

Predicting Customer Churn using ML methods

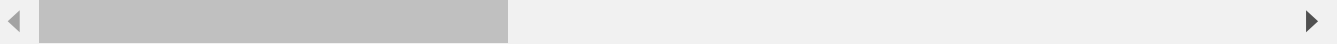
```
In [1]: #import basic Libraries
import os,sys
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
sns.set()
import warnings
warnings.filterwarnings('ignore')
```

```
In [2]: #import dataset
dataset=pd.read_csv('Telcom Data.csv')
dataset.head()
```

```
Out[2]:
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service
1	5575-GNVDE	Male	0	No	No	34	Yes	No
2	3668-QPYBK	Male	0	No	No	2	Yes	No
3	7795-CFOCW	Male	0	No	No	45	No	No phone service
4	9237-HQITU	Female	0	No	No	2	Yes	No

5 rows × 21 columns



```
In [3]: dataset.shape
```

```
Out[3]: (7043, 21)
```

```
In [4]: dataset1=dataset.copy()
```

```
In [5]: dataset.info()
```

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
#   Column                Non-Null Count  Dtype
---  -
0   customerID            7043 non-null   object
1   gender                 7043 non-null   object
2   SeniorCitizen          7043 non-null   int64
3   Partner                7043 non-null   object
4   Dependents             7043 non-null   object
5   tenure                 7043 non-null   int64
6   PhoneService           7043 non-null   object
7   MultipleLines           7043 non-null   object
8   InternetService        7043 non-null   object
9   OnlineSecurity         7043 non-null   object
10  OnlineBackup            7043 non-null   object
11  DeviceProtection       7043 non-null   object
12  TechSupport            7043 non-null   object
13  StreamingTV            7043 non-null   object
14  StreamingMovies        7043 non-null   object
15  Contract               7043 non-null   object
16  PaperlessBilling       7043 non-null   object
17  PaymentMethod          7043 non-null   object
18  MonthlyCharges         7043 non-null   float64
19  TotalCharges           7043 non-null   object
20  Churn                  7043 non-null   object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB

```

```

In [6]: # Total Charges given as object ,check for values
for i in dataset.columns:
    print('*****',i,'*****')
    print()
    print(set(dataset[i].tolist()))
    print()

```

***** customerID *****

{ '5624-BQSSA', '7209-JCUDS', '1062-LHZOD', '2969-VAPYH', '7779-LGOVN', '0795-XCCT
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H', '1837-YQUCE', '7598-UAASY', '4625-EWPTF', '4250-FDVOU', '3313-QKNKB', '3908-MK
IMJ', '3196-NVXLZ', '3727-JEZTU', '1352-HNSAW', '5127-BZENZ', '1066-JKSGK', '7580-
UGXNC', '1897-RCFUM', '4592-IWTJI', '4800-CZMPC', '9499-XPZXM', '5271-YNWVR', '546
8-BPMMO', '1403-LKLIK', '1448-CYWKC', '7203-OYKCT', '4906-ZHGPK', '8946-BFWSG', '5
046-NUHWD', '3703-VAVCL', '5651-YLPRD', '4385-GZQXV', '7672-VFMXZ', '5377-NDTOU',
'3170-NMYVV', '8022-BECsI', '8089-UZWLX', '3590-TCXTB', '3807-BPOMJ', '1597-FZRE
H', '1455-HFBXA', '5386-THSLQ', '1092-GANHU', '6979-TNDEU', '5141-ZUVBH', '1475-VW
VDO', '4312-GVYNH', '9334-GWGOW', '2546-KZAAT', '3221-CJMSG', '4832-VRBMR', '8792-
AOROI', '4547-FZJWE', '2300-RQGOI', '9055-MOJjJ', '8229-BUJHX', '0219-QAERP', '588
4-FBCTL', '6928-ONTRW', '2501-XWWTZ', '2979-SXESE', '9631-KEYKE', '6142-VSjQO', '3
005-TYFRD', '6797-LNAQX', '2815-CPTUL', '9776-CLUJA', '7762-URZQH', '1626-ERCMM',
'1574-DYCWE', '3090-QFUVd', '5317-FLPJF', '6345-FZOQH', '0707-HOVVN', '7581-EBBO
U', '5561-NWEVX', '3401-URHDA', '0749-IRGQE', '9788-YTFGE', '6892-XPFPu', '1258-YM
ZNM', '5787-KXGIY', '9081-WWxKP', '0661-WCQnQ', '5753-QQWPW', '6169-PGNCD', '8992-
VONJD', '6629-CZTTH', '7730-IUTDZ', '9448-REEVD', '4138-NAXED', '1707-HABPF', '051
6-OOHAR', '6016-LVTJQ', '5397-NSKQG', '4369-NYSCF', '0684-AOSIH', '9112-WSNPU', '5
287-QWLKY', '0523-VNGTF', '0374-FIUCA', '9351-LZYGf', '4139-DETXS', '7881-INRLC',
'4640-UHDOS', '8185-UPYBR', '6686-YPGhk', '8782-NUUOL', '9972-EWRJS', '5639-NTUP
K', '1265-XTECC', '9971-ZWPBF', '7634-WSWDB', '8780-IXSTS', '7067-KSAZT', '7641-TQ
FHN', '4080-IIARD', '1656-DRSMG', '3372-KWFBM', '2690-DVRVK', '4143-OOBWZ', '9214-
EKVXR', '8071-SBTRN', '5649-TJHOV', '2070-XYMFH', '0420-BWTPW', '1347-KTTTA', '407
7-HWUYD', '5077-DXTCG', '5650-VDUDS', '4404-HIBDJ', '1550-LOAHA', '7526-BEZQB', '7
398-HPYZQ', '7872-RDDLZ', '8242-JSVBO', '8824-RWFXJ', '8571-ZCMCX', '6794-HKIAJ',
'6752-APNJL', '5893-PYOLZ', '3646-ITDGM', '3763-GCZHZ', '0871-OPBXW', '7163-OCEQ
I', '3247-ZVOUO', '5044-LRQAQ'}

***** gender *****

{'Male', 'Female'}

***** SeniorCitizen *****

```
{0, 1}

***** Partner *****

{'No', 'Yes'}

***** Dependents *****

{'No', 'Yes'}

***** tenure *****

{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 4
3, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63,
64, 65, 66, 67, 68, 69, 70, 71, 72}

***** PhoneService *****

{'No', 'Yes'}

***** MultipleLines *****

{'No phone service', 'Yes', 'No'}

***** InternetService *****

{'No', 'Fiber optic', 'DSL'}

***** OnlineSecurity *****

{'No', 'No internet service', 'Yes'}

***** OnlineBackup *****

{'No', 'No internet service', 'Yes'}

***** DeviceProtection *****

{'No', 'No internet service', 'Yes'}

***** TechSupport *****

{'No', 'No internet service', 'Yes'}

***** StreamingTV *****

{'No', 'No internet service', 'Yes'}

***** StreamingMovies *****

{'No', 'No internet service', 'Yes'}

***** Contract *****

{'Month-to-month', 'Two year', 'One year'}

***** PaperlessBilling *****

{'No', 'Yes'}

***** PaymentMethod *****
```

{'Credit card (automatic)', 'Bank transfer (automatic)', 'Mailed check', 'Electronic check'}

***** MonthlyCharges *****

{18.95, 19.8, 20.65, 20.15, 20.2, 20.75, 24.95, 20.4, 24.25, 25.9, 19.95, 29.75, 29.85, 30.2, 24.3, 33.75, 30.15, 31.05, 35.45, 29.95, 30.4, 39.65, 35.9, 40.2, 42.3, 42.1, 44.35, 45.25, 45.55, 45.65, 45.3, 49.95, 49.55, 49.25, 49.05, 53.85, 54.4, 55.2, 56.95, 56.15, 55.3, 59.9, 59.6, 55.65, 54.65, 62.15, 64.7, 64.15, 66.15, 64.5, 66.85, 69.7, 70.7, 69.2, 69.5, 70.45, 74.8, 74.85, 76.2, 75.3, 78.9, 79.85, 80.65, 79.75, 79.2, 74.75, 84.5, 79.35, 82.05, 84.0, 85.2, 89.1, 90.05, 90.25, 89.9, 91.65, 94.4, 95.5, 96.35, 97.85, 95.45, 99.65, 100.35, 99.35, 102.45, 102.7, 103.8, 103.4, 104.15, 104.4, 104.6, 105.35, 108.0, 109.2, 103.7, 104.8, 105.5, 106.7, 108.45, 111.6, 110.5, 113.25, 111.05, 112.25, 24.75, 115.1, 115.05, 116.05, 25.25, 24.5, 25.75, 25.0, 25.5, 26.25, 26.0, 26.5, 28.5, 29.5, 29.25, 30.75, 30.5, 30.25, 31.0, 33.5, 34.25, 34.5, 34.0, 35.75, 35.5, 35.0, 35.25, 36.0, 36.25, 36.5, 38.5, 38.25, 39.0, 39.5, 40.25, 40.0, 40.75, 43.75, 43.25, 44.0, 44.75, 44.25, 44.5, 45.0, 45.75, 45.5, 46.0, 46.25, 48.75, 48.25, 49.5, 49.0, 49.75, 50.25, 50.0, 50.5, 50.75, 51.25, 51.0, 51.75, 51.5, 52.5, 52.0, 53.75, 53.5, 53.0, 54.75, 54.25, 54.0, 54.5, 55.0, 55.5, 55.25, 55.75, 56.0, 56.75, 56.25, 56.5, 57.75, 57.5, 58.75, 58.25, 58.5, 58.0, 59.75, 59.0, 59.5, 59.25, 60.0, 60.25, 60.5, 60.75, 61.5, 61.25, 61.75, 61.0, 62.25, 62.5, 63.25, 63.75, 64.25, 64.75, 64.0, 65.0, 65.5, 65.75, 65.25, 66.5, 66.25, 66.0, 66.75, 67.25, 67.5, 67.75, 68.75, 68.5, 68.25, 69.75, 69.0, 69.25, 70.0, 70.5, 70.75, 70.25, 71.5, 71.0, 71.25, 71.75, 72.75, 72.25, 72.0, 73.25, 73.5, 73.0, 73.75, 74.5, 74.25, 74.0, 75.0, 75.25, 75.5, 75.75, 76.5, 76.0, 76.75, 76.25, 77.75, 77.0, 77.5, 78.75, 78.0, 78.5, 78.25, 79.25, 79.5, 79.0, 80.0, 80.25, 80.5, 80.75, 81.0, 81.25, 81.5, 81.75, 82.5, 82.75, 82.0, 83.25, 83.75, 83.5, 83.0, 84.25, 84.75, 85.75, 85.5, 85.0, 85.25, 86.75, 86.0, 86.5, 86.25, 87.0, 87.25, 87.75, 88.0, 88.5, 88.75, 88.25, 89.25, 89.0, 89.75, 89.5, 90.0, 90.5, 90.75, 18.25, 18.75, 91.0, 91.5, 91.25, 91.75, 92.0, 92.5, 93.0, 93.5, 93.25, 93.75, 94.5, 94.25, 94.75, 94.0, 95.25, 95.0, 95.75, 19.5, 19.75, 19.25, 96.75, 96.5, 19.0, 96.0, 96.25, 97.0, 97.75, 97.25, 98.75, 98.25, 98.5, 98.0, 99.25, 99.0, 99.75, 99.5, 100.0, 100.75, 100.25, 20.25, 20.5, 101.75, 100.5, 20.0, 101.0, 101.5, 102.5, 102.0, 101.25, 102.25, 103.75, 103.25, 103.0, 103.5, 104.0, 104.5, 104.75, 104.25, 105.0, 105.25, 21.0, 21.25, 105.75, 106.0, 106.75, 106.5, 106.25, 107.5, 107.25, 107.0, 107.75, 108.5, 108.25, 108.75, 109.25, 109.5, 109.75, 109.0, 110.0, 110.75, 110.25, 111.25, 111.5, 111.75, 112.75, 113.0, 113.75, 114.5, 114.0, 114.75, 115.75, 115.0, 23.75, 115.5, 115.25, 116.25, 116.75, 116.0, 116.5, 23.5, 117.5, 118.75, 24.0, 18.4, 18.9, 19.4, 19.9, 19.65, 19.15, 20.9, 21.15, 23.65, 23.4, 23.9, 23.15, 24.9, 24.4, 24.15, 24.65, 25.15, 25.4, 25.65, 26.4, 26.9, 29.65, 29.9, 29.15, 29.4, 30.9, 31.65, 33.15, 33.65, 33.9, 34.65, 34.4, 35.4, 35.65, 35.15, 36.65, 36.15, 38.9, 39.9, 39.4, 39.15, 40.4, 40.65, 40.15, 40.9, 41.15, 41.9, 42.9, 42.4, 43.65, 43.9, 44.4, 44.65, 44.9, 44.15, 45.4, 45.15, 45.9, 46.4, 47.15, 47.4, 48.15, 48.9, 48.65, 48.4, 49.15, 49.9, 49.4, 49.65, 50.65, 50.15, 50.9, 50.4, 51.65, 51.4, 51.15, 52.15, 53.65, 53.9, 53.4, 53.15, 54.9, 54.15, 55.15, 55.9, 55.4, 56.4, 56.9, 56.65, 57.15, 57.65, 58.65, 58.9, 58.4, 59.4, 59.65, 59.15, 60.9, 60.15, 60.65, 60.4, 61.65, 61.9, 61.4, 61.15, 62.65, 63.15, 63.4, 63.9, 18.55, 64.9, 64.4, 64.65, 65.15, 65.65, 19.05, 65.4, 65.9, 66.4, 66.9, 66.65, 67.65, 67.4, 68.65, 68.4, 68.9, 68.15, 69.65, 69.9, 69.15, 69.4, 70.9, 70.15, 70.4, 70.65, 71.15, 71.9, 71.4, 71.65, 72.65, 72.9, 72.15, 73.9, 73.15, 73.65, 74.9, 74.4, 74.65, 74.15, 75.9, 75.15, 75.65, 75.4, 21.3, 76.9, 76.65, 76.4, 76.15, 77.4, 77.15, 77.9, 77.65, 78.4, 78.65, 78.15, 79.9, 79.15, 79.4, 79.65, 80.9, 80.4, 80.15, 81.15, 81.4, 81.65, 81.9, 82.4, 82.9, 82.65, 82.15, 83.4, 83.15, 83.9, 83.65, 84.15, 84.9, 84.4, 84.65, 85.4, 85.65, 85.15, 85.9, 23.05, 86.65, 86.15, 86.4, 86.9, 87.65, 87.9, 87.4, 87.15, 88.15, 88.9, 88.65, 88.4, 89.15, 89.65, 89.4, 75.05, 90.4, 90.15, 90.65, 90.9, 91.4, 91.15, 92.9, 92.65, 92.15, 92.4, 93.15, 93.4, 93.9, 93.65, 94.9, 94.65, 94.15, 76.55, 95.15, 95.4, 95.65, 95.9, 96.65, 96.15, 96.9, 96.4, 97.65, 97.9, 98.65, 98.9, 98.15, 98.4, 99.9, 99.4, 99.15, 77.8, 77.55, 100.9, 100.15, 100.65, 100.4, 101.9, 101.15, 101.4, 102.15, 102.65, 102.9, 102.4, 103.9, 103.15, 103.65, 104.65, 104.9, 105.65, 105.15, 105.9, 105.4, 106.9, 106.4, 106.65, 106.15, 107.15, 107.65, 107.9, 107.4, 108.15, 108.65, 108.4, 108.9, 109.9, 109.4, 109.15, 109.65, 110.65, 110.15, 110.9, 111.9, 111.65, 111.15, 111.4, 112.4, 112.9, 113.65, 113.4, 113.15, 114.65, 114.9, 115.65, 115.15, 29.3, 116.15, 116.4, 117.15, 118.65, 33.55, 34.55, 34.8, 34.05, 34.3, 35.8, 35.55, 35.05, 35.3, 36.05, 38.55, 38.8, 39.3, 39.5

5, 39.05, 40.05, 40.3, 40.55, 41.05, 43.8, 43.55, 43.3, 43.05, 44.8, 44.3, 44.05, 44.55, 45.05, 45.8, 46.3, 46.05, 47.8, 47.05, 48.55, 48.8, 49.3, 49.8, 50.55, 50.05, 50.3, 50.8, 51.8, 51.05, 51.55, 51.3, 52.55, 52.3, 53.8, 53.3, 53.55, 54.8, 54.3, 54.55, 54.05, 55.05, 55.8, 55.55, 56.8, 56.05, 56.3, 56.55, 57.8, 57.55, 58.55, 59.8, 59.3, 59.55, 59.05, 60.3, 60.05, 60.8, 60.55, 61.05, 61.8, 61.55, 61.3, 62.8, 62.05, 62.55, 62.3, 63.3, 63.55, 63.8, 63.05, 64.8, 64.05, 64.3, 64.55, 65.55, 65.8, 65.05, 65.3, 66.8, 66.05, 66.3, 67.8, 67.05, 68.55, 68.8, 68.05, 68.3, 18.8, 69.3, 69.55, 69.05, 69.8, 19.3, 70.8, 70.05, 19.55, 70.3, 20.3, 71.55, 20.55, 20.05, 20.8, 70.55, 72.8, 21.05, 71.05, 71.3, 71.8, 73.8, 73.55, 73.05, 73.3, 23.8, 74.3, 74.05, 23.3, 23.55, 24.55, 24.05, 74.55, 24.8, 75.55, 25.3, 75.8, 25.05, 76.05, 25.55, 26.8, 26.05, 26.3, 76.8, 25.8, 76.3, 78.05, 78.3, 78.55, 78.8, 77.3, 79.3, 79.05, 79.55, 79.8, 29.05, 80.55, 29.8, 80.05, 80.3, 30.3, 81.8, 81.3, 80.8, 81.05, 81.55, 82.3, 30.55, 30.05, 82.55, 83.3, 83.55, 83.8, 83.05, 84.55, 84.8, 84.3, 84.05, 85.8, 85.3, 85.05, 85.55, 86.8, 86.05, 86.3, 86.55, 87.05, 87.55, 87.8, 87.3, 88.55, 88.05, 88.8, 88.3, 89.05, 89.55, 89.8, 89.3, 90.3, 90.55, 90.8, 91.3, 91.55, 91.05, 91.8, 92.05, 92.55, 92.3, 93.05, 93.8, 93.55, 93.3, 94.05, 94.8, 94.3, 94.55, 95.05, 95.8, 95.3, 95.55, 96.05, 96.8, 96.55, 96.3, 97.55, 97.8, 97.05, 98.3, 98.8, 98.05, 98.55, 99.3, 99.8, 99.05, 99.55, 100.8, 100.55, 100.05, 100.3, 101.05, 101.55, 101.3, 101.8, 102.05, 102.55, 102.8, 103.05, 103.3, 104.3, 104.55, 104.05, 105.3, 105.55, 105.05, 105.8, 106.05, 106.8, 106.55, 106.3, 107.05, 107.55, 108.55, 108.05, 108.3, 108.8, 109.55, 109.8, 109.05, 109.3, 110.05, 110.3, 110.8, 110.55, 111.55, 111.8, 111.3, 112.55, 113.3, 113.05, 113.8, 114.05, 114.55, 114.3, 115.8, 115.55, 116.8, 116.3, 116.55, 117.8, 18.7, 19.2, 19.45, 19.7, 20.7, 20.45, 20.95, 21.2, 21.45, 22.95, 23.95, 23.45, 24.7, 24.45, 24.2, 25.7, 25.2, 25.45, 25.95, 26.2, 26.45, 28.45, 29.45, 29.2, 29.7, 30.45, 31.2, 33.45, 33.7, 34.7, 34.2, 34.95, 35.7, 35.2, 36.45, 37.7, 39.7, 39.2, 39.95, 39.45, 40.7, 40.45, 41.95, 43.95, 43.7, 43.45, 44.95, 44.45, 44.7, 44.2, 45.7, 45.95, 45.2, 45.45, 46.2, 47.95, 48.95, 48.7, 48.2, 48.45, 49.2, 49.45, 49.7, 50.2, 50.45, 50.95, 50.7, 51.2, 51.7, 51.45, 52.2, 52.7, 53.95, 53.45, 53.7, 54.7, 54.2, 54.45, 54.95, 55.45, 55.95, 55.7, 56.45, 56.7, 56.2, 57.95, 57.45, 57.2, 58.45, 58.95, 58.7, 58.2, 59.95, 59.45, 59.2, 59.7, 60.45, 60.2, 60.7, 60.95, 61.2, 61.95, 61.45, 62.7, 62.45, 63.95, 63.7, 64.95, 64.2, 64.45, 65.2, 65.7, 65.45, 66.7, 66.2, 67.45, 67.95, 67.2, 67.7, 68.95, 68.7, 68.45, 69.45, 69.95, 70.2, 70.95, 71.7, 71.45, 71.95, 72.95, 72.45, 72.2, 73.2, 73.45, 73.95, 73.7, 74.2, 74.7, 74.45, 74.95, 75.95, 75.45, 75.7, 75.2, 76.45, 76.95, 77.95, 77.2, 78.45, 78.95, 78.2, 78.7, 79.95, 79.45, 79.7, 80.95, 80.7, 80.45, 80.2, 81.95, 81.45, 81.7, 81.2, 82.95, 82.45, 82.7, 83.7, 83.2, 83.45, 83.95, 84.2, 84.95, 84.7, 84.45, 85.95, 85.45, 85.7, 86.2, 86.45, 86.95, 86.7, 87.95, 87.2, 87.45, 87.7, 88.95, 88.2, 88.45, 88.7, 89.7, 89.2, 89.45, 89.95, 90.95, 90.45, 90.7, 90.2, 91.7, 91.2, 91.45, 91.95, 92.2, 92.95, 92.45, 92.7, 93.95, 93.45, 93.2, 93.7, 94.45, 94.2, 94.7, 94.95, 95.2, 95.95, 95.7, 96.7, 96.2, 96.95, 97.45, 97.95, 97.2, 97.7, 98.7, 98.2, 98.45, 99.45, 99.7, 99.95, 99.2, 100.45, 100.7, 100.95, 100.2, 101.45, 101.95, 101.7, 102.95, 103.2, 103.45, 103.95, 104.95, 104.7, 104.45, 104.2, 105.45, 105.2, 105.95, 105.7, 106.45, 106.95, 106.2, 107.95, 107.45, 107.2, 107.7, 108.95, 108.2, 109.7, 109.95, 109.45, 110.45, 110.2, 110.7, 111.95, 111.2, 111.45, 112.95, 112.2, 113.2, 113.45, 113.95, 114.95, 114.7, 114.45, 114.2, 116.45, 116.95, 116.2, 117.2, 117.45, 118.2, 64.35, 64.85, 64.6, 64.1, 65.35, 65.85, 65.1, 65.6, 66.35, 66.1, 66.6, 67.85, 67.6, 68.85, 68.6, 68.35, 68.1, 69.35, 69.85, 69.1, 69.6, 70.35, 70.6, 70.85, 70.1, 71.1, 71.35, 71.6, 71.85, 72.1, 72.85, 72.35, 72.6, 73.6, 73.85, 73.35, 73.1, 74.35, 74.6, 74.1, 75.35, 75.6, 75.1, 75.85, 76.1, 76.85, 76.35, 76.6, 77.35, 77.85, 78.85, 78.1, 78.6, 78.35, 79.1, 79.6, 80.6, 80.35, 80.1, 80.85, 81.85, 81.35, 81.1, 81.6, 82.85, 82.1, 82.35, 83.35, 83.85, 83.6, 84.6, 84.85, 84.35, 84.1, 85.1, 85.35, 85.6, 85.85, 86.1, 86.6, 86.85, 86.35, 87.35, 87.1, 87.6, 88.1, 88.6, 88.85, 88.35, 89.85, 89.35, 89.6, 90.85, 90.35, 90.1, 90.6, 91.35, 91.1, 91.85, 91.6, 92.1, 92.35, 92.85, 92.6, 93.35, 93.85, 93.6, 94.35, 94.85, 94.1, 94.6, 95.6, 95.1, 95.35, 95.85, 96.1, 96.85, 96.6, 97.1, 97.35, 98.85, 98.6, 98.35, 98.1, 99.1, 99.85, 99.6, 100.6, 100.85, 100.1, 101.35, 101.1, 101.6, 101.85, 102.1, 102.85, 102.6, 102.35, 103.1, 103.85, 103.35, 103.6, 104.1, 104.85, 104.35, 105.1, 105.6, 105.85, 106.35, 106.6, 106.1, 106.85, 107.35, 107.6, 108.1, 108.85, 108.6, 108.35, 109.85, 109.6, 109.1, 110.85, 110.35, 110.1, 110.6, 111.35, 111.1, 112.6, 112.1, 112.35, 113.1, 113.6, 113.35, 114.35, 114.85, 114.1, 114.6, 115.6, 115.85, 116.1, 116.85, 116.6, 117.6, 117.35, 118.6, 118.35, 18.85, 19.6, 19.35, 19.85, 19.1, 20.85, 20.6, 20.1, 20.35, 21.1, 23.6, 23.85, 24.1, 24.85, 24.6, 24.35, 25.35, 25.6, 25.1, 25.85, 26.1, 26.35, 28.6, 29.6, 29.35, 29.1, 30.1, 30.85, 30.35, 30.6, 31.35, 31.1, 33.6, 34.6, 34.85, 35.6,

35.1, 35.35, 36.1, 36.85, 38.6, 38.1, 38.85, 39.6, 39.1, 39.85, 39.35, 40.6, 40.3
5, 40.1, 41.35, 41.1, 41.6, 42.6, 42.35, 43.85, 43.35, 43.6, 44.6, 44.85, 44.1, 4
5.6, 45.35, 45.85, 45.1, 46.35, 46.1, 46.6, 47.85, 47.6, 48.6, 48.85, 48.35, 49.8
5, 49.35, 49.1, 49.6, 50.6, 50.35, 50.1, 50.85, 51.6, 51.35, 51.1, 52.1, 52.85, 5
3.6, 53.1, 53.35, 54.1, 54.6, 54.85, 54.35, 55.1, 55.35, 55.85, 55.6, 56.6, 56.35,
56.1, 56.85, 57.6, 58.6, 58.35, 58.85, 59.85, 59.1, 60.85, 60.35, 60.6, 60.1, 61.
6, 61.35, 61.1, 62.1, 62.85, 63.85, 63.35, 63.6, 63.1}

***** TotalCharges *****

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5.3', '1020.2', '1745.5', '57.5', '3038.55'}

```

***** Churn *****

```
{'No', 'Yes'}
```

```
In [7]: dataset['TotalCharges'].value_counts()    #11 space as values
```

```

Out[7]:
20.2      11
19.75      9
20.05      8
19.9       8
..
6849.4     1
692.35     1
130.15     1
3211.9     1
6844.5     1
Name: TotalCharges, Length: 6531, dtype: int64

```

```

In [8]: dataset['TotalCharges']=dataset['TotalCharges'].replace(" ",np.nan)
dataset['TotalCharges']=dataset['TotalCharges'].fillna(dataset['TotalCharges'].medi

```

```
In [9]: dataset['TotalCharges']=dataset['TotalCharges'].astype('float')
```

```
In [10]: dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column                Non-Null Count  Dtype
---  -
 0   customerID            7043 non-null   object
 1   gender                7043 non-null   object
 2   SeniorCitizen         7043 non-null   int64
 3   Partner               7043 non-null   object
 4   Dependents            7043 non-null   object
 5   tenure               7043 non-null   int64
 6   PhoneService          7043 non-null   object
 7   MultipleLines         7043 non-null   object
 8   InternetService       7043 non-null   object
 9   OnlineSecurity        7043 non-null   object
10   OnlineBackup          7043 non-null   object
11   DeviceProtection      7043 non-null   object
12   TechSupport           7043 non-null   object
13   StreamingTV           7043 non-null   object
14   StreamingMovies       7043 non-null   object
15   Contract              7043 non-null   object
16   PaperlessBilling      7043 non-null   object
17   PaymentMethod         7043 non-null   object
18   MonthlyCharges        7043 non-null   float64
19   TotalCharges          7043 non-null   float64
20   Churn                 7043 non-null   object
dtypes: float64(2), int64(2), object(17)
memory usage: 1.1+ MB
```

```
In [11]: dataset=dataset.drop(['customerID'],axis=1)
```

Missing Values

```
In [12]: dataset.isnull().sum()
```

```
Out[12]: gender                0
SeniorCitizen                0
Partner                     0
Dependents                   0
tenure                      0
PhoneService                 0
MultipleLines                0
InternetService              0
OnlineSecurity               0
OnlineBackup                 0
DeviceProtection             0
TechSupport                  0
StreamingTV                  0
StreamingMovies              0
Contract                     0
PaperlessBilling             0
PaymentMethod                0
MonthlyCharges               0
TotalCharges                 0
Churn                        0
dtype: int64
```

Outlier Treatment

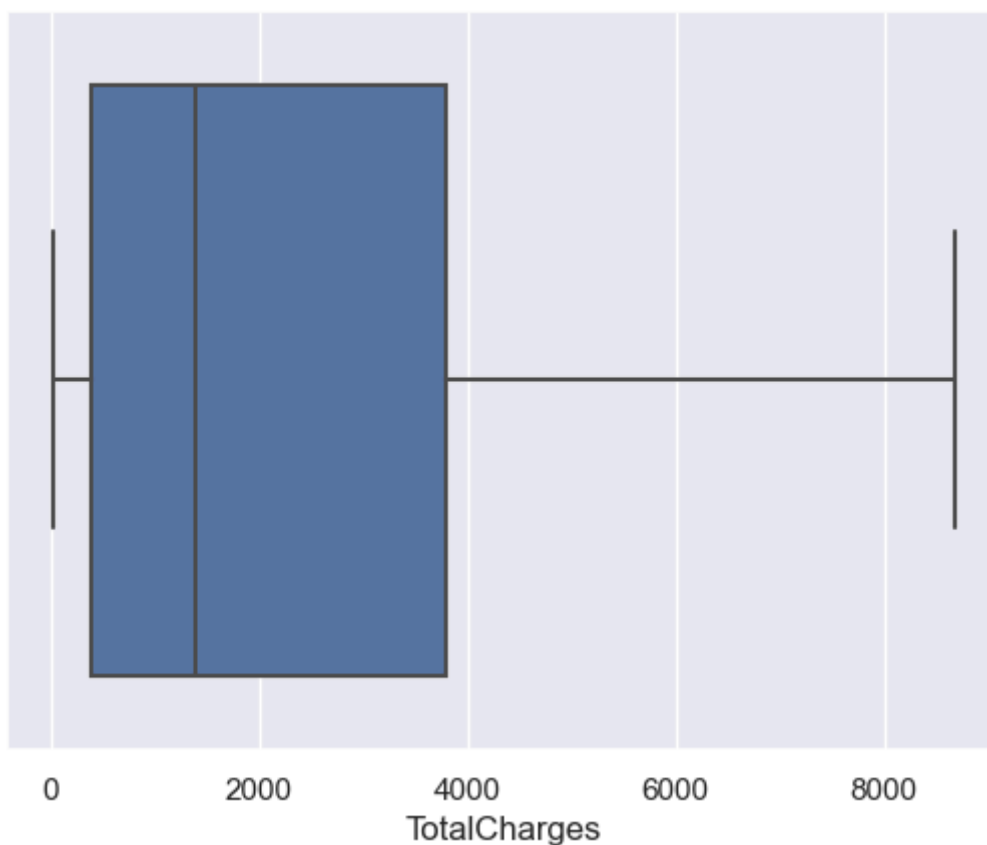
```
In [13]: dataset.describe()
```

```
Out[13]:
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
count	7043.000000	7043.000000	7043.000000	7043.000000
mean	0.162147	32.371149	64.761692	2281.916928
std	0.368612	24.559481	30.090047	2265.270398
min	0.000000	0.000000	18.250000	18.800000
25%	0.000000	9.000000	35.500000	402.225000
50%	0.000000	29.000000	70.350000	1397.475000
75%	0.000000	55.000000	89.850000	3786.600000
max	1.000000	72.000000	118.750000	8684.800000

```
In [14]: sns.boxplot(dataset['TotalCharges']) #No outliers
```

```
Out[14]: <AxesSubplot:xlabel='TotalCharges'>
```



EDA

```
In [15]: dataset.shape
```

```
Out[15]: (7043, 20)
```

```
In [16]: dataset['gender'].value_counts()
```

```
Out[16]: Male      3555  
Female    3488  
Name: gender, dtype: int64
```

```
In [17]: dataset['SeniorCitizen'].value_counts()    #most people are not senior citizen
```

```
Out[17]: 0      5901  
        1      1142  
Name: SeniorCitizen, dtype: int64
```

```
In [18]: dataset['Partner'].value_counts()
```

```
Out[18]: No      3641  
        Yes     3402  
Name: Partner, dtype: int64
```

```
In [19]: dataset['Dependents'].value_counts()
```

```
Out[19]: No      4933  
        Yes     2110  
Name: Dependents, dtype: int64
```

```
In [20]: dataset['InternetService'].value_counts()
```

```
Out[20]: Fiber optic    3096  
        DSL             2421  
        No              1526  
Name: InternetService, dtype: int64
```

```
In [21]: dataset['PhoneService'].value_counts()
```

```
Out[21]: Yes     6361  
        No      682  
Name: PhoneService, dtype: int64
```

```
In [22]: dataset['PaperlessBilling'].value_counts()
```

```
Out[22]: Yes     4171  
        No      2872  
Name: PaperlessBilling, dtype: int64
```

```
In [23]: dataset['Churn'].value_counts()    #imbalance dataset
```

```
Out[23]: No      5174  
        Yes     1869  
Name: Churn, dtype: int64
```

```
In [24]: #pandas profiling
```

```
from pandas_profiling import ProfileReport  
report=ProfileReport(dataset)  
report.to_file(output_file="Pandas Profiling EDA.html")
```

```
Summarize dataset:  0%|          | 0/5 [00:00<?, ?it/s]  
Generate report structure:  0%|          | 0/1 [00:00<?, ?it/s]  
Render HTML:  0%|          | 0/1 [00:00<?, ?it/s]  
Export report to file:  0%|          | 0/1 [00:00<?, ?it/s]
```

Imbalance Treatment

```
In [25]: dataset['Churn'].value_counts()/len(dataset)*100
```



```
Out[25]: No      73.463013
        Yes     26.536987
        Name: Churn, dtype: float64
```

```
In [26]: dataset['Churn']=dataset['Churn'].replace({'Yes':1,'No':0})
        dataset['Churn'].value_counts()
```

```
Out[26]: 0      5174
        1      1869
        Name: Churn, dtype: int64
```

Encoding

```
In [27]: dataset.columns
```

```
Out[27]: Index(['gender', 'SeniorCitizen', 'Partner', 'Dependents', 'tenure',
               'PhoneService', 'MultipleLines', 'InternetService', 'OnlineSecurity',
               'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',
               'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod',
               'MonthlyCharges', 'TotalCharges', 'Churn'],
              dtype='object')
```

```
In [28]: dataset=pd.get_dummies(dataset,columns=['gender', 'Partner', 'Dependents',
        'PhoneService', 'MultipleLines', 'InternetService', 'OnlineSecurity',
        'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',
        'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod'],drop_fir
```

```
In [29]: dataset.head()
```

```
Out[29]:
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Male	Partner_Yes	Dependents
0	0	1	29.85	29.85	0	0	1	
1	0	34	56.95	1889.50	0	1	0	
2	0	2	53.85	108.15	1	1	0	
3	0	45	42.30	1840.75	0	1	0	
4	0	2	70.70	151.65	1	0	0	

5 rows × 31 columns

Feature Scaling

```
In [30]: #required in tenure, MonthlyCharges, TotalCharges
```

```
In [31]: from sklearn.preprocessing import StandardScaler
        scaler=StandardScaler()
        scaler_columns=['tenure','MonthlyCharges','TotalCharges']
        dataset[scaler_columns]=scaler.fit_transform(dataset[scaler_columns])
        dataset.head()
```

Out[31]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Male	Partner_Yes	Depo
0	0	-1.277445	-1.160323	-0.994242	0	0	1	
1	0	0.066327	-0.259629	-0.173244	0	1	0	
2	0	-1.236724	-0.362660	-0.959674	1	1	0	
3	0	0.514251	-0.746535	-0.194766	0	1	0	
4	0	-1.236724	0.197365	-0.940470	1	0	0	

5 rows × 31 columns

Split data into I.V. and D.V

```
In [32]: x=dataset.drop(['Churn'],axis=1)
y=dataset['Churn']
x.head(2)
```

Out[32]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	gender_Male	Partner_Yes	Dependents
0	0	-1.277445	-1.160323	-0.994242	0	1	
1	0	0.066327	-0.259629	-0.173244	1	0	

2 rows × 30 columns

```
In [33]: y.head(2)
```

Out[33]:

```
0    0
1    0
Name: Churn, dtype: int64
```

Handling imbalance (SMOTE)

```
In [34]: import imblearn
from imblearn.over_sampling import SMOTE
smote=SMOTE()
x_sm,y_sm=smote.fit_resample(x,y)
print(y.value_counts())
print("*****")
print(y_sm.value_counts())
```

```
0    5174
1    1869
Name: Churn, dtype: int64
*****
0    5174
1    5174
Name: Churn, dtype: int64
```

```
In [35]: print(x.shape)
print("*****")
print(x_sm.shape)
```

```
(7043, 30)
*****
(10348, 30)
```

Split the data into training and test

```
In [36]: from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x_sm,y_sm,test_size=0.3,random_state
```

Model Building

1. Logistic Regression

```
In [37]: from sklearn.linear_model import LogisticRegression
logit=LogisticRegression()
logit.fit(x_train,y_train)
```

```
Out[37]: LogisticRegression()
```

```
In [38]: #predict result
y_pred_logit_train=logit.predict(x_train)
y_pred_logit_test=logit.predict(x_test)
```

```
In [39]: #evaluate the model
from sklearn.metrics import confusion_matrix,classification_report,accuracy_score
print(classification_report(y_test,y_pred_logit_test))
```

	precision	recall	f1-score	support
0	0.85	0.77	0.81	1560
1	0.79	0.86	0.82	1545
accuracy			0.82	3105
macro avg	0.82	0.82	0.82	3105
weighted avg	0.82	0.82	0.82	3105

```
In [40]: print('Confusion matrix is :')
print(confusion_matrix(y_test,y_pred_logit_test))
```

```
Confusion matrix is :
[[1208  352]
 [ 221 1324]]
```

```
In [41]: print("Training Accuracy is :",accuracy_score(y_train,y_pred_logit_train))
print("Test Accuracy is :",accuracy_score(y_test,y_pred_logit_test))
```

```
Training Accuracy is : 0.7987021952229739
Test Accuracy is : 0.8154589371980676
```

```
In [42]: #good accuracy,no bias and variance
#precision- 0.81
#recall - 0.81
```

Probability that customers will churn

```
In [43]: dataset['Probability']=logit.predict_proba(dataset[x_test.columns])[:,1]
```

```
In [44]: dataset.head()
```

```
Out[44]:
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Male	Partner_Yes	Dependents
0	0	-1.277445	-1.160323	-0.994242	0	0	1	
1	0	0.066327	-0.259629	-0.173244	0	1	0	
2	0	-1.236724	-0.362660	-0.959674	1	1	0	
3	0	0.514251	-0.746535	-0.194766	0	1	0	
4	0	-1.236724	0.197365	-0.940470	1	0	0	

5 rows × 32 columns

```
In [48]: dataset2=pd.concat([dataset1['customerID'],dataset['Probability']],axis=1)
#dataset2=dataset1['customerID']+dataset['Probability']
dataset2.head()
```

```
Out[48]:
```

	customerID	Probability
0	7590-VHVEG	0.778890
1	5575-GNVDE	0.106710
2	3668-QPYBK	0.291422
3	7795-CFOCW	0.104462
4	9237-HQITU	0.901783

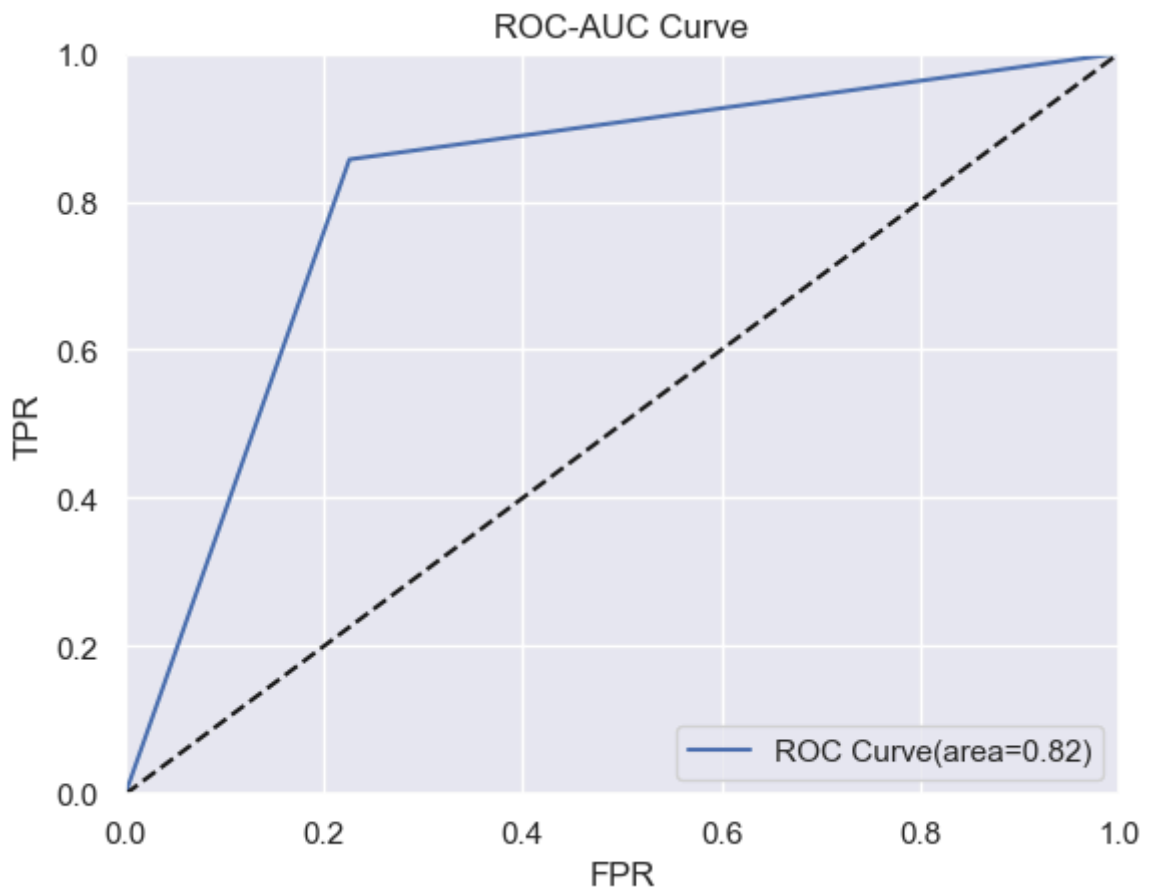
ROC-AUC

```
In [49]: from sklearn.metrics import roc_auc_score
logit_roc_auc=roc_auc_score(y_test,y_pred_logit_test)
print(logit_roc_auc) # 81% accuracy

0.8156584515807818
```

```
In [50]: #ROC-AUC Curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds=roc_curve(y_test,y_pred_logit_test)
```

```
In [51]: plt.figure()
plt.plot(fpr,tpr,label='ROC Curve(area=%0.2f)%logit_roc_auc')
plt.plot([0,1],[0,1], 'k--')
plt.xlim([0.0,1.0])
plt.ylim([0.0,1.0])
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title('ROC-AUC Curve')
plt.legend(loc='lower right')
plt.show()
```



In [52]: *#ROC curve above AUC, good model*

2. Decision Tree Model

```
In [56]: from sklearn.tree import DecisionTreeClassifier
dtree=DecisionTreeClassifier(criterion='entropy')    #criterion gini / entropy, check
dtree.fit(x_train,y_train)
```

Out[56]: DecisionTreeClassifier(criterion='entropy')

```
In [57]: y_pred_dt_train=dtree.predict(x_train)
y_pred_dt_test=dtree.predict(x_test)
```

```
In [58]: print("Training Accuracy is :",accuracy_score(y_train,y_pred_dt_train))
print("Test Accuracy is :",accuracy_score(y_test,y_pred_dt_test))
```

Training Accuracy is : 0.9987574209581666
Test Accuracy is : 0.7758454106280194

In [59]: *#high variance (DT is overfitting the model) ---- solution- Bagging*

3. Random Forest

```
In [60]: from sklearn.ensemble import RandomForestClassifier
rf=RandomForestClassifier(n_estimators=500,criterion='entropy',random_state=101)
rf.fit(x_train,y_train)
```

Out[60]: RandomForestClassifier(criterion='entropy', n_estimators=500, random_state=101)

```
In [61]: y_pred_rf_train=rf.predict(x_train)
         y_pred_rf_test=rf.predict(x_test)

In [62]: print("Training Accuracy is :",accuracy_score(y_train,y_pred_rf_train))
         print("Test Accuracy is :",accuracy_score(y_test,y_pred_rf_test))  #(variance less

Training Accuracy is : 0.9987574209581666
Test Accuracy is : 0.8553945249597423

In [63]: #Cross validation or XGBoost now for improving model more
```

4. XGBoost

```
In [72]: from xgboost import XGBClassifier
         xgb=XGBClassifier()
         xgb.fit(x_train,y_train)

Out[72]: XGBClassifier(base_score=None, booster=None, callbacks=None,
                        colsample_bylevel=None, colsample_bynode=None,
                        colsample_bytree=None, early_stopping_rounds=None,
                        enable_categorical=False, eval_metric=None, feature_types=None,
                        gamma=None, gpu_id=None, grow_policy=None, importance_type=None,
                        interaction_constraints=None, learning_rate=None, max_bin=None,
                        max_cat_threshold=None, max_cat_to_onehot=None,
                        max_delta_step=None, max_depth=None, max_leaves=None,
                        min_child_weight=None, missing=nan, monotone_constraints=None,
                        n_estimators=100, n_jobs=None, num_parallel_tree=None,
                        predictor=None, random_state=None, ...)

In [73]: #predict
         y_pred_xgb_train=xgb.predict(x_train)
         y_pred_xgb_test=xgb.predict(x_test)

In [74]: #evaluate
         print('Train accuracy: ',accuracy_score(y_train,y_pred_xgb_train))
         print('Test accuracy: ',accuracy_score(y_test,y_pred_xgb_test))

Train accuracy:  0.9486400662708823
Test accuracy:  0.8312399355877617
```

5. AdaBoost

```
In [75]: from sklearn.ensemble import AdaBoostClassifier
         adaboost=AdaBoostClassifier(n_estimators=100,random_state=101)
         adaboost.fit(x_train,y_train)

Out[75]: AdaBoostClassifier(n_estimators=100, random_state=101)

In [76]: #predict
         y_pred_ada_train=adaboost.predict(x_train)
         y_pred_ada_test=adaboost.predict(x_test)

In [77]: #evaluate
         print('Train accuracy: ',accuracy_score(y_train,y_pred_ada_train))
         print('Test accuracy: ',accuracy_score(y_test,y_pred_ada_test))

Train accuracy:  0.794008007731603
Test accuracy:  0.8054750402576489
```

6.PyCaret Package

```
In [78]: from pycaret.classification import *
```

```
In [79]: clf=setup(data=dataset,target='Churn',session_id=123)
```

	Description	Value
0	Session id	123
1	Target	Churn
2	Target type	Binary
3	Original data shape	(7043, 32)
4	Transformed data shape	(7043, 32)
5	Transformed train set shape	(4930, 32)
6	Transformed test set shape	(2113, 32)
7	Numeric features	31
8	Preprocess	True
9	Imputation type	simple
10	Numeric imputation	mean
11	Categorical imputation	mode
12	Fold Generator	StratifiedKFold
13	Fold Number	10
14	CPU Jobs	-1
15	Use GPU	False
16	Log Experiment	False
17	Experiment Name	clf-default-name
18	USI	54d8

```
In [80]: compare_models()
```

	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
lr	Logistic Regression	0.8022	0.8449	0.5520	0.6521	0.5974	0.4675	0.4707	0.5480
ada	Ada Boost Classifier	0.7990	0.8410	0.5131	0.6563	0.5745	0.4458	0.4524	0.1760
ridge	Ridge Classifier	0.7984	0.0000	0.5528	0.6416	0.5929	0.4600	0.4629	0.0110
lda	Linear Discriminant Analysis	0.7984	0.8412	0.5925	0.6291	0.6096	0.4740	0.4748	0.0300
gbc	Gradient Boosting Classifier	0.7980	0.8436	0.5123	0.6526	0.5730	0.4434	0.4496	0.4670
lightgbm	Light Gradient Boosting Machine	0.7895	0.8297	0.5131	0.6270	0.5629	0.4264	0.4310	0.2730
rf	Random Forest Classifier	0.7874	0.8244	0.4840	0.6309	0.5469	0.4113	0.4180	0.2560
svm	SVM - Linear Kernel	0.7809	0.0000	0.4596	0.6389	0.5007	0.3756	0.3958	0.0170
xgboost	Extreme Gradient Boosting	0.7803	0.8205	0.5070	0.6032	0.5499	0.4063	0.4096	0.4930
et	Extra Trees Classifier	0.7732	0.8080	0.4695	0.5923	0.5223	0.3767	0.3818	0.2670
knn	K Neighbors Classifier	0.7684	0.7804	0.5222	0.5688	0.5437	0.3891	0.3902	0.0420
dummy	Dummy Classifier	0.7347	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0190
dt	Decision Tree Classifier	0.7245	0.6553	0.5046	0.4827	0.4927	0.3041	0.3046	0.0150
nb	Naive Bayes	0.6846	0.8226	0.8571	0.4505	0.5905	0.3721	0.4235	0.0110
qda	Quadratic Discriminant Analysis	0.4540	0.6067	0.9320	0.3193	0.4754	0.1326	0.2266	0.0250

Processing: 0% | 0/65 [00:00<?, ?it/s]

Out[80]: LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True, intercept_scaling=1, l1_ratio=None, max_iter=1000, multi_class='auto', n_jobs=None, penalty='l2', random_state=123, solver='lbfgs', tol=0.0001, verbose=0, warm_start=False)

In [81]: *#best model- logistic reg*
logistic=create_model("lr")

	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC
Fold							
0	0.7870	0.8425	0.5538	0.6050	0.5783	0.4362	0.4370
1	0.7931	0.8285	0.5538	0.6207	0.5854	0.4481	0.4494
2	0.8053	0.8202	0.5725	0.6522	0.6098	0.4808	0.4826
3	0.7992	0.8427	0.5344	0.6481	0.5858	0.4549	0.4586
4	0.7688	0.8235	0.5191	0.5714	0.5440	0.3896	0.3904
5	0.7951	0.8342	0.5420	0.6339	0.5844	0.4495	0.4520
6	0.8174	0.8666	0.5725	0.6881	0.6250	0.5057	0.5094
7	0.8053	0.8586	0.5420	0.6636	0.5966	0.4700	0.4742
8	0.8235	0.8659	0.5725	0.7075	0.6329	0.5185	0.5235
9	0.8276	0.8662	0.5573	0.7300	0.6320	0.5221	0.5302
Mean	0.8022	0.8449	0.5520	0.6521	0.5974	0.4675	0.4707
Std	0.0169	0.0174	0.0170	0.0454	0.0265	0.0389	0.0406

Processing: 0%| | 0/4 [00:00<?, ?it/s]

```
In [82]: #further tuning
tuned=tune_model(logistic)
```

	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC
Fold							
0	0.7890	0.8426	0.5615	0.6083	0.5840	0.4430	0.4436
1	0.7951	0.8286	0.5538	0.6261	0.5878	0.4521	0.4536
2	0.8032	0.8209	0.5649	0.6491	0.6041	0.4740	0.4760
3	0.8012	0.8432	0.5420	0.6514	0.5917	0.4618	0.4652
4	0.7728	0.8234	0.5267	0.5798	0.5520	0.4003	0.4011
5	0.7951	0.8335	0.5496	0.6316	0.5878	0.4523	0.4543
6	0.8195	0.8679	0.5725	0.6944	0.6276	0.5099	0.5141
7	0.8053	0.8590	0.5344	0.6667	0.5932	0.4673	0.4722
8	0.8235	0.8662	0.5725	0.7075	0.6329	0.5185	0.5235
9	0.8276	0.8665	0.5573	0.7300	0.6320	0.5221	0.5302
Mean	0.8032	0.8452	0.5535	0.6545	0.5993	0.4701	0.4734
Std	0.0159	0.0176	0.0147	0.0440	0.0242	0.0360	0.0379

Processing: 0%| | 0/7 [00:00<?, ?it/s]
Fitting 10 folds for each of 10 candidates, totalling 100 fits

```
In [83]: evaluate_model(tuned)

interactive(children=(ToggleButtons(description='Plot Type:', icons=(' ', ), options
= (('Pipeline Plot', 'pipelin...
```

