Lending Club Loan

August 5, 2022

[1]:

```
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense,Dropout
from tensorflow.keras.callbacks import EarlyStopping
from tensorflow.keras.models import load_model
from tensorflow.keras.optimizers import Adam
from sklearn.metrics import confusion_matrix, classification_report
from pickle import dump, load
import warnings
warnings.filterwarnings('ignore')
```

0.0.1 load dataset

[2]:

```
loan = pd.read_csv('loan_data.csv')
```

[3]:

```
loan.head()
```

[3]:

```
   credit.policy             purpose  int.rate  installment  log.annual.inc  \
0              1  debt_consolidation    0.1189       829.10       11.350407
1              1         credit_card    0.1071       228.22       11.082143
2              1  debt_consolidation    0.1357       366.86       10.373491
3              1  debt_consolidation    0.1008       162.34       11.350407
4              1         credit_card    0.1426       102.92       11.299732

     dti  fico  days.with.cr.line  revol.bal  revol.util  inq.last.6mths  \
0  19.48   737        5639.958333      28854        52.1               0
1  14.29   707        2760.000000      33623        76.7               0
2  11.63   682        4710.000000       3511        25.6               1
3   8.10   712        2699.958333      33667        73.2               1
4  14.97   667        4066.000000       4740        39.5               0
```

```
   delinq.2yrs  pub.rec  not.fully.paid
0            0        0               0
1            0        0               0
2            0        0               0
3            0        0               0
4            1        0               0
```

[4]:
```
loan.info
```

[4]:
```
<bound method DataFrame.info of       credit.policy             purpose
int.rate  installment  \
0                 1  debt_consolidation    0.1189       829.10
1                 1         credit_card    0.1071       228.22
2                 1  debt_consolidation    0.1357       366.86
3                 1  debt_consolidation    0.1008       162.34
4                 1         credit_card    0.1426       102.92
…              …                   …       …          …
9573              0           all_other    0.1461       344.76
9574              0           all_other    0.1253       257.70
9575              0  debt_consolidation    0.1071        97.81
9576              0    home_improvement    0.1600       351.58
9577              0  debt_consolidation    0.1392       853.43

      log.annual.inc    dti  fico  days.with.cr.line  revol.bal  revol.util  \
0          11.350407  19.48   737        5639.958333      28854        52.1
1          11.082143  14.29   707        2760.000000      33623        76.7
2          10.373491  11.63   682        4710.000000       3511        25.6
3          11.350407   8.10   712        2699.958333      33667        73.2
4          11.299732  14.97   667        4066.000000       4740        39.5
…                …     …    …                …         …          …
9573       12.180755  10.39   672       10474.000000     215372        82.1
9574       11.141862   0.21   722        4380.000000        184         1.1
9575       10.596635  13.09   687        3450.041667      10036        82.9
9576       10.819778  19.18   692        1800.000000          0         3.2
9577       11.264464  16.28   732        4740.000000      37879        57.0

      inq.last.6mths  delinq.2yrs  pub.rec  not.fully.paid
0                  0            0        0               0
1                  0            0        0               0
2                  1            0        0               0
3                  1            0        0               0
4                  0            1        0               0
…                …           …       …             …
9573               2            0        0               1
9574               5            0        0               1
9575               8            0        0               1
```

```
9576                  5            0        0                1
9577                  6            0        0                1

[9578 rows x 14 columns]>
```

[5]:

```
print(loan.isnull().sum())
```

```
credit.policy        0
purpose              0
int.rate             0
installment          0
log.annual.inc       0
dti                  0
fico                 0
days.with.cr.line    0
revol.bal            0
revol.util           0
inq.last.6mths       0
delinq.2yrs          0
pub.rec              0
not.fully.paid       0
dtype: int64
```

[6]:

```
print(loan.isna().sum())
```

```
credit.policy        0
purpose              0
int.rate             0
installment          0
log.annual.inc       0
dti                  0
fico                 0
days.with.cr.line    0
revol.bal            0
revol.util           0
inq.last.6mths       0
delinq.2yrs          0
pub.rec              0
not.fully.paid       0
dtype: int64
```

[7]:

```
#print(loan.isna().sum())
for col in loan.columns:
    print(col,loan[col].dtypes)
    print(loan[col].unique())
    print(sum(loan[col].isna()))
```

```
credit.policy int64
```

```
[1 0]
0
purpose object
['debt_consolidation' 'credit_card' 'all_other' 'home_improvement'
 'small_business' 'major_purchase' 'educational']
0
int.rate float64
[0.1189 0.1071 0.1357 0.1008 0.1426 0.0788 0.1496 0.1114 0.1134 0.1221
 0.1347 0.1324 0.0859 0.0714 0.0863 0.1103 0.1317 0.0894 0.1039 0.1513
 0.08   0.1355 0.1229 0.0901 0.0743 0.1375 0.0807 0.1028 0.087  0.1122
 0.0996 0.0933 0.0838 0.0775 0.1059 0.1596 0.1154 0.1343 0.1249 0.0964
 0.1186 0.1501 0.128  0.1091 0.1217 0.1533 0.0712 0.1438 0.1565 0.1467
 0.1312 0.147  0.1407 0.1014 0.1046 0.133  0.0983 0.1393 0.092  0.1236
 0.1362 0.1078 0.1583 0.1109 0.1141 0.1267 0.1204 0.0951 0.1172 0.1299
 0.1488 0.152  0.1425 0.1836 0.1615 0.06   0.0832 0.1261 0.0945 0.1197
 0.1387 0.0976 0.1292 0.0737 0.0768 0.1166 0.1418 0.1545 0.1482 0.1703
 0.145  0.1671 0.1576 0.1608 0.164  0.1734 0.1051 0.157  0.1222 0.1273
 0.1379 0.1253 0.1128 0.1286 0.1287 0.097  0.1001 0.1538 0.1191 0.1254
 0.1159 0.138  0.1096 0.1064 0.1349 0.1033 0.1475 0.1601 0.1507 0.1412
 0.1633 0.1696 0.1146 0.1304 0.1272 0.1209 0.1083 0.1178 0.1241 0.1588
 0.0907 0.102  0.1336 0.1557 0.0938 0.1493 0.1462 0.1367 0.0963 0.1126
 0.1442 0.1148 0.1399 0.1525 0.143  0.1392 0.1904 0.1872 0.162  0.1715
 0.1568 0.0988 0.1062 0.1746 0.0932 0.1411 0.1505 0.1316 0.16   0.1158
 0.1284 0.1095 0.1695 0.1474 0.1537 0.1632 0.0751 0.1422 0.1218 0.1663
 0.1726 0.1853 0.1348 0.1531 0.1635 0.179  0.1758 0.1843 0.1821 0.1183
 0.074  0.1682 0.0774 0.1322 0.2086 0.1461 0.1311 0.1916 0.1884 0.1607
 0.2011 0.167  0.1979 0.1739 0.1704 0.1913 0.1774 0.0705 0.1878 0.1809
 0.2017 0.1982 0.1947 0.2121 0.1459 0.1385 0.1025 0.1099 0.1136 0.2052
 0.1719 0.0639 0.1645 0.0676 0.1793 0.209  0.2016 0.183  0.1941 0.1756
 0.1691 0.1754 0.1722 0.1628 0.1786 0.1659 0.1741 0.1709 0.1457 0.1804
 0.1646 0.1551 0.1772 0.1829 0.1861 0.1797 0.1766 0.1854 0.1665 0.1791
 0.1886 0.1759 0.1443 0.1728 0.1936 0.1683 0.1778 0.2164 0.1867]
0
installment float64
[829.1  228.22 366.86 … 161.01 257.7  853.43]
0
log.annual.inc float64
[11.35040654 11.08214255 10.37349118 … 12.29225034 10.99909533
 10.11047245]
0
dti float64
[19.48 14.29 11.63 … 10.31 23.74 24.05]
0
fico int64
[737 707 682 712 667 727 722 677 662 767 747 702 672 797 772 782 802 812
 742 692 777 762 757 787 717 752 792 627 687 697 732 822 632 807 817 827
 642 647 652 657 637 612 617 622]
0
```

```
days.with.cr.line float64
[ 5639.958333  2760.         4710.        …  3423.041667  5916.
 10474.      ]
0
revol.bal int64
[28854 33623  3511 …   184 10036 37879]
0
revol.util float64
[ 52.1   76.7   25.6  … 104.3  106.4   69.14]
0
inq.last.6mths int64
[ 0  1  2  3  4  5  6  8  7 33  9 18 14 15 13 12 10 19 11 16 20 27 25 28
 31 24 17 32]
0
delinq.2yrs int64
[ 0  1  2  4  3  5  6 13  7  8 11]
0
pub.rec int64
[0 1 2 3 4 5]
0
not.fully.paid int64
[0 1]
0
```

[8]:
```
loan['not.fully.paid'].isnull().mean()
```

[8]:
```
0.0
```

[9]:
```
loan_1=pd.get_dummies(loan, columns=['purpose'])
```

[10]:
```
loan_1['log.annual.inc'] = np.exp(loan_1['log.annual.inc'])
```

[11]:
```
loan_1.head()
```

[11]:
```
   credit.policy  int.rate  installment  log.annual.inc    dti  fico  \
0              1    0.1189       829.10    85000.000385  19.48   737
1              1    0.1071       228.22    65000.000073  14.29   707
2              1    0.1357       366.86    31999.999943  11.63   682
3              1    0.1008       162.34    85000.000385   8.10   712
4              1    0.1426       102.92    80799.999636  14.97   667

   days.with.cr.line  revol.bal  revol.util  inq.last.6mths  delinq.2yrs  \
0        5639.958333      28854        52.1               0            0
1        2760.000000      33623        76.7               0            0
2        4710.000000       3511        25.6               1            0
3        2699.958333      33667        73.2               1            0
4        4066.000000       4740        39.5               0            1
```

```
   pub.rec  not.fully.paid  purpose_all_other  purpose_credit_card  \
0        0               0                  0                    0
1        0               0                  0                    1
2        0               0                  0                    0
3        0               0                  0                    0
4        0               0                  0                    1

   purpose_debt_consolidation  purpose_educational  purpose_home_improvement  \
0                           1                    0                         0
1                           0                    0                         0
2                           1                    0                         0
3                           1                    0                         0
4                           0                    0                         0

   purpose_major_purchase  purpose_small_business
0                       0                       0
1                       0                       0
2                       0                       0
3                       0                       0
4                       0                       0
```

[12]:
```
loan_class_0, loan_class_1 = loan['not.fully.paid'].value_counts()
```

[13]:
```
loan_0 = loan[loan['not.fully.paid'] == 0]
loan_1 = loan[loan['not.fully.paid'] == 1]
```

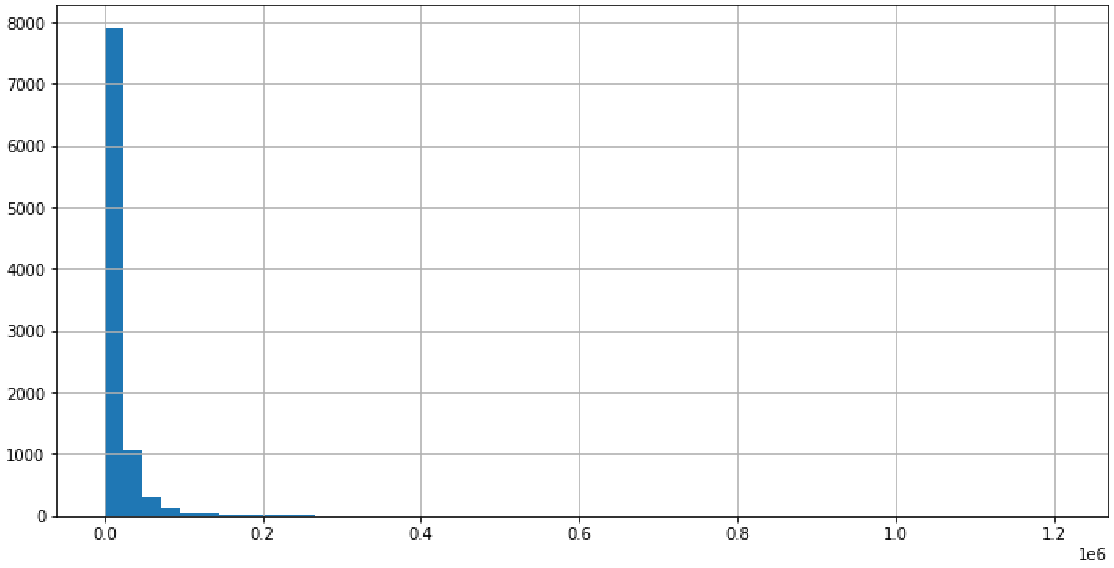
[14]:
```
loan_1_over = loan_1.sample(loan_class_0, replace=True)
loan_test_over = pd.concat([loan_0, loan_1_over], axis=0)
```

[15]:
```
print('over-sampling:')
print(loan_test_over['not.fully.paid'].value_counts())
```

```
over-sampling:
1    8045
0    8045
Name: not.fully.paid, dtype: int64
```

[16]:
```
loan['revol.bal'].hist(figsize=[12,6], bins=50)
```

[16]:
```
<AxesSubplot:>
```



0.0.2 Transform categorical values into numerical values

[17]:
```
obj_loan = loan.select_dtypes(include=['object']).copy()
obj_loan.head()
```

[17]:
```
              purpose
0  debt_consolidation
1         credit_card
2  debt_consolidation
3  debt_consolidation
4         credit_card
```

[18]:
```
obj_loan["purpose"].value_counts()
```

[18]:
```
debt_consolidation    3957
all_other             2331
credit_card           1262
home_improvement       629
small_business         619
major_purchase         437
educational            343
Name: purpose, dtype: int64
```

[19]:
```
obj_loan = obj_loan.fillna({"purpose" : "credit_card"})
```

[20]:
```
cleanup_nums = {"purpose": {"credit_card": 1,"debt_consolidation": 2 }}
```

[21]:

```
obj_loan=obj_loan.replace(cleanup_nums)
obj_loan.head()
```

[21]:

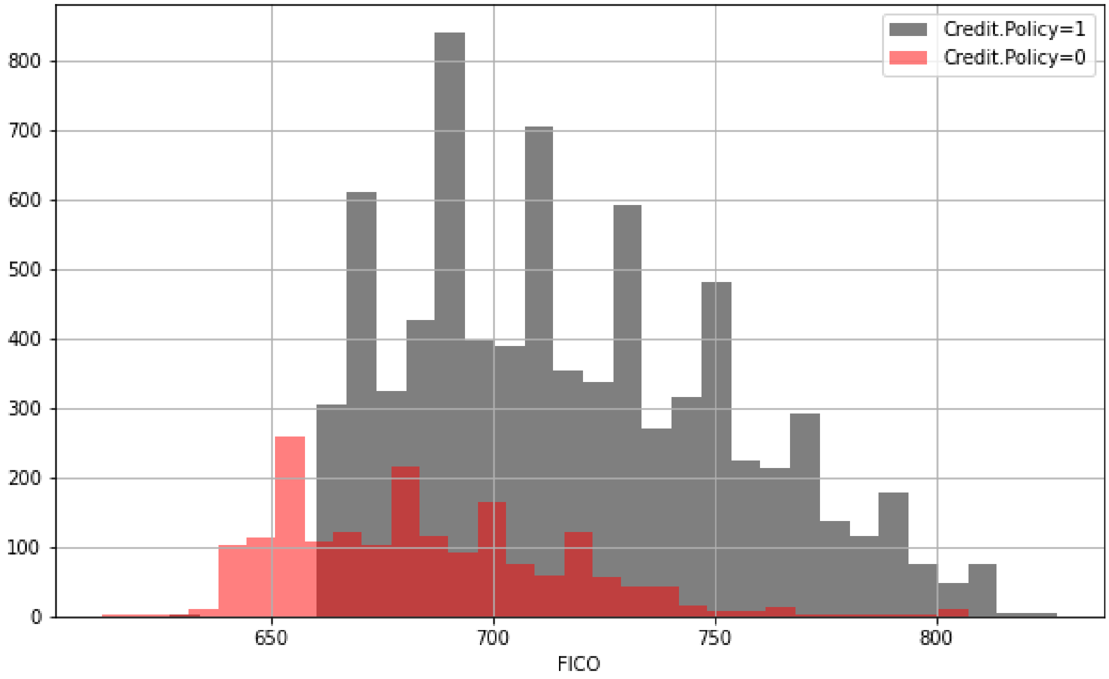
```
  purpose
0       2
1       1
2       2
3       2
4       1
```

[22]:

```
plt.figure(figsize=(10,6))
loan[loan['credit.policy']==1]['fico'].hist(alpha=0.
 ↪5,color='black',bins=30,label='Credit.Policy=1')
loan[loan['credit.policy']==0]['fico'].hist(alpha=0.
 ↪5,color='red',bins=30,label='Credit.Policy=0')
plt.legend()
plt.xlabel('FICO')
```

[22]:

```
Text(0.5, 0, 'FICO')
```

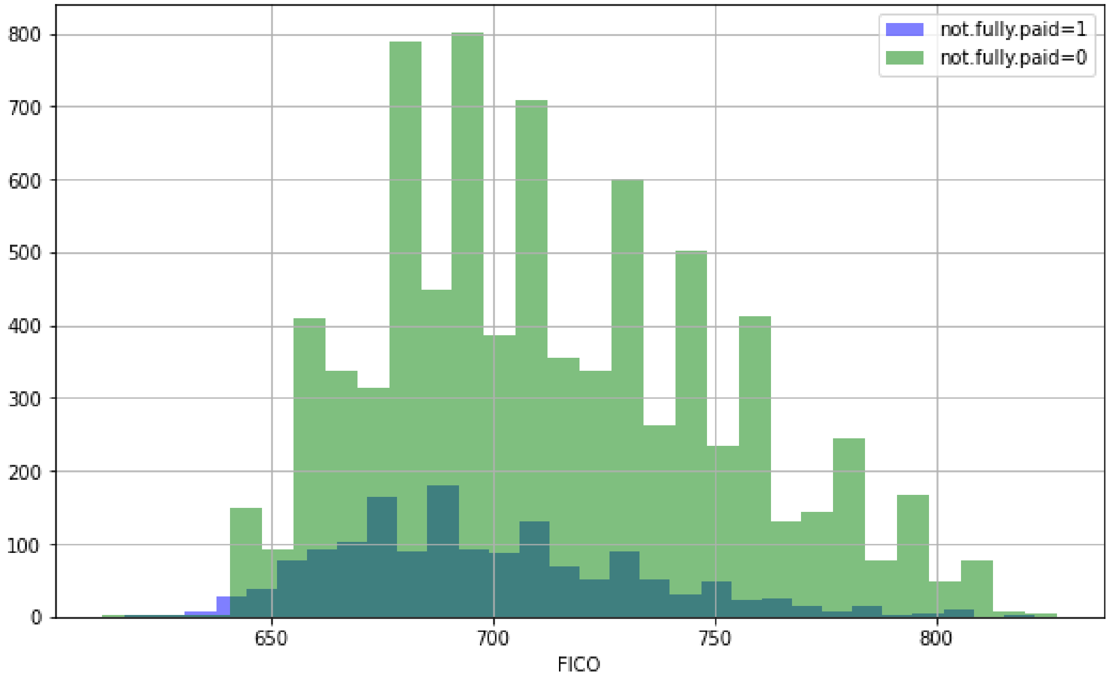


[23]:

```
plt.figure(figsize=(10,6))
loan[loan['not.fully.paid']==1]['fico'].hist(alpha=0.5,color='blue',
bins=30,label='not.fully.paid=1')
loan[loan['not.fully.paid']==0]['fico'].hist(alpha=0.5,color='green',
bins=30,label='not.fully.paid=0')
```

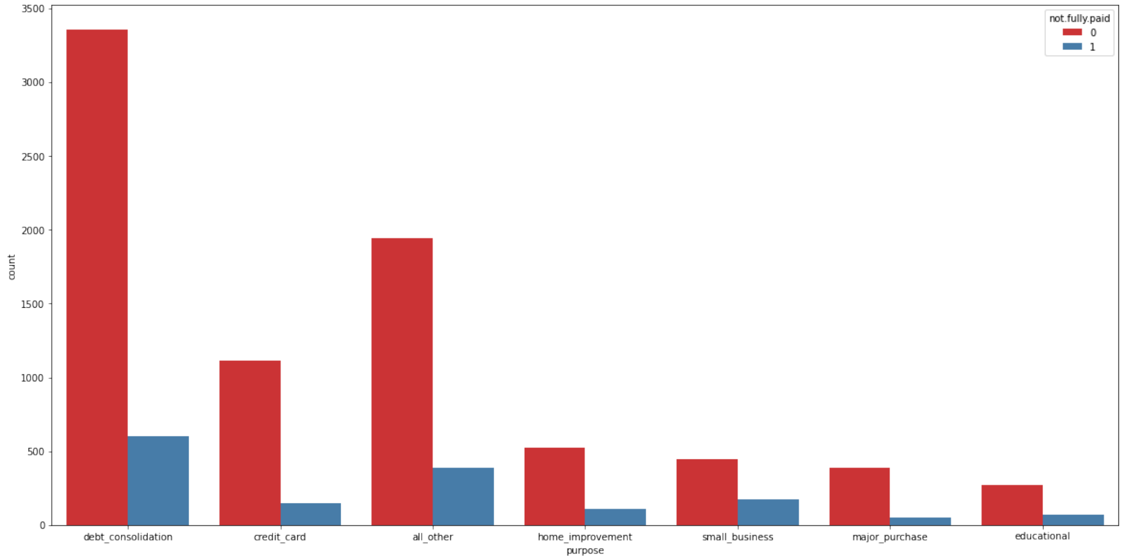
```
plt.legend()
plt.xlabel('FICO')
```

```
[23]: Text(0.5, 0, 'FICO')
```



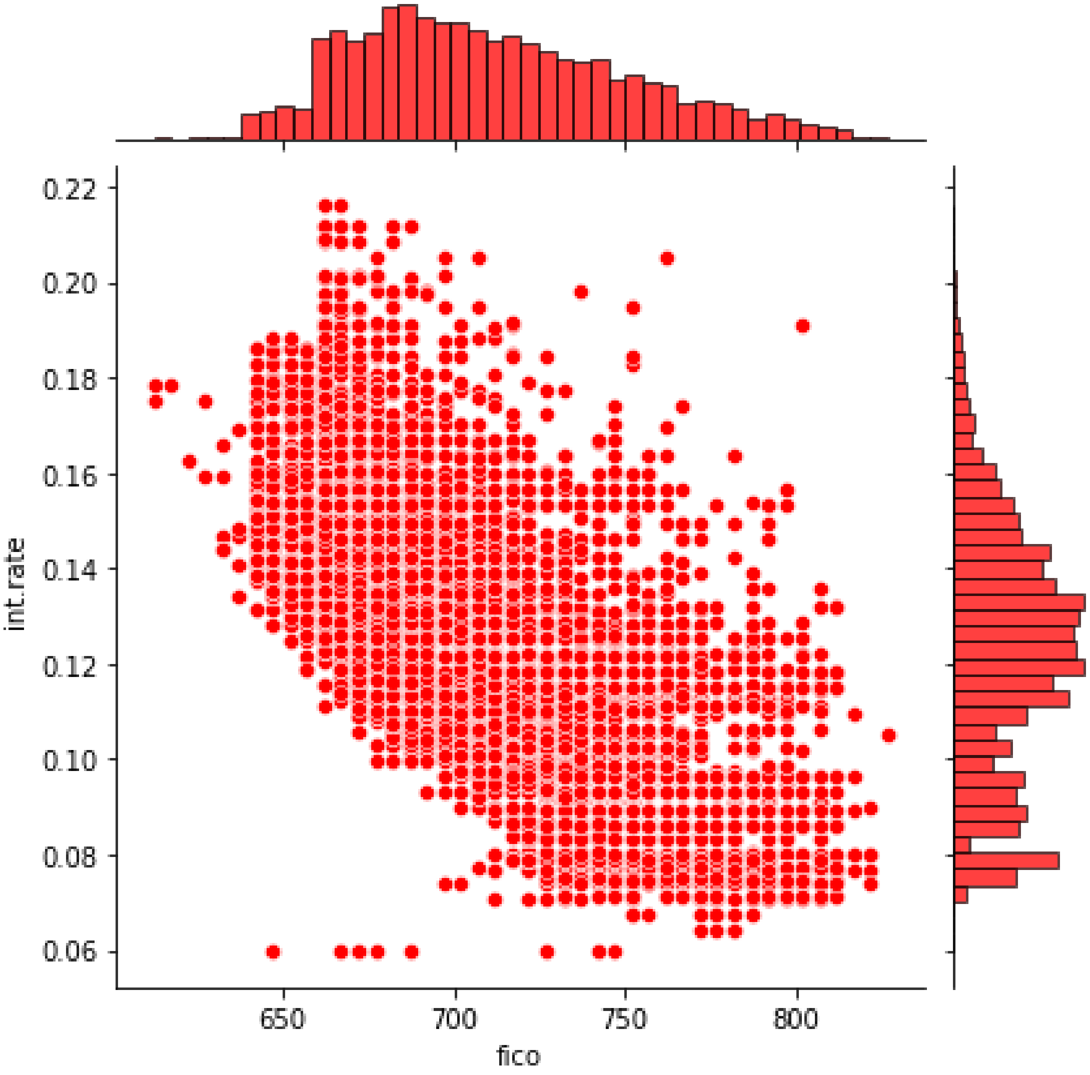
```
[24]: plt.figure(figsize=(20,10))
      sns.countplot(x='purpose',hue='not.fully.paid',data=loan,palette='Set1')
```

```
[24]: <AxesSubplot:xlabel='purpose', ylabel='count'>
```



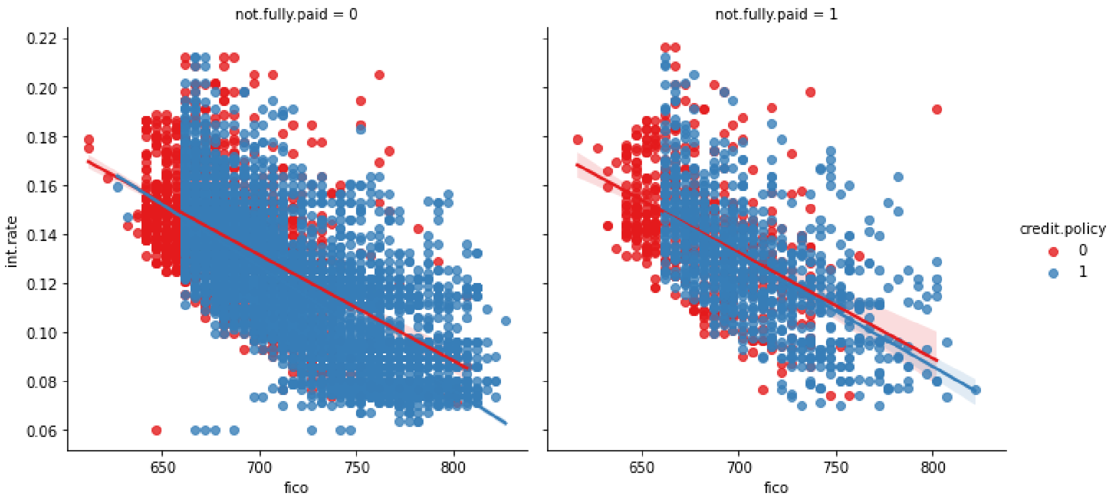
```
[25]: sns.jointplot(x='fico',y='int.rate',data=loan,color='red')
```

```
[25]: <seaborn.axisgrid.JointGrid at 0x7fbf36013190>
```



```
[26]: plt.figure(figsize=(20,10))
      sns.lmplot(y='int.rate',x='fico',data=loan,hue='credit.policy',
      col='not.fully.paid',palette='Set1')
```

```
[26]: <seaborn.axisgrid.FacetGrid at 0x7fbf35cf4350>

      <Figure size 1440x720 with 0 Axes>
```



[27]:
```
loan_num = loan.select_dtypes(include = ['float64','int64'])
loan_num
```

[27]:
```
      credit.policy  int.rate  installment  log.annual.inc    dti  fico  \
0                 1    0.1189       829.10       11.350407  19.48   737
1                 1    0.1071       228.22       11.082143  14.29   707
2                 1    0.1357       366.86       10.373491  11.63   682
3                 1    0.1008       162.34       11.350407   8.10   712
4                 1    0.1426       102.92       11.299732  14.97   667
…             …       …          …             …    …   …
9573              0    0.1461       344.76       12.180755  10.39   672
9574              0    0.1253       257.70       11.141862   0.21   722
9575              0    0.1071        97.81       10.596635  13.09   687
9576              0    0.1600       351.58       10.819778  19.18   692
9577              0    0.1392       853.43       11.264464  16.28   732

      days.with.cr.line  revol.bal  revol.util  inq.last.6mths  delinq.2yrs  \
0           5639.958333      28854        52.1               0            0
1           2760.000000      33623        76.7               0            0
2           4710.000000       3511        25.6               1            0
3           2699.958333      33667        73.2               1            0
4           4066.000000       4740        39.5               0            1
…                 …        …         …             …          …
9573       10474.000000     215372        82.1               2            0
9574        4380.000000        184         1.1               5            0
9575        3450.041667      10036        82.9               8            0
9576        1800.000000          0         3.2               5            0
9577        4740.000000      37879        57.0               6            0

      pub.rec  not.fully.paid
```

```
0            0                0
1            0                0
2            0                0
3            0                0
4            0                0
…       …             …
9573         0                1
9574         0                1
9575         0                1
9576         0                1
9577         0                1

[9578 rows x 13 columns]
```

0.0.3 correlation

[28]:
```
cor_matrix = loan.corr().abs()
print(cor_matrix)
```

```
                   credit.policy  int.rate  installment  log.annual.inc  \
credit.policy           1.000000  0.294089     0.058770        0.034906
int.rate                0.294089  1.000000     0.276140        0.056383
installment             0.058770  0.276140     1.000000        0.448102
log.annual.inc          0.034906  0.056383     0.448102        1.000000
dti                     0.090901  0.220006     0.050202        0.054065
fico                    0.348319  0.714821     0.086039        0.114576
days.with.cr.line       0.099026  0.124022     0.183297        0.336896
revol.bal               0.187518  0.092527     0.233625        0.372140
revol.util              0.104095  0.464837     0.081356        0.054881
inq.last.6mths          0.535511  0.202780     0.010419        0.029171
delinq.2yrs             0.076318  0.156079     0.004368        0.029203
pub.rec                 0.054243  0.098162     0.032760        0.016506
not.fully.paid          0.158119  0.159552     0.049955        0.033439

                        dti      fico  days.with.cr.line  revol.bal  \
credit.policy      0.090901  0.348319           0.099026   0.187518
int.rate           0.220006  0.714821           0.124022   0.092527
installment        0.050202  0.086039           0.183297   0.233625
log.annual.inc     0.054065  0.114576           0.336896   0.372140
dti                1.000000  0.241191           0.060101   0.188748
fico               0.241191  1.000000           0.263880   0.015553
days.with.cr.line  0.060101  0.263880           1.000000   0.229344
revol.bal          0.188748  0.015553           0.229344   1.000000
revol.util         0.337109  0.541289           0.024239   0.203779
inq.last.6mths     0.029189  0.185293           0.041736   0.022394
delinq.2yrs        0.021792  0.216340           0.081374   0.033243
```

```
pub.rec            0.006209  0.147592           0.071826   0.031010
not.fully.paid     0.037362  0.149666           0.029237   0.053699

                   revol.util  inq.last.6mths  delinq.2yrs   pub.rec  \
credit.policy        0.104095        0.535511     0.076318  0.054243
int.rate             0.464837        0.202780     0.156079  0.098162
installment          0.081356        0.010419     0.004368  0.032760
log.annual.inc       0.054881        0.029171     0.029203  0.016506
dti                  0.337109        0.029189     0.021792  0.006209
fico                 0.541289        0.185293     0.216340  0.147592
days.with.cr.line    0.024239        0.041736     0.081374  0.071826
revol.bal            0.203779        0.022394     0.033243  0.031010
revol.util           1.000000        0.013880     0.042740  0.066717
inq.last.6mths       0.013880        1.000000     0.021245  0.072673
delinq.2yrs          0.042740        0.021245     1.000000  0.009184
pub.rec              0.066717        0.072673     0.009184  1.000000
not.fully.paid       0.082088        0.149452     0.008881  0.048634

                   not.fully.paid
credit.policy            0.158119
int.rate                 0.159552
installment              0.049955
log.annual.inc           0.033439
dti                      0.037362
fico                     0.149666
days.with.cr.line        0.029237
revol.bal                0.053699
revol.util               0.082088
inq.last.6mths           0.149452
delinq.2yrs              0.008881
pub.rec                  0.048634
not.fully.paid           1.000000
```

[29]:

```
upper_tri = cor_matrix.where(np.triu(np.ones(cor_matrix.shape),k=1).astype(np.
 ↪bool))
print(upper_tri)
```

```
                   credit.policy  int.rate  installment  log.annual.inc  \
credit.policy                NaN  0.294089      0.05877        0.034906
int.rate                     NaN       NaN      0.27614        0.056383
installment                  NaN       NaN          NaN        0.448102
log.annual.inc               NaN       NaN          NaN             NaN
dti                          NaN       NaN          NaN             NaN
fico                         NaN       NaN          NaN             NaN
days.with.cr.line            NaN       NaN          NaN             NaN
revol.bal                    NaN       NaN          NaN             NaN
revol.util                   NaN       NaN          NaN             NaN
inq.last.6mths               NaN       NaN          NaN             NaN
```

```
delinq.2yrs                  NaN       NaN          NaN             NaN
pub.rec                      NaN       NaN          NaN             NaN
not.fully.paid               NaN       NaN          NaN             NaN

                        dti      fico  days.with.cr.line  revol.bal  \
credit.policy      0.090901  0.348319           0.099026   0.187518
int.rate           0.220006  0.714821           0.124022   0.092527
installment        0.050202  0.086039           0.183297   0.233625
log.annual.inc     0.054065  0.114576           0.336896   0.372140
dti                     NaN  0.241191           0.060101   0.188748
fico                    NaN       NaN           0.263880   0.015553
days.with.cr.line       NaN       NaN                NaN   0.229344
revol.bal               NaN       NaN                NaN        NaN
revol.util              NaN       NaN                NaN        NaN
inq.last.6mths          NaN       NaN                NaN        NaN
delinq.2yrs             NaN       NaN                NaN        NaN
pub.rec                 NaN       NaN                NaN        NaN
not.fully.paid          NaN       NaN                NaN        NaN

                   revol.util  inq.last.6mths  delinq.2yrs   pub.rec  \
credit.policy        0.104095        0.535511     0.076318  0.054243
int.rate             0.464837        0.202780     0.156079  0.098162
installment          0.081356        0.010419     0.004368  0.032760
log.annual.inc       0.054881        0.029171     0.029203  0.016506
dti                  0.337109        0.029189     0.021792  0.006209
fico                 0.541289        0.185293     0.216340  0.147592
days.with.cr.line    0.024239        0.041736     0.081374  0.071826
revol.bal            0.203779        0.022394     0.033243  0.031010
revol.util                NaN        0.013880     0.042740  0.066717
inq.last.6mths            NaN             NaN     0.021245  0.072673
delinq.2yrs               NaN             NaN          NaN  0.009184
pub.rec                   NaN             NaN          NaN       NaN
not.fully.paid            NaN             NaN          NaN       NaN

                   not.fully.paid
credit.policy            0.158119
int.rate                 0.159552
installment              0.049955
log.annual.inc           0.033439
dti                      0.037362
fico                     0.149666
days.with.cr.line        0.029237
revol.bal                0.053699
revol.util               0.082088
inq.last.6mths           0.149452
delinq.2yrs              0.008881
pub.rec                  0.048634
not.fully.paid                NaN
```

[30]:

```
loan_feats = ['purpose']
```

[31]:

```
final_data = pd.get_dummies(loan_test_over,columns=loan_feats,drop_first=True)
```

[32]:

```
final_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 16090 entries, 0 to 5247
Data columns (total 19 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   credit.policy               16090 non-null  int64
 1   int.rate                    16090 non-null  float64
 2   installment                 16090 non-null  float64
 3   log.annual.inc              16090 non-null  float64
 4   dti                         16090 non-null  float64
 5   fico                        16090 non-null  int64
 6   days.with.cr.line           16090 non-null  float64
 7   revol.bal                   16090 non-null  int64
 8   revol.util                  16090 non-null  float64
 9   inq.last.6mths              16090 non-null  int64
 10  delinq.2yrs                 16090 non-null  int64
 11  pub.rec                     16090 non-null  int64
 12  not.fully.paid              16090 non-null  int64
 13  purpose_credit_card         16090 non-null  uint8
 14  purpose_debt_consolidation  16090 non-null  uint8
 15  purpose_educational         16090 non-null  uint8
 16  purpose_home_improvement    16090 non-null  uint8
 17  purpose_major_purchase      16090 non-null  uint8
 18  purpose_small_business      16090 non-null  uint8
dtypes: float64(6), int64(7), uint8(6)
memory usage: 1.8 MB
```

[33]:

```
final_data.corr().head()
```

[33]:

```
                credit.policy  int.rate  installment  log.annual.inc  \
credit.policy        1.000000 -0.285715     0.057394        0.021102
int.rate            -0.285715  1.000000     0.261221        0.080622
installment          0.057394  0.261221     1.000000        0.476400
log.annual.inc       0.021102  0.080622     0.476400        1.000000
dti                 -0.098093  0.200391     0.020021       -0.031347

                     dti      fico  days.with.cr.line  revol.bal  revol.util  \
credit.policy  -0.098093  0.372529           0.105735  -0.200859   -0.102824
int.rate        0.200391 -0.681670          -0.111505   0.085462    0.415365
installment     0.020021  0.118053           0.180533   0.274939    0.046141
log.annual.inc -0.031347  0.108209           0.337744   0.418789    0.072960
```

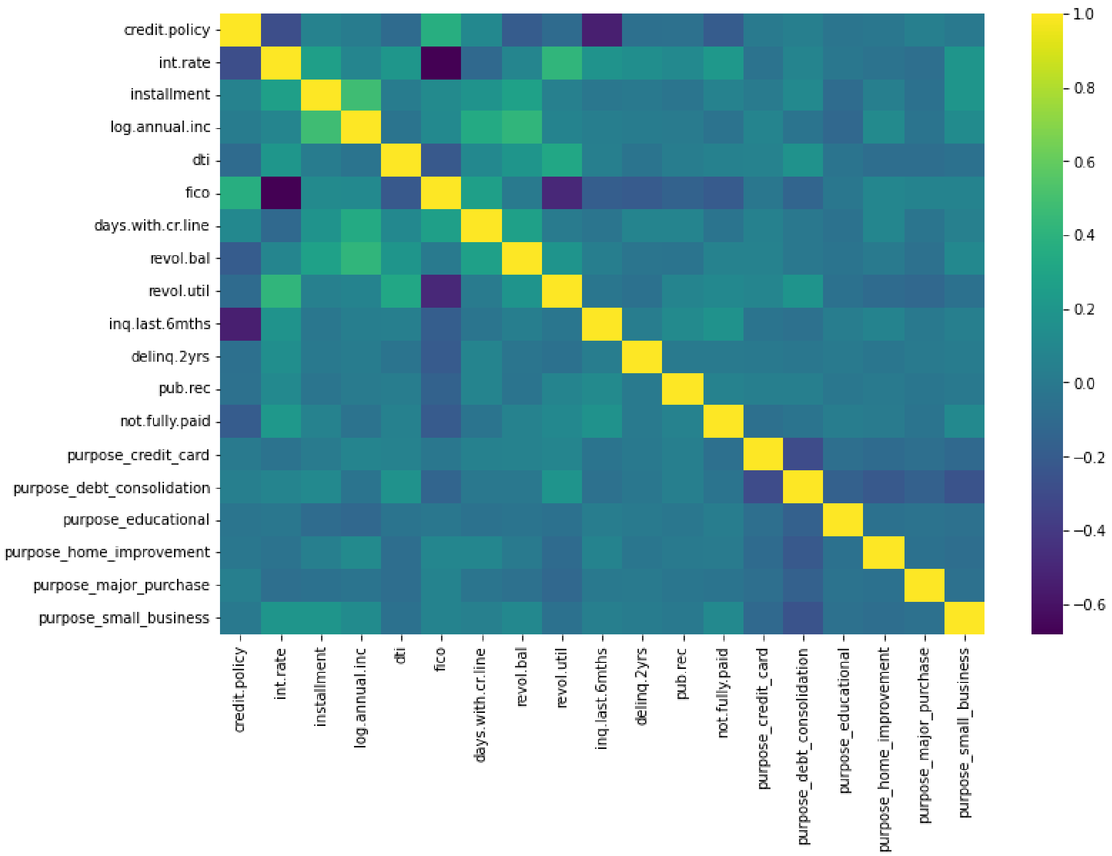
```
dti             1.000000 -0.217686           0.101284   0.194746    0.323075

                inq.last.6mths  delinq.2yrs   pub.rec  not.fully.paid  \
credit.policy        -0.539332    -0.067231 -0.063797       -0.197300
int.rate              0.180460     0.142390  0.111791        0.215678
installment          -0.017138    -0.003465 -0.026791        0.060361
log.annual.inc        0.033796     0.020589  0.010661       -0.043414
dti                   0.034873    -0.033015  0.027393        0.052626

                purpose_credit_card  purpose_debt_consolidation  \
credit.policy              0.007494                    0.038306
int.rate                  -0.040861                    0.075537
installment                0.009656                    0.111323
log.annual.inc             0.076833                   -0.034204
dti                        0.066190                    0.177766

                purpose_educational  purpose_home_improvement  \
credit.policy             -0.027751                 -0.012143
int.rate                  -0.017241                 -0.039113
installment               -0.095046                  0.039367
log.annual.inc            -0.120965                  0.113437
dti                       -0.034902                 -0.077576

                purpose_major_purchase  purpose_small_business
credit.policy                 0.039231               -0.003756
int.rate                     -0.071089                0.192079
installment                  -0.053912                0.196142
log.annual.inc               -0.031937                0.122623
dti                          -0.079619               -0.052172
```

[34]:

```
plt.figure(
figsize=[12,8]
)
sns.heatmap(
data=final_data.corr(),
cmap='viridis',
annot=False,
fmt='.2g'
)
```

[34]:

```
<AxesSubplot:>
```



```
[35]: loan.describe().transpose()
```

```
[35]:                     count          mean           std         min  \
      credit.policy       9578.0      0.804970      0.396245    0.000000
      int.rate            9578.0      0.122640      0.026847    0.060000
      installment         9578.0    319.089413    207.071301   15.670000
      log.annual.inc      9578.0     10.932117      0.614813    7.547502
      dti                 9578.0     12.606679      6.883970    0.000000
      fico                9578.0    710.846314     37.970537  612.000000
      days.with.cr.line   9578.0   4560.767197   2496.930377  178.958333
      revol.bal           9578.0  16913.963876  33756.189557    0.000000
      revol.util          9578.0     46.799236     29.014417    0.000000
      inq.last.6mths      9578.0      1.577469      2.200245    0.000000
      delinq.2yrs         9578.0      0.163708      0.546215    0.000000
      pub.rec             9578.0      0.062122      0.262126    0.000000
      not.fully.paid      9578.0      0.160054      0.366676    0.000000

                                  25%          50%           75%           max
      credit.policy          1.000000     1.000000      1.000000  1.000000e+00
      int.rate               0.103900     0.122100      0.140700  2.164000e-01
```

```
installment         163.770000   268.950000    432.762500  9.401400e+02
log.annual.inc       10.558414    10.928884     11.291293  1.452835e+01
dti                   7.212500    12.665000     17.950000  2.996000e+01
fico                682.000000   707.000000    737.000000  8.270000e+02
days.with.cr.line  2820.000000  4139.958333   5730.000000  1.763996e+04
revol.bal          3187.000000  8596.000000  18249.500000  1.207359e+06
revol.util           22.600000    46.300000     70.900000  1.190000e+02
inq.last.6mths        0.000000     1.000000      2.000000  3.300000e+01
delinq.2yrs           0.000000     0.000000      0.000000  1.300000e+01
pub.rec               0.000000     0.000000      0.000000  5.000000e+00
not.fully.paid        0.000000     0.000000      0.000000  1.000000e+00
```

```
[36]: drop = ['revol.bal', 'days.with.cr.line', 'installment', 'revol.bal']
      final_data.drop(drop, axis=1, inplace=True)
```

```
[37]: final_data.drop
```

```
[37]: <bound method DataFrame.drop of       credit.policy  int.rate  log.annual.inc
      dti  fico  revol.util  \
      0                 1    0.1189       11.350407  19.48   737        52.1
      1                 1    0.1071       11.082143  14.29   707        76.7
      2                 1    0.1357       10.373491  11.63   682        25.6
      3                 1    0.1008       11.350407   8.10   712        73.2
      4                 1    0.1426       11.299732  14.97   667        39.5
      …             …       …             …     …   …        …
      1013              1    0.1292       10.819778  18.01   672        53.4
      904               1    0.0976       10.902280   4.24   707        61.6
      9497              0    0.1183       11.082143  23.54   722        51.8
      9165              0    0.1758       11.561716  15.89   662        78.9
      5247              1    0.1253        9.639522  20.63   697        14.7

            inq.last.6mths  delinq.2yrs  pub.rec  not.fully.paid  \
      0                  0            0        0               0
      1                  0            0        0               0
      2                  1            0        0               0
      3                  1            0        0               0
      4                  0            1        0               0
      …                …          …       …            …
      1013               0            0        0               1
      904                0            0        0               1
      9497               5            0        0               1
      9165               5            0        1               1
      5247               1            1        0               1

            purpose_credit_card  purpose_debt_consolidation  purpose_educational  \
      0                       0                           1                    0
      1                       1                           0                    0
```

```
2                        0                           1                     0
3                        0                           1                     0
4                        1                           0                     0
…                    …                          …                  …
1013                     0                           0                     0
904                      0                           1                     0
9497                     0                           0                     0
9165                     0                           1                     0
5247                     0                           0                     0

      purpose_home_improvement  purpose_major_purchase  purpose_small_business
0                            0                       0                       0
1                            0                       0                       0
2                            0                       0                       0
3                            0                       0                       0
4                            0                       0                       0
…                        …                      …                      …
1013                         0                       0                       0
904                          0                       0                       0
9497                         0                       0                       0
9165                         0                       0                       0
5247                         0                       0                       0

[16090 rows x 16 columns]>
```

```
[38]: final_data.isnull().mean()
```

```
[38]: credit.policy                 0.0
      int.rate                      0.0
      log.annual.inc                0.0
      dti                           0.0
      fico                          0.0
      revol.util                    0.0
      inq.last.6mths                0.0
      delinq.2yrs                   0.0
      pub.rec                       0.0
      not.fully.paid                0.0
      purpose_credit_card           0.0
      purpose_debt_consolidation    0.0
      purpose_educational           0.0
      purpose_home_improvement      0.0
      purpose_major_purchase        0.0
      purpose_small_business        0.0
      dtype: float64
```

```
[39]: loan['not.fully.paid'].isnull().mean()
      loan.groupby('not.fully.paid')['not.fully.paid'].count()/len(loan)
```

[39]:

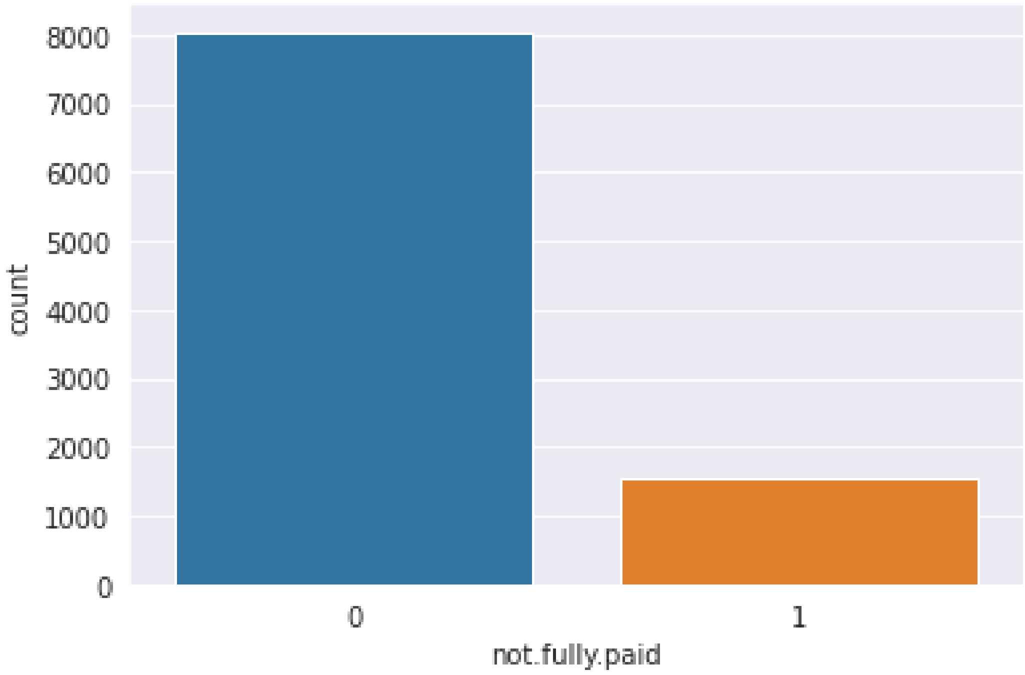
```
not.fully.paid
0    0.839946
1    0.160054
Name: not.fully.paid, dtype: float64
```

[40]:

```
sns.set_style('darkgrid')
sns.countplot(x='not.fully.paid', data=loan)
```

[40]:

```
<AxesSubplot:xlabel='not.fully.paid', ylabel='count'>
```

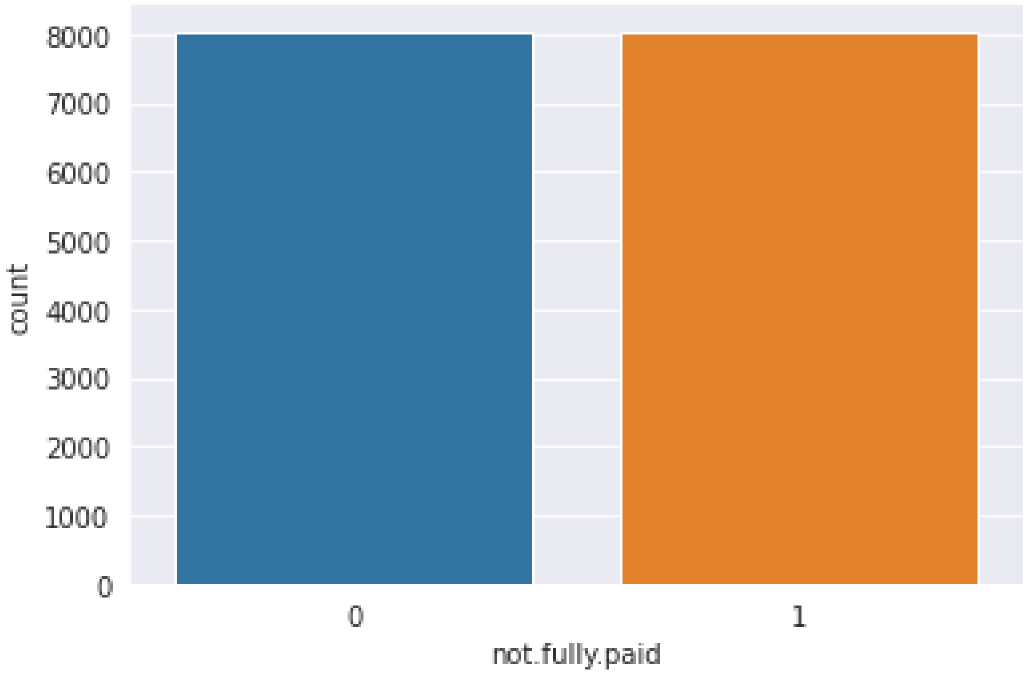


[41]:

```
count_class_0, count_class_1 = loan['not.fully.paid'].value_counts()
loan_0 = loan[loan['not.fully.paid'] == 0]
loan_1 = loan[loan['not.fully.paid'] == 1]
loan_1_over = loan_1.sample(count_class_0, replace=True)
loan_test_over = pd.concat([loan_0, loan_1_over], axis=0)
print('Random over-sampling:')
print(loan_test_over['not.fully.paid'].value_counts())
sns.set_style('darkgrid')
sns.countplot(x='not.fully.paid', data=loan_test_over)
```

```
Random over-sampling:
1    8045
0    8045
Name: not.fully.paid, dtype: int64
```

```
[41]: <AxesSubplot:xlabel='not.fully.paid', ylabel='count'>
```



```
[42]: col_fea = ['purpose']
      final_data = pd.get_dummies(loan_test_over,columns=col_fea,drop_first=True)
      final_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 16090 entries, 0 to 9574
Data columns (total 19 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   credit.policy               16090 non-null  int64
 1   int.rate                    16090 non-null  float64
 2   installment                 16090 non-null  float64
 3   log.annual.inc              16090 non-null  float64
 4   dti                         16090 non-null  float64
 5   fico                        16090 non-null  int64
 6   days.with.cr.line           16090 non-null  float64
 7   revol.bal                   16090 non-null  int64
 8   revol.util                  16090 non-null  float64
 9   inq.last.6mths              16090 non-null  int64
 10  delinq.2yrs                 16090 non-null  int64
 11  pub.rec                     16090 non-null  int64
 12  not.fully.paid              16090 non-null  int64
 13  purpose_credit_card         16090 non-null  uint8
 14  purpose_debt_consolidation  16090 non-null  uint8
 15  purpose_educational         16090 non-null  uint8
 16  purpose_home_improvement    16090 non-null  uint8
 17  purpose_major_purchase      16090 non-null  uint8
 18  purpose_small_business      16090 non-null  uint8
dtypes: float64(6), int64(7), uint8(6)
memory usage: 2.1 MB
```

0.0.4 split the dataset

[43]:

```
train = final_data[final_data['not.fully.paid'].isin([0,1])]
pred = final_data[final_data['not.fully.paid'] == 2]
X = train.drop('not.fully.paid', axis=1).values
y = train['not.fully.paid'].values
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
 ↪3,random_state = 101)
scaler = MinMaxScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

0.0.5 creating model

[44]:

```
model = Sequential()
model.add(
Dense(19, activation='relu')
)
model.add(
Dense(10, activation='relu')
)
model.add(
Dense(5, activation='relu')
)
model.add(
Dense(1, activation='sigmoid')
)
```

[45]:

```
model.compile(
optimizer='adam',
loss='binary_crossentropy',
metrics=['accuracy']
)
```

[46]:

```
early_stop = EarlyStopping(
monitor='val_loss',
mode='min',
    verbose=1,
patience=25
)
model.fit(
X_train,
y_train,
epochs=200,
batch_size=256,
validation_data=(X_test, y_test),
callbacks=[early_stop]
)
```

```
Epoch 1/200
44/44 [==============================] - 1s 6ms/step - loss: 0.6794 - accuracy:
0.5982 - val_loss: 0.6715 - val_accuracy: 0.6120
Epoch 2/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6625 - accuracy:
0.6133 - val_loss: 0.6598 - val_accuracy: 0.6126
Epoch 3/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6515 - accuracy:
0.6213 - val_loss: 0.6542 - val_accuracy: 0.6114
Epoch 4/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6456 - accuracy:
0.6224 - val_loss: 0.6498 - val_accuracy: 0.6215
Epoch 5/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6423 - accuracy:
0.6284 - val_loss: 0.6484 - val_accuracy: 0.6196
Epoch 6/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6402 - accuracy:
0.6270 - val_loss: 0.6479 - val_accuracy: 0.6145
Epoch 7/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6394 - accuracy:
0.6284 - val_loss: 0.6456 - val_accuracy: 0.6223
Epoch 8/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6376 - accuracy:
0.6274 - val_loss: 0.6462 - val_accuracy: 0.6178
Epoch 9/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6362 - accuracy:
0.6273 - val_loss: 0.6442 - val_accuracy: 0.6248
Epoch 10/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6350 - accuracy:
0.6319 - val_loss: 0.6436 - val_accuracy: 0.6215
Epoch 11/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6339 - accuracy:
0.6319 - val_loss: 0.6435 - val_accuracy: 0.6223
Epoch 12/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6329 - accuracy:
```

```
0.6331 - val_loss: 0.6426 - val_accuracy: 0.6209
Epoch 13/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6318 - accuracy:
0.6322 - val_loss: 0.6419 - val_accuracy: 0.6271
Epoch 14/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6311 - accuracy:
0.6348 - val_loss: 0.6418 - val_accuracy: 0.6225
Epoch 15/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6309 - accuracy:
0.6370 - val_loss: 0.6407 - val_accuracy: 0.6259
Epoch 16/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6296 - accuracy:
0.6355 - val_loss: 0.6402 - val_accuracy: 0.6267
Epoch 17/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6290 - accuracy:
0.6375 - val_loss: 0.6404 - val_accuracy: 0.6277
Epoch 18/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6285 - accuracy:
0.6345 - val_loss: 0.6403 - val_accuracy: 0.6259
Epoch 19/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6276 - accuracy:
0.6370 - val_loss: 0.6392 - val_accuracy: 0.6300
Epoch 20/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6272 - accuracy:
0.6378 - val_loss: 0.6408 - val_accuracy: 0.6310
Epoch 21/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6268 - accuracy:
0.6367 - val_loss: 0.6384 - val_accuracy: 0.6300
Epoch 22/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6260 - accuracy:
0.6388 - val_loss: 0.6387 - val_accuracy: 0.6325
Epoch 23/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6255 - accuracy:
0.6406 - val_loss: 0.6409 - val_accuracy: 0.6277
Epoch 24/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6250 - accuracy:
0.6379 - val_loss: 0.6385 - val_accuracy: 0.6341
Epoch 25/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6242 - accuracy:
0.6401 - val_loss: 0.6383 - val_accuracy: 0.6335
Epoch 26/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6237 - accuracy:
0.6407 - val_loss: 0.6365 - val_accuracy: 0.6300
Epoch 27/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6237 - accuracy:
0.6413 - val_loss: 0.6364 - val_accuracy: 0.6314
Epoch 28/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6242 - accuracy:
```

```
0.6430 - val_loss: 0.6375 - val_accuracy: 0.6356
Epoch 29/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6222 - accuracy:
0.6412 - val_loss: 0.6351 - val_accuracy: 0.6298
Epoch 30/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6226 - accuracy:
0.6394 - val_loss: 0.6353 - val_accuracy: 0.6360
Epoch 31/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6213 - accuracy:
0.6425 - val_loss: 0.6349 - val_accuracy: 0.6331
Epoch 32/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6209 - accuracy:
0.6413 - val_loss: 0.6342 - val_accuracy: 0.6368
Epoch 33/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6203 - accuracy:
0.6450 - val_loss: 0.6351 - val_accuracy: 0.6335
Epoch 34/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6206 - accuracy:
0.6441 - val_loss: 0.6348 - val_accuracy: 0.6319
Epoch 35/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6200 - accuracy:
0.6452 - val_loss: 0.6342 - val_accuracy: 0.6397
Epoch 36/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6192 - accuracy:
0.6470 - val_loss: 0.6334 - val_accuracy: 0.6350
Epoch 37/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6191 - accuracy:
0.6482 - val_loss: 0.6343 - val_accuracy: 0.6356
Epoch 38/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6188 - accuracy:
0.6417 - val_loss: 0.6340 - val_accuracy: 0.6346
Epoch 39/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6181 - accuracy:
0.6453 - val_loss: 0.6338 - val_accuracy: 0.6362
Epoch 40/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6184 - accuracy:
0.6482 - val_loss: 0.6334 - val_accuracy: 0.6348
Epoch 41/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6174 - accuracy:
0.6460 - val_loss: 0.6337 - val_accuracy: 0.6360
Epoch 42/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6171 - accuracy:
0.6480 - val_loss: 0.6332 - val_accuracy: 0.6370
Epoch 43/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6170 - accuracy:
0.6472 - val_loss: 0.6359 - val_accuracy: 0.6377
Epoch 44/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6161 - accuracy:
```

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0.6501 - val_loss: 0.6329 - val_accuracy: 0.6370
Epoch 45/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6159 - accuracy:
0.6512 - val_loss: 0.6327 - val_accuracy: 0.6341
Epoch 46/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6154 - accuracy:
0.6490 - val_loss: 0.6331 - val_accuracy: 0.6391
Epoch 47/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6150 - accuracy:
0.6505 - val_loss: 0.6334 - val_accuracy: 0.6346
Epoch 48/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6153 - accuracy:
0.6504 - val_loss: 0.6328 - val_accuracy: 0.6370
Epoch 49/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6142 - accuracy:
0.6477 - val_loss: 0.6332 - val_accuracy: 0.6343
Epoch 50/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6139 - accuracy:
0.6515 - val_loss: 0.6323 - val_accuracy: 0.6379
Epoch 51/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6136 - accuracy:
0.6506 - val_loss: 0.6324 - val_accuracy: 0.6358
Epoch 52/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6133 - accuracy:
0.6520 - val_loss: 0.6326 - val_accuracy: 0.6341
Epoch 53/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6127 - accuracy:
0.6501 - val_loss: 0.6329 - val_accuracy: 0.6362
Epoch 54/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6128 - accuracy:
0.6511 - val_loss: 0.6323 - val_accuracy: 0.6339
Epoch 55/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6122 - accuracy:
0.6503 - val_loss: 0.6326 - val_accuracy: 0.6364
Epoch 56/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6120 - accuracy:
0.6514 - val_loss: 0.6332 - val_accuracy: 0.6352
Epoch 57/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6115 - accuracy:
0.6530 - val_loss: 0.6326 - val_accuracy: 0.6348
Epoch 58/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6118 - accuracy:
0.6513 - val_loss: 0.6322 - val_accuracy: 0.6375
Epoch 59/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6106 - accuracy:
0.6532 - val_loss: 0.6331 - val_accuracy: 0.6346
Epoch 60/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6110 - accuracy:
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0.6545 - val_loss: 0.6317 - val_accuracy: 0.6381
Epoch 61/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6104 - accuracy:
0.6522 - val_loss: 0.6317 - val_accuracy: 0.6387
Epoch 62/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6096 - accuracy:
0.6541 - val_loss: 0.6327 - val_accuracy: 0.6325
Epoch 63/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6097 - accuracy:
0.6538 - val_loss: 0.6307 - val_accuracy: 0.6354
Epoch 64/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6090 - accuracy:
0.6523 - val_loss: 0.6317 - val_accuracy: 0.6404
Epoch 65/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6083 - accuracy:
0.6553 - val_loss: 0.6309 - val_accuracy: 0.6364
Epoch 66/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6085 - accuracy:
0.6548 - val_loss: 0.6310 - val_accuracy: 0.6377
Epoch 67/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6078 - accuracy:
0.6497 - val_loss: 0.6331 - val_accuracy: 0.6368
Epoch 68/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6075 - accuracy:
0.6555 - val_loss: 0.6305 - val_accuracy: 0.6385
Epoch 69/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6072 - accuracy:
0.6550 - val_loss: 0.6300 - val_accuracy: 0.6404
Epoch 70/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6074 - accuracy:
0.6548 - val_loss: 0.6346 - val_accuracy: 0.6356
Epoch 71/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6073 - accuracy:
0.6578 - val_loss: 0.6303 - val_accuracy: 0.6410
Epoch 72/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6062 - accuracy:
0.6565 - val_loss: 0.6307 - val_accuracy: 0.6393
Epoch 73/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6059 - accuracy:
0.6560 - val_loss: 0.6300 - val_accuracy: 0.6412
Epoch 74/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6059 - accuracy:
0.6566 - val_loss: 0.6339 - val_accuracy: 0.6368
Epoch 75/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6066 - accuracy:
0.6555 - val_loss: 0.6300 - val_accuracy: 0.6406
Epoch 76/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6054 - accuracy:
```

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0.6598 - val_loss: 0.6346 - val_accuracy: 0.6379
Epoch 77/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6049 - accuracy:
0.6573 - val_loss: 0.6306 - val_accuracy: 0.6453
Epoch 78/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6053 - accuracy:
0.6588 - val_loss: 0.6299 - val_accuracy: 0.6428
Epoch 79/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6047 - accuracy:
0.6577 - val_loss: 0.6297 - val_accuracy: 0.6435
Epoch 80/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6037 - accuracy:
0.6569 - val_loss: 0.6311 - val_accuracy: 0.6341
Epoch 81/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6038 - accuracy:
0.6582 - val_loss: 0.6294 - val_accuracy: 0.6412
Epoch 82/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6036 - accuracy:
0.6593 - val_loss: 0.6307 - val_accuracy: 0.6464
Epoch 83/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6030 - accuracy:
0.6591 - val_loss: 0.6300 - val_accuracy: 0.6389
Epoch 84/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6024 - accuracy:
0.6629 - val_loss: 0.6294 - val_accuracy: 0.6447
Epoch 85/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6035 - accuracy:
0.6612 - val_loss: 0.6289 - val_accuracy: 0.6418
Epoch 86/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6022 - accuracy:
0.6607 - val_loss: 0.6290 - val_accuracy: 0.6422
Epoch 87/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6020 - accuracy:
0.6625 - val_loss: 0.6308 - val_accuracy: 0.6385
Epoch 88/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6026 - accuracy:
0.6565 - val_loss: 0.6287 - val_accuracy: 0.6420
Epoch 89/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6015 - accuracy:
0.6642 - val_loss: 0.6295 - val_accuracy: 0.6412
Epoch 90/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6016 - accuracy:
0.6580 - val_loss: 0.6295 - val_accuracy: 0.6459
Epoch 91/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6013 - accuracy:
0.6584 - val_loss: 0.6311 - val_accuracy: 0.6424
Epoch 92/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6019 - accuracy:
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0.6602 - val_loss: 0.6292 - val_accuracy: 0.6383
Epoch 93/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6006 - accuracy:
0.6593 - val_loss: 0.6287 - val_accuracy: 0.6416
Epoch 94/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6010 - accuracy:
0.6580 - val_loss: 0.6282 - val_accuracy: 0.6459
Epoch 95/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5998 - accuracy:
0.6591 - val_loss: 0.6285 - val_accuracy: 0.6466
Epoch 96/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6002 - accuracy:
0.6605 - val_loss: 0.6295 - val_accuracy: 0.6435
Epoch 97/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6007 - accuracy:
0.6598 - val_loss: 0.6281 - val_accuracy: 0.6422
Epoch 98/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6013 - accuracy:
0.6623 - val_loss: 0.6286 - val_accuracy: 0.6457
Epoch 99/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6001 - accuracy:
0.6612 - val_loss: 0.6283 - val_accuracy: 0.6443
Epoch 100/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5999 - accuracy:
0.6618 - val_loss: 0.6293 - val_accuracy: 0.6433
Epoch 101/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5993 - accuracy:
0.6615 - val_loss: 0.6302 - val_accuracy: 0.6410
Epoch 102/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5992 - accuracy:
0.6612 - val_loss: 0.6299 - val_accuracy: 0.6424
Epoch 103/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5989 - accuracy:
0.6609 - val_loss: 0.6287 - val_accuracy: 0.6426
Epoch 104/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5983 - accuracy:
0.6610 - val_loss: 0.6283 - val_accuracy: 0.6441
Epoch 105/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5984 - accuracy:
0.6645 - val_loss: 0.6287 - val_accuracy: 0.6430
Epoch 106/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5987 - accuracy:
0.6625 - val_loss: 0.6290 - val_accuracy: 0.6470
Epoch 107/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5984 - accuracy:
0.6635 - val_loss: 0.6312 - val_accuracy: 0.6416
Epoch 108/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5977 - accuracy:
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0.6590 - val_loss: 0.6299 - val_accuracy: 0.6422
Epoch 109/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5977 - accuracy:
0.6623 - val_loss: 0.6277 - val_accuracy: 0.6489
Epoch 110/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5973 - accuracy:
0.6609 - val_loss: 0.6283 - val_accuracy: 0.6455
Epoch 111/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5974 - accuracy:
0.6633 - val_loss: 0.6285 - val_accuracy: 0.6447
Epoch 112/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5968 - accuracy:
0.6651 - val_loss: 0.6301 - val_accuracy: 0.6399
Epoch 113/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5974 - accuracy:
0.6641 - val_loss: 0.6278 - val_accuracy: 0.6470
Epoch 114/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5971 - accuracy:
0.6608 - val_loss: 0.6298 - val_accuracy: 0.6424
Epoch 115/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5975 - accuracy:
0.6631 - val_loss: 0.6308 - val_accuracy: 0.6428
Epoch 116/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5968 - accuracy:
0.6612 - val_loss: 0.6278 - val_accuracy: 0.6435
Epoch 117/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5961 - accuracy:
0.6650 - val_loss: 0.6290 - val_accuracy: 0.6470
Epoch 118/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5972 - accuracy:
0.6645 - val_loss: 0.6275 - val_accuracy: 0.6489
Epoch 119/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5959 - accuracy:
0.6646 - val_loss: 0.6268 - val_accuracy: 0.6459
Epoch 120/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5963 - accuracy:
0.6628 - val_loss: 0.6283 - val_accuracy: 0.6443
Epoch 121/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5962 - accuracy:
0.6663 - val_loss: 0.6262 - val_accuracy: 0.6445
Epoch 122/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5956 - accuracy:
0.6623 - val_loss: 0.6279 - val_accuracy: 0.6470
Epoch 123/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5952 - accuracy:
0.6618 - val_loss: 0.6271 - val_accuracy: 0.6476
Epoch 124/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5950 - accuracy:
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0.6641 - val_loss: 0.6273 - val_accuracy: 0.6457
Epoch 125/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5947 - accuracy:
0.6648 - val_loss: 0.6266 - val_accuracy: 0.6462
Epoch 126/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5954 - accuracy:
0.6624 - val_loss: 0.6270 - val_accuracy: 0.6439
Epoch 127/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5942 - accuracy:
0.6649 - val_loss: 0.6271 - val_accuracy: 0.6430
Epoch 128/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5956 - accuracy:
0.6645 - val_loss: 0.6315 - val_accuracy: 0.6393
Epoch 129/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5947 - accuracy:
0.6626 - val_loss: 0.6266 - val_accuracy: 0.6457
Epoch 130/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5940 - accuracy:
0.6663 - val_loss: 0.6281 - val_accuracy: 0.6466
Epoch 131/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5935 - accuracy:
0.6672 - val_loss: 0.6264 - val_accuracy: 0.6451
Epoch 132/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5960 - accuracy:
0.6656 - val_loss: 0.6268 - val_accuracy: 0.6476
Epoch 133/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5933 - accuracy:
0.6644 - val_loss: 0.6268 - val_accuracy: 0.6464
Epoch 134/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5940 - accuracy:
0.6657 - val_loss: 0.6266 - val_accuracy: 0.6457
Epoch 135/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5932 - accuracy:
0.6641 - val_loss: 0.6263 - val_accuracy: 0.6493
Epoch 136/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5928 - accuracy:
0.6671 - val_loss: 0.6276 - val_accuracy: 0.6486
Epoch 137/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5928 - accuracy:
0.6678 - val_loss: 0.6276 - val_accuracy: 0.6476
Epoch 138/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5930 - accuracy:
0.6682 - val_loss: 0.6264 - val_accuracy: 0.6497
Epoch 139/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5931 - accuracy:
0.6678 - val_loss: 0.6252 - val_accuracy: 0.6513
Epoch 140/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5918 - accuracy:
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0.6671 - val_loss: 0.6264 - val_accuracy: 0.6462
Epoch 141/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5920 - accuracy:
0.6673 - val_loss: 0.6255 - val_accuracy: 0.6495
Epoch 142/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5931 - accuracy:
0.6667 - val_loss: 0.6292 - val_accuracy: 0.6449
Epoch 143/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5916 - accuracy:
0.6653 - val_loss: 0.6267 - val_accuracy: 0.6474
Epoch 144/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5914 - accuracy:
0.6699 - val_loss: 0.6254 - val_accuracy: 0.6482
Epoch 145/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5915 - accuracy:
0.6680 - val_loss: 0.6248 - val_accuracy: 0.6495
Epoch 146/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5918 - accuracy:
0.6668 - val_loss: 0.6258 - val_accuracy: 0.6474
Epoch 147/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5925 - accuracy:
0.6695 - val_loss: 0.6283 - val_accuracy: 0.6480
Epoch 148/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5905 - accuracy:
0.6668 - val_loss: 0.6256 - val_accuracy: 0.6497
Epoch 149/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5930 - accuracy:
0.6639 - val_loss: 0.6268 - val_accuracy: 0.6528
Epoch 150/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5909 - accuracy:
0.6700 - val_loss: 0.6284 - val_accuracy: 0.6482
Epoch 151/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5901 - accuracy:
0.6689 - val_loss: 0.6272 - val_accuracy: 0.6476
Epoch 152/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5916 - accuracy:
0.6685 - val_loss: 0.6261 - val_accuracy: 0.6482
Epoch 153/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5901 - accuracy:
0.6704 - val_loss: 0.6264 - val_accuracy: 0.6499
Epoch 154/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5901 - accuracy:
0.6691 - val_loss: 0.6281 - val_accuracy: 0.6470
Epoch 155/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5904 - accuracy:
0.6699 - val_loss: 0.6261 - val_accuracy: 0.6493
Epoch 156/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5914 - accuracy:
```

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0.6690 - val_loss: 0.6252 - val_accuracy: 0.6466
Epoch 157/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5886 - accuracy:
0.6709 - val_loss: 0.6274 - val_accuracy: 0.6478
Epoch 158/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5900 - accuracy:
0.6679 - val_loss: 0.6257 - val_accuracy: 0.6449
Epoch 159/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5886 - accuracy:
0.6690 - val_loss: 0.6243 - val_accuracy: 0.6518
Epoch 160/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5900 - accuracy:
0.6690 - val_loss: 0.6255 - val_accuracy: 0.6513
Epoch 161/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5887 - accuracy:
0.6737 - val_loss: 0.6249 - val_accuracy: 0.6493
Epoch 162/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5892 - accuracy:
0.6738 - val_loss: 0.6255 - val_accuracy: 0.6534
Epoch 163/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5883 - accuracy:
0.6682 - val_loss: 0.6247 - val_accuracy: 0.6505
Epoch 164/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5898 - accuracy:
0.6691 - val_loss: 0.6253 - val_accuracy: 0.6559
Epoch 165/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5884 - accuracy:
0.6706 - val_loss: 0.6246 - val_accuracy: 0.6507
Epoch 166/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5881 - accuracy:
0.6728 - val_loss: 0.6260 - val_accuracy: 0.6480
Epoch 167/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5884 - accuracy:
0.6718 - val_loss: 0.6250 - val_accuracy: 0.6476
Epoch 168/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5887 - accuracy:
0.6720 - val_loss: 0.6259 - val_accuracy: 0.6497
Epoch 169/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5873 - accuracy:
0.6719 - val_loss: 0.6271 - val_accuracy: 0.6491
Epoch 170/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5885 - accuracy:
0.6741 - val_loss: 0.6245 - val_accuracy: 0.6495
Epoch 171/200
44/44 [==============================] - 0s 3ms/step - loss: 0.5862 - accuracy:
0.6752 - val_loss: 0.6237 - val_accuracy: 0.6534
Epoch 172/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5871 - accuracy:
```

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0.6748 - val_loss: 0.6300 - val_accuracy: 0.6491
Epoch 173/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5880 - accuracy:
0.6702 - val_loss: 0.6241 - val_accuracy: 0.6503
Epoch 174/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5866 - accuracy:
0.6716 - val_loss: 0.6243 - val_accuracy: 0.6522
Epoch 175/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5862 - accuracy:
0.6759 - val_loss: 0.6250 - val_accuracy: 0.6520
Epoch 176/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5857 - accuracy:
0.6767 - val_loss: 0.6271 - val_accuracy: 0.6555
Epoch 177/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5865 - accuracy:
0.6767 - val_loss: 0.6257 - val_accuracy: 0.6513
Epoch 178/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5862 - accuracy:
0.6733 - val_loss: 0.6255 - val_accuracy: 0.6549
Epoch 179/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5852 - accuracy:
0.6756 - val_loss: 0.6249 - val_accuracy: 0.6505
Epoch 180/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5855 - accuracy:
0.6741 - val_loss: 0.6247 - val_accuracy: 0.6542
Epoch 181/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5874 - accuracy:
0.6763 - val_loss: 0.6246 - val_accuracy: 0.6513
Epoch 182/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5858 - accuracy:
0.6695 - val_loss: 0.6235 - val_accuracy: 0.6499
Epoch 183/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5850 - accuracy:
0.6747 - val_loss: 0.6236 - val_accuracy: 0.6540
Epoch 184/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5860 - accuracy:
0.6751 - val_loss: 0.6283 - val_accuracy: 0.6536
Epoch 185/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5864 - accuracy:
0.6735 - val_loss: 0.6337 - val_accuracy: 0.6511
Epoch 186/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5855 - accuracy:
0.6750 - val_loss: 0.6266 - val_accuracy: 0.6524
Epoch 187/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5862 - accuracy:
0.6747 - val_loss: 0.6247 - val_accuracy: 0.6532
Epoch 188/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5846 - accuracy:
```
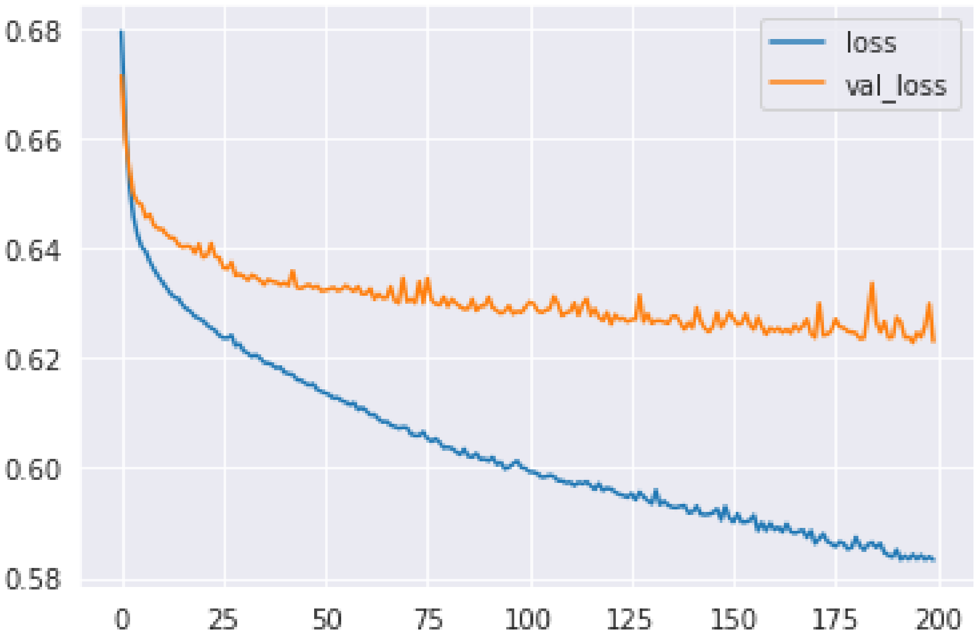

```
0.6741 - val_loss: 0.6267 - val_accuracy: 0.6532
Epoch 189/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5840 - accuracy:
0.6748 - val_loss: 0.6237 - val_accuracy: 0.6495
Epoch 190/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5838 - accuracy:
0.6770 - val_loss: 0.6238 - val_accuracy: 0.6538
Epoch 191/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5851 - accuracy:
0.6729 - val_loss: 0.6274 - val_accuracy: 0.6501
Epoch 192/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5833 - accuracy:
0.6795 - val_loss: 0.6265 - val_accuracy: 0.6515
Epoch 193/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5840 - accuracy:
0.6747 - val_loss: 0.6237 - val_accuracy: 0.6538
Epoch 194/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5834 - accuracy:
0.6764 - val_loss: 0.6238 - val_accuracy: 0.6584
Epoch 195/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5842 - accuracy:
0.6777 - val_loss: 0.6228 - val_accuracy: 0.6563
Epoch 196/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5834 - accuracy:
0.6788 - val_loss: 0.6246 - val_accuracy: 0.6571
Epoch 197/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5841 - accuracy:
0.6781 - val_loss: 0.6238 - val_accuracy: 0.6505
Epoch 198/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5833 - accuracy:
0.6789 - val_loss: 0.6260 - val_accuracy: 0.6580
Epoch 199/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5838 - accuracy:
0.6781 - val_loss: 0.6299 - val_accuracy: 0.6522
Epoch 200/200
44/44 [==============================] - 0s 2ms/step - loss: 0.5832 - accuracy:
0.6755 - val_loss: 0.6231 - val_accuracy: 0.6553
```

```
[46]: <keras.callbacks.History at 0x7fbf2c480b10>
```

```
[47]: pd.DataFrame(model.history.history)[['loss','val_loss']].plot()
```

```
[47]: <AxesSubplot:>
```



[48]:

```
prediction = (model.predict(X_test) >= 0.2).astype('int')
print("     confusion_matrix      ")
print(confusion_matrix(y_test,prediction))
```

```
     confusion_matrix
[[ 393 2044]
 [  70 2320]]
```

[49]:

```
print(classification_report(y_test,prediction))
```

```
              precision    recall  f1-score   support

           0       0.85      0.16      0.27      2437
           1       0.53      0.97      0.69      2390

    accuracy                           0.56      4827
   macro avg       0.69      0.57      0.48      4827
weighted avg       0.69      0.56      0.48      4827
```

[50]:

```
model_new = Sequential()
model_new.add(
Dense(19, activation='relu')
)
model_new.add(Dropout(0.2))
model_new.add(
Dense(10, activation='relu')
)
model_new.add(Dropout(0.2))
model_new.add(
Dense(5, activation='relu')
)
model_new.add(Dropout(0.2))
model_new.add(
Dense(1, activation='sigmoid')
)
```

[51]:

```
model_new.compile(
optimizer='adam',
loss='binary_crossentropy',
metrics=['binary_accuracy']
)
```

[52]:

```
model_new.fit(
X_train,
y_train,
epochs=200,
batch_size=256,
validation_data=(X_test, y_test),
callbacks=[early_stop]
)
```

```
Epoch 1/200
44/44 [==============================] - 1s 5ms/step - loss: 0.6963 -
binary_accuracy: 0.4995 - val_loss: 0.6910 - val_binary_accuracy: 0.5478
Epoch 2/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6899 -
binary_accuracy: 0.5378 - val_loss: 0.6864 - val_binary_accuracy: 0.5770
Epoch 3/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6869 -
binary_accuracy: 0.5564 - val_loss: 0.6818 - val_binary_accuracy: 0.6022
Epoch 4/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6835 -
binary_accuracy: 0.5649 - val_loss: 0.6779 - val_binary_accuracy: 0.6016
Epoch 5/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6789 -
binary_accuracy: 0.5764 - val_loss: 0.6704 - val_binary_accuracy: 0.6043
Epoch 6/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6729 -
binary_accuracy: 0.5836 - val_loss: 0.6620 - val_binary_accuracy: 0.6053
Epoch 7/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6682 -
binary_accuracy: 0.5918 - val_loss: 0.6582 - val_binary_accuracy: 0.6097
```

```
Epoch 8/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6640 -
binary_accuracy: 0.5977 - val_loss: 0.6557 - val_binary_accuracy: 0.6076
Epoch 9/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6608 -
binary_accuracy: 0.6069 - val_loss: 0.6531 - val_binary_accuracy: 0.6192
Epoch 10/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6626 -
binary_accuracy: 0.6062 - val_loss: 0.6520 - val_binary_accuracy: 0.6230
Epoch 11/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6580 -
binary_accuracy: 0.6101 - val_loss: 0.6508 - val_binary_accuracy: 0.6211
Epoch 12/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6567 -
binary_accuracy: 0.6156 - val_loss: 0.6501 - val_binary_accuracy: 0.6188
Epoch 13/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6582 -
binary_accuracy: 0.6101 - val_loss: 0.6498 - val_binary_accuracy: 0.6167
Epoch 14/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6548 -
binary_accuracy: 0.6132 - val_loss: 0.6488 - val_binary_accuracy: 0.6184
Epoch 15/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6534 -
binary_accuracy: 0.6161 - val_loss: 0.6483 - val_binary_accuracy: 0.6163
Epoch 16/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6517 -
binary_accuracy: 0.6178 - val_loss: 0.6465 - val_binary_accuracy: 0.6240
Epoch 17/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6513 -
binary_accuracy: 0.6172 - val_loss: 0.6454 - val_binary_accuracy: 0.6244
Epoch 18/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6495 -
binary_accuracy: 0.6215 - val_loss: 0.6452 - val_binary_accuracy: 0.6203
Epoch 19/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6471 -
binary_accuracy: 0.6233 - val_loss: 0.6432 - val_binary_accuracy: 0.6242
Epoch 20/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6474 -
binary_accuracy: 0.6194 - val_loss: 0.6443 - val_binary_accuracy: 0.6186
Epoch 21/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6497 -
binary_accuracy: 0.6196 - val_loss: 0.6427 - val_binary_accuracy: 0.6254
Epoch 22/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6465 -
binary_accuracy: 0.6237 - val_loss: 0.6430 - val_binary_accuracy: 0.6227
Epoch 23/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6476 -
binary_accuracy: 0.6218 - val_loss: 0.6424 - val_binary_accuracy: 0.6209
```

```
Epoch 24/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6437 -
binary_accuracy: 0.6267 - val_loss: 0.6404 - val_binary_accuracy: 0.6269
Epoch 25/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6446 -
binary_accuracy: 0.6267 - val_loss: 0.6408 - val_binary_accuracy: 0.6263
Epoch 26/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6433 -
binary_accuracy: 0.6231 - val_loss: 0.6404 - val_binary_accuracy: 0.6248
Epoch 27/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6431 -
binary_accuracy: 0.6323 - val_loss: 0.6407 - val_binary_accuracy: 0.6256
Epoch 28/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6441 -
binary_accuracy: 0.6253 - val_loss: 0.6411 - val_binary_accuracy: 0.6248
Epoch 29/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6406 -
binary_accuracy: 0.6306 - val_loss: 0.6380 - val_binary_accuracy: 0.6308
Epoch 30/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6422 -
binary_accuracy: 0.6202 - val_loss: 0.6388 - val_binary_accuracy: 0.6283
Epoch 31/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6455 -
binary_accuracy: 0.6231 - val_loss: 0.6392 - val_binary_accuracy: 0.6306
Epoch 32/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6413 -
binary_accuracy: 0.6273 - val_loss: 0.6377 - val_binary_accuracy: 0.6302
Epoch 33/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6387 -
binary_accuracy: 0.6353 - val_loss: 0.6373 - val_binary_accuracy: 0.6312
Epoch 34/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6401 -
binary_accuracy: 0.6294 - val_loss: 0.6368 - val_binary_accuracy: 0.6302
Epoch 35/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6409 -
binary_accuracy: 0.6318 - val_loss: 0.6372 - val_binary_accuracy: 0.6267
Epoch 36/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6372 -
binary_accuracy: 0.6371 - val_loss: 0.6371 - val_binary_accuracy: 0.6300
Epoch 37/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6394 -
binary_accuracy: 0.6351 - val_loss: 0.6359 - val_binary_accuracy: 0.6312
Epoch 38/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6376 -
binary_accuracy: 0.6330 - val_loss: 0.6356 - val_binary_accuracy: 0.6298
Epoch 39/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6371 -
binary_accuracy: 0.6354 - val_loss: 0.6356 - val_binary_accuracy: 0.6343
```

```
Epoch 40/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6391 -
binary_accuracy: 0.6272 - val_loss: 0.6361 - val_binary_accuracy: 0.6317
Epoch 41/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6356 -
binary_accuracy: 0.6343 - val_loss: 0.6347 - val_binary_accuracy: 0.6312
Epoch 42/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6363 -
binary_accuracy: 0.6326 - val_loss: 0.6352 - val_binary_accuracy: 0.6368
Epoch 43/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6384 -
binary_accuracy: 0.6355 - val_loss: 0.6353 - val_binary_accuracy: 0.6302
Epoch 44/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6345 -
binary_accuracy: 0.6391 - val_loss: 0.6337 - val_binary_accuracy: 0.6327
Epoch 45/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6351 -
binary_accuracy: 0.6346 - val_loss: 0.6337 - val_binary_accuracy: 0.6327
Epoch 46/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6330 -
binary_accuracy: 0.6408 - val_loss: 0.6333 - val_binary_accuracy: 0.6379
Epoch 47/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6367 -
binary_accuracy: 0.6357 - val_loss: 0.6331 - val_binary_accuracy: 0.6360
Epoch 48/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6351 -
binary_accuracy: 0.6394 - val_loss: 0.6332 - val_binary_accuracy: 0.6375
Epoch 49/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6340 -
binary_accuracy: 0.6420 - val_loss: 0.6322 - val_binary_accuracy: 0.6391
Epoch 50/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6328 -
binary_accuracy: 0.6430 - val_loss: 0.6320 - val_binary_accuracy: 0.6387
Epoch 51/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6345 -
binary_accuracy: 0.6359 - val_loss: 0.6318 - val_binary_accuracy: 0.6401
Epoch 52/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6339 -
binary_accuracy: 0.6394 - val_loss: 0.6313 - val_binary_accuracy: 0.6406
Epoch 53/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6333 -
binary_accuracy: 0.6406 - val_loss: 0.6321 - val_binary_accuracy: 0.6356
Epoch 54/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6341 -
binary_accuracy: 0.6370 - val_loss: 0.6316 - val_binary_accuracy: 0.6383
Epoch 55/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6325 -
binary_accuracy: 0.6391 - val_loss: 0.6311 - val_binary_accuracy: 0.6387
```

```
Epoch 56/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6306 -
binary_accuracy: 0.6454 - val_loss: 0.6316 - val_binary_accuracy: 0.6395
Epoch 57/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6331 -
binary_accuracy: 0.6389 - val_loss: 0.6302 - val_binary_accuracy: 0.6410
Epoch 58/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6313 -
binary_accuracy: 0.6483 - val_loss: 0.6308 - val_binary_accuracy: 0.6391
Epoch 59/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6313 -
binary_accuracy: 0.6441 - val_loss: 0.6315 - val_binary_accuracy: 0.6385
Epoch 60/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6301 -
binary_accuracy: 0.6449 - val_loss: 0.6301 - val_binary_accuracy: 0.6412
Epoch 61/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6323 -
binary_accuracy: 0.6414 - val_loss: 0.6303 - val_binary_accuracy: 0.6408
Epoch 62/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6310 -
binary_accuracy: 0.6467 - val_loss: 0.6298 - val_binary_accuracy: 0.6393
Epoch 63/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6309 -
binary_accuracy: 0.6428 - val_loss: 0.6295 - val_binary_accuracy: 0.6414
Epoch 64/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6283 -
binary_accuracy: 0.6476 - val_loss: 0.6285 - val_binary_accuracy: 0.6455
Epoch 65/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6279 -
binary_accuracy: 0.6458 - val_loss: 0.6287 - val_binary_accuracy: 0.6389
Epoch 66/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6274 -
binary_accuracy: 0.6496 - val_loss: 0.6301 - val_binary_accuracy: 0.6428
Epoch 67/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6282 -
binary_accuracy: 0.6524 - val_loss: 0.6282 - val_binary_accuracy: 0.6433
Epoch 68/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6268 -
binary_accuracy: 0.6473 - val_loss: 0.6277 - val_binary_accuracy: 0.6433
Epoch 69/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6264 -
binary_accuracy: 0.6442 - val_loss: 0.6276 - val_binary_accuracy: 0.6414
Epoch 70/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6287 -
binary_accuracy: 0.6449 - val_loss: 0.6278 - val_binary_accuracy: 0.6383
Epoch 71/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6271 -
binary_accuracy: 0.6477 - val_loss: 0.6282 - val_binary_accuracy: 0.6468
```

```
Epoch 72/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6306 -
binary_accuracy: 0.6509 - val_loss: 0.6282 - val_binary_accuracy: 0.6445
Epoch 73/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6293 -
binary_accuracy: 0.6501 - val_loss: 0.6274 - val_binary_accuracy: 0.6462
Epoch 74/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6287 -
binary_accuracy: 0.6461 - val_loss: 0.6276 - val_binary_accuracy: 0.6474
Epoch 75/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6266 -
binary_accuracy: 0.6482 - val_loss: 0.6267 - val_binary_accuracy: 0.6464
Epoch 76/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6286 -
binary_accuracy: 0.6457 - val_loss: 0.6268 - val_binary_accuracy: 0.6457
Epoch 77/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6279 -
binary_accuracy: 0.6487 - val_loss: 0.6280 - val_binary_accuracy: 0.6451
Epoch 78/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6264 -
binary_accuracy: 0.6497 - val_loss: 0.6262 - val_binary_accuracy: 0.6422
Epoch 79/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6273 -
binary_accuracy: 0.6491 - val_loss: 0.6273 - val_binary_accuracy: 0.6435
Epoch 80/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6253 -
binary_accuracy: 0.6514 - val_loss: 0.6253 - val_binary_accuracy: 0.6462
Epoch 81/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6264 -
binary_accuracy: 0.6521 - val_loss: 0.6256 - val_binary_accuracy: 0.6503
Epoch 82/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6262 -
binary_accuracy: 0.6496 - val_loss: 0.6263 - val_binary_accuracy: 0.6466
Epoch 83/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6245 -
binary_accuracy: 0.6477 - val_loss: 0.6252 - val_binary_accuracy: 0.6489
Epoch 84/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6239 -
binary_accuracy: 0.6486 - val_loss: 0.6256 - val_binary_accuracy: 0.6437
Epoch 85/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6253 -
binary_accuracy: 0.6474 - val_loss: 0.6262 - val_binary_accuracy: 0.6447
Epoch 86/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6274 -
binary_accuracy: 0.6455 - val_loss: 0.6249 - val_binary_accuracy: 0.6480
Epoch 87/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6273 -
binary_accuracy: 0.6522 - val_loss: 0.6249 - val_binary_accuracy: 0.6474
```

```
Epoch 88/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6287 -
binary_accuracy: 0.6512 - val_loss: 0.6255 - val_binary_accuracy: 0.6447
Epoch 89/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6237 -
binary_accuracy: 0.6481 - val_loss: 0.6245 - val_binary_accuracy: 0.6495
Epoch 90/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6229 -
binary_accuracy: 0.6559 - val_loss: 0.6251 - val_binary_accuracy: 0.6489
Epoch 91/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6230 -
binary_accuracy: 0.6509 - val_loss: 0.6246 - val_binary_accuracy: 0.6462
Epoch 92/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6268 -
binary_accuracy: 0.6536 - val_loss: 0.6243 - val_binary_accuracy: 0.6478
Epoch 93/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6256 -
binary_accuracy: 0.6515 - val_loss: 0.6247 - val_binary_accuracy: 0.6495
Epoch 94/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6221 -
binary_accuracy: 0.6544 - val_loss: 0.6242 - val_binary_accuracy: 0.6478
Epoch 95/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6226 -
binary_accuracy: 0.6516 - val_loss: 0.6245 - val_binary_accuracy: 0.6511
Epoch 96/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6244 -
binary_accuracy: 0.6511 - val_loss: 0.6242 - val_binary_accuracy: 0.6472
Epoch 97/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6236 -
binary_accuracy: 0.6518 - val_loss: 0.6242 - val_binary_accuracy: 0.6480
Epoch 98/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6216 -
binary_accuracy: 0.6554 - val_loss: 0.6239 - val_binary_accuracy: 0.6474
Epoch 99/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6204 -
binary_accuracy: 0.6579 - val_loss: 0.6232 - val_binary_accuracy: 0.6472
Epoch 100/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6214 -
binary_accuracy: 0.6536 - val_loss: 0.6236 - val_binary_accuracy: 0.6524
Epoch 101/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6233 -
binary_accuracy: 0.6476 - val_loss: 0.6236 - val_binary_accuracy: 0.6526
Epoch 102/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6216 -
binary_accuracy: 0.6552 - val_loss: 0.6227 - val_binary_accuracy: 0.6549
Epoch 103/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6219 -
binary_accuracy: 0.6581 - val_loss: 0.6240 - val_binary_accuracy: 0.6466
```

```
Epoch 104/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6202 -
binary_accuracy: 0.6565 - val_loss: 0.6229 - val_binary_accuracy: 0.6540
Epoch 105/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6214 -
binary_accuracy: 0.6528 - val_loss: 0.6232 - val_binary_accuracy: 0.6536
Epoch 106/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6212 -
binary_accuracy: 0.6541 - val_loss: 0.6232 - val_binary_accuracy: 0.6509
Epoch 107/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6202 -
binary_accuracy: 0.6557 - val_loss: 0.6227 - val_binary_accuracy: 0.6538
Epoch 108/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6193 -
binary_accuracy: 0.6531 - val_loss: 0.6232 - val_binary_accuracy: 0.6476
Epoch 109/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6220 -
binary_accuracy: 0.6508 - val_loss: 0.6222 - val_binary_accuracy: 0.6526
Epoch 110/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6217 -
binary_accuracy: 0.6533 - val_loss: 0.6230 - val_binary_accuracy: 0.6491
Epoch 111/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6187 -
binary_accuracy: 0.6539 - val_loss: 0.6221 - val_binary_accuracy: 0.6544
Epoch 112/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6210 -
binary_accuracy: 0.6598 - val_loss: 0.6220 - val_binary_accuracy: 0.6511
Epoch 113/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6204 -
binary_accuracy: 0.6560 - val_loss: 0.6225 - val_binary_accuracy: 0.6538
Epoch 114/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6191 -
binary_accuracy: 0.6591 - val_loss: 0.6220 - val_binary_accuracy: 0.6518
Epoch 115/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6219 -
binary_accuracy: 0.6594 - val_loss: 0.6228 - val_binary_accuracy: 0.6528
Epoch 116/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6183 -
binary_accuracy: 0.6563 - val_loss: 0.6219 - val_binary_accuracy: 0.6520
Epoch 117/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6204 -
binary_accuracy: 0.6610 - val_loss: 0.6220 - val_binary_accuracy: 0.6526
Epoch 118/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6196 -
binary_accuracy: 0.6606 - val_loss: 0.6207 - val_binary_accuracy: 0.6540
Epoch 119/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6215 -
binary_accuracy: 0.6516 - val_loss: 0.6215 - val_binary_accuracy: 0.6526
```

```
Epoch 120/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6209 -
binary_accuracy: 0.6557 - val_loss: 0.6221 - val_binary_accuracy: 0.6530
Epoch 121/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6209 -
binary_accuracy: 0.6552 - val_loss: 0.6212 - val_binary_accuracy: 0.6565
Epoch 122/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6195 -
binary_accuracy: 0.6556 - val_loss: 0.6211 - val_binary_accuracy: 0.6544
Epoch 123/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6197 -
binary_accuracy: 0.6603 - val_loss: 0.6202 - val_binary_accuracy: 0.6563
Epoch 124/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6196 -
binary_accuracy: 0.6561 - val_loss: 0.6200 - val_binary_accuracy: 0.6528
Epoch 125/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6177 -
binary_accuracy: 0.6568 - val_loss: 0.6196 - val_binary_accuracy: 0.6569
Epoch 126/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6216 -
binary_accuracy: 0.6557 - val_loss: 0.6202 - val_binary_accuracy: 0.6569
Epoch 127/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6175 -
binary_accuracy: 0.6592 - val_loss: 0.6200 - val_binary_accuracy: 0.6528
Epoch 128/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6189 -
binary_accuracy: 0.6569 - val_loss: 0.6199 - val_binary_accuracy: 0.6565
Epoch 129/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6155 -
binary_accuracy: 0.6562 - val_loss: 0.6201 - val_binary_accuracy: 0.6551
Epoch 130/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6167 -
binary_accuracy: 0.6620 - val_loss: 0.6203 - val_binary_accuracy: 0.6573
Epoch 131/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6195 -
binary_accuracy: 0.6596 - val_loss: 0.6198 - val_binary_accuracy: 0.6540
Epoch 132/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6195 -
binary_accuracy: 0.6555 - val_loss: 0.6204 - val_binary_accuracy: 0.6578
Epoch 133/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6172 -
binary_accuracy: 0.6593 - val_loss: 0.6194 - val_binary_accuracy: 0.6540
Epoch 134/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6161 -
binary_accuracy: 0.6611 - val_loss: 0.6205 - val_binary_accuracy: 0.6495
Epoch 135/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6170 -
binary_accuracy: 0.6610 - val_loss: 0.6199 - val_binary_accuracy: 0.6549
```

```
Epoch 136/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6154 -
binary_accuracy: 0.6607 - val_loss: 0.6190 - val_binary_accuracy: 0.6580
Epoch 137/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6199 -
binary_accuracy: 0.6545 - val_loss: 0.6186 - val_binary_accuracy: 0.6526
Epoch 138/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6199 -
binary_accuracy: 0.6607 - val_loss: 0.6193 - val_binary_accuracy: 0.6555
Epoch 139/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6188 -
binary_accuracy: 0.6623 - val_loss: 0.6187 - val_binary_accuracy: 0.6573
Epoch 140/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6124 -
binary_accuracy: 0.6647 - val_loss: 0.6184 - val_binary_accuracy: 0.6588
Epoch 141/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6187 -
binary_accuracy: 0.6582 - val_loss: 0.6186 - val_binary_accuracy: 0.6586
Epoch 142/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6200 -
binary_accuracy: 0.6555 - val_loss: 0.6187 - val_binary_accuracy: 0.6571
Epoch 143/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6169 -
binary_accuracy: 0.6586 - val_loss: 0.6190 - val_binary_accuracy: 0.6547
Epoch 144/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6162 -
binary_accuracy: 0.6625 - val_loss: 0.6183 - val_binary_accuracy: 0.6561
Epoch 145/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6172 -
binary_accuracy: 0.6608 - val_loss: 0.6183 - val_binary_accuracy: 0.6588
Epoch 146/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6186 -
binary_accuracy: 0.6584 - val_loss: 0.6188 - val_binary_accuracy: 0.6549
Epoch 147/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6172 -
binary_accuracy: 0.6577 - val_loss: 0.6180 - val_binary_accuracy: 0.6578
Epoch 148/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6172 -
binary_accuracy: 0.6606 - val_loss: 0.6179 - val_binary_accuracy: 0.6567
Epoch 149/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6181 -
binary_accuracy: 0.6608 - val_loss: 0.6187 - val_binary_accuracy: 0.6563
Epoch 150/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6143 -
binary_accuracy: 0.6666 - val_loss: 0.6188 - val_binary_accuracy: 0.6559
Epoch 151/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6167 -
binary_accuracy: 0.6591 - val_loss: 0.6187 - val_binary_accuracy: 0.6573
```

```
Epoch 152/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6168 -
binary_accuracy: 0.6597 - val_loss: 0.6194 - val_binary_accuracy: 0.6571
Epoch 153/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6174 -
binary_accuracy: 0.6561 - val_loss: 0.6196 - val_binary_accuracy: 0.6563
Epoch 154/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6170 -
binary_accuracy: 0.6573 - val_loss: 0.6178 - val_binary_accuracy: 0.6625
Epoch 155/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6165 -
binary_accuracy: 0.6640 - val_loss: 0.6195 - val_binary_accuracy: 0.6561
Epoch 156/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6132 -
binary_accuracy: 0.6623 - val_loss: 0.6194 - val_binary_accuracy: 0.6578
Epoch 157/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6145 -
binary_accuracy: 0.6618 - val_loss: 0.6185 - val_binary_accuracy: 0.6569
Epoch 158/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6185 -
binary_accuracy: 0.6631 - val_loss: 0.6176 - val_binary_accuracy: 0.6559
Epoch 159/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6139 -
binary_accuracy: 0.6643 - val_loss: 0.6174 - val_binary_accuracy: 0.6578
Epoch 160/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6150 -
binary_accuracy: 0.6654 - val_loss: 0.6173 - val_binary_accuracy: 0.6623
Epoch 161/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6175 -
binary_accuracy: 0.6573 - val_loss: 0.6194 - val_binary_accuracy: 0.6547
Epoch 162/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6140 -
binary_accuracy: 0.6648 - val_loss: 0.6172 - val_binary_accuracy: 0.6598
Epoch 163/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6154 -
binary_accuracy: 0.6586 - val_loss: 0.6179 - val_binary_accuracy: 0.6588
Epoch 164/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6161 -
binary_accuracy: 0.6603 - val_loss: 0.6172 - val_binary_accuracy: 0.6609
Epoch 165/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6169 -
binary_accuracy: 0.6630 - val_loss: 0.6169 - val_binary_accuracy: 0.6642
Epoch 166/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6154 -
binary_accuracy: 0.6645 - val_loss: 0.6166 - val_binary_accuracy: 0.6617
Epoch 167/200
44/44 [==============================] - 0s 2ms/step - loss: 0.6128 -
binary_accuracy: 0.6655 - val_loss: 0.6182 - val_binary_accuracy: 0.6605
```

```
Epoch 168/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6161 -
binary_accuracy: 0.6626 - val_loss: 0.6170 - val_binary_accuracy: 0.6619
Epoch 169/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6119 -
binary_accuracy: 0.6648 - val_loss: 0.6162 - val_binary_accuracy: 0.6646
Epoch 170/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6157 -
binary_accuracy: 0.6612 - val_loss: 0.6172 - val_binary_accuracy: 0.6609
Epoch 171/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6124 -
binary_accuracy: 0.6650 - val_loss: 0.6168 - val_binary_accuracy: 0.6615
Epoch 172/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6137 -
binary_accuracy: 0.6671 - val_loss: 0.6158 - val_binary_accuracy: 0.6648
Epoch 173/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6102 -
binary_accuracy: 0.6670 - val_loss: 0.6169 - val_binary_accuracy: 0.6625
Epoch 174/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6148 -
binary_accuracy: 0.6627 - val_loss: 0.6166 - val_binary_accuracy: 0.6652
Epoch 175/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6111 -
binary_accuracy: 0.6718 - val_loss: 0.6166 - val_binary_accuracy: 0.6611
Epoch 176/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6110 -
binary_accuracy: 0.6616 - val_loss: 0.6165 - val_binary_accuracy: 0.6596
Epoch 177/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6131 -
binary_accuracy: 0.6655 - val_loss: 0.6159 - val_binary_accuracy: 0.6596
Epoch 178/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6134 -
binary_accuracy: 0.6666 - val_loss: 0.6157 - val_binary_accuracy: 0.6646
Epoch 179/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6142 -
binary_accuracy: 0.6700 - val_loss: 0.6156 - val_binary_accuracy: 0.6621
Epoch 180/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6101 -
binary_accuracy: 0.6671 - val_loss: 0.6159 - val_binary_accuracy: 0.6631
Epoch 181/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6121 -
binary_accuracy: 0.6680 - val_loss: 0.6157 - val_binary_accuracy: 0.6615
Epoch 182/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6122 -
binary_accuracy: 0.6652 - val_loss: 0.6169 - val_binary_accuracy: 0.6642
Epoch 183/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6147 -
binary_accuracy: 0.6696 - val_loss: 0.6151 - val_binary_accuracy: 0.6654
```

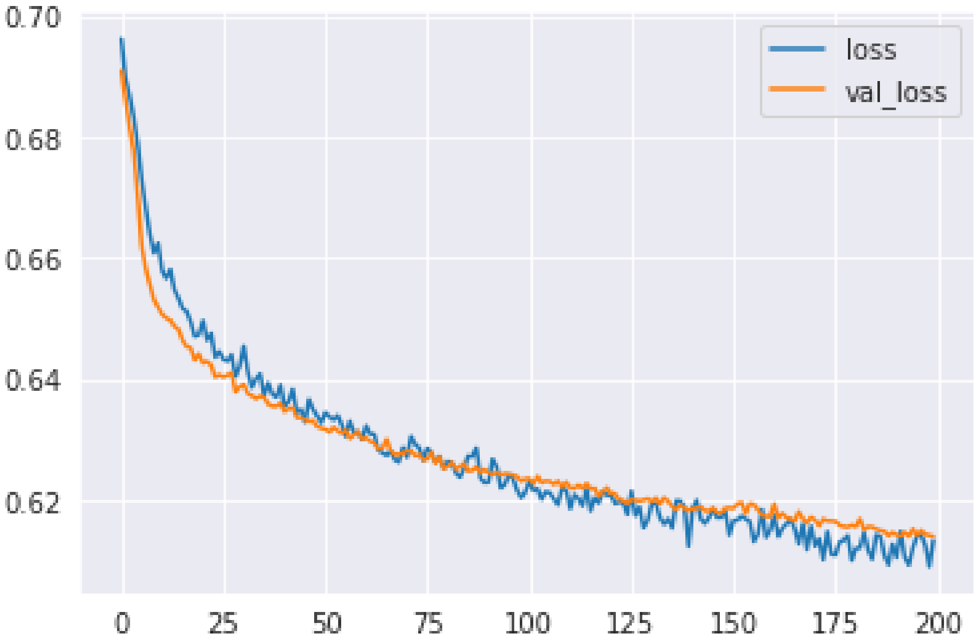
```
Epoch 184/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6119 -
binary_accuracy: 0.6645 - val_loss: 0.6156 - val_binary_accuracy: 0.6692
Epoch 185/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6103 -
binary_accuracy: 0.6643 - val_loss: 0.6156 - val_binary_accuracy: 0.6667
Epoch 186/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6143 -
binary_accuracy: 0.6643 - val_loss: 0.6153 - val_binary_accuracy: 0.6681
Epoch 187/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6141 -
binary_accuracy: 0.6679 - val_loss: 0.6150 - val_binary_accuracy: 0.6658
Epoch 188/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6109 -
binary_accuracy: 0.6690 - val_loss: 0.6149 - val_binary_accuracy: 0.6658
Epoch 189/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6094 -
binary_accuracy: 0.6678 - val_loss: 0.6142 - val_binary_accuracy: 0.6689
Epoch 190/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6128 -
binary_accuracy: 0.6658 - val_loss: 0.6147 - val_binary_accuracy: 0.6669
Epoch 191/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6106 -
binary_accuracy: 0.6678 - val_loss: 0.6143 - val_binary_accuracy: 0.6671
Epoch 192/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6149 -
binary_accuracy: 0.6626 - val_loss: 0.6141 - val_binary_accuracy: 0.6671
Epoch 193/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6106 -
binary_accuracy: 0.6687 - val_loss: 0.6147 - val_binary_accuracy: 0.6694
Epoch 194/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6093 -
binary_accuracy: 0.6701 - val_loss: 0.6141 - val_binary_accuracy: 0.6663
Epoch 195/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6122 -
binary_accuracy: 0.6681 - val_loss: 0.6153 - val_binary_accuracy: 0.6679
Epoch 196/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6141 -
binary_accuracy: 0.6629 - val_loss: 0.6142 - val_binary_accuracy: 0.6692
Epoch 197/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6143 -
binary_accuracy: 0.6647 - val_loss: 0.6151 - val_binary_accuracy: 0.6671
Epoch 198/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6126 -
binary_accuracy: 0.6662 - val_loss: 0.6144 - val_binary_accuracy: 0.6658
Epoch 199/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6091 -
binary_accuracy: 0.6683 - val_loss: 0.6142 - val_binary_accuracy: 0.6646
```

```
Epoch 200/200
44/44 [==============================] - 0s 3ms/step - loss: 0.6134 -
binary_accuracy: 0.6666 - val_loss: 0.6140 - val_binary_accuracy: 0.6673
```

```
[52]: <keras.callbacks.History at 0x7fbefc396b50>
```

```
[53]: pd.DataFrame(model_new.history.history)[['loss','val_loss']].plot()
```

```
[53]: <AxesSubplot:>
```



0.0.6 model accuracy

```
[54]: predictions_new = (model_new.predict(X_test) >= 0.2).astype('int')
      print("     confusion_matrix      ")
      print(confusion_matrix(y_test,predictions_new))
```

```
     confusion_matrix
[[ 286 2151]
 [  35 2355]]
```

```
[55]: print(classification_report(y_test,predictions_new))
```

```
              precision    recall  f1-score   support

           0       0.89      0.12      0.21      2437
           1       0.52      0.99      0.68      2390

    accuracy                           0.55      4827
   macro avg       0.71      0.55      0.45      4827
weighted avg       0.71      0.55      0.44      4827
```