In [256]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [257]:
```
d=pd.read_csv('https://github.com/YBI-Foundation/Dataset/raw/main/Bank%20Churn%20
```

In [258]:
```
d.head()
```

Out[258]:

	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance	Num Of Products	H Cre Ca
0	15634602	Hargrave	619	France	Female	42	2	0.00	1	
1	15647311	Hill	608	Spain	Female	41	1	83807.86	1	
2	15619304	Onio	502	France	Female	42	8	159660.80	3	
3	15701354	Boni	699	France	Female	39	1	0.00	2	
4	15737888	Mitchell	850	Spain	Female	43	2	125510.82	1	

In [259]:
```
d.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 13 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   CustomerId        10000 non-null  int64  
 1   Surname           10000 non-null  object 
 2   CreditScore       10000 non-null  int64  
 3   Geography         10000 non-null  object 
 4   Gender            10000 non-null  object 
 5   Age               10000 non-null  int64  
 6   Tenure            10000 non-null  int64  
 7   Balance           10000 non-null  float64
 8   Num Of Products   10000 non-null  int64  
 9   Has Credit Card   10000 non-null  int64  
 10  Is Active Member  10000 non-null  int64  
 11  Estimated Salary  10000 non-null  float64
 12  Churn             10000 non-null  int64  
dtypes: float64(2), int64(8), object(3)
memory usage: 1015.8+ KB
```

In [260]:
```
d.duplicated('CustomerId').sum()
```

Out[260]: 0

In [261]:
```
d=d.set_index('CustomerId')
```

In [262]:
```
d.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10000 entries, 15634602 to 15628319
Data columns (total 12 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   Surname           10000 non-null  object 
 1   CreditScore       10000 non-null  int64  
 2   Geography         10000 non-null  object 
 3   Gender            10000 non-null  object 
 4   Age               10000 non-null  int64  
 5   Tenure            10000 non-null  int64  
 6   Balance           10000 non-null  float64
 7   Num Of Products   10000 non-null  int64  
 8   Has Credit Card   10000 non-null  int64  
 9   Is Active Member  10000 non-null  int64  
 10  Estimated Salary  10000 non-null  float64
 11  Churn             10000 non-null  int64  
dtypes: float64(2), int64(7), object(3)
memory usage: 1015.6+ KB
```

Encoding

In [263]:
```
d['Geography'].value_counts()
```

Out[263]:
```
France     5014
Germany    2509
Spain      2477
Name: Geography, dtype: int64
```

In [264]:
```
d.replace({'Geography': {'France':2,'Germany':1,'Spain':0}},inplace=True)
```

In [265]:
```
d['Gender'].value_counts()
```

Out[265]:
```
Male      5457
Female    4543
Name: Gender, dtype: int64
```

In [266]:
```
d.replace({'Gender': {'Male':0,'Female':1}},inplace=True)
```

In [267]:
```
d['Num Of Products'].value_counts()
```

Out[267]:
```
1    5084
2    4590
3     266
4      60
Name: Num Of Products, dtype: int64
```

In [268]:
```
d.replace({'Num Of Products': {1:0,2:1,3:1,4:1}},inplace=True)
```

In [269]:
```
d['Has Credit Card'].value_counts()
```

Out[269]:
```
1    7055
0    2945
Name: Has Credit Card, dtype: int64
```

In [270]:
```
d['Is Active Member'].value_counts()
```

Out[270]:
```
1    5151
0    4849
Name: Is Active Member, dtype: int64
```

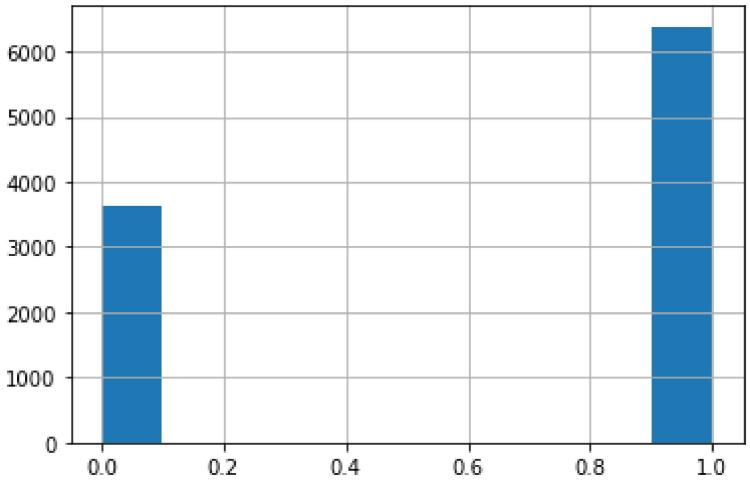
In [271]:
```
d.loc[(d['Balance']==0),'Churn'].value_counts()
```

Out[271]:
```
0    3117
1     500
Name: Churn, dtype: int64
```

In [272]:
```
d['Zero Balance']=np.where(d['Balance']>0,1,0)
```

In [273]:
```
d['Zero Balance'].hist()
```

Out[273]:
```
<AxesSubplot:>
```



In [274]:
```
d.groupby(['Churn','Geography']).count()
```

Out[274]:

		Surname	CreditScore	Gender	Age	Tenure	Balance	Num Of Products	Has Credit Card	Ac Mem
Churn	**Geography**									
0	**0**	2064	2064	2064	2064	2064	2064	2064	2064	2
	1	1695	1695	1695	1695	1695	1695	1695	1695	1
	2	4204	4204	4204	4204	4204	4204	4204	4204	4
1	**0**	413	413	413	413	413	413	413	413	
	1	814	814	814	814	814	814	814	814	
	2	810	810	810	810	810	810	810	810	

In [275]:
```
d.columns
```

Out[275]:
```
Index(['Surname', 'CreditScore', 'Geography', 'Gender', 'Age', 'Tenure',
       'Balance', 'Num Of Products', 'Has Credit Card', 'Is Active Member',
       'Estimated Salary', 'Churn', 'Zero Balance'],
      dtype='object')
```

In [276]:
```
x=d.drop(['Surname','Churn'],axis=1)
```

In [277]:
```
y=d['Churn']
```

In [278]:
```
x.shape,y.shape
```

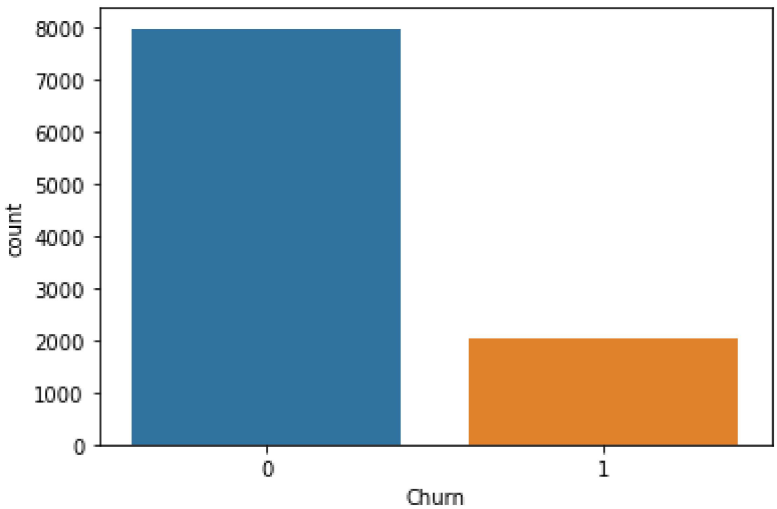
Out[278]:
```
((10000, 11), (10000,))
```

In [279]:
```
d['Churn'].value_counts()
```

Out[279]:
```
0    7963
1    2037
Name: Churn, dtype: int64
```

In [280]:
```
sns.countplot(x='Churn',data=d)
```

Out[280]:
```
<AxesSubplot:xlabel='Churn', ylabel='count'>
```



In [281]:
```
x.shape,y.shape
```

Out[281]:
```
((10000, 11), (10000,))
```

Random Under sampling

In [282]:
```
!pip install imblearn
```

```
Requirement already satisfied: imblearn in c:\users\g.ravi prakash reddy\anacon
da3\lib\site-packages (0.0)
Requirement already satisfied: imbalanced-learn in c:\users\g.ravi prakash redd
y\anaconda3\lib\site-packages (from imblearn) (0.9.1)
Requirement already satisfied: joblib>=1.0.0 in c:\users\g.ravi prakash reddy\a
naconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.1.0)
Requirement already satisfied: scikit-learn>=1.1.0 in c:\users\g.ravi prakash r
eddy\anaconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.1.0)
Requirement already satisfied: scipy>=1.3.2 in c:\users\g.ravi prakash reddy\an
aconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.7.1)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\users\g.ravi prakash
reddy\anaconda3\lib\site-packages (from imbalanced-learn->imblearn) (2.2.0)
Requirement already satisfied: numpy>=1.17.3 in c:\users\g.ravi prakash reddy\a
naconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.20.3)
```

In [283]:
```
from imblearn.under_sampling import RandomUnderSampler
```

In [284]:
```
r=RandomUnderSampler(random_state=2529)
```

In [285]:
```
x_r,y_r=r.fit_resample(x,y)
```

In [286]:
```
x_r.shape,y_r.shape,x.shape,y.shape
```

Out[286]:
```
((4074, 11), (4074,), (10000, 11), (10000,))
```

In [287]:
```
y.value_counts()
```

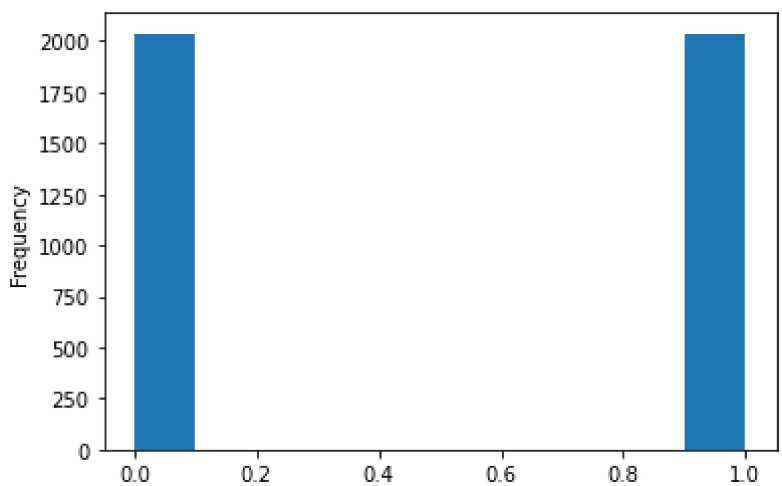
Out[287]:
```
0    7963
1    2037
Name: Churn, dtype: int64
```

In [288]:
```
y_r.value_counts()
```

Out[288]:
```
0    2037
1    2037
Name: Churn, dtype: int64
```

In [289]:
```
y_r.plot(kind='hist')
```

Out[289]:
```
<AxesSubplot:ylabel='Frequency'>
```



In [290]:
```
#RANDOM OVER SAMPLING
from imblearn.over_sampling import RandomOverSampler
```

In [291]:
```
ros=RandomOverSampler(random_state=2529)
```

In [292]:
```
x_ros,y_ros=ros.fit_resample(x,y)
```

In [293]:
```
x_ros.shape,y_ros.shape,x.shape,y.shape
```

Out[293]:
```
((15926, 11), (15926,), (10000, 11), (10000,))
```

In [294]:
```
y.value_counts()
```

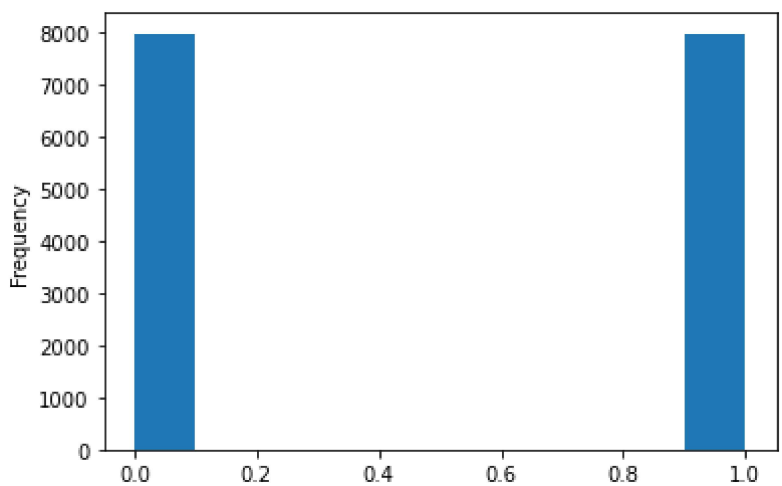
Out[294]:
```
0    7963
1    2037
Name: Churn, dtype: int64
```

In [295]:
```
y_ros.value_counts()
```

Out[295]:
```
1    7963
0    7963
Name: Churn, dtype: int64
```

In [296]:
```
y_ros.plot(kind='hist')
```

Out[296]:
```
<AxesSubplot:ylabel='Frequency'>
```



Train Test Split

In [297]:
```
from sklearn.model_selection import train_test_split
```

In [298]:
```
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.3,random_state=25)
```

In [299]:
```
x_train_r,x_test_r,y_train_r,y_test_r=train_test_split(x_r,y_r,test_size=0.3,rand
```

In [300]:
```
x_train_ros,x_test_ros,y_train_ros,y_test_ros=train_test_split(x_ros,y_ros,test_s
```

In [301]:
```
from sklearn.preprocessing import StandardScaler
```

In [302]:
```
sc=StandardScaler()
```

In [303]:
```
x_train[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit_tra
x_test[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit_tran
```

In [304]:
```
x_train_r[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit_t
x_test_r[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit_tr
```

In [305]:
```
x_train_rus[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit
x_test_rus[['CreditScore','Age','Tenure','Balance','Estimated Salary']] = sc.fit_
```

In [306]:
```
from sklearn.svm import SVC
svc=SVC()
```

In [307]:
```
svc.fit(x_train,y_train)
```

Out[307]:
```
SVC
SVC()
```

In [308]:
```
y_pred=svc.predict(x_test)
```

Model accuracy

In [309]:
```
from sklearn.metrics import confusion_matrix,classification_report
confusion_matrix(y_test,y_pred)
```

Out[309]:
```
array([[2374,   45],
       [ 421,  160]], dtype=int64)
```

In [310]:
```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.85      0.98      0.91      2419
           1       0.78      0.28      0.41       581

    accuracy                           0.84      3000
   macro avg       0.81      0.63      0.66      3000
weighted avg       0.84      0.84      0.81      3000
```

Hyperparameter Tunning

In [311]:
```
from sklearn.model_selection import GridSearchCV
```

In [312]:
```
param_grid={'C':[0.1,1,10],
            'gamma':[1,0.1,0.01],
            'kernel':['rbf'],
            'class_weight':['balanced']}
```

In [313]:
```
grid=GridSearchCV(SVC(),param_grid,refit=True,verbose=2,cv=2)
grid.fit(x_train,y_train)
```

```
Fitting 2 folds for each of 9 candidates, totalling 18 fits
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.8
s
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.8
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.2
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.2
s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.
3s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.
3s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.4
s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.4
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.0
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.0
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.1
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.1
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.3
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   1.4
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.0
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   1.0
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.1
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   1.1
s
```

Out[313]:

```
▸ GridSearchCV
▸ estimator: SVC
    ▸ SVC
```

In [314]:
```
print(grid.best_estimator_)
```

```
SVC(C=10, class_weight='balanced', gamma=1)
```

In [315]:
```
grid_predictions=grid.predict(x_test)
```

In [316]:
```
confusion_matrix(y_test,grid_predictions)
```

Out[316]:
```
array([[2166,  253],
       [ 365,  216]], dtype=int64)
```

In [317]:
```
print(classification_report(y_test,grid_predictions))
```

```
              precision    recall  f1-score   support

           0       0.86      0.90      0.88      2419
           1       0.46      0.37      0.41       581

    accuracy                           0.79      3000
   macro avg       0.66      0.63      0.64      3000
weighted avg       0.78      0.79      0.79      3000
```

Model with Random Under Sampling

In [318]:
```
svc_r=SVC()
```

In [319]:
```
svc_r.fit(x_train_r,y_train_r)
```

Out[319]:
```
▾ SVC
SVC()
```

In [320]:
```
y_pred_r=svc_r.predict(x_test_r)
```

Model Accuracy

In [321]:
```
confusion_matrix(y_test_r,y_pred_r)
```

Out[321]:
```
array([[483, 120],
       [172, 448]], dtype=int64)
```

In [322]:
```
print(classification_report(y_test_r,y_pred_r))
```

```
              precision    recall  f1-score   support

           0       0.74      0.80      0.77       603
           1       0.79      0.72      0.75       620

    accuracy                           0.76      1223
   macro avg       0.76      0.76      0.76      1223
weighted avg       0.76      0.76      0.76      1223
```

In [323]:
```
param_grid={'C':[0.1,1,10],
            'gamma':[1,0.1,0.01],
            'kernel':['rbf'],
            'class_weight':['balanced']}
```

In [324]:
```
grid_r=GridSearchCV(SVC(),param_grid,refit=True,verbose=2,cv=2)
grid_r.fit(x_train_r,y_train_r)
```

```
Fitting 2 folds for each of 9 candidates, totalling 18 fits
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.1
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.2
s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.
2s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.
2s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.1
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.1
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.1
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.1
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   0.2
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.1
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   0.1
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.1
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   0.1
s
```

Out[324]:

```
▸ GridSearchCV
▸ estimator: SVC
    ▸ SVC
```

In [325]:
```
print(grid_r.best_estimator_)
```

```
SVC(C=10, class_weight='balanced', gamma=0.01)
```

In [326]:
```
grid_predictions_r=grid_r.predict(x_test_r)
```

In [327]:
```
confusion_matrix(y_test_r,grid_predictions_r)
```

Out[327]:
```
array([[456, 147],
       [161, 459]], dtype=int64)
```

In [328]:
```
print(classification_report(y_test_r,grid_predictions_r))
```

```
              precision    recall  f1-score   support

           0       0.74      0.76      0.75       603
           1       0.76      0.74      0.75       620

    accuracy                           0.75      1223
   macro avg       0.75      0.75      0.75      1223
weighted avg       0.75      0.75      0.75      1223
```

Model with Random Over Sampling

In [329]:
```
svc_ros=SVC()
```

In [330]:
```
svc_ros.fit(x_train_ros,y_train_ros)
```

Out[330]:
```
▾ SVC
SVC()
```

In [331]:
```
y_pred_ros=svc_ros.predict(x_test_ros)
```

Model Accuracy

In [332]:
```
from sklearn.metrics import confusion_matrix,classification_report
confusion_matrix(y_test_ros,y_pred_ros)
```

Out[332]:
```
array([[ 969, 1457],
       [ 562, 1790]], dtype=int64)
```

In [333]:
```
print(classification_report(y_test_ros,y_pred_ros))
```

```
              precision    recall  f1-score   support

           0       0.63      0.40      0.49      2426
           1       0.55      0.76      0.64      2352

    accuracy                           0.58      4778
   macro avg       0.59      0.58      0.56      4778
weighted avg       0.59      0.58      0.56      4778
```

In [334]:
```
param_grid={'C':[0.1,1,10],
            'gamma':[1,0.1,0.01],
            'kernel':['rbf'],
            'class_weight':['balanced']}
```

In [335]:
```
grid_ros=GridSearchCV(SVC(),param_grid,refit=True,verbose=2,cv=2)
grid_ros.fit(x_train_ros,y_train_ros)
```

```
Fitting 2 folds for each of 9 candidates, totalling 18 fits
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   8.0
s
[CV] END ..C=0.1, class_weight=balanced, gamma=1, kernel=rbf; total time=   8.0
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   7.9
s
[CV] END C=0.1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   8.3
s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   8.
2s
[CV] END C=0.1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   8.
3s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=   9.9
s
[CV] END ....C=1, class_weight=balanced, gamma=1, kernel=rbf; total time=  10.1
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   8.4
s
[CV] END ..C=1, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   8.2
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   8.9
s
[CV] END .C=1, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   7.9
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   6.7
s
[CV] END ...C=10, class_weight=balanced, gamma=1, kernel=rbf; total time=   6.6
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   6.8
s
[CV] END .C=10, class_weight=balanced, gamma=0.1, kernel=rbf; total time=   6.4
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   6.7
s
[CV] END C=10, class_weight=balanced, gamma=0.01, kernel=rbf; total time=   6.3
s
```

Out[335]:

```
▸ GridSearchCV
▸ estimator: SVC
    ▸ SVC
```

In [336]:
```
print(grid_ros.best_estimator_)
```

```
SVC(C=1, class_weight='balanced', gamma=1)
```

In [337]:
```
grid_predictions_ros=grid_ros.predict(x_test_ros)
```

In [338]:
```
confusion_matrix(y_test_ros,grid_predictions_ros)
```

Out[338]:
```
array([[2426,    0],
       [ 151, 2201]], dtype=int64)
```

In [339]:
```
print(classification_report(y_test_ros,grid_predictions_ros))
```

```
              precision    recall  f1-score   support

           0       0.94      1.00      0.97      2426
           1       1.00      0.94      0.97      2352

    accuracy                           0.97      4778
   macro avg       0.97      0.97      0.97      4778
weighted avg       0.97      0.97      0.97      4778
```

In [340]:
```
print(classification_report(y_test_ros,grid_predictions_ros))
```

```
              precision    recall  f1-score   support

           0       0.94      1.00      0.97      2426
           1       1.00      0.94      0.97      2352

    accuracy                           0.97      4778
   macro avg       0.97      0.97      0.97      4778
weighted avg       0.97      0.97      0.97      4778
```

In [ ]:

In [ ]:

In [ ]:

In [ ]: