   ...   200
201  \
1178  1.0  3.0  3.0  4.0  2.0  3.0  3.0   9.0   9.0  12.0  ...  36.0
54.0
585   1.0  2.0  2.0  2.0  3.0  1.0  1.0   4.0   4.0   4.0  ...   9.0
3.0
1552  1.0  4.0  3.0  2.0  2.0  2.0  2.0  16.0  12.0   8.0  ...  16.0
16.0
1169  1.0  3.0  3.0  4.0  1.0  3.0  3.0   9.0   9.0  12.0  ...   9.0
27.0
1033  1.0  3.0  2.0  3.0  1.0  3.0  2.0   9.0   6.0   9.0  ...   4.0
27.0
...   ...  ...  ...  ...  ...  ...  ...   ...   ...   ...  ...   ...
...
1130  1.0  3.0  3.0  2.0  3.0  2.0  3.0   9.0   9.0   6.0  ...  81.0
24.0
1294  1.0  3.0  4.0  4.0  3.0  3.0  2.0   9.0  12.0  12.0  ...  36.0
81.0
860   1.0  2.0  4.0  4.0  3.0  2.0  3.0   4.0   8.0   8.0  ...  81.0
24.0
1459  1.0  4.0  2.0  3.0  1.0  1.0  2.0  16.0   8.0  12.0  ...   4.0
1.0
1126  1.0  3.0  3.0  2.0  3.0  1.0  2.0   9.0   9.0   6.0  ...  36.0
3.0
```

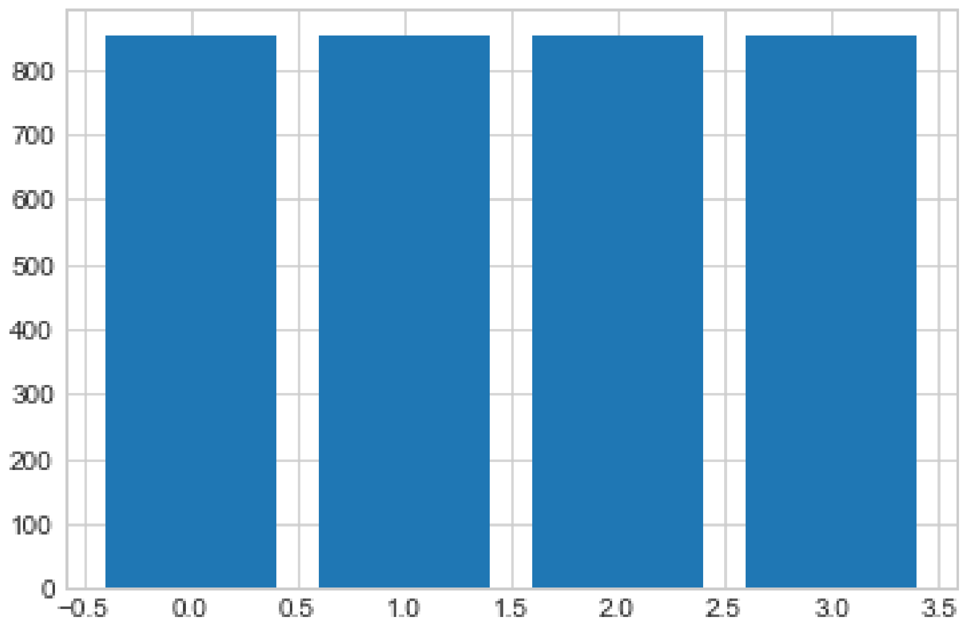
```
        202   203   204   205   206   207   208   209
1178  54.0  54.0  54.0  81.0  81.0  81.0  81.0  81.0
585    3.0   3.0   3.0   1.0   1.0   1.0   1.0   1.0
1552  16.0  16.0  16.0  16.0  16.0  16.0  16.0  16.0
1169  27.0  27.0  27.0  81.0  81.0  81.0  81.0  81.0
1033  18.0  12.0   8.0  81.0  54.0  36.0  24.0  16.0
...    ...   ...   ...   ...   ...   ...   ...   ...
1130  36.0  54.0  81.0  16.0  24.0  36.0  54.0  81.0
1294  54.0  36.0  24.0  81.0  54.0  36.0  24.0  16.0
860   36.0  54.0  81.0  16.0  24.0  36.0  54.0  81.0
1459   2.0   4.0   8.0   1.0   2.0   4.0   8.0  16.0
1126   6.0  12.0  24.0   1.0   2.0   4.0   8.0  16.0

[1209 rows x 210 columns]
```

```
y_train
```

```
1178    vgood
585     unacc
1552      acc
1169    unacc
1033    unacc
        ...
1130    vgood
1294     good
860       acc
1459    unacc
1126      acc
Name: target, Length: 1209, dtype: object
```

```
from imblearn.over_sampling import SMOTE
from collections import Counter
from matplotlib import pyplot
from sklearn.preprocessing import LabelEncoder

# label encode the target variable
y = LabelEncoder().fit_transform(y_train)
# transform the dataset
oversample = SMOTE()
X, y = oversample.fit_resample(X_train, y)
# summarize distribution
counter = Counter(y)
for k,v in counter.items():
      per = v / len(y) * 100
      print('Class=%d, n=%d (%.3f%%)' % (k, v, per))
# plot the distribution
pyplot.bar(counter.keys(), counter.values())
pyplot.show()
```

```
Class=3, n=852 (25.000%)
Class=2, n=852 (25.000%)
Class=0, n=852 (25.000%)
Class=1, n=852 (25.000%)
```

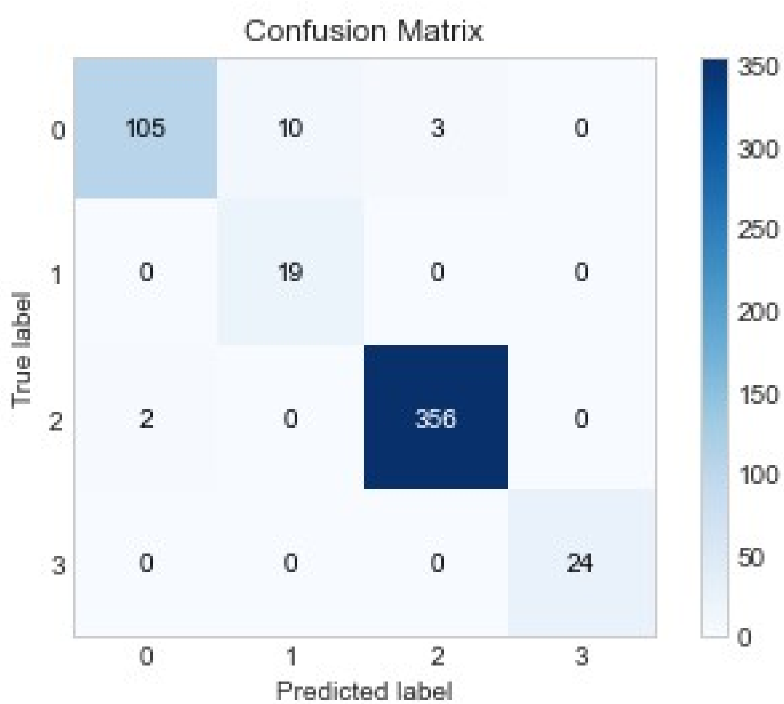



```
X_train = X
y_train = y

y_test = LabelEncoder().fit_transform(y_test)

# Using Grid search to find the best decision tree classifier with the
given set of parameters.
from sklearn.model_selection import GridSearchCV

parameters={'max_depth': list(range(1,10)),
            'min_samples_leaf' : list(range(2,10,1)),
            'min_samples_split': list(range(5,10,10)),
            }
model=GridSearchCV(DecisionTreeClassifier(class_weight='balanced'),par
ameters,n_jobs=-1,cv=10,scoring='accuracy', )
model.fit(X_train,y_train)
print('The best model is ', model.best_estimator_)
print("\n The best model parameters are ",model.best_params_)
print("\n The model accuracy on train set
is",model.score(X_train,y_train))
print("\n The model accuracy on test set
is",model.score(X_test,y_test))

y_predict=model.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
```

```
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
 The model accuracy on test set is 0.9710982658959537


 Classification Report
              precision    recall  f1-score   support

           0       0.98      0.89      0.93       118
           1       0.66      1.00      0.79        19
           2       0.99      0.99      0.99       358
           3       1.00      1.00      1.00        24

    accuracy                           0.97       519
   macro avg       0.91      0.97      0.93       519
weighted avg       0.98      0.97      0.97       519
```

```
<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



```python
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns

# Reading the data
df = pd.read_csv('car_evaluation.csv', names=['buying', 'maint',
'doors', 'persons', 'lug_boot', 'safety', 'target'])

# Visualizing the dataframe
df.head()
```

```
  buying  maint doors persons lug_boot safety target
0  vhigh  vhigh     2       2    small    low  unacc
1  vhigh  vhigh     2       2    small    med  unacc
2  vhigh  vhigh     2       2    small   high  unacc
3  vhigh  vhigh     2       2      med    low  unacc
4  vhigh  vhigh     2       2      med    med  unacc
```

```python
# Checking the shape of the data
df.shape
```

```
(1728, 7)
```

```python
#Checking for null values and data types
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1728 entries, 0 to 1727
Data columns (total 7 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   buying    1728 non-null   object
 1   maint     1728 non-null   object
 2   doors     1728 non-null   object
 3   persons   1728 non-null   object
 4   lug_boot  1728 non-null   object
 5   safety    1728 non-null   object
 6   target    1728 non-null   object
dtypes: object(7)
memory usage: 94.6+ KB
```

```python
# Null alues
df.isnull().sum()
```

```
buying      0
maint       0
```

```
doors       0
persons     0
lug_boot    0
safety      0
target      0
dtype: int64
```

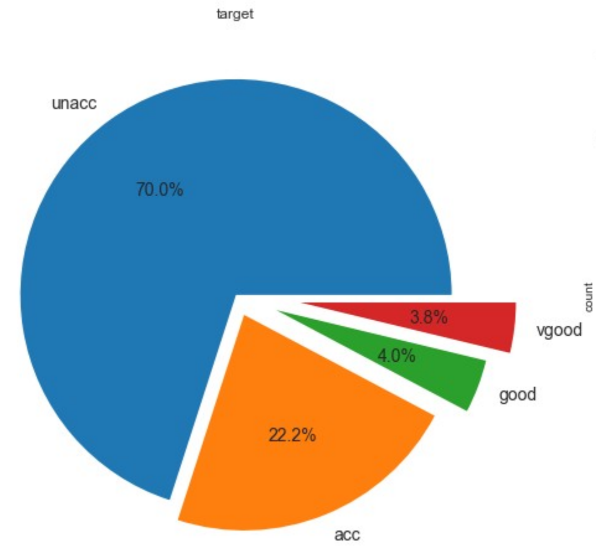
We do not have any null values!

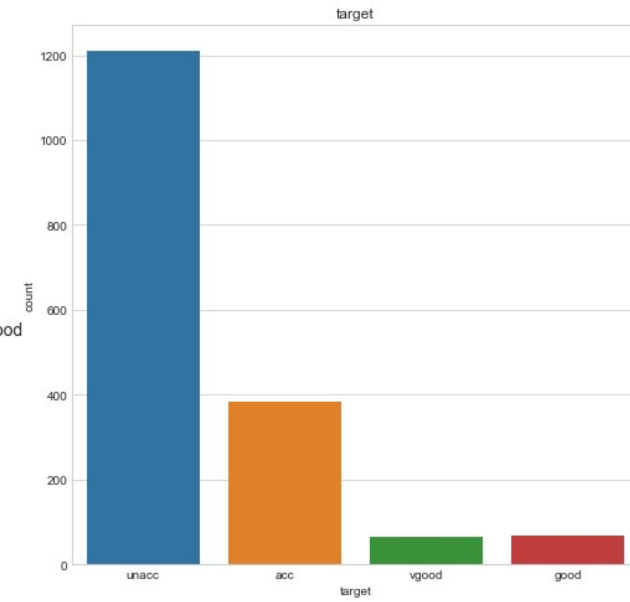
```
#description
df.describe().transpose()
```

```
         count unique    top  freq
buying    1728      4  vhigh   432
maint     1728      4  vhigh   432
doors     1728      4      2   432
persons   1728      3      2   576
lug_boot  1728      3  small   576
safety    1728      3    low   576
target    1728      4  unacc  1210
```

```
#Plotting target distribution
f,ax=plt.subplots(1,2,figsize=(18,8))
df['target'].value_counts().plot.pie(ax = ax[0], explode=[0,0.1, 0.2,
0.3],autopct='%1.1f%%',shadow=False, textprops={'fontsize': 14})
ax[0].set_title('target')
ax[0].set_ylabel('')
sns.countplot('target',data=df,ax=ax[1])
ax[1].set_title('target')
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning

Text(0.5, 1.0, 'target')
```





Pre-processing

```
#Checking the Columns or features
df.columns

Index(['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety',
'target'], dtype='object')

# find categorical variables

categorical = [var for var in df.columns if df[var].dtype=='O']
print(categorical)

['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety',
'target']

# Find numerical variables

numerical = [var for var in df.columns if df[var].dtype !='O']
print(numerical)

[]

# Printing all the unique classes in the features.
for col in categorical:
    print(df[col].value_counts())

vhigh    432
high     432
med      432
low      432
```

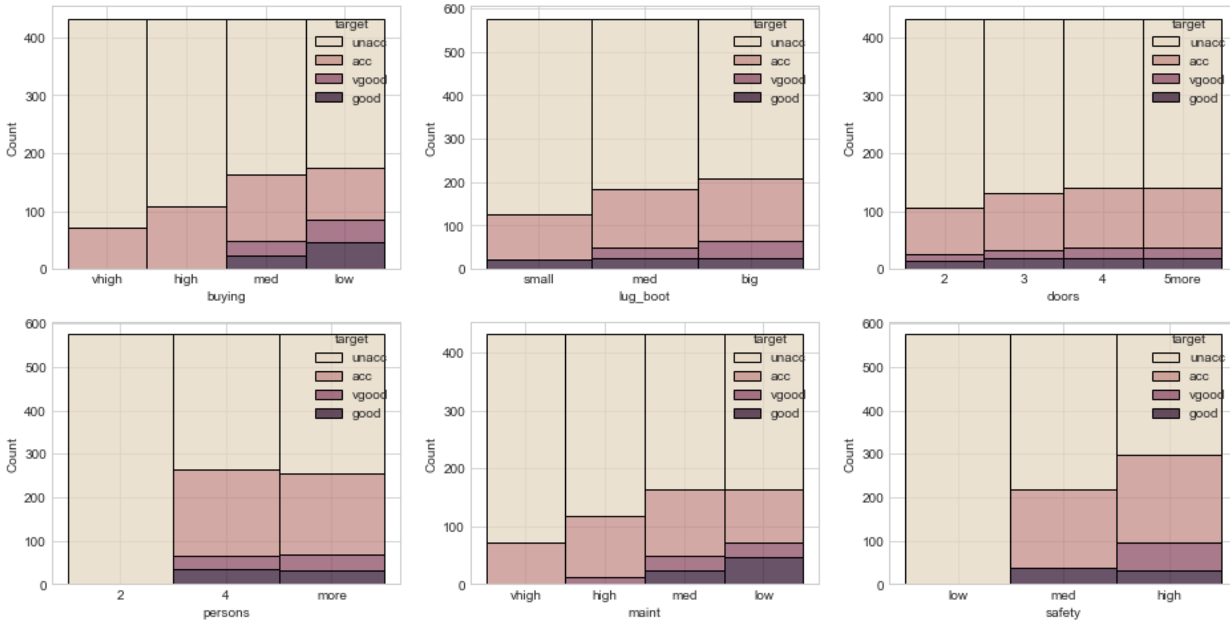
```
Name: buying, dtype: int64
vhigh    432
high     432
med      432
low      432
Name: maint, dtype: int64
2        432
3        432
4        432
5more    432
Name: doors, dtype: int64
2       576
4       576
more    576
Name: persons, dtype: int64
small    576
med      576
big      576
Name: lug_boot, dtype: int64
low     576
med     576
high    576
Name: safety, dtype: int64
unacc    1210
acc       384
good       69
vgood      65
Name: target, dtype: int64
```

EDA

```
# Creating pairwise list
cols = df.drop('target', axis = 1).columns
paircols = []
for i in range(len(cols)-1):
    for j in range(i+1, len(cols)):
        paircols.append([cols[i], cols[j]])
```

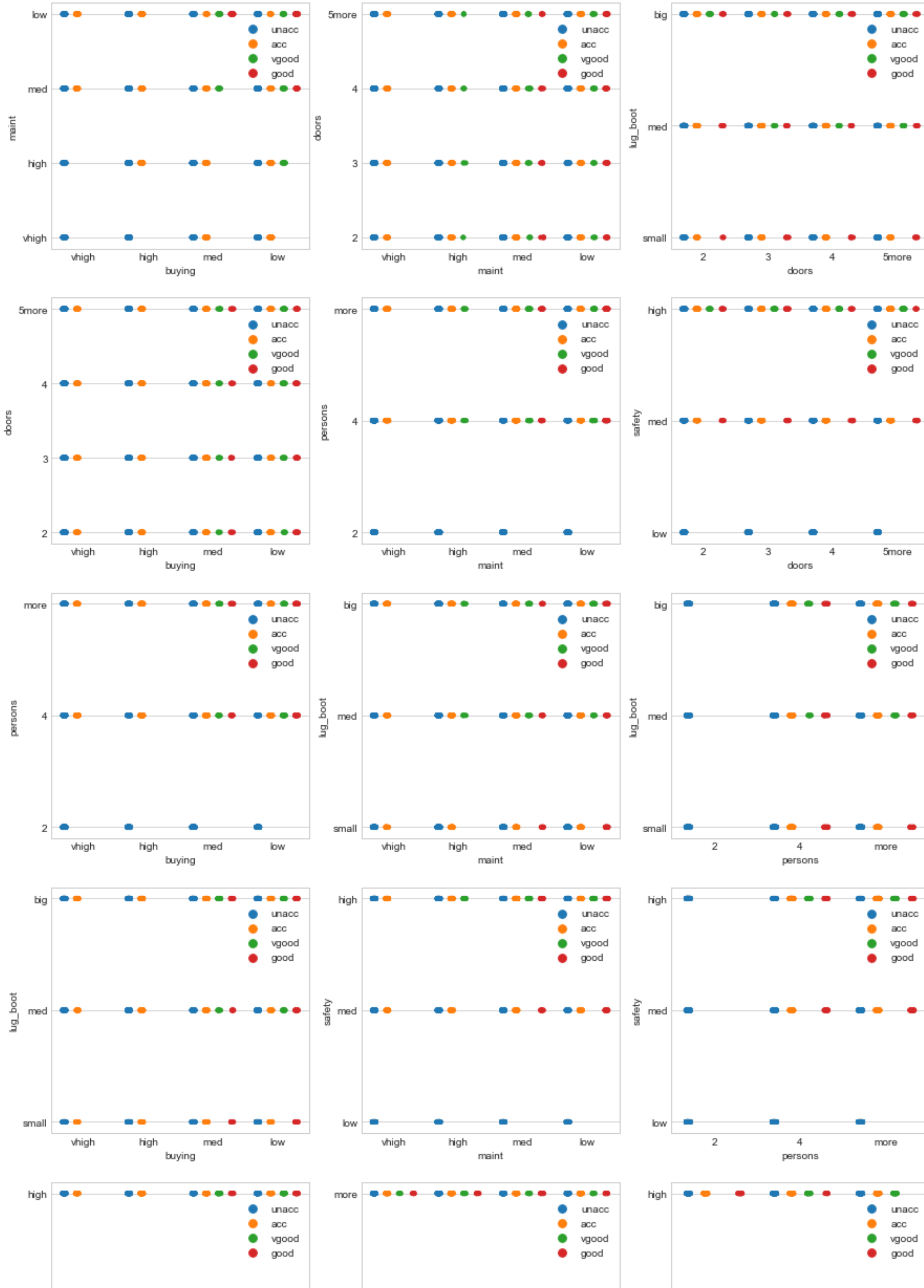
Univariate Analysis

```
# Histplots for each feature
f,ax=plt.subplots(2,3,figsize=(16,8))
for i, col in enumerate(cols):
    sns.histplot(binwidth=0.5, x=col, hue="target", data=df,
stat="count", multiple="stack", palette="ch:0.25", ax=ax[i%2, i%3])
```



Multivariate analysis

```
# Stripplot for each feature
f,ax=plt.subplots(5,3,figsize=(15,25))
j = -1
for i, col in enumerate(paircols):
    if i%5 == 0: j = j+1
    sns.stripplot(x =col[0], y =col[1], data = df,jitter = True, hue
='target', dodge = True, ax=ax[i%5, j],)
    ax[i%5, j].legend(bbox_to_anchor=(0.7, 0.95), loc=2)
```


unacc
acc
vgood
good
buying
maint
doors
persons
lug_boot
safety
vhigh
high
med
low
2
3
4
5more
more
big
small

Modelling the Decision Tree models

As the dataset has categorical features and hence they needs to be encoded in the appropriate form. There are two main method of encodig:

1. One hot encoding
2. Label encoding

As we have categorial features that are ordinal in nature i.e that can be ranked (ordered) hence label encoding will solve our purpose.Had there been nominal features we could have preferred one hot encoding.

```
# Getting X and y
X = df.drop('target', axis = 1)
y = df['target']

# importing necessary package for encoding our categorial features
import category_encoders as ce

encoder = ce.OrdinalEncoder(cols=cols)
x= encoder.fit_transform(X)

x.head()
```

	buying	maint	doors	persons	lug_boot	safety
0	1	1	1	1	1	1
1	1	1	1	1	1	2
2	1	1	1	1	1	3
3	1	1	1	1	2	1
4	1	1	1	1	2	2

```
# importing necessary packages
from sklearn.metrics import
accuracy_score,confusion_matrix,classification_report
from sklearn.tree import DecisionTreeClassifier
import scikitplot.metrics as skplt
from sklearn import tree
from sklearn.model_selection import train_test_split

# Splitting data into test train, using a 0.3 split
X_train, X_test, y_train, y_test = train_test_split(x, y,
test_size=0.3, random_state=42)

# Exploring class distribution under train ,crossvalidation dataset
print('Training Dataset',X_train.shape,y_train.shape)
print('\n Class label distribution in Training Set\
n',y_train.value_counts())
print('\n**********')
print("\n CrossValidation Dataset",X_test.shape,y_test.shape)
print('\nClass label distribution in Cross Validation Set\
```

```
n',y_test.value_counts())
print('\n***********')
```

```
Training Dataset (1209, 6) (1209,)

 Class label distribution in Training Set
 unacc    852
acc      266
good      50
vgood     41
Name: target, dtype: int64

***********

 CrossValidation Dataset (519, 6) (519,)

Class label distribution in Cross Validation Set
 unacc    358
acc      118
vgood     24
good      19
Name: target, dtype: int64

***********
```

Random Forest Classifier

```
# Importing and defining the random search feature space.
from sklearn.ensemble import RandomForestClassifier

from sklearn.model_selection import RandomizedSearchCV

# Number of trees in random forest
n_estimators = [int(x) for x in range(400,1400,200)]
# Number of features to consider at every split
max_features = ['auto', 'sqrt']
# Maximum number of levels in tree
max_depth = [int(x) for x in np.linspace(2, 15, num = 1)]
max_depth.append(None)
# Minimum number of samples required to split a node
min_samples_split = [ 2,3, 4, 5, 7,10]
# Minimum number of samples required at each leaf node
min_samples_leaf = [1, 2, 4, 5]
# Method of selecting samples for training each tree
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
```

```
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
print(random_grid)
```

```
{'n_estimators': [400, 600, 800, 1000, 1200], 'max_features': ['auto',
'sqrt'], 'max_depth': [2, None], 'min_samples_split': [2, 3, 4, 5, 7,
10], 'min_samples_leaf': [1, 2, 4, 5], 'bootstrap': [True, False]}
```

```
# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestClassifier()
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available
cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions =
random_grid, n_iter = 50, cv = 3, verbose=2, random_state=42, n_jobs =
-1)
# Fit the random search model
rf_random.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 50 candidates, totalling 150 fits
```

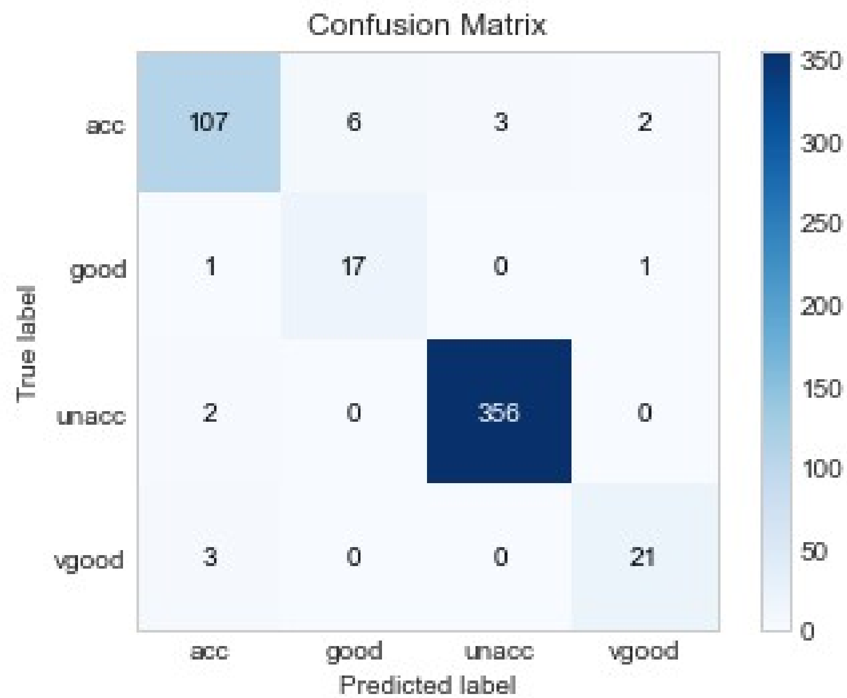
```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(),
n_iter=50,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [2, None],
                                        'max_features': ['auto',
'sqrt'],
                                        'min_samples_leaf': [1, 2, 4,
5],
                                        'min_samples_split': [2, 3, 4,
5, 7,
                                                              10],
                                        'n_estimators': [400, 600,
800, 1000,
                                                         1200]},
                   random_state=42, verbose=2)
```

```
# Printing the best hyperparameters

rf_random.best_params_
```

```
{'n_estimators': 400,
 'min_samples_split': 2,
 'min_samples_leaf': 1,
 'max_features': 'auto',
 'max_depth': None,
 'bootstrap': False}
```

```python
# Checking accuracies on the train and test data, predicting on the
test data.

print('The best model is ', rf_random.best_estimator_)
print("\n The best model parameters are ",rf_random.best_params_)
print("\n The model accuracy on train set
is",rf_random.score(X_train,y_train))
print("\n The model accuracy on test set
is",rf_random.score(X_test,y_test))

y_predict=rf_random.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  RandomForestClassifier(bootstrap=False,
n_estimators=400)

 The best model parameters are  {'n_estimators': 400,
'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'auto',
'max_depth': None, 'bootstrap': False}

 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9653179190751445


 Classification Report
              precision    recall  f1-score   support

         acc       0.95      0.91      0.93       118
        good       0.74      0.89      0.81        19
       unacc       0.99      0.99      0.99       358
       vgood       0.88      0.88      0.88        24

    accuracy                           0.97       519
   macro avg       0.89      0.92      0.90       519
weighted avg       0.97      0.97      0.97       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



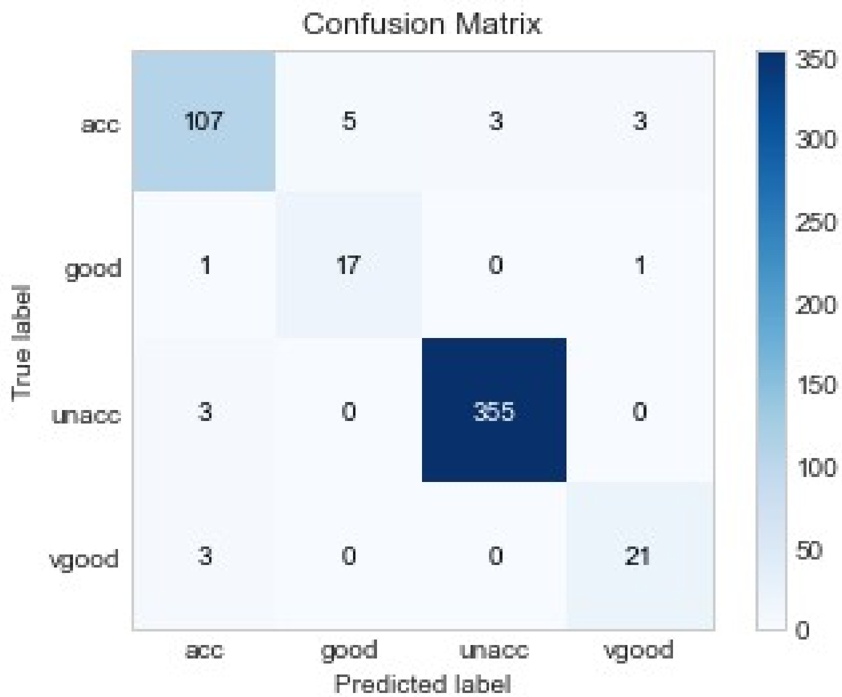

```
# Defining the model with the best parameters
clf = RandomForestClassifier(bootstrap=True, max_depth=None,
max_features='auto', min_samples_leaf=1, min_samples_split=3,
n_estimators = 1000)
clf.fit(X_train, y_train)
```

```
RandomForestClassifier(min_samples_split=3, n_estimators=1000)
```

```
print("\n The model accuracy on train set
is",clf.score(X_train,y_train))
print("\n The model accuracy on test set is",clf.score(X_test,y_test))

y_predict=clf.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

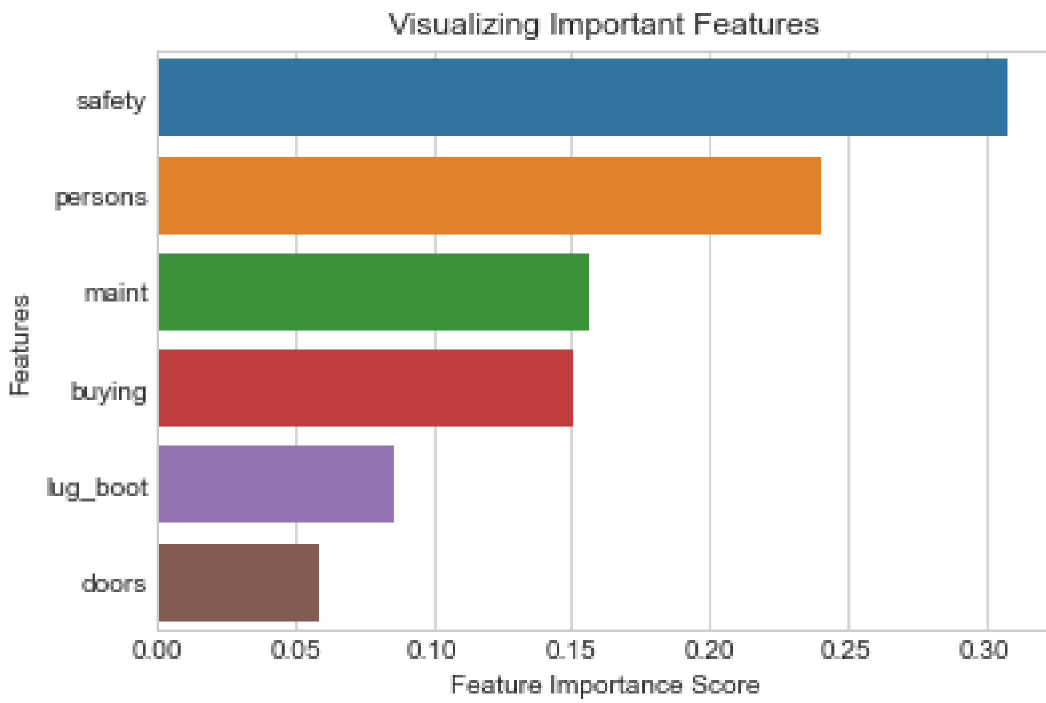
```
 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9633911368015414


 Classification Report
              precision    recall  f1-score   support

         acc       0.94      0.91      0.92       118
        good       0.77      0.89      0.83        19
```

```
       unacc       0.99      0.99      0.99       358
       vgood       0.84      0.88      0.86        24

    accuracy                           0.96       519
   macro avg       0.89      0.92      0.90       519
weighted avg       0.96      0.96      0.96       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```




```
# view the feature scores

feature_scores = pd.Series(clf.feature_importances_,
index=X_train.columns).sort_values(ascending=False)

feature_scores

safety      0.308498
persons     0.240509
maint       0.156148
buying      0.150323
lug_boot    0.085616
doors       0.058907
dtype: float64

# Creating a seaborn bar plot
```

```
sns.barplot(x=feature_scores, y=feature_scores.index)
# Add labels to the graph

plt.xlabel('Feature Importance Score')
plt.ylabel('Features')

# Add title to the graph
plt.title("Visualizing Important Features")

# Visualize the graph
plt.show()
```



Building a model on selected features without the least important feature

```
# declare feature vector and target variable, without the least
important feature

X1 = df.drop(['target', 'doors'], axis=1)

y1 = df['target']

# split data into training and testing sets

from sklearn.model_selection import train_test_split

X_train1, X_test1, y_train1, y_test1 = train_test_split(X1, y1,
test_size = 0.33, random_state = 42)
```

```python
# encode categorical variables with ordinal encoding

encoder = ce.OrdinalEncoder(cols=['buying', 'maint', 'persons',
'lug_boot', 'safety'])


X_train1 = encoder.fit_transform(X_train1)

X_test1 = encoder.transform(X_test1)

# modelling without the least important feature
clf = RandomForestClassifier(bootstrap=True, max_depth=None,
max_features='auto', min_samples_leaf=1, min_samples_split=3,
n_estimators = 1000)
clf.fit(X_train1, y_train1)
```

```
RandomForestClassifier(min_samples_split=3, n_estimators=1000)
```

```python
print("\n The model accuracy on train set
is",clf.score(X_train1,y_train1))
print("\n The model accuracy on test set
is",clf.score(X_test1,y_test1))

y_predict1=clf.predict(X_test1)
accuracy=accuracy_score(y_test1,y_predict1,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test1,y_predict1))
skplt.plot_confusion_matrix(y_test1,y_predict1)
```

```

 The model accuracy on train set is 0.9688850475367329

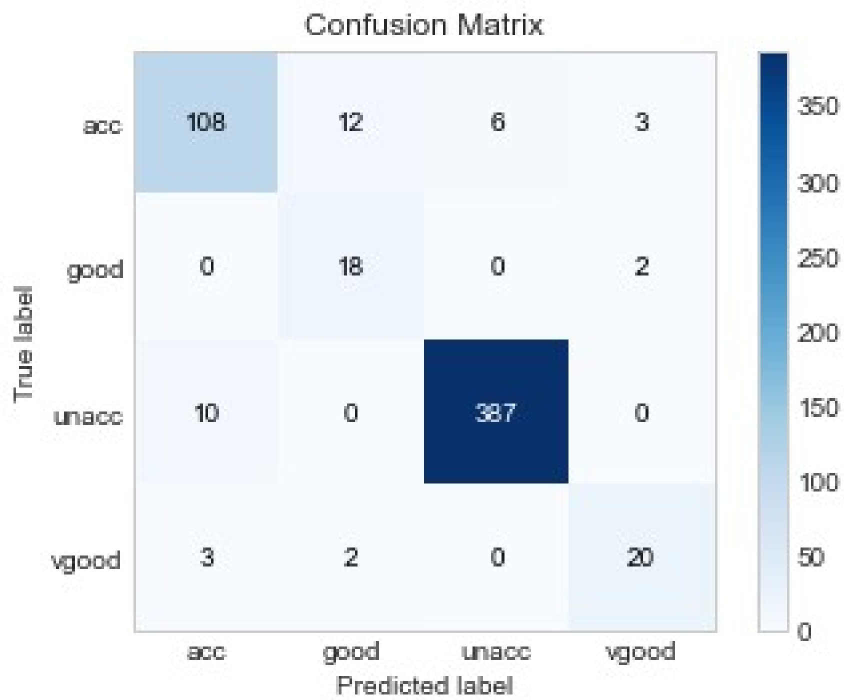
 The model accuracy on test set is 0.9334500875656743


 Classification Report
              precision    recall  f1-score   support

         acc       0.89      0.84      0.86       129
        good       0.56      0.90      0.69        20
       unacc       0.98      0.97      0.98       397
       vgood       0.80      0.80      0.80        25

    accuracy                           0.93       571
   macro avg       0.81      0.88      0.83       571
weighted avg       0.94      0.93      0.94       571


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Xgboost

```
# import machine learning libraries
import xgboost as xgb

# import packages for hyperparameters tuning
from hyperopt import STATUS_OK, Trials, fmin, hp, tpe

# Defining the feature space for search
space={'max_depth': hp.quniform("max_depth", 3, 18, 1),
        'gamma': hp.uniform ('gamma', 1,9),
        'reg_alpha' : hp.quniform('reg_alpha', 40,180,1),
        'reg_lambda' : hp.uniform('reg_lambda', 0,1),
        'colsample_bytree' : hp.uniform('colsample_bytree', 0.5,1),
        'min_child_weight' : hp.quniform('min_child_weight', 0, 10,
1),
        'n_estimators': 180,
        'seed': 42
    }

# Deifning the objective function to minimize as this is required by
hyperopt library
def objective(space):
    clf=xgb.XGBClassifier(
                    n_estimators =space['n_estimators'], max_depth =
int(space['max_depth']), gamma = space['gamma'],
                    reg_alpha =
int(space['reg_alpha']),min_child_weight=int(space['min_child_weight']
```

```
),
                    colsample_bytree=int(space['colsample_bytree']))

    evaluation = [( X_train, y_train), ( X_test, y_test)]

    clf.fit(X_train, y_train,
            eval_set=evaluation, eval_metric = 'merror',
            early_stopping_rounds=10,verbose=2)


    pred = clf.predict(X_test)
    accuracy = accuracy_score(y_test, pred)
    print ("SCORE:", accuracy)
    return {'loss': -accuracy, 'status': STATUS_OK }

# Getting the optimum
trials = Trials()

best_hyperparams = fmin(fn = objective,
                        space = space,
                        algo = tpe.suggest,
                        max_evals = 100,
                        trials = trials)

   0%|
| 0/100 [00:00<?, ?trial/s, best loss=?]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

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[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

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SCORE:

0.6897880539499036

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

  2%|█                                               | 2/100
[00:00<00:30,  3.26trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:
```

```
0.6897880539499036

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SCORE:

0.6897880539499036

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[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

  4%|█                                              | 4/100
[00:01<00:16,  5.80trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:

0.6897880539499036

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SCORE:

0.6897880539499036

  6%|███                                                  | 6/100
[00:01<00:12,  7.62trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:

0.6897880539499036

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SCORE:

0.6897880539499036

  8%|████                                              | 8/100
[00:01<00:10,  8.57trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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```
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SCORE:

0.6897880539499036

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SCORE:



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0.6897880539499036
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SCORE:

0.6897880539499036

 13%|██████                                              | 13/100
[00:01<00:09,  9.66trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:

0.6897880539499036

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 15%|███████                                        | 15/100
[00:01<00:08,  9.93trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:

0.6897880539499036

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 17%|███████                                      | 17/100
[00:02<00:08, 10.12trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 19%|███████                                       | 19/100
[00:02<00:07, 10.38trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
```

```
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

 23%|██████████                                  | 23/100
[00:02<00:08,  8.78trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 25%|███████████                                 | 25/100
[00:03<00:09,  8.09trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

 27%|████████████▍                                  | 27/100
[00:03<00:09,  7.73trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

 29%|█████████████                                | 29/100
[00:03<00:09,  7.71trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 31%|██████████                                 | 31/100
[00:04<00:09,  7.24trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 33%|███████████                       | 33/100
[00:04<00:09,  6.93trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
 37%|█████████████████                             | 37/100
[00:04<00:10,  6.07trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 38%|█████████████████▍                            | 38/100
[00:05<00:10,  6.19trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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and will be removed in a future release. To remove this warning, do
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 40%|██████████████████                              | 40/100
[00:05<00:09,  6.34trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[2]   validation_0-merror:0.29529 validation_1-merror:0.31021
[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[9]   validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 44%|████████████████████                          | 44/100
[00:06<00:09,  5.96trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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and will be removed in a future release. To remove this warning, do
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 45%|████████████████████▋                         | 45/100
[00:06<00:11,  4.95trial/s, best loss: -0.6897880539499036]


[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

 46%|█████████████████████▏                        | 46/100
[00:06<00:10,  5.34trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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```
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

 48%|██████████████████████                        | 48/100
[00:06<00:09,  5.70trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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```
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 50%|███████████████████████                       | 50/100
[00:07<00:09,  5.52trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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constructing XGBClassifier object; and 2) Encode your labels (y) as
```

```
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 52%|████████████████████████                      | 52/100
[00:07<00:08,  5.67trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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```

```
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 54%|█████████████████████████                     | 54/100
[00:07<00:09,  4.99trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 55%|█████████████████████████                     | 55/100
[00:08<00:08,  5.32trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

 57%|██████████████████████████                    | 57/100
[00:08<00:07,  5.99trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


0.6897880539499036
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 59%|███████████████████████████                   | 59/100
[00:09<00:07,  5.25trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 61%|████████████████████████████                  | 61/100
[00:09<00:10,  3.67trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

 61%|████████████████████████████                  | 61/100
[00:09<00:10,  3.67trial/s, best loss: -0.6897880539499036]
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 63%|█████████████████████████████                 | 63/100
[00:10<00:10,  3.46trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 64%|█████████████████████████████▍                | 64/100
[00:10<00:09,  3.69trial/s, best loss: -0.6897880539499036]
```

```
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 64%|█████████████████████████████                 | 64/100
[00:10<00:09,  3.69trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 66%|██████████████████████████████                | 66/100
[00:11<00:08,  3.78trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021


C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 70%|█████████████████████████████████              | 70/100
[00:11<00:05,  5.57trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 72%|█████████████████████████████████             | 72/100
[00:12<00:04,  6.13trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 74%|█████████████████████████████████▎           | 74/100
[00:12<00:04,  6.16trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

 78%|███████████████████████████████████▉          | 78/100
[00:13<00:03,  6.02trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

 79%|████████████████████████████████████▎         | 79/100
[00:13<00:03,  5.91trial/s, best loss: -0.6897880539499036]
```

```
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 81%|█████████████████████████████████████         | 81/100
[00:13<00:04,  4.14trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
```

```
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 83%|████████████████████████████████████████         | 83/100
[00:14<00:04,  3.94trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

 83%|██████████████████████████████████████        | 83/100
[00:14<00:04,  3.94trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


SCORE:

0.6897880539499036

[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 85%|███████████████████████████████████████       | 85/100
[00:14<00:04,  3.67trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 86%|████████████████████████████████████████      | 86/100
[00:15<00:03,  4.05trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021

SCORE:

0.6897880539499036

 88%|████████████████████████████████████████      | 88/100
[00:15<00:02,  4.12trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]   validation_0-merror:0.29529 validation_1-merror:0.31021

[2]   validation_0-merror:0.29529 validation_1-merror:0.31021

 88%|████████████████████████████████████████      | 88/100
[00:15<00:02,  4.12trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[4]   validation_0-merror:0.29529 validation_1-merror:0.31021

[6]   validation_0-merror:0.29529 validation_1-merror:0.31021

[8]   validation_0-merror:0.29529 validation_1-merror:0.31021

[10]  validation_0-merror:0.29529 validation_1-merror:0.31021
```

```
SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

 90%|██████████████████████████████████████████     | 90/100
[00:16<00:02,  3.37trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
 91%|██████████████████████████████████████████    | 91/100
[00:16<00:02,  3.88trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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UserWarning: The use of label encoder in XGBClassifier is deprecated
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  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

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[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021
```

```
 93%|██████████████████████████████████████████    | 93/100
[00:16<00:01,  4.71trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
 95%|████████████████████████████████████████████   | 95/100
[00:17<00:00,  5.25trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as
integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036
```

```
[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

 97%|█████████████████████████████████████████████▍ | 97/100
[00:17<00:00,  5.69trial/s, best loss: -0.6897880539499036]

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
UserWarning: The use of label encoder in XGBClassifier is deprecated
and will be removed in a future release. To remove this warning, do
the following: 1) Pass option use_label_encoder=False when
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224:
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[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[10]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021

[2]	validation_0-merror:0.29529	validation_1-merror:0.31021

[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:
```

```
0.6897880539499036

[0]	validation_0-merror:0.29529	validation_1-merror:0.31021



C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: 
UserWarning: The use of label encoder in XGBClassifier is deprecated 
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
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C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: 
UserWarning: The use of label encoder in XGBClassifier is deprecated 
and will be removed in a future release. To remove this warning, do 
the following: 1) Pass option use_label_encoder=False when 
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integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)


[2]	validation_0-merror:0.29529	validation_1-merror:0.31021
[4]	validation_0-merror:0.29529	validation_1-merror:0.31021

[6]	validation_0-merror:0.29529	validation_1-merror:0.31021

[8]	validation_0-merror:0.29529	validation_1-merror:0.31021

[9]	validation_0-merror:0.29529	validation_1-merror:0.31021

SCORE:

0.6897880539499036

100%|█████████████████████████████████████████████| 100/100 
[00:18<00:00,  5.55trial/s, best loss: -0.6897880539499036]

# Getting the best model
print("The best hyperparameters are : ","\n")
print(best_hyperparams)

The best hyperparameters are : 

{'colsample_bytree': 0.5356402785750933, 'gamma': 8.930986603401166, 
'max_depth': 9.0, 'min_child_weight': 1.0, 'reg_alpha': 119.0, 
'reg_lambda': 0.09812781449273855}

# Best model
clf=xgb.XGBClassifier(best_hyperparams)
```

```python
evaluation = [( X_train, y_train), ( X_test, y_test)]
clf.fit(X_train, y_train,
            eval_set=evaluation,
            early_stopping_rounds=10,verbose=2)
```

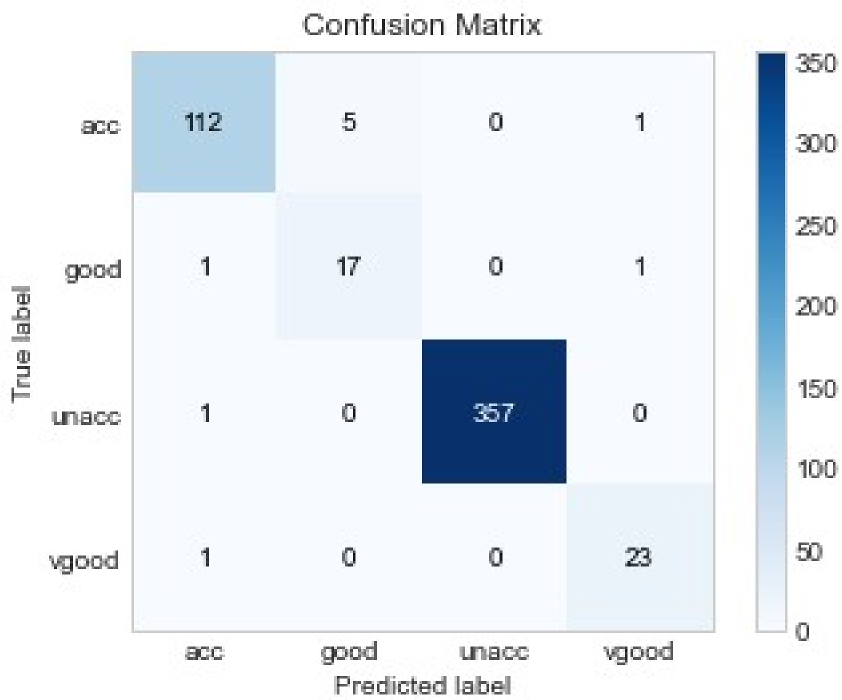
```
[08:15:56] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.5.0/src/learner.cc:1115: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[0]	validation_0-mlogloss:0.94153	validation_1-mlogloss:0.94379
[2]	validation_0-mlogloss:0.53773	validation_1-mlogloss:0.55620
[4]	validation_0-mlogloss:0.34786	validation_1-mlogloss:0.37244
[6]	validation_0-mlogloss:0.23741	validation_1-mlogloss:0.26699
[8]	validation_0-mlogloss:0.17458	validation_1-mlogloss:0.21000
[10]	validation_0-mlogloss:0.13339	validation_1-mlogloss:0.17272
[12]	validation_0-mlogloss:0.10732	validation_1-mlogloss:0.14942
[14]	validation_0-mlogloss:0.08744	validation_1-mlogloss:0.12898

C:\Users\hp\Anaconda3\lib\site-packages\xgboost\core.py:502: FutureWarning: Pass `objective` as keyword args.  Passing these as positional arguments will be considered as error in future releases.
  format(", ".join(args_msg)), FutureWarning
C:\Users\hp\Anaconda3\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)

[16]	validation_0-mlogloss:0.07224	validation_1-mlogloss:0.11262
[18]	validation_0-mlogloss:0.06176	validation_1-mlogloss:0.10467
[20]	validation_0-mlogloss:0.05197	validation_1-mlogloss:0.09462
[22]	validation_0-mlogloss:0.04259	validation_1-mlogloss:0.08466
[24]	validation_0-mlogloss:0.03656	validation_1-mlogloss:0.08024
[26]	validation_0-mlogloss:0.03204	validation_1-mlogloss:0.07596
[28]	validation_0-mlogloss:0.02850	validation_1-mlogloss:0.07431
[30]	validation_0-mlogloss:0.02557	validation_1-mlogloss:0.07131
[32]	validation_0-mlogloss:0.02324	validation_1-mlogloss:0.07019
[34]	validation_0-mlogloss:0.02097	validation_1-mlogloss:0.06757
[36]	validation_0-mlogloss:0.01961	validation_1-mlogloss:0.06629
[38]	validation_0-mlogloss:0.01840	validation_1-mlogloss:0.06548
[40]	validation_0-mlogloss:0.01672	validation_1-mlogloss:0.06358
[42]	validation_0-mlogloss:0.01589	validation_1-mlogloss:0.06396
[44]	validation_0-mlogloss:0.01541	validation_1-mlogloss:0.06414
[46]	validation_0-mlogloss:0.01478	validation_1-mlogloss:0.06455
[48]	validation_0-mlogloss:0.01420	validation_1-mlogloss:0.06383
[50]	validation_0-mlogloss:0.01369	validation_1-mlogloss:0.06387
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1,
enable_categorical=False,
              gamma=0, gpu_id=-1, importance_type=None,
              interaction_constraints='', learning_rate=0.300000012,
              max_delta_step=0, max_depth=6, min_child_weight=1,
missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=4,
              num_parallel_tree=1, objective='multi:softprob',
predictor='auto',
              random_state=0, reg_alpha=0, reg_lambda=1,
scale_pos_weight=None,
              subsample=1, tree_method='exact', validate_parameters=1,
              verbosity=None)
```

```
print("\n The model accuracy on train set
is",clf.score(X_train,y_train))
print("\n The model accuracy on test set is",clf.score(X_test,y_test))

y_predict=clf.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9807321772639692


 Classification Report
              precision    recall  f1-score   support

         acc       0.97      0.95      0.96       118
        good       0.77      0.89      0.83        19
       unacc       1.00      1.00      1.00       358
       vgood       0.92      0.96      0.94        24

    accuracy                           0.98       519
   macro avg       0.92      0.95      0.93       519
weighted avg       0.98      0.98      0.98       519
```

```
<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Updates

```
import category_encoders as ce
encoder = ce.OrdinalEncoder(cols=['buying', 'maint', 'doors',
'persons', 'lug_boot', 'safety'])
df = encoder.fit_transform(df)

from sklearn.preprocessing import PolynomialFeatures

# summarize the shape of the dataset
print(df.shape)
# summarize each variable
display(df.head(2))

# perform a polynomial features transform of the dataset
trans = PolynomialFeatures(degree=4)
data = trans.fit_transform(df.iloc[:,:-1])

# convert the array back to a dataframe
dataset = pd.DataFrame(data)

# summarize
display(dataset.head(2))
```

```
(1728, 7)
```

	buying	maint	doors	persons	lug_boot	safety	target
0	1	1	1	1	1	1	unacc
1	1	1	1	1	1	2	unacc

```
   0    1    2    3    4    5    6    7    8    9    ...  200  201  
202  203  \
0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  ...  1.0  1.0  
1.0  1.0   
1  1.0  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  ...  4.0  1.0  
2.0  4.0   

   204  205  206  207  208   209  
0  1.0  1.0  1.0  1.0  1.0   1.0  
1  8.0  1.0  2.0  4.0  8.0  16.0  

[2 rows x 210 columns]

# Getting X and y
X = dataset
y = df['target']

X.head()

   0    1    2    3    4    5    6    7    8    9    ...  200  201  
202  203  \
0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  ...  1.0  1.0  
1.0  1.0   
1  1.0  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  ...  4.0  1.0  
2.0  4.0   
2  1.0  1.0  1.0  1.0  1.0  1.0  3.0  1.0  1.0  1.0  ...  9.0  1.0  
3.0  9.0   
3  1.0  1.0  1.0  1.0  1.0  2.0  1.0  1.0  1.0  1.0  ...  1.0  8.0  
4.0  2.0   
4  1.0  1.0  1.0  1.0  1.0  2.0  2.0  1.0  1.0  1.0  ...  4.0  8.0  
8.0  8.0   

    204   205   206   207   208   209  
0   1.0   1.0   1.0   1.0   1.0   1.0  
1   8.0   1.0   2.0   4.0   8.0  16.0  
2  27.0   1.0   3.0   9.0  27.0  81.0  
3   1.0  16.0   8.0   4.0   2.0   1.0  
4   8.0  16.0  16.0  16.0  16.0  16.0  

[5 rows x 210 columns]

# importing necessary packages
from sklearn.metrics import 
accuracy_score,confusion_matrix,classification_report
from sklearn.tree import DecisionTreeClassifier
import scikitplot.metrics as skplt
from sklearn import tree
from sklearn.model_selection import train_test_split
```

```
# Splitting data into test train, using a 0.3 split
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)

# Exploring class distribution under train ,crossvalidation dataset
print('Training Dataset',X_train.shape,y_train.shape)
print('\n Class label distribution in Training Set\
n',y_train.value_counts())
print('\n***********')
print("\n CrossValidation Dataset",X_test.shape,y_test.shape)
print('\nClass label distribution in Cross Validation Set\
n',y_test.value_counts())
print('\n***********')
```

```
Training Dataset (1209, 210) (1209,)

 Class label distribution in Training Set
 unacc    852
acc      266
good      50
vgood     41
Name: target, dtype: int64

***********

 CrossValidation Dataset (519, 210) (519,)

Class label distribution in Cross Validation Set
 unacc    358
acc      118
vgood     24
good      19
Name: target, dtype: int64

***********
```

```
# Importing and defining the random search feature space.
from sklearn.ensemble import RandomForestClassifier

from sklearn.model_selection import RandomizedSearchCV

# Number of trees in random forest
n_estimators = [int(x) for x in range(400,1400,200)]
# Number of features to consider at every split
max_features = ['auto', 'sqrt']
# Maximum number of levels in tree
max_depth = [int(x) for x in np.linspace(2, 15, num = 1)]
max_depth.append(None)
# Minimum number of samples required to split a node
min_samples_split = [ 2,3, 4, 5, 7,10]
# Minimum number of samples required at each leaf node
```

```python
min_samples_leaf = [1, 2, 4, 5]
# Method of selecting samples for training each tree
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
print(random_grid)
```

```
{'n_estimators': [400, 600, 800, 1000, 1200], 'max_features': ['auto',
'sqrt'], 'max_depth': [2, None], 'min_samples_split': [2, 3, 4, 5, 7,
10], 'min_samples_leaf': [1, 2, 4, 5], 'bootstrap': [True, False]}
```

```python
# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestClassifier()
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available
cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions =
random_grid, n_iter = 50, cv = 3, verbose=2, random_state=42, n_jobs =
-1)
# Fit the random search model
rf_random.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 50 candidates, totalling 150 fits
```

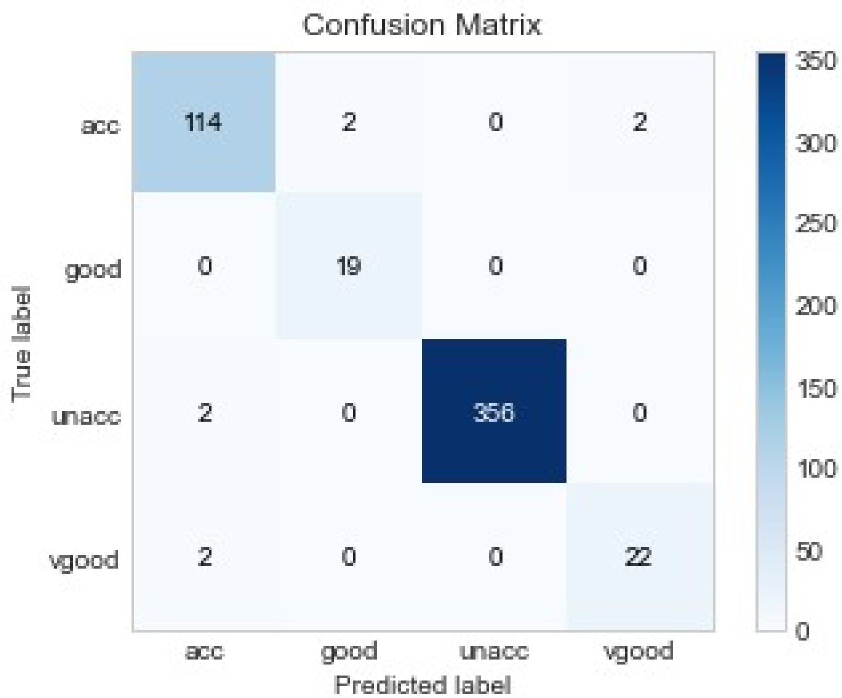
```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(),
n_iter=50,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [2, None],
                                        'max_features': ['auto',
'sqrt'],
                                        'min_samples_leaf': [1, 2, 4,
5],
                                        'min_samples_split': [2, 3, 4,
5, 7,
                                                              10],
                                        'n_estimators': [400, 600,
800, 1000,
                                                         1200]},
                   random_state=42, verbose=2)
```

```python
# Printing the best hyperparameters

rf_random.best_params_
```

```
{'n_estimators': 1000,
 'min_samples_split': 3,
 'min_samples_leaf': 2,
 'max_features': 'sqrt',
 'max_depth': None,
 'bootstrap': False}
```

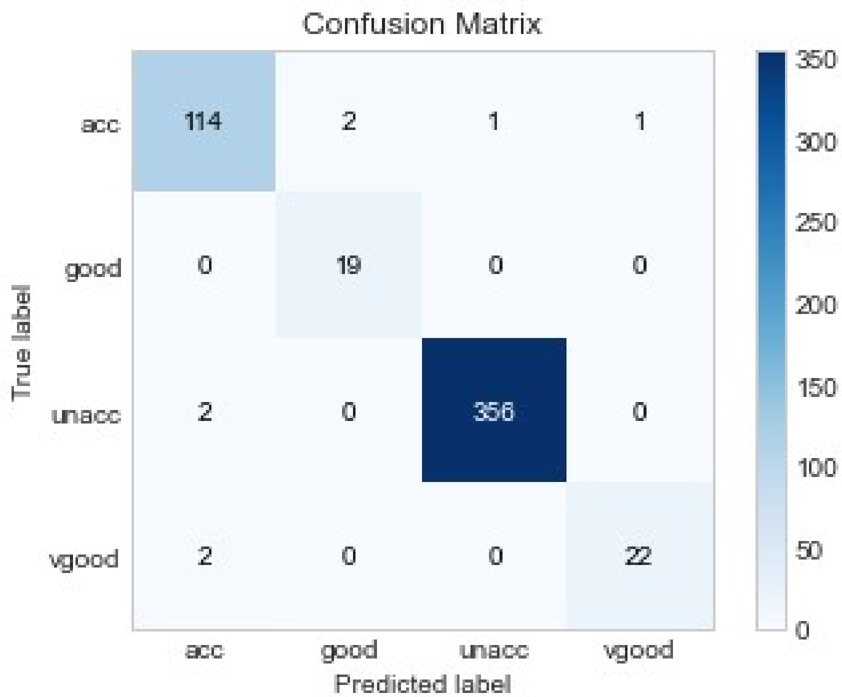
```python
# Checking accuracies on the train and test data, predicting on the test data.

print('The best model is ', rf_random.best_estimator_)
print("\n The best model parameters are ",rf_random.best_params_)
print("\n The model accuracy on train set is",rf_random.score(X_train,y_train))
print("\n The model accuracy on test set is",rf_random.score(X_test,y_test))

y_predict=rf_random.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  RandomForestClassifier(bootstrap=False, max_features='sqrt', min_samples_leaf=2,
                       min_samples_split=3, n_estimators=1000)

 The best model parameters are  {'n_estimators': 1000, 'min_samples_split': 3, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}

 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9845857418111753


 Classification Report
              precision    recall  f1-score   support

         acc       0.97      0.97      0.97       118
        good       0.90      1.00      0.95        19
       unacc       1.00      0.99      1.00       358
       vgood       0.92      0.92      0.92        24

    accuracy                           0.98       519
   macro avg       0.95      0.97      0.96       519
weighted avg       0.98      0.98      0.98       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted label', ylabel='True label'>
```



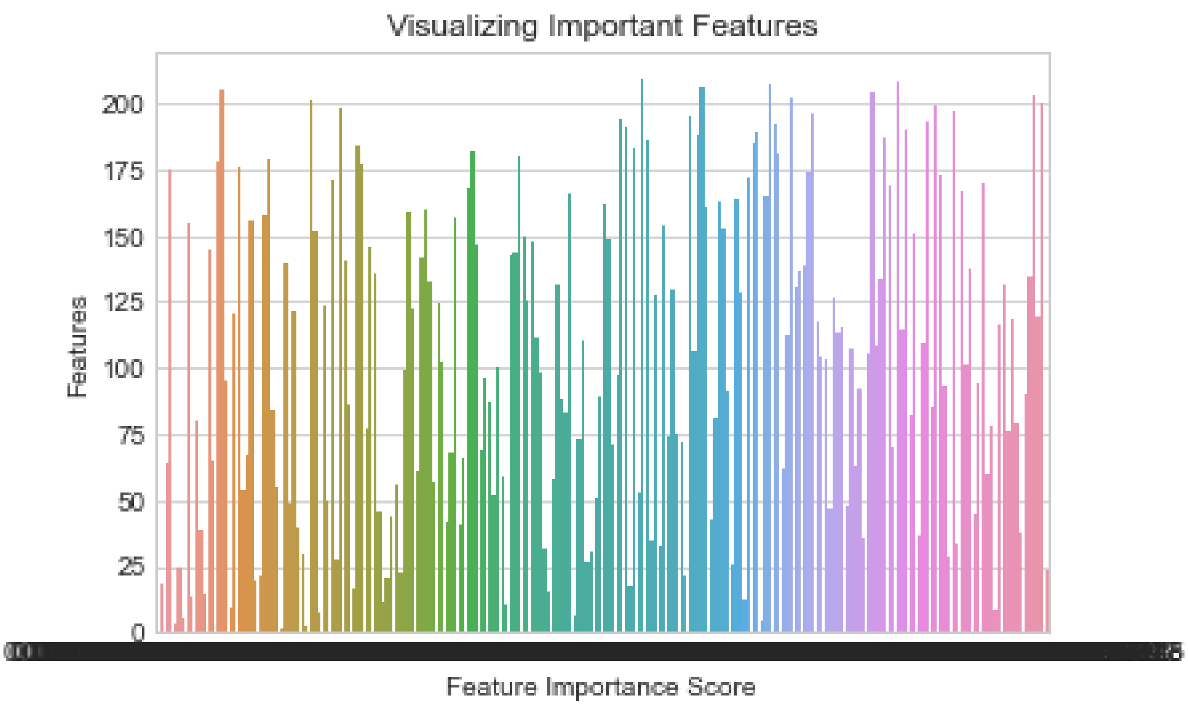

```
# Defining the model with the best parameters
clf = RandomForestClassifier(bootstrap=True, max_depth=None,
max_features='auto', min_samples_leaf=1, min_samples_split=3,
n_estimators = 1000)
clf.fit(X_train, y_train)

RandomForestClassifier(min_samples_split=3, n_estimators=1000)

print("\n The model accuracy on train set
is",clf.score(X_train,y_train))
print("\n The model accuracy on test set is",clf.score(X_test,y_test))

y_predict=clf.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)


 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9845857418111753


 Classification Report
              precision    recall  f1-score   support

         acc       0.97      0.97      0.97       118
        good       0.90      1.00      0.95        19
```

```
       unacc       1.00      0.99      1.00       358
       vgood       0.96      0.92      0.94        24

    accuracy                           0.98       519
   macro avg       0.96      0.97      0.96       519
weighted avg       0.98      0.98      0.98       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```




```
# view the feature scores

feature_scores = pd.Series(clf.feature_importances_,
index=X_train.columns).sort_values(ascending=False)

feature_scores

24      0.035130
200     0.032737
119     0.027746
203     0.024956
135     0.020424
          ...
3       0.000210
175     0.000153
64      0.000112
18      0.000102
```

```
0      0.000000
Length: 210, dtype: float64

# Creating a seaborn bar plot

sns.barplot(x=feature_scores, y=feature_scores.index)
# Add labels to the graph

plt.xlabel('Feature Importance Score')
plt.ylabel('Features')

# Add title to the graph
plt.title("Visualizing Important Features")

# Visualize the graph
plt.show()
```




```
list(feature_scores[feature_scores < 0.01].index)

[109,
 37,
 151,
 82,
 190,
 114,
 208,
 70,
 169,
```

```
187,
134,
108,
204,
105,
36,
92,
63,
107,
48,
115,
113,
126,
47,
103,
104,
117,
196,
174,
139,
137,
130,
202,
112,
62,
181,
192,
207,
165,
4,
189,
185,
172,
12,
128,
164,
26,
91,
153,
163,
81,
43,
161,
206,
188,
106,
195,
22,
72,
```

```
75,
129,
74,
154,
33,
127,
35,
186,
209,
53,
183,
17,
191,
194,
97,
71,
149,
162,
89,
51,
31,
27,
110,
73,
6,
166,
83,
88,
131,
58,
15,
32,
98,
111,
148,
125,
150,
180,
144,
143,
10,
59,
100,
52,
87,
96,
69,
147,
182,
```

```
168,
66,
41,
157,
68,
42,
102,
124,
57,
133,
160,
142,
61,
122,
159,
99,
23,
56,
44,
20,
11,
46,
136,
146,
77,
177,
184,
16,
86,
141,
198,
28,
171,
50,
123,
7,
152,
201,
2,
30,
40,
121,
49,
140,
1,
55,
84,
179,
158,
```

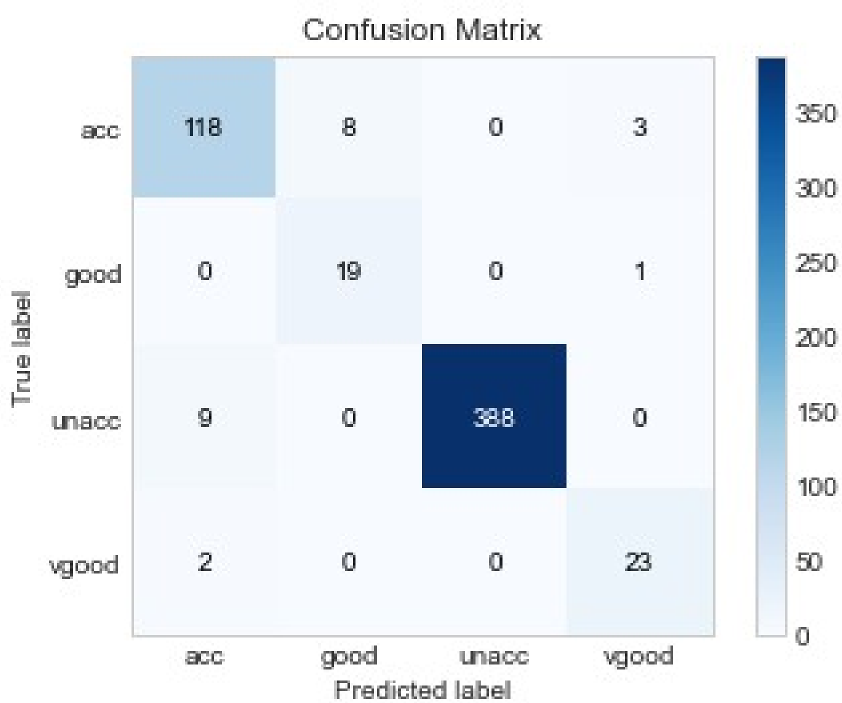
```
21,
19,
156,
67,
54,
176,
120,
9,
95,
205,
178,
65,
145,
14,
39,
80,
13,
155,
5,
25,
3,
175,
64,
18,
0]
```

Building a model on selected features without the least important feature

```
# declare feature vector and target variable, without the least
important feature

X1 = X.drop(list(feature_scores[feature_scores < 0.01].index), axis=1)

y1 = df['target']

# split data into training and testing sets

from sklearn.model_selection import train_test_split

X_train1, X_test1, y_train1, y_test1 = train_test_split(X1, y1,
test_size = 0.33, random_state = 42)

# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestClassifier()
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available
cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions =
random_grid, n_iter = 50, cv = 3, verbose=2, random_state=42, n_jobs =
```

```
-1)
# Fit the random search model
rf_random.fit(X_train1, y_train1)

Fitting 3 folds for each of 50 candidates, totalling 150 fits

RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(),
n_iter=50,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [2, None],
                                        'max_features': ['auto',
'sqrt'],
                                        'min_samples_leaf': [1, 2, 4,
5],
                                        'min_samples_split': [2, 3, 4,
5, 7,
                                                              10],
                                        'n_estimators': [400, 600,
800, 1000,
                                                         1200]},
                   random_state=42, verbose=2)

# Printing the best hyperparameters

rf_random.best_params_

{'n_estimators': 600,
 'min_samples_split': 7,
 'min_samples_leaf': 1,
 'max_features': 'auto',
 'max_depth': None,
 'bootstrap': True}

# Checking accuracies on the train and test data, predicting on the
test data.

print('The best model is ', rf_random.best_estimator_)
print("\n The best model parameters are ",rf_random.best_params_)
print("\n The model accuracy on train set
is",rf_random.score(X_train1,y_train1))
print("\n The model accuracy on test set
is",rf_random.score(X_test1,y_test1))

y_predict=rf_random.predict(X_test1)
accuracy=accuracy_score(y_test1,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test1,y_predict))
skplt.plot_confusion_matrix(y_test1,y_predict)
```

```
The best model is  RandomForestClassifier(min_samples_split=7,
n_estimators=600)

 The best model parameters are  {'n_estimators': 600,
'min_samples_split': 7, 'min_samples_leaf': 1, 'max_features': 'auto',
'max_depth': None, 'bootstrap': True}

 The model accuracy on train set is 0.9904926534140017

 The model accuracy on test set is 0.9597197898423818


 Classification Report
              precision    recall  f1-score   support

         acc       0.91      0.91      0.91       129
        good       0.70      0.95      0.81        20
       unacc       1.00      0.98      0.99       397
       vgood       0.85      0.92      0.88        25

    accuracy                           0.96       571
   macro avg       0.87      0.94      0.90       571
weighted avg       0.96      0.96      0.96       571


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```



Using SMOTE for Upsampling

```
X_train
```

```
      0    1    2    3    4    5    6     7     8     9    ...   200  
201  \
1178  1.0  3.0  3.0  4.0  2.0  3.0  3.0   9.0   9.0  12.0  ...  36.0  
54.0   
585   1.0  2.0  2.0  2.0  3.0  1.0  1.0   4.0   4.0   4.0  ...   9.0  
3.0   
1552  1.0  4.0  3.0  2.0  2.0  2.0  2.0  16.0  12.0   8.0  ...  16.0  
16.0   
1169  1.0  3.0  3.0  4.0  1.0  3.0  3.0   9.0   9.0  12.0  ...   9.0  
27.0   
1033  1.0  3.0  2.0  3.0  1.0  3.0  2.0   9.0   6.0   9.0  ...   4.0  
27.0   
...   ...  ...  ...  ...  ...  ...  ...   ...   ...   ...  ...   ...  
...   
1130  1.0  3.0  3.0  2.0  3.0  2.0  3.0   9.0   9.0   6.0  ...  81.0  
24.0   
1294  1.0  3.0  4.0  4.0  3.0  3.0  2.0   9.0  12.0  12.0  ...  36.0  
81.0   
860   1.0  2.0  4.0  4.0  3.0  2.0  3.0   4.0   8.0   8.0  ...  81.0  
24.0   
1459  1.0  4.0  2.0  3.0  1.0  1.0  2.0  16.0   8.0  12.0  ...   4.0  
1.0   
1126  1.0  3.0  3.0  2.0  3.0  1.0  2.0   9.0   9.0   6.0  ...  36.0  
3.0   

       202   203   204   205   206   207   208   209  
1178  54.0  54.0  54.0  81.0  81.0  81.0  81.0  81.0  
585    3.0   3.0   3.0   1.0   1.0   1.0   1.0   1.0  
1552  16.0  16.0  16.0  16.0  16.0  16.0  16.0  16.0  
1169  27.0  27.0  27.0  81.0  81.0  81.0  81.0  81.0  
1033  18.0  12.0   8.0  81.0  54.0  36.0  24.0  16.0  
...    ...   ...   ...   ...   ...   ...   ...   ...  
1130  36.0  54.0  81.0  16.0  24.0  36.0  54.0  81.0  
1294  54.0  36.0  24.0  81.0  54.0  36.0  24.0  16.0  
860   36.0  54.0  81.0  16.0  24.0  36.0  54.0  81.0  
1459   2.0   4.0   8.0   1.0   2.0   4.0   8.0  16.0  
1126   6.0  12.0  24.0   1.0   2.0   4.0   8.0  16.0  

[1209 rows x 210 columns]
```

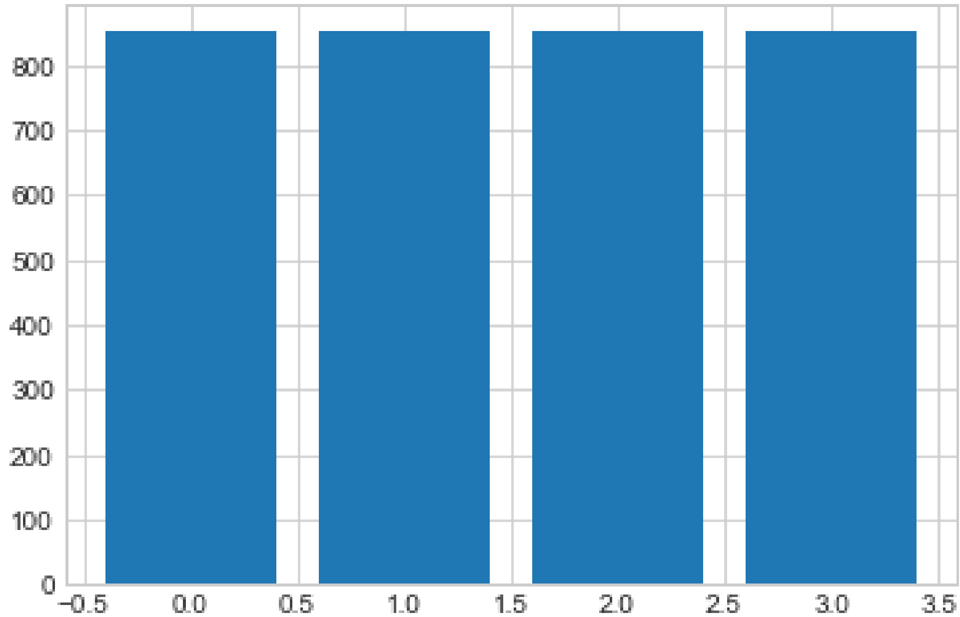
```
y_train
```

```
1178    vgood
585     unacc
1552      acc
1169    unacc
```

```
1033    unacc
         ...
1130    vgood
1294     good
860       acc
1459    unacc
1126      acc
Name: target, Length: 1209, dtype: object
```

```
from imblearn.over_sampling import SMOTE
from collections import Counter
from matplotlib import pyplot
from sklearn.preprocessing import LabelEncoder

# label encode the target variable
y = LabelEncoder().fit_transform(y_train)
# transform the dataset
oversample = SMOTE()
X, y = oversample.fit_resample(X_train, y)
# summarize distribution
counter = Counter(y)
for k,v in counter.items():
     per = v / len(y) * 100
     print('Class=%d, n=%d (%.3f%%)' % (k, v, per))
# plot the distribution
pyplot.bar(counter.keys(), counter.values())
pyplot.show()
```

```
Class=3, n=852 (25.000%)
Class=2, n=852 (25.000%)
Class=0, n=852 (25.000%)
Class=1, n=852 (25.000%)
```




```python
X_train = X
y_train = y

y_test = LabelEncoder().fit_transform(y_test)

# Importing and defining the random search feature space.
from sklearn.ensemble import RandomForestClassifier

from sklearn.model_selection import RandomizedSearchCV

# Number of trees in random forest
n_estimators = [int(x) for x in range(400,1400,200)]
# Number of features to consider at every split
max_features = ['auto', 'sqrt']
# Maximum number of levels in tree
max_depth = [int(x) for x in np.linspace(2, 15, num = 1)]
max_depth.append(None)
# Minimum number of samples required to split a node
min_samples_split = [ 2,3, 4, 5, 7,10]
# Minimum number of samples required at each leaf node
min_samples_leaf = [1, 2, 4, 5]
# Method of selecting samples for training each tree
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
```

```
                'bootstrap': bootstrap}
print(random_grid)
```

```
{'n_estimators': [400, 600, 800, 1000, 1200], 'max_features': ['auto',
'sqrt'], 'max_depth': [2, None], 'min_samples_split': [2, 3, 4, 5, 7,
10], 'min_samples_leaf': [1, 2, 4, 5], 'bootstrap': [True, False]}
```

```
# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestClassifier()
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available
cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions =
random_grid, n_iter = 30, cv = 3, verbose=2, random_state=42, n_jobs =
-1)
# Fit the random search model
rf_random.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 30 candidates, totalling 90 fits
```

```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(),
n_iter=30,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [2, None],
                                        'max_features': ['auto',
'sqrt'],
                                        'min_samples_leaf': [1, 2, 4,
5],
                                        'min_samples_split': [2, 3, 4,
5, 7,
                                                              10],
                                        'n_estimators': [400, 600,
800, 1000,
                                                         1200]},
                   random_state=42, verbose=2)
```

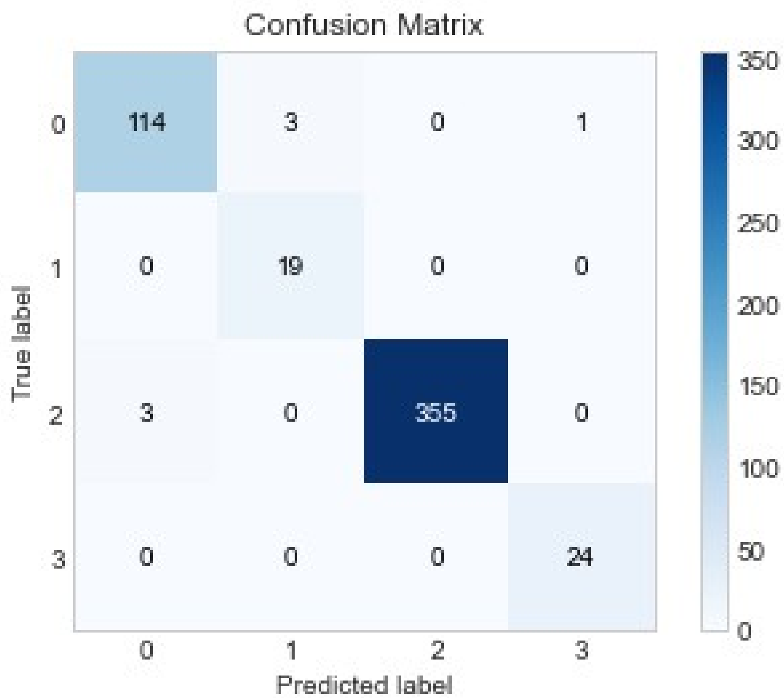
```
# Printing the best hyperparameters

rf_random.best_params_
```

```
{'n_estimators': 600,
 'min_samples_split': 5,
 'min_samples_leaf': 1,
 'max_features': 'auto',
 'max_depth': None,
 'bootstrap': False}
```

```
# Checking accuracies on the train and test data, predicting on the
test data.
```

```
print('The best model is ', rf_random.best_estimator_)
print("\n The best model parameters are ",rf_random.best_params_)
print("\n The model accuracy on train set
is",rf_random.score(X_train,y_train))
print("\n The model accuracy on test set
is",rf_random.score(X_test,y_test))

y_predict=rf_random.predict(X_test)
accuracy=accuracy_score(y_test,y_predict,normalize=True)*float(100)
print('\n\n Classification Report')
print(classification_report(y_test,y_predict))
skplt.plot_confusion_matrix(y_test,y_predict)
```

```
The best model is  RandomForestClassifier(bootstrap=False,
min_samples_split=5, n_estimators=600)

 The best model parameters are  {'n_estimators': 600,
'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto',
'max_depth': None, 'bootstrap': False}

 The model accuracy on train set is 1.0

 The model accuracy on test set is 0.9865125240847784


 Classification Report
              precision    recall  f1-score   support

           0       0.97      0.97      0.97       118
           1       0.86      1.00      0.93        19
           2       1.00      0.99      1.00       358
           3       0.96      1.00      0.98        24

    accuracy                           0.99       519
   macro avg       0.95      0.99      0.97       519
weighted avg       0.99      0.99      0.99       519


<AxesSubplot:title={'center':'Confusion Matrix'}, xlabel='Predicted
label', ylabel='True label'>
```


Confusion Matrix
True label
0
1
2
3
114
3
0
1
0
19
0
0
3
0
355
0
0
0
0
24
Predicted label
0
1
2
3
350
300
250
200
150
100
50
0

```python
# Importing the required Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler

# import SVC classifier
from sklearn.svm import SVC

# Hyperparameter tunning libraries
from sklearn.model_selection import RandomizedSearchCV

# import metrics to compute accuracy
from sklearn.metrics import accuracy_score, f1_score,
classification_report, confusion_matrix, roc_curve, roc_auc_score

# Reading the data
df_train = pd.read_csv('pulsar_data_train.csv')
df_test = pd.read_csv('pulsar_data_test.csv')

# Visualizing the dataframe
df_train.head()
```

```
    Mean of the integrated profile  \
0                       121.156250
1                        76.968750
2                       130.585938
3                       156.398438
4                        84.804688

    Standard deviation of the integrated profile  \
0                                      48.372971
1                                      36.175557
2                                      53.229534
3                                      48.865942
4                                      36.117659

    Excess kurtosis of the integrated profile  \
0                                   0.375485
1                                   0.712898
2                                   0.133408
3                                  -0.215989
4                                   0.825013

    Skewness of the integrated profile   Mean of the DM-SNR curve  \
0                            -0.013165                   3.168896
```

```
1                              3.388719                      2.399666
2                             -0.297242                      2.743311
3                             -0.171294                     17.471572
4                              3.274125                      2.790134

    Standard deviation of the DM-SNR curve  \
0                                18.399367
1                                17.570997
2                                22.362553
3                                      NaN
4                                20.618009

    Excess kurtosis of the DM-SNR curve   Skewness of the DM-SNR curve
\
0                              7.449874                      65.159298

1                              9.414652                     102.722975

2                              8.508364                      74.031324

3                              2.958066                       7.197842

4                              8.405008                      76.291128


   target_class
0           0.0
1           0.0
2           0.0
3           0.0
4           0.0
```

```
df_test.head()
```

```
    Mean of the integrated profile  \
0                       116.906250
1                        75.585938
2                       103.273438
3                       101.078125
4                       113.226562

    Standard deviation of the integrated profile  \
0                                      48.920605
1                                      34.386254
2                                      46.996628
3                                      48.587487
4                                      48.608804

    Excess kurtosis of the integrated profile  \
0                                    0.186046
1                                    2.025498
```

```
2                                    0.504295
3                                    1.011427
4                                    0.291538

    Skewness of the integrated profile   Mean of the DM-SNR curve  \
0                            -0.129815                   3.037625
1                             8.652913                   3.765050
2                             0.821088                   2.244983
3                             1.151870                  81.887960
4                             0.292120                   6.291806

    Standard deviation of the DM-SNR curve  \
0                                17.737102
1                                21.897049
2                                15.622566
3                                81.464136
4                                26.585056

    Excess kurtosis of the DM-SNR curve   Skewness of the DM-SNR curve
\
0                              8.122621                      78.813405

1                              7.048189                      55.878791

2                              9.330498                     105.134941

3                              0.485105                      -1.117904

4                              4.540138                      21.708268


   target_class
0           NaN
1           NaN
2           NaN
3           NaN
4           NaN
```

```python
# Checking the shape of the data
df_train.shape
```

```
(12528, 9)
```

```python
df_test.shape
```

```
(5370, 9)
```

```python
#Checking for null values and data types
df_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12528 entries, 0 to 12527
Data columns (total 9 columns):
 #   Column                                         Non-Null Count
Dtype
---  ------                                         --------------
-----
 0    Mean of the integrated profile                12528 non-null
float64
 1    Standard deviation of the integrated profile  12528 non-null
float64
 2    Excess kurtosis of the integrated profile     10793 non-null
float64
 3    Skewness of the integrated profile            12528 non-null
float64
 4    Mean of the DM-SNR curve                      12528 non-null
float64
 5    Standard deviation of the DM-SNR curve        11350 non-null
float64
 6    Excess kurtosis of the DM-SNR curve           12528 non-null
float64
 7    Skewness of the DM-SNR curve                  11903 non-null
float64
 8   target_class                                   12528 non-null
float64
dtypes: float64(9)
memory usage: 881.0 KB
```

```
df_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5370 entries, 0 to 5369
Data columns (total 9 columns):
 #   Column                                         Non-Null Count
Dtype
---  ------                                         --------------
-----
 0    Mean of the integrated profile                5370 non-null
float64
 1    Standard deviation of the integrated profile  5370 non-null
float64
 2    Excess kurtosis of the integrated profile     4603 non-null
float64
 3    Skewness of the integrated profile            5370 non-null
float64
 4    Mean of the DM-SNR curve                      5370 non-null
float64
 5    Standard deviation of the DM-SNR curve        4846 non-null
float64
 6    Excess kurtosis of the DM-SNR curve           5370 non-null
```

```
float64
 7    Skewness of the DM-SNR curve                     5126 non-null
float64
 8   target_class                                      0 non-null
float64
dtypes: float64(9)
memory usage: 377.7 KB
```

```python
# Null values
df_train.isnull().sum()
```

```
 Mean of the integrated profile                        0
 Standard deviation of the integrated profile          0
 Excess kurtosis of the integrated profile          1735
 Skewness of the integrated profile                    0
 Mean of the DM-SNR curve                              0
 Standard deviation of the DM-SNR curve             1178
 Excess kurtosis of the DM-SNR curve                   0
 Skewness of the DM-SNR curve                        625
target_class                                           0
dtype: int64
```

```python
# Null values
df_test.isnull().sum()
```

```
 Mean of the integrated profile                        0
 Standard deviation of the integrated profile          0
 Excess kurtosis of the integrated profile           767
 Skewness of the integrated profile                    0
 Mean of the DM-SNR curve                              0
 Standard deviation of the DM-SNR curve              524
 Excess kurtosis of the DM-SNR curve                   0
 Skewness of the DM-SNR curve                        244
target_class                                        5370
dtype: int64
```

```python
#description
df_train.describe().transpose()
```

```
                                                 count        mean  \
 Mean of the integrated profile                12528.0  111.041841
 Standard deviation of the integrated profile  12528.0   46.521437
 Excess kurtosis of the integrated profile     10793.0    0.478548
 Skewness of the integrated profile            12528.0    1.778431
 Mean of the DM-SNR curve                      12528.0   12.674758
 Standard deviation of the DM-SNR curve        11350.0   26.351318
 Excess kurtosis of the DM-SNR curve           12528.0    8.333489
 Skewness of the DM-SNR curve                  11903.0  105.525779
target_class                                   12528.0    0.092034

                                                      std
```

```
min  \
 Mean of the integrated profile                   25.672828   5.812500
 Standard deviation of the integrated profile      6.801077  24.772042
 Excess kurtosis of the integrated profile         1.064708  -1.738021
 Skewness of the integrated profile                6.208450  -1.791886
 Mean of the DM-SNR curve                         29.613230   0.213211
 Standard deviation of the DM-SNR curve           19.610842   7.370432
 Excess kurtosis of the DM-SNR curve               4.535783  -3.139270
 Skewness of the DM-SNR curve                    107.399585  -1.976976
target_class                                       0.289085   0.000000

                                                        25%         50%
\
 Mean of the integrated profile                  100.871094  115.183594
 Standard deviation of the integrated profile     42.362222   46.931022
 Excess kurtosis of the integrated profile         0.024652    0.223678
 Skewness of the integrated profile               -0.188142    0.203317
 Mean of the DM-SNR curve                          1.910535    2.792642
 Standard deviation of the DM-SNR curve           14.404353   18.412402
 Excess kurtosis of the DM-SNR curve               5.803063    8.451097
 Skewness of the DM-SNR curve                     35.199899   83.126301
target_class                                       0.000000    0.000000

                                                        75%          max
 Mean of the integrated profile                  127.109375   189.734375
 Standard deviation of the integrated profile     50.979103    91.808628
 Excess kurtosis of the integrated profile         0.473125     8.069522
 Skewness of the integrated profile                0.932374    68.101622
 Mean of the DM-SNR curve                          5.413253   222.421405
```

```
 Standard deviation of the DM-SNR curve          28.337418   110.642211

 Excess kurtosis of the DM-SNR curve             10.727927    34.539844

 Skewness of the DM-SNR curve                   139.997850  1191.000837

target_class                                      0.000000     1.000000
```

```
#description
df_test.describe().transpose()
```

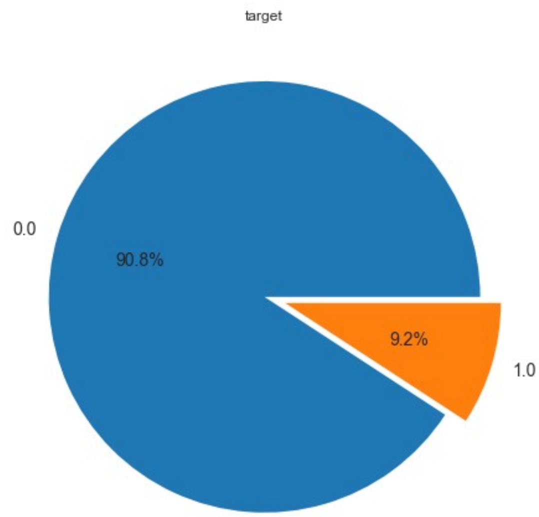
```
                                               count        mean
std  \
 Mean of the integrated profile               5370.0  111.168917
25.608635
 Standard deviation of the integrated profile  5370.0   46.615074
6.940638
 Excess kurtosis of the integrated profile     4603.0    0.483676
1.076893
 Skewness of the integrated profile            5370.0    1.751260
6.072820
 Mean of the DM-SNR curve                      5370.0   12.473587
29.145134
 Standard deviation of the DM-SNR curve        4846.0   26.425371
19.384489
 Excess kurtosis of the DM-SNR curve           5370.0    8.233724
4.435683
 Skewness of the DM-SNR curve                  5126.0  102.869088
104.748418
target_class                                     0.0         NaN
NaN

                                                    min
25%  \
 Mean of the integrated profile                 6.179688  101.041016

 Standard deviation of the integrated profile  24.791612   42.408020

 Excess kurtosis of the integrated profile     -1.876011    0.030643

 Skewness of the integrated profile            -1.764717   -0.189557

 Mean of the DM-SNR curve                       0.213211    1.956522

 Standard deviation of the DM-SNR curve         7.370432   14.555826

 Excess kurtosis of the DM-SNR curve           -2.721857    5.700461

 Skewness of the DM-SNR curve                  -1.964998   33.817330
```

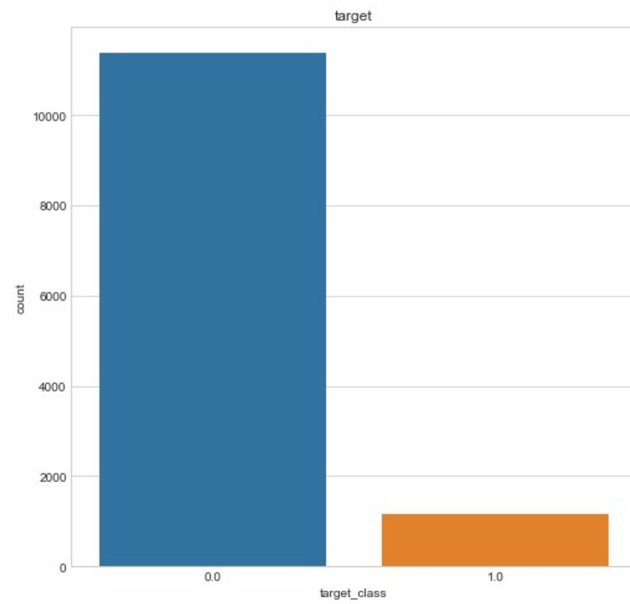
```
target_class                                             NaN        NaN


                                                          50%        75%
\
 Mean of the integrated profile                    114.757812  127.023438

 Standard deviation of the integrated profile       47.031304   51.133444

 Excess kurtosis of the integrated profile           0.227314    0.475056

 Skewness of the integrated profile                  0.186468    0.918807

 Mean of the DM-SNR curve                            2.830686    5.590301

 Standard deviation of the DM-SNR curve             18.549670   28.681787

 Excess kurtosis of the DM-SNR curve                 8.383695   10.632265

 Skewness of the DM-SNR curve                       81.392046  136.893502

target_class                                              NaN        NaN


                                                          max
 Mean of the integrated profile                    192.617188
 Standard deviation of the integrated profile       98.778911
 Excess kurtosis of the integrated profile           7.608370
 Skewness of the integrated profile                 65.385974
 Mean of the DM-SNR curve                          223.392141
 Standard deviation of the DM-SNR curve            109.712649
 Excess kurtosis of the DM-SNR curve                34.539844
 Skewness of the DM-SNR curve                     1191.000837
target_class                                              NaN
```

```
#Plotting target distribution
f,ax=plt.subplots(1,2,figsize=(18,8))
df_train['target_class'].value_counts().plot.pie(ax = ax[0],
explode=[0,0.1],autopct='%1.1f%%',shadow=False, textprops={'fontsize':
14})
ax[0].set_title('target')
ax[0].set_ylabel('')
sns.countplot('target_class',data=df_train,ax=ax[1])
ax[1].set_title('target')
```

```
C:\Users\hp\Anaconda3\lib\site-packages\seaborn\_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
```

```
error or misinterpretation.
  FutureWarning

Text(0.5, 1.0, 'target')
```





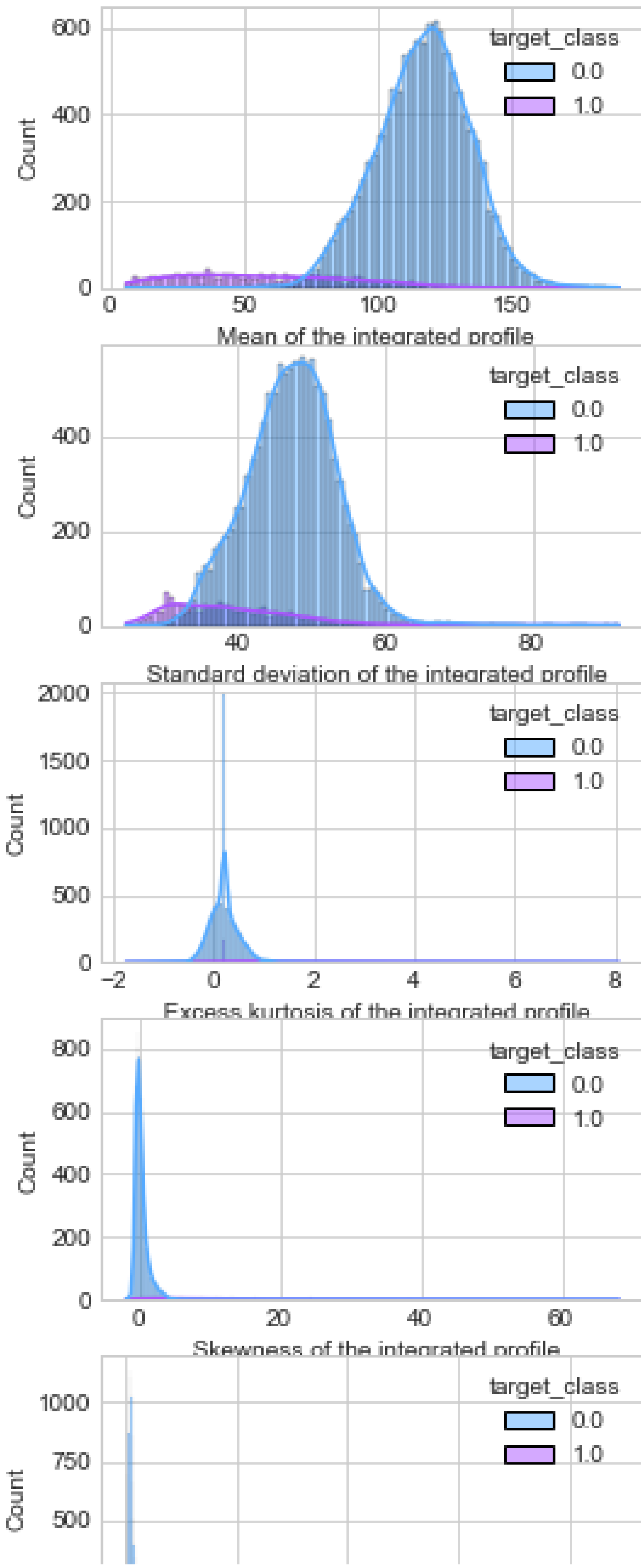
Preprocessing

```
# Checking the column names
df_train.columns

Index([' Mean of the integrated profile',
       ' Standard deviation of the integrated profile',
       ' Excess kurtosis of the integrated profile',
       ' Skewness of the integrated profile', ' Mean of the DM-SNR
curve',
       ' Standard deviation of the DM-SNR curve',
       ' Excess kurtosis of the DM-SNR curve', ' Skewness of the DM-
SNR curve',
       'target_class'],
      dtype='object')

# Getting the feature and target matrices
target = df_train["target_class"]
features = df_train.drop("target_class", axis=1)
```

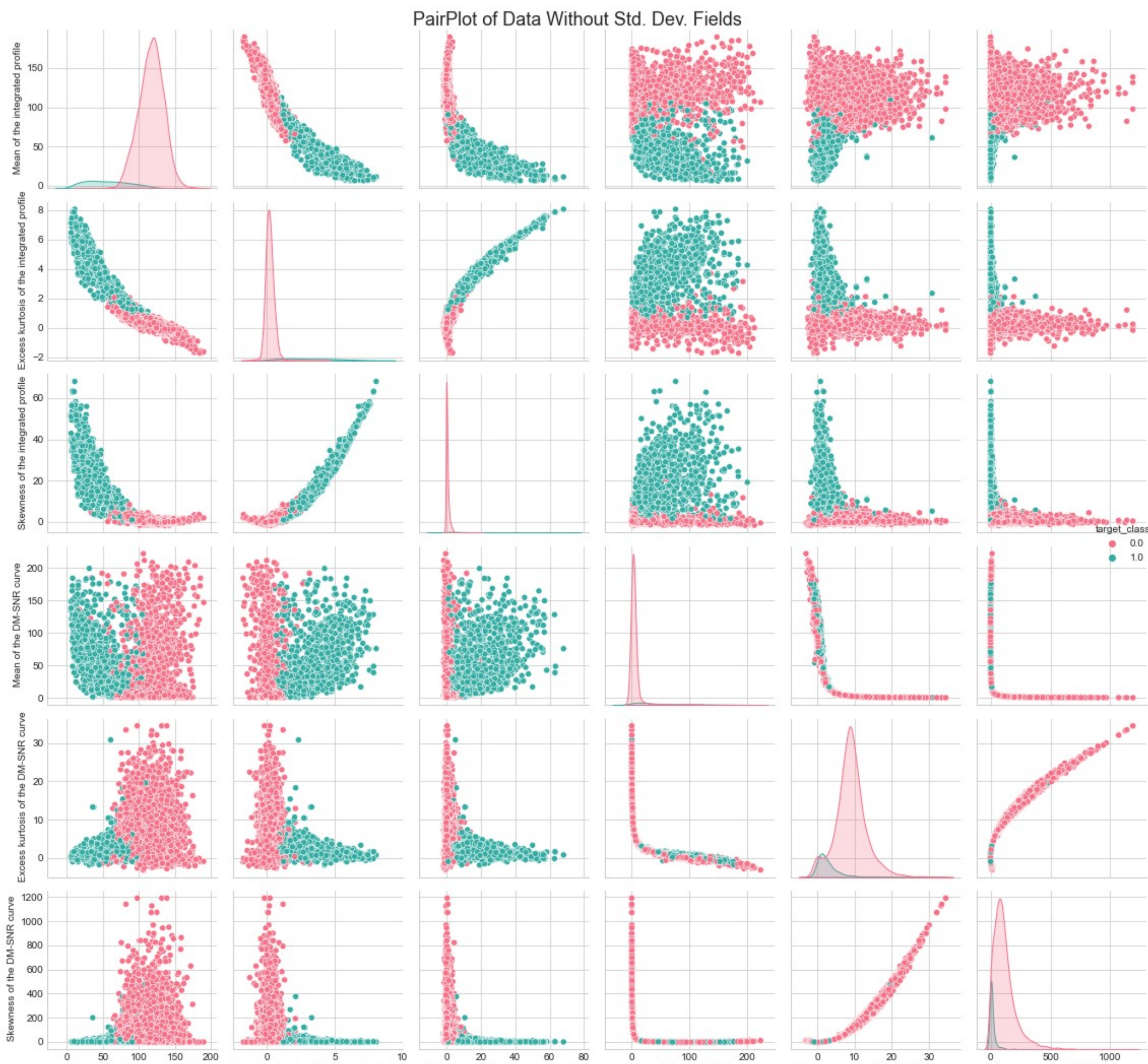
EDA

```
# Creating histplots
fig, axes = plt.subplots(nrows=8, ncols=1, figsize=(4,20))
```

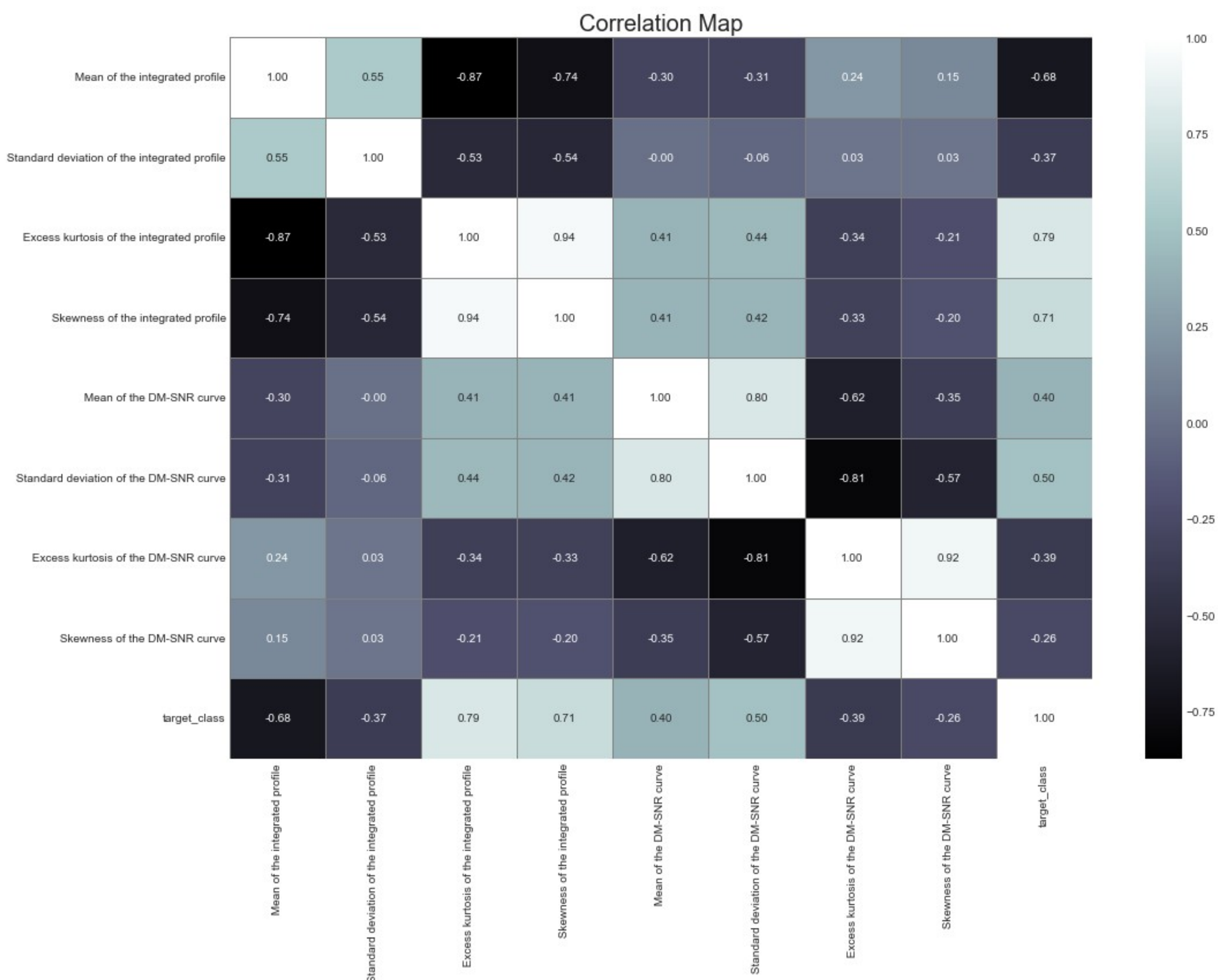
```
for i in range(len(features.columns)):
    col = features.columns[i]
    sns.histplot(x=df_train[col], hue=target, palette="cool",
kde=True, ax=axes[i])
plt.show()
```


target_class
0.0
1.0
Count
Mean of the integrated profile
Standard deviation of the integrated profile
Excess kurtosis of the integrated profile
Skewness of the integrated profile
0
200
400
600
800
1000
1500
2000
750
500
50
100
150
20
40
60
80
−2
2
4
6
8

```python
# Pairplotusing seaborn
sns.pairplot(data=df_train,
             palette="husl",
             hue="target_class",
             vars=[" Mean of the integrated profile",
                   " Excess kurtosis of the integrated profile",
                   " Skewness of the integrated profile",
                   " Mean of the DM-SNR curve",
                   " Excess kurtosis of the DM-SNR curve",
                   " Skewness of the DM-SNR curve"])

plt.suptitle("PairPlot of Data Without Std. Dev. Fields",fontsize=18)

plt.tight_layout()
plt.show()
```



```
#Plotting the Correlation Heatmap
plt.figure(figsize=(16,12))
sns.heatmap(data=df_train.corr(),annot=True,cmap="bone",linewidths=1,f
mt=".2f",linecolor="gray")
plt.title("Correlation Map",fontsize=20)
plt.tight_layout()
plt.show()
```



Handling Missing Values

```
3 Computing the median for the three features with null values
median1 = df_train[' Excess kurtosis of the integrated
profile'].median()
median2 = df_train[' Standard deviation of the DM-SNR curve'].median()
median3 = df_train[' Skewness of the DM-SNR curve'].median()

# Imputing the null values
df_train[' Excess kurtosis of the integrated profile'] = df_train['
Excess kurtosis of the integrated profile'].fillna(median1)
```

```
df_test[' Excess kurtosis of the integrated profile'] = df_test['
Excess kurtosis of the integrated profile'].fillna(median1)

df_train[' Standard deviation of the DM-SNR curve'] = df_train['
Standard deviation of the DM-SNR curve'].fillna(median1)
df_test[' Standard deviation of the DM-SNR curve'] = df_test['
Standard deviation of the DM-SNR curve'].fillna(median1)

df_train[' Skewness of the DM-SNR curve'] = df_train[' Skewness of the
DM-SNR curve'].fillna(median1)
df_test[' Skewness of the DM-SNR curve'] = df_test[' Skewness of the
DM-SNR curve'].fillna(median1)

# Checking for null values again
df_train.isna().sum()
```

```
 Mean of the integrated profile                   0
 Standard deviation of the integrated profile    0
 Excess kurtosis of the integrated profile       0
 Skewness of the integrated profile              0
 Mean of the DM-SNR curve                        0
 Standard deviation of the DM-SNR curve          0
 Excess kurtosis of the DM-SNR curve             0
 Skewness of the DM-SNR curve                    0
target_class                                     0
dtype: int64
```

```
df_test.isna().sum()
```

```
 Mean of the integrated profile                     0
 Standard deviation of the integrated profile       0
 Excess kurtosis of the integrated profile          0
 Skewness of the integrated profile                 0
 Mean of the DM-SNR curve                           0
 Standard deviation of the DM-SNR curve             0
 Excess kurtosis of the DM-SNR curve                0
 Skewness of the DM-SNR curve                       0
target_class                                     5370
dtype: int64
```

Modelling

```
# Splitting into test and train data
xtrain, xtest, ytrain, ytest = train_test_split(features, target,
test_size=0.2)

print(xtrain.shape)
print(xtest.shape)
```

```
(10022, 8)
(2506, 8)

# Using standard scalar to scale
ss = StandardScaler()
ss.fit(xtrain)
xtrain_array = ss.transform(xtrain)
xtest_array = ss.transform(xtest)

xtrain = pd.DataFrame(xtrain_array, columns = xtrain.columns)
xtest = pd.DataFrame(xtest_array, columns=xtest.columns)
```

Running SVM with default hyperparameters

Default hyperparameter means C=1.0, kernel=rbf and gamma=auto among other parameters.

```
xtrain.fillna(0, inplace=True)
xtest.fillna(0, inplace=True)

# instantiate classifier with default hyperparameters
svc=SVC()


# fit classifier to training set
svc.fit(xtrain,ytrain)


# make predictions on test set
y_pred=svc.predict(xtest)


# compute and print accuracy score
print('Model accuracy score with default hyperparameters: {0:0.4f}'.
format(accuracy_score(ytest, y_pred)))
print('Model f1 score with default hyperparameters: {0:0.4f}'.
format(f1_score(ytest, y_pred)))

Model accuracy score with default hyperparameters: 0.9741
Model f1 score with default hyperparameters: 0.8426
```

Using Random Search to find the best hyperparameters

```
# USing grid search
svc_clf = SVC()
params = [{
    'C':np.arange(0.01,10.0,0.1),
    'kernel':['linear','poly','rbf','sigmoid'],
    'degree':range(1,20),
    "gamma" : ['scale','auto'],
    'probability':[True],
```

```
    'class_weight':['balanced'],
    'random_state':[21],
    'max_iter':[-1],
}]


random_search_svc_clf = RandomizedSearchCV(svc_clf, scoring = 'f1',
param_distributions=params, n_jobs = -1, return_train_score = True,
n_iter=100, cv=2, random_state=21)
random_search_svc_clf.fit(xtrain,ytrain)
print("Best parameters scores:")
print(random_search_svc_clf.best_params_)
df = pd.DataFrame(random_search_svc_clf.cv_results_)
print("Mean Train Score:",
random_search_svc_clf.cv_results_['mean_train_score']
[df[df['mean_test_score']==random_search_svc_clf.best_score_].index]
[0])
print("Mean Validation score:", random_search_svc_clf.best_score_)
```

```
Best parameters scores:
{'random_state': 21, 'probability': True, 'max_iter': -1, 'kernel':
'rbf', 'gamma': 'auto', 'degree': 9, 'class_weight': 'balanced', 'C':
2.51}
Mean Train Score: 0.8691440763105074
Mean Validation score: 0.8572325581395349
```

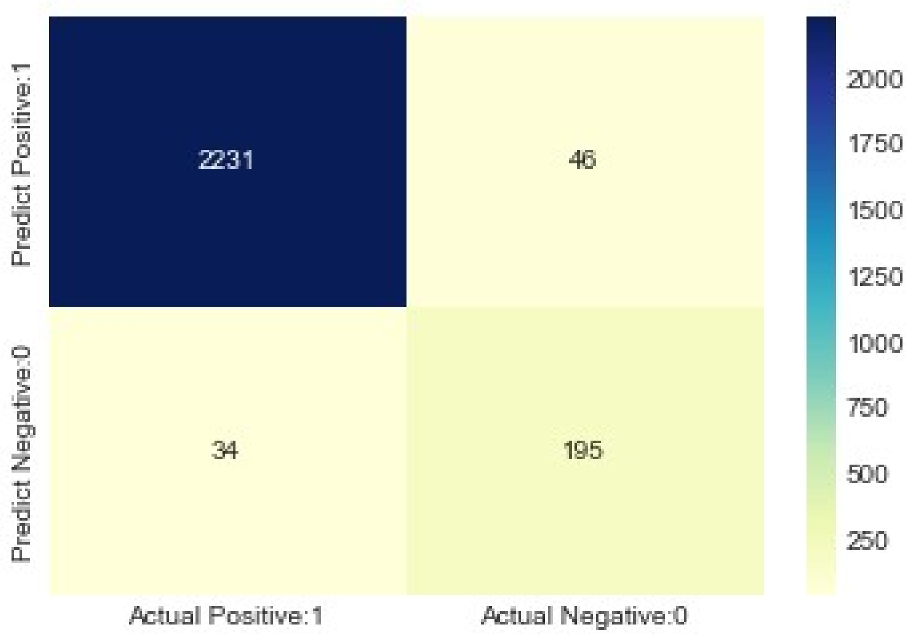
Building the best model

```
clf = SVC(random_state=21, probability= True, max_iter= -1, kernel=
'rbf', gamma= 'auto', degree = 9, class_weight= 'balanced', C= 2.51)

# fit classifier to training set
clf.fit(xtrain,ytrain)


# make predictions on test set
y_pred=clf.predict(xtest)

cm = confusion_matrix(ytest, y_pred)

print('Confusion matrix\n\n', cm)

print('\nTrue Positives(TP) = ', cm[0,0])

print('\nTrue Negatives(TN) = ', cm[1,1])

print('\nFalse Positives(FP) = ', cm[0,1])

print('\nFalse Negatives(FN) = ', cm[1,0])
```

```
Confusion matrix

 [[2231   46]
 [  34  195]]

True Positives(TP) =  2231

True Negatives(TN) =  195

False Positives(FP) =  46

False Negatives(FN) =  34
```

```python
# visualize confusion matrix with seaborn heatmap

cm_matrix = pd.DataFrame(data=cm, columns=['Actual Positive:1',
'Actual Negative:0'],
                                 index=['Predict Positive:1', 'Predict
Negative:0'])

sns.heatmap(cm_matrix, annot=True, fmt='d', cmap='YlGnBu')
```

```
<AxesSubplot:>
```

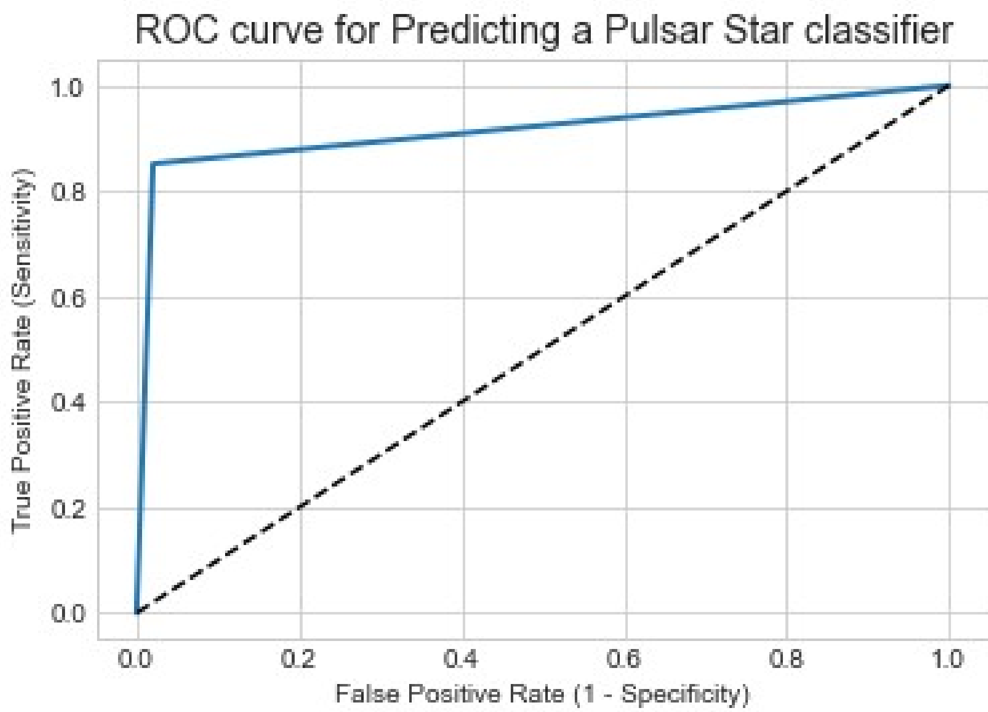



```python
print(classification_report(ytest, y_pred))
```

```
              precision    recall  f1-score   support

         0.0       0.98      0.98      0.98      2277
         1.0       0.81      0.85      0.83       229
```

```
    accuracy                           0.97      2506
   macro avg       0.90      0.92      0.91      2506
weighted avg       0.97      0.97      0.97      2506


TP = cm[0,0]
TN = cm[1,1]
FP = cm[0,1]
FN = cm[1,0]

# print precision score

precision = TP / float(TP + FP)
print('Precision : {0:0.4f}'.format(precision))

recall = TP / float(TP + FN)
print('Recall or Sensitivity : {0:0.4f}'.format(recall))

true_positive_rate = TP / float(TP + FN)
print('True Positive Rate : {0:0.4f}'.format(true_positive_rate))

false_positive_rate = FP / float(FP + TN)
print('False Positive Rate : {0:0.4f}'.format(false_positive_rate))

specificity = TN / (TN + FP)
print('Specificity : {0:0.4f}'.format(specificity))

Precision : 0.9798
Recall or Sensitivity : 0.9850
True Positive Rate : 0.9850
False Positive Rate : 0.1909
Specificity : 0.8091

# plot ROC Curve

fpr, tpr, thresholds = roc_curve(ytest, y_pred)

plt.figure(figsize=(6,4))

plt.plot(fpr, tpr, linewidth=2)

plt.plot([0,1], [0,1], 'k--' )

plt.rcParams['font.size'] = 12

plt.title('ROC curve for Predicting a Pulsar Star classifier')

plt.xlabel('False Positive Rate (1 - Specificity)')

plt.ylabel('True Positive Rate (Sensitivity)')
```

```
plt.show()
```




```
ROC_AUC = roc_auc_score(ytest, y_pred)

print('ROC AUC : {:.4f}'.format(ROC_AUC))

ROC AUC : 0.9157
```