Wells Fargo all models

October 17, 2021

0.1 Team Members

0.1.1 Adila Abdulwahid

0.1.2 Kevon Cambridge

0.1.3 Kevin Stewart

GitHub Link: https://github.com/kjcambri/Team-6-Final-Project

[229]:
```python
# importing required libraries
%matplotlib inline

import seaborn as sns
import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split, cross_val_score,␣
 ↪GridSearchCV
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn.impute import KNNImputer
from dmba import adjusted_r2_score, AIC_score, BIC_score
from sklearn.linear_model import LogisticRegressionCV, LogisticRegression
import statsmodels.formula.api as sm
from dmba import classificationSummary, regressionSummary, exhaustive_search,␣
 ↪gainsChart, liftChart
from sklearn.tree import DecisionTreeClassifier, DecisionTreeRegressor
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from dmba import plotDecisionTree, classificationSummary, regressionSummary
from mlxtend.feature_selection import SequentialFeatureSelector as SFS
```

[151]:
```python
def confusionMatrices(model, title):
    print(title + ' - training results')
    classificationSummary(y_train, model.predict(x_train))
    print(title + ' - validation results')
    classificationSummary(y_test, model.predict(x_test))
```

[152]:
```python
#checking file directory
! ls
```

```
Well_3_fargo.ipynb
Wells Fargo (1).ipynb
Wells Fargo all models.ipynb
b765dc3d8076-Campus+Analytics+2021+Challenge+Rules-FINAL+(1) (1).docx
cadc27b08144-Data+Definitions+-+Campus+Challenge.xlsx
test.csv
test.xlsx
train.csv
train.xlsx
~$cadc27b08144-Data+Definitions+-+Campus+Challenge.xlsx
```

[153]:
```
#loading the train and test dataset into a dataframe
train = pd.read_csv('train.csv')
```

[154]:
```
#printing train dataframe head
train.head()
```

[154]:
```
   TRAN_AMT  ACCT_PRE_TRAN_AVAIL_BAL  CUST_AGE  OPEN_ACCT_CT  WF_dvc_age  \
0      5.38                 23619.91        47             4        2777
1     65.19                     0.00        45             5        2721
2     54.84                 34570.63        36             8        1531
3      0.01                     0.00        62             3         835
4    497.08                 12725.18        81             2        1095

           PWD_UPDT_TS                  CARR_NAME       RGN_NAME  \
0    1/16/2018 11:3:58  cox communications inc.      southwest
1                  NaN   charter communications      southwest
2  12/22/2021 10:42:51        utah broadband llc       mountain
3     2/8/2020 7:28:31        t-mobile usa  inc.      southwest
4  12/28/2020 12:12:44    cogent communications  south central

  STATE_PRVNC_TXT ALERT_TRGR_CD  … CUST_STATE      PH_NUM_UPDT_TS  \
0          nevada          MOBL  …         NV  2/24/2021 15:55:10
1      california          MOBL  …         CA                 NaN
2            utah          ONLN  …         MD     5/5/2019 1:8:39
3      california          MOBL  …         NV   2/16/2019 6:45:37
4           texas          MOBL  …         UT    5/8/2020 10:27:6

         CUST_SINCE_DT             TRAN_TS    TRAN_DT ACTN_CD ACTN_INTNL_TXT  \
0  1993-01-06 00:00:00    5/3/2021 18:3:58   5/3/2021  SCHPMT     P2P_COMMIT
1  1971-01-07 00:00:00  1/13/2021 19:19:37  1/13/2021  SCHPMT     P2P_COMMIT
2  1994-02-01 00:00:00    4/8/2021 9:42:51   4/8/2021  SCHPMT     P2P_COMMIT
3  2001-11-01 00:00:00  8/10/2021 15:28:31  8/10/2021  SCHPMT     P2P_COMMIT
4  1987-02-07 00:00:00  6/27/2021 11:12:44  6/27/2021  SCHPMT     P2P_COMMIT

  TRAN_TYPE_CD   ACTVY_DT FRAUD_NONFRAUD
0          P2P   5/3/2021      Non-Fraud
```

```
1          P2P  1/13/2021      Non-Fraud
2          P2P   4/8/2021          Fraud
3          P2P  8/10/2021      Non-Fraud
4          P2P  6/27/2021          Fraud

[5 rows x 24 columns]
```

[155]:
```
train.isna().sum()
```

[155]:
```
TRAN_AMT                    0
ACCT_PRE_TRAN_AVAIL_BAL     0
CUST_AGE                    0
OPEN_ACCT_CT                0
WF_dvc_age                  0
PWD_UPDT_TS              3125
CARR_NAME                2709
RGN_NAME                 2709
STATE_PRVNC_TXT          2709
ALERT_TRGR_CD               0
DVC_TYPE_TXT             1761
AUTHC_PRIM_TYPE_CD          0
AUTHC_SCNDRY_STAT_TXT      74
CUST_ZIP                    0
CUST_STATE                 36
PH_NUM_UPDT_TS           7061
CUST_SINCE_DT               0
TRAN_TS                     0
TRAN_DT                     0
ACTN_CD                     0
ACTN_INTNL_TXT              0
TRAN_TYPE_CD                0
ACTVY_DT                    0
FRAUD_NONFRAUD              0
dtype: int64
```

[156]:
```
#train = train.drop(columns = ['CARR_NAME','STATE_PRVNC_TXT','CUST_STATE'],␣
 ↪axis = 1)
```

[157]:
```
#Getting most frequent carrier
train['CARR_NAME'].value_counts().head()
```

[157]:
```
cox communications inc.               1278
t-mobile usa  inc.                    1146
charter communications inc            1145
comcast                               1063
comcast cable communications  llc      892
Name: CARR_NAME, dtype: int64
```

```
[158]: #Filling in missing null values with most frequent value
       train['CARR_NAME']= train['CARR_NAME'].fillna('cox communications inc.')
```

```
[159]: #Getting most frequent region
       train['RGN_NAME'].value_counts().head()
```

```
[159]: southwest        7123
       south central    1346
       southeast         572
       mountain          467
       northeast         419
       Name: RGN_NAME, dtype: int64
```

```
[160]: #Filling in missing null values with most frequent value
       train['RGN_NAME']= train['RGN_NAME'].fillna('southwest')
```

```
[161]: #getting most frequent value
       train['STATE_PRVNC_TXT'].value_counts().head()
```

```
[161]: california    5438
       arizona       1235
       texas         1234
       nevada         450
       new york       369
       Name: STATE_PRVNC_TXT, dtype: int64
```

```
[162]: #Filling in missing null values with most frequent value
       train['STATE_PRVNC_TXT']= train['STATE_PRVNC_TXT'].fillna('california')
```

```
[163]: #getting most frequent value
       train['DVC_TYPE_TXT'].value_counts()
```

```
[163]: MOBILE     8796
       DESKTOP    2986
       TABLET      238
       PHONE       219
       Name: DVC_TYPE_TXT, dtype: int64
```

```
[164]: #Filling in missing null values with most frequent value
       train['DVC_TYPE_TXT'] = train['DVC_TYPE_TXT'].fillna('MOBILE')
```

```
[165]: #getting most frequent value
       train['CUST_STATE'].value_counts().head()
```

```
[165]: CA    4570
       TX    2368
       AZ    1288
       FL     914
```

```
NV     535
Name: CUST_STATE, dtype: int64
```

[166]:
```
#Filling in missing null values with most frequent value
train['CUST_STATE'] = train['CUST_STATE'].fillna('CA')
```

[167]:
```
#getting most frequent value
train['AUTHC_SCNDRY_STAT_TXT'].value_counts()
```

[167]:
```
ALLOW                13193
CHALLENGE_SUCCESS      646
CHALLENGE_ISSUED        87
Name: AUTHC_SCNDRY_STAT_TXT, dtype: int64
```

[168]:
```
#Filling in missing null values with most frequent value
train['AUTHC_SCNDRY_STAT_TXT']= train['AUTHC_SCNDRY_STAT_TXT'].fillna('ALLOW')
```

[169]:
```
#Getting shape of data
train.shape
```

[169]:
```
(14000, 24)
```

[170]:
```
#dropping PH_NUM_UPDT_TS too many missing values
train = train.drop(columns='PH_NUM_UPDT_TS')
```

[171]:
```
#Dropping the remaining null values
train = train.dropna()
```

[172]:
```
#Getting shape of data
train.shape
```

[172]:
```
(10875, 23)
```

[173]:
```
# convert date to day of week and time

#dropping TRAN_DT because it is the same as TRAN_TS
train = train.drop(columns = ['TRAN_DT'], axis = 1)
train.PWD_UPDT_TS = pd.to_datetime(train.PWD_UPDT_TS,␣
 ↪infer_datetime_format=True, dayfirst=True, errors='coerce')
train.CUST_SINCE_DT = pd.to_datetime(train.CUST_SINCE_DT,␣
 ↪infer_datetime_format=True, errors='coerce')
train.TRAN_TS = pd.to_datetime(train.TRAN_TS, infer_datetime_format=True,␣
 ↪errors='coerce')
train.ACTVY_DT = pd.to_datetime(train.ACTVY_DT, infer_datetime_format=True,␣
 ↪errors='coerce')

train['pwd_date_Hour'] = train.PWD_UPDT_TS.dt.hour
```

```
train['tran_Hour'] = train.TRAN_TS.dt.hour
train['pwd_date_DOW'] = train.PWD_UPDT_TS.dt.dayofweek
train['tran_DOW'] = train.TRAN_TS.dt.dayofweek
train['cust_since_DOW'] = train.CUST_SINCE_DT.dt.dayofweek
train['activity_DOW'] = train.ACTVY_DT.dt.dayofweek
train['pwd_date_MONTH'] = train.PWD_UPDT_TS.dt.month
train['tran_MONTH'] = train.TRAN_TS.dt.month
train['cust_since_MONTH'] = train.CUST_SINCE_DT.dt.month
train['activity_MONTH'] = train.ACTVY_DT.dt.month

train.head()
```

```
[173]:    TRAN_AMT  ACCT_PRE_TRAN_AVAIL_BAL  CUST_AGE  OPEN_ACCT_CT  WF_dvc_age  \
       0      5.38                 23619.91        47             4        2777
       2     54.84                 34570.63        36             8        1531
       3      0.01                     0.00        62             3         835
       4    497.08                 12725.18        81             2        1095
       5    488.55                  2851.44        45             8           1

                 PWD_UPDT_TS                      CARR_NAME       RGN_NAME  \
       0 2018-01-16 11:03:58        cox communications inc.      southwest
       2 2021-12-22 10:42:51             utah broadband llc       mountain
       3 2020-02-08 07:28:31             t-mobile usa  inc.      southwest
       4 2020-12-28 12:12:44          cogent communications  south central
       5 2021-03-15 15:36:36  ultimate internet access, inc      southwest

         STATE_PRVNC_TXT ALERT_TRGR_CD  … pwd_date_Hour tran_Hour pwd_date_DOW  \
       0          nevada          MOBL  …          11.0      18.0          1.0
       2            utah          ONLN  …          10.0       9.0          2.0
       3      california          MOBL  …           7.0      15.0          5.0
       4           texas          MOBL  …          12.0      11.0          0.0
       5      california          ONLN  …          15.0      14.0          0.0

          tran_DOW cust_since_DOW activity_DOW pwd_date_MONTH tran_MONTH  \
       0       0.0              2          0.0            1.0        5.0
       2       3.0              1          3.0           12.0        4.0
       3       1.0              3          1.0            2.0        8.0
       4       6.0              5          6.0           12.0        6.0
       5       1.0              0          1.0            3.0        5.0

         cust_since_MONTH activity_MONTH
       0                1            5.0
       2                2            4.0
       3               11            8.0
       4                2            6.0
       5                6            5.0
```

```
[5 rows x 32 columns]
```

[174]:
```
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10875 entries, 0 to 13998
Data columns (total 32 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   TRAN_AMT                  10875 non-null  float64
 1   ACCT_PRE_TRAN_AVAIL_BAL   10875 non-null  float64
 2   CUST_AGE                  10875 non-null  int64
 3   OPEN_ACCT_CT              10875 non-null  int64
 4   WF_dvc_age                10875 non-null  int64
 5   PWD_UPDT_TS               10868 non-null  datetime64[ns]
 6   CARR_NAME                 10875 non-null  object
 7   RGN_NAME                  10875 non-null  object
 8   STATE_PRVNC_TXT           10875 non-null  object
 9   ALERT_TRGR_CD             10875 non-null  object
 10  DVC_TYPE_TXT              10875 non-null  object
 11  AUTHC_PRIM_TYPE_CD        10875 non-null  object
 12  AUTHC_SCNDRY_STAT_TXT     10875 non-null  object
 13  CUST_ZIP                  10875 non-null  int64
 14  CUST_STATE                10875 non-null  object
 15  CUST_SINCE_DT             10875 non-null  datetime64[ns]
 16  TRAN_TS                   10760 non-null  datetime64[ns]
 17  ACTN_CD                   10875 non-null  object
 18  ACTN_INTNL_TXT            10875 non-null  object
 19  TRAN_TYPE_CD              10875 non-null  object
 20  ACTVY_DT                  10760 non-null  datetime64[ns]
 21  FRAUD_NONFRAUD            10875 non-null  object
 22  pwd_date_Hour             10868 non-null  float64
 23  tran_Hour                 10760 non-null  float64
 24  pwd_date_DOW              10868 non-null  float64
 25  tran_DOW                  10760 non-null  float64
 26  cust_since_DOW            10875 non-null  int64
 27  activity_DOW              10760 non-null  float64
 28  pwd_date_MONTH            10868 non-null  float64
 29  tran_MONTH                10760 non-null  float64
 30  cust_since_MONTH          10875 non-null  int64
 31  activity_MONTH            10760 non-null  float64
dtypes: datetime64[ns](4), float64(10), int64(6), object(12)
memory usage: 2.7+ MB
```

[175]:
```
train['TRAN_TYPE_CD'].nunique()
```

[175]:
```
1
```

```
[176]: #Dropping remaining null values
       train = train.dropna()
```

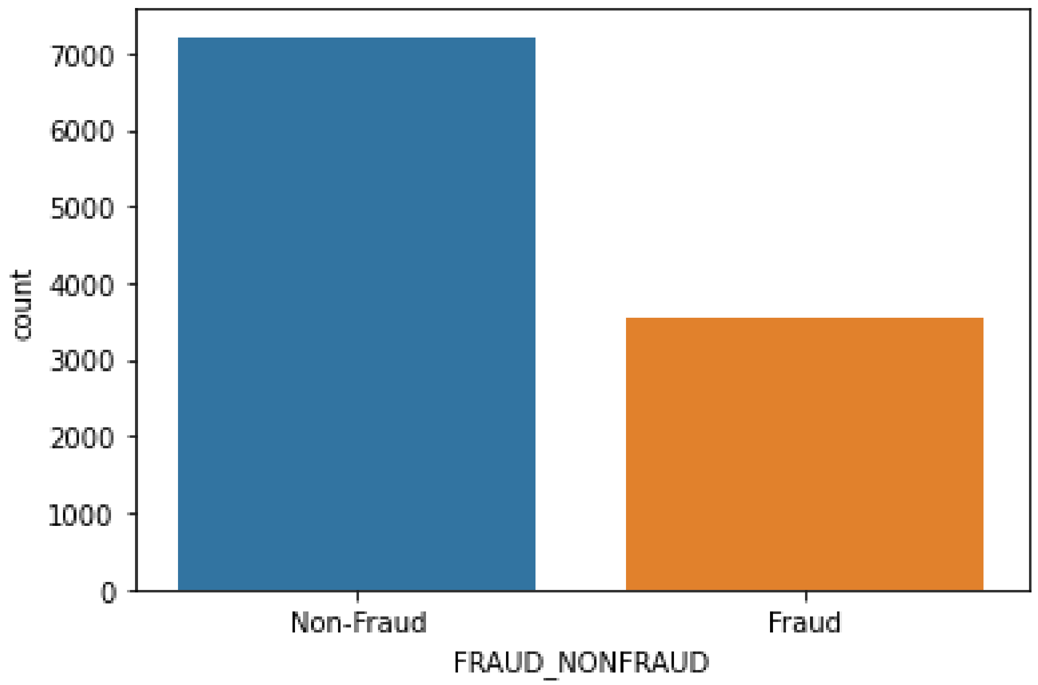
```
[177]: #Getting new shape of data
       train.shape
```

```
[177]: (10753, 32)
```

```
[178]: #Creating a barplot to show the distribution of fraud and non fraud.
       sns.countplot(train['FRAUD_NONFRAUD'])
       print(train['FRAUD_NONFRAUD'].value_counts(normalize= 'TRUE'))
```

```
Non-Fraud    0.670604
Fraud        0.329396
Name: FRAUD_NONFRAUD, dtype: float64
```

```
/Users/kevoncambridge/opt/anaconda3/lib/python3.8/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable
as a keyword arg: x. From version 0.12, the only valid positional argument will
be `data`, and passing other arguments without an explicit keyword will result
in an error or misinterpretation.
  warnings.warn(
```



```
[179]: train['PWD_UPDT_TS']= train['PWD_UPDT_TS'].apply(lambda x:x.toordinal())
       train['CUST_SINCE_DT'] = train['CUST_SINCE_DT'].apply(lambda x:x.toordinal())
```

```
train['TRAN_TS'] = train['TRAN_TS'].apply(lambda x:x.toordinal())
train['ACTVY_DT'] = train['ACTVY_DT'].apply(lambda x:x.toordinal())
```

[180]:
```
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10753 entries, 0 to 13998
Data columns (total 32 columns):
 #   Column                  Non-Null Count  Dtype
---  ------                  --------------  -----
 0   TRAN_AMT                10753 non-null  float64
 1   ACCT_PRE_TRAN_AVAIL_BAL  10753 non-null  float64
 2   CUST_AGE                10753 non-null  int64
 3   OPEN_ACCT_CT            10753 non-null  int64
 4   WF_dvc_age              10753 non-null  int64
 5   PWD_UPDT_TS             10753 non-null  int64
 6   CARR_NAME               10753 non-null  object
 7   RGN_NAME                10753 non-null  object
 8   STATE_PRVNC_TXT         10753 non-null  object
 9   ALERT_TRGR_CD           10753 non-null  object
 10  DVC_TYPE_TXT            10753 non-null  object
 11  AUTHC_PRIM_TYPE_CD      10753 non-null  object
 12  AUTHC_SCNDRY_STAT_TXT   10753 non-null  object
 13  CUST_ZIP                10753 non-null  int64
 14  CUST_STATE              10753 non-null  object
 15  CUST_SINCE_DT           10753 non-null  int64
 16  TRAN_TS                 10753 non-null  int64
 17  ACTN_CD                 10753 non-null  object
 18  ACTN_INTNL_TXT          10753 non-null  object
 19  TRAN_TYPE_CD            10753 non-null  object
 20  ACTVY_DT                10753 non-null  int64
 21  FRAUD_NONFRAUD          10753 non-null  object
 22  pwd_date_Hour           10753 non-null  float64
 23  tran_Hour               10753 non-null  float64
 24  pwd_date_DOW            10753 non-null  float64
 25  tran_DOW                10753 non-null  float64
 26  cust_since_DOW          10753 non-null  int64
 27  activity_DOW            10753 non-null  float64
 28  pwd_date_MONTH          10753 non-null  float64
 29  tran_MONTH              10753 non-null  float64
 30  cust_since_MONTH        10753 non-null  int64
 31  activity_MONTH          10753 non-null  float64
dtypes: float64(10), int64(10), object(12)
memory usage: 3.0+ MB
```

[181]:
```
train['FRAUD_NONFRAUD'].nunique()
```

[181]: 2

[182]:
```
train['FRAUD_NONFRAUD'] = train['FRAUD_NONFRAUD'].replace('Fraud', 1)
train['FRAUD_NONFRAUD'] = train['FRAUD_NONFRAUD'].replace('Non-Fraud', 0)
```

1 Checking for outliers and dealing with them

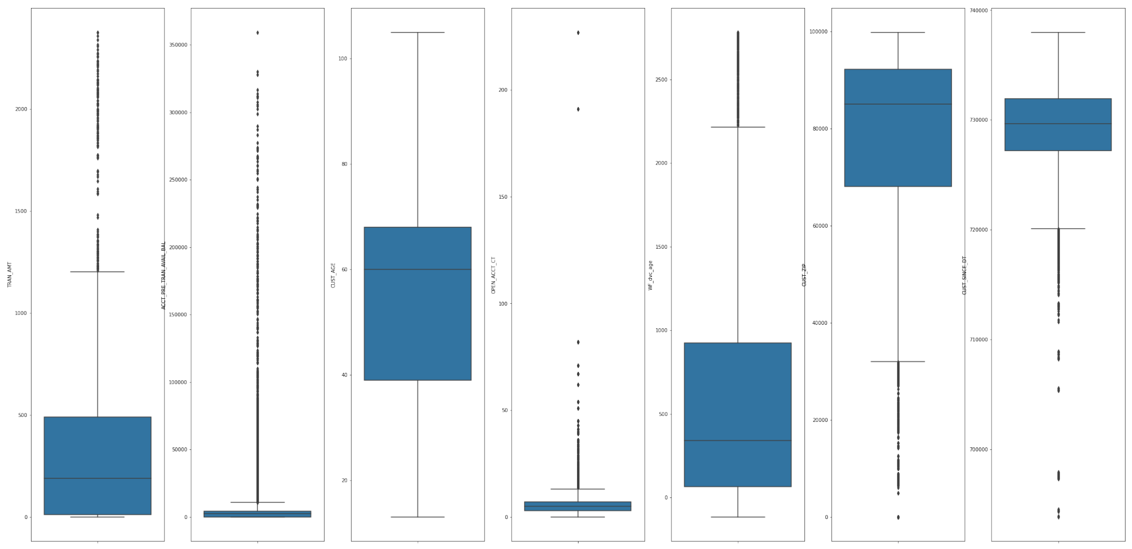
[183]:
```
train.describe()
```

[183]:
```
            TRAN_AMT  ACCT_PRE_TRAN_AVAIL_BAL      CUST_AGE  OPEN_ACCT_CT  \
count   10753.000000             10753.000000  10753.000000  10753.000000
mean      277.803487              9506.187956     54.148796      6.421278
std       308.265437             28481.126538     18.853741      8.071467
min         0.010000                 0.000000     13.000000      0.000000
25%        11.620000                 0.000000     39.000000      3.000000
50%       189.430000              2392.680000     60.000000      5.000000
75%       489.160000              4405.970000     68.000000      7.000000
max      2376.060000            359345.380000    105.000000    227.000000

          WF_dvc_age    PWD_UPDT_TS      CUST_ZIP  CUST_SINCE_DT  \
count   10753.000000   10753.000000  10753.000000   10753.000000
mean      590.007068  737408.135404  74262.129452  729628.639263
std       662.335396     515.139032  24726.974417    4939.255805
min      -117.000000  736330.000000      0.000000  693844.000000
25%        64.000000  737083.000000  68104.000000  727198.000000
50%       339.000000  737548.000000  85040.000000  729646.000000
75%       925.000000  737826.000000  92203.000000  731945.000000
max      2783.000000  738155.000000  99835.000000  737987.000000

             TRAN_TS      ACTVY_DT  …  pwd_date_Hour     tran_Hour  \
count   10753.000000  10753.000000  …   10753.000000  10753.000000
mean   737896.156979 737896.156979  …      10.488515     12.483307
std        61.724452     61.724452  …       5.457432      4.743154
min    737791.000000 737791.000000  …       0.000000      0.000000
25%    737847.000000 737847.000000  …       6.000000      9.000000
50%    737891.000000 737891.000000  …      10.000000     12.000000
75%    737950.000000 737950.000000  …      14.000000     16.000000
max    738033.000000 738033.000000  …      23.000000     23.000000

        pwd_date_DOW      tran_DOW  cust_since_DOW  activity_DOW  \
count   10753.000000  10753.000000    10753.000000  10753.000000
mean        2.954710      3.013857        2.977867      3.013857
std         1.998906      2.002717        2.007675      2.002717
min         0.000000      0.000000        0.000000      0.000000
25%         1.000000      1.000000        1.000000      1.000000
50%         3.000000      3.000000        3.000000      3.000000
75%         5.000000      5.000000        5.000000      5.000000
max         6.000000      6.000000        6.000000      6.000000
```

```
       pwd_date_MONTH    tran_MONTH  cust_since_MONTH  activity_MONTH
count    10753.000000  10753.000000      10753.000000    10753.000000
mean         5.824049      4.040547          6.329489        4.040547
std          3.322608      2.023769          3.364258        2.023769
min          1.000000      1.000000          1.000000        1.000000
25%          3.000000      2.000000          3.000000        2.000000
50%          5.000000      4.000000          6.000000        4.000000
75%          8.000000      6.000000          9.000000        6.000000
max         12.000000      8.000000         12.000000        8.000000

[8 rows x 21 columns]
```

[184]:
```
#creating box plot to check for outliers
plt.figure(figsize=(40, 20))
plt.subplot(1,7,1)
sns.boxplot(y = train.TRAN_AMT)

plt.subplot(1,7,2)
sns.boxplot(y = train.ACCT_PRE_TRAN_AVAIL_BAL)

plt.subplot(1,7,3)
sns.boxplot(y = train.CUST_AGE)

plt.subplot(1,7,4)
sns.boxplot(y = train.OPEN_ACCT_CT)

plt.subplot(1,7,5)
sns.boxplot(y = train.WF_dvc_age)

plt.subplot(1,7,6)
sns.boxplot(y = train.CUST_ZIP)

plt.subplot(1,7,7)
sns.boxplot(y = train.CUST_SINCE_DT)
```

[184]:
```
<AxesSubplot:ylabel='CUST_SINCE_DT'>
```



[185]:
```python
def outlier_limits(col):
    Q3, Q1 = np.nanpercentile(col, [75,25])
    IQR = Q3 - Q1
    UL = Q3 + 1.5*IQR
    LL = Q1 - 1.5*IQR
    return UL, LL
```

[186]:
```python
for column in train.columns:
    if train[column].dtype != 'object':
        UL, LL = outlier_limits(train[column])
        train[column] = np.where((train[column] > UL) | (train[column] < LL),␣
 ↪np.nan, train[column])
```

[187]:
```python
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10753 entries, 0 to 13998
Data columns (total 32 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   TRAN_AMT                 10593 non-null  float64
 1   ACCT_PRE_TRAN_AVAIL_BAL  9149 non-null   float64
 2   CUST_AGE                 10753 non-null  float64
 3   OPEN_ACCT_CT             10077 non-null  float64
 4   WF_dvc_age               10394 non-null  float64
 5   PWD_UPDT_TS              10753 non-null  float64
 6   CARR_NAME                10753 non-null  object
 7   RGN_NAME                 10753 non-null  object
 8   STATE_PRVNC_TXT          10753 non-null  object
 9   ALERT_TRGR_CD            10753 non-null  object
 10  DVC_TYPE_TXT             10753 non-null  object
 11  AUTHC_PRIM_TYPE_CD       10753 non-null  object
 12  AUTHC_SCNDRY_STAT_TXT    10753 non-null  object
 13  CUST_ZIP                 9681 non-null   float64
 14  CUST_STATE               10753 non-null  object
 15  CUST_SINCE_DT            10384 non-null  float64
 16  TRAN_TS                  10753 non-null  float64
 17  ACTN_CD                  10753 non-null  object
 18  ACTN_INTNL_TXT           10753 non-null  object
 19  TRAN_TYPE_CD             10753 non-null  object
 20  ACTVY_DT                 10753 non-null  float64
 21  FRAUD_NONFRAUD           10753 non-null  float64
 22  pwd_date_Hour            10753 non-null  float64
 23  tran_Hour                10753 non-null  float64
 24  pwd_date_DOW             10753 non-null  float64
 25  tran_DOW                 10753 non-null  float64
 26  cust_since_DOW           10753 non-null  float64
 27  activity_DOW             10753 non-null  float64
 28  pwd_date_MONTH           10753 non-null  float64
 29  tran_MONTH               10753 non-null  float64
 30  cust_since_MONTH         10753 non-null  float64
 31  activity_MONTH           10753 non-null  float64
dtypes: float64(21), object(11)
memory usage: 3.0+ MB
```

[188]:
```
train.isna().sum()
```

[188]:
```
TRAN_AMT                    160
ACCT_PRE_TRAN_AVAIL_BAL    1604
CUST_AGE                      0
OPEN_ACCT_CT                676
WF_dvc_age                  359
PWD_UPDT_TS                   0
CARR_NAME                     0
RGN_NAME                      0
STATE_PRVNC_TXT               0
ALERT_TRGR_CD                 0
DVC_TYPE_TXT                  0
AUTHC_PRIM_TYPE_CD            0
AUTHC_SCNDRY_STAT_TXT         0
CUST_ZIP                   1072
CUST_STATE                    0
CUST_SINCE_DT               369
TRAN_TS                       0
ACTN_CD                       0
ACTN_INTNL_TXT                0
TRAN_TYPE_CD                  0
```

```
ACTVY_DT                    0
FRAUD_NONFRAUD              0
pwd_date_Hour               0
tran_Hour                   0
pwd_date_DOW                0
tran_DOW                    0
cust_since_DOW              0
activity_DOW                0
pwd_date_MONTH              0
tran_MONTH                  0
cust_since_MONTH            0
activity_MONTH              0
dtype: int64
```

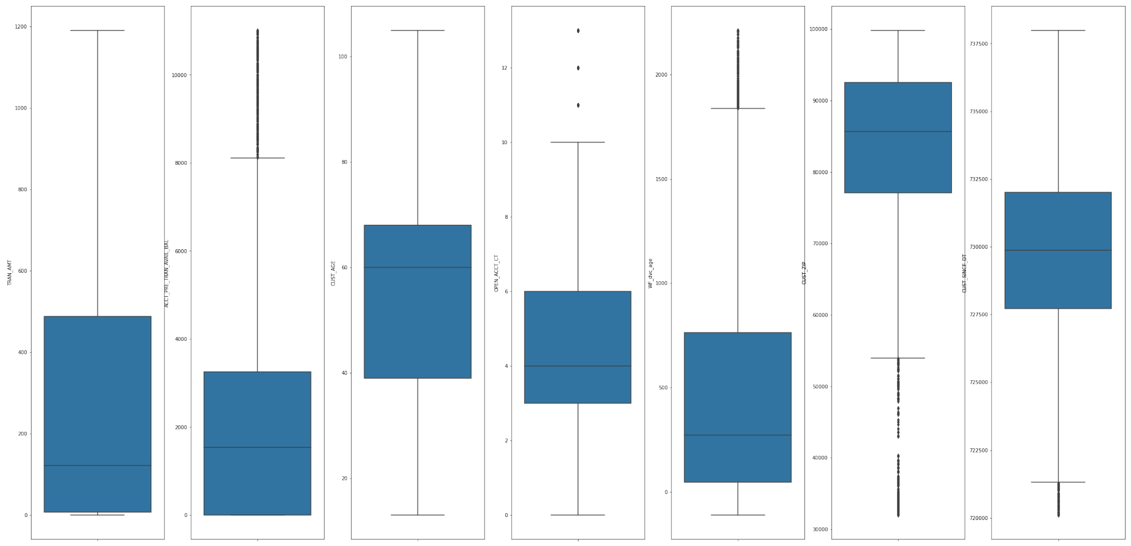
[189]:
```
# dropping outliers
train = train.dropna()
```

[190]:
```
train.info()
```

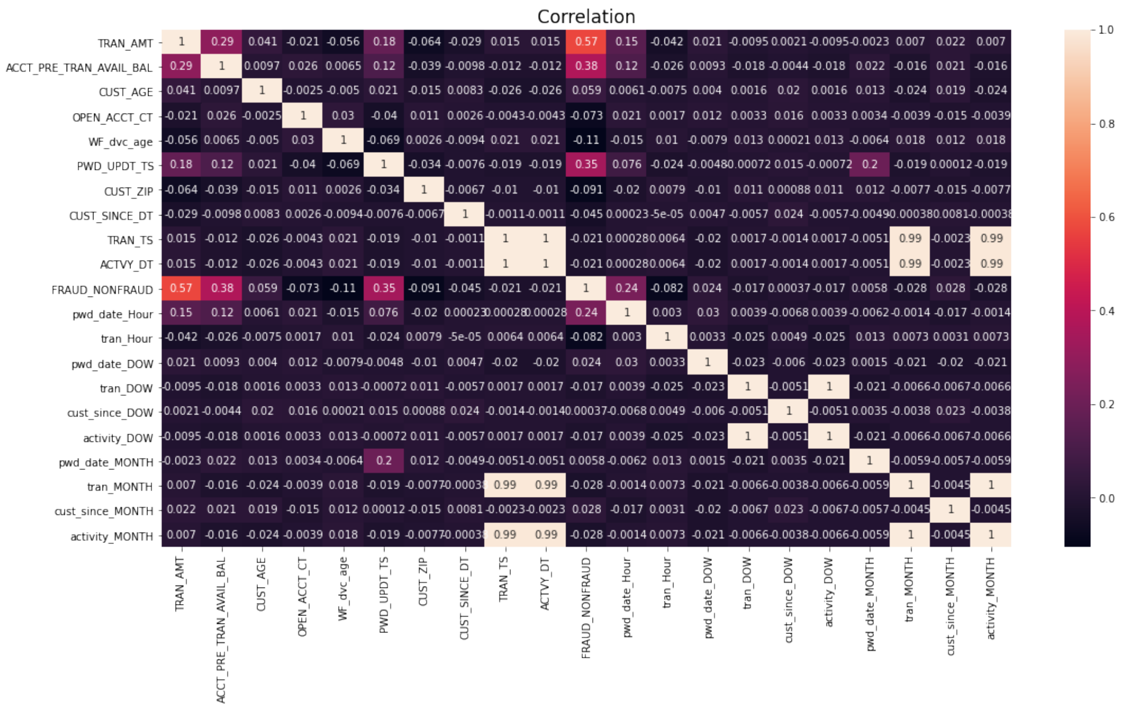
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7299 entries, 3 to 13998
Data columns (total 32 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   TRAN_AMT                 7299 non-null   float64
 1   ACCT_PRE_TRAN_AVAIL_BAL  7299 non-null   float64
 2   CUST_AGE                 7299 non-null   float64
 3   OPEN_ACCT_CT             7299 non-null   float64
 4   WF_dvc_age               7299 non-null   float64
 5   PWD_UPDT_TS              7299 non-null   float64
 6   CARR_NAME                7299 non-null   object
 7   RGN_NAME                 7299 non-null   object
 8   STATE_PRVNC_TXT          7299 non-null   object
 9   ALERT_TRGR_CD            7299 non-null   object
 10  DVC_TYPE_TXT             7299 non-null   object
 11  AUTHC_PRIM_TYPE_CD       7299 non-null   object
 12  AUTHC_SCNDRY_STAT_TXT    7299 non-null   object
 13  CUST_ZIP                 7299 non-null   float64
 14  CUST_STATE               7299 non-null   object
 15  CUST_SINCE_DT            7299 non-null   float64
 16  TRAN_TS                  7299 non-null   float64
 17  ACTN_CD                  7299 non-null   object
 18  ACTN_INTNL_TXT           7299 non-null   object
 19  TRAN_TYPE_CD             7299 non-null   object
 20  ACTVY_DT                 7299 non-null   float64
 21  FRAUD_NONFRAUD           7299 non-null   float64
 22  pwd_date_Hour            7299 non-null   float64
 23  tran_Hour                7299 non-null   float64
 24   pwd_date_DOW            7299 non-null   float64
 25   tran_DOW                7299 non-null   float64
 26   cust_since_DOW          7299 non-null   float64
 27   activity_DOW            7299 non-null   float64
 28   pwd_date_MONTH          7299 non-null   float64
 29   tran_MONTH              7299 non-null   float64
 30   cust_since_MONTH        7299 non-null   float64
 31   activity_MONTH          7299 non-null   float64
dtypes: float64(21), object(11)
memory usage: 1.8+ MB
```

[191]:
```
#creating box plot to check for outliers
plt.figure(figsize=(40, 20))
plt.subplot(1,7,1)
sns.boxplot(y = train.TRAN_AMT)

plt.subplot(1,7,2)
sns.boxplot(y = train.ACCT_PRE_TRAN_AVAIL_BAL)

plt.subplot(1,7,3)
sns.boxplot(y = train.CUST_AGE)

plt.subplot(1,7,4)
sns.boxplot(y = train.OPEN_ACCT_CT)

plt.subplot(1,7,5)
sns.boxplot(y = train.WF_dvc_age)

plt.subplot(1,7,6)
sns.boxplot(y = train.CUST_ZIP)

plt.subplot(1,7,7)
sns.boxplot(y = train.CUST_SINCE_DT)
```

[191]:
```
<AxesSubplot:ylabel='CUST_SINCE_DT'>
```



```
[192]: plt.figure(figsize=(18, 9))
       sns.heatmap(data=train.corr(), annot=True)
       plt.title('Correlation',size=17)
       plt.show()
```



```
[193]: X= train.drop(columns='FRAUD_NONFRAUD')
       y= train['FRAUD_NONFRAUD']
```

```
[194]: #Applying OneHotEncoder on the features
       from sklearn.preprocessing import OneHotEncoder
       enc = OneHotEncoder()
       X = enc.fit_transform(X)
```

```
[195]: X.shape
```

```
[195]: (7299, 21455)
```

```
[196]: from sklearn.preprocessing import MaxAbsScaler
       norm1 = MaxAbsScaler()
```

```
[197]: X = norm1.fit_transform(X)
```

2 Splitting Data into Train and Validation

```
[198]: #Splitiing the data
       x_train, x_test, y_train, y_test = train_test_split(X,y, test_size=0.2,␣
        ↪random_state=42)
```

```
[199]: #getting shape of the split data
       print('X Train:', x_train.shape)
       print('X Valid:', x_test.shape)
       print('Y Train:', y_train.shape)
       print('Y Valid:', y_test.shape)
```

```
X Train: (5839, 21455)
X Valid: (1460, 21455)
Y Train: (5839,)
Y Valid: (1460,)
```

3 Models

4 Linear Discriminant Analysis

```
[200]: from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
       from sklearn.metrics import classification_report
```

```
[201]: ldaModel = LinearDiscriminantAnalysis()
       ldaModel.fit(x_train.toarray(), y_train)
       y_pred_lda = ldaModel.predict(x_test)
       print(classification_report(y_test, y_pred_lda))
       confusionMatrices(ldaModel, 'Linear discriminant analysis')
```

```
              precision    recall  f1-score   support

         0.0       0.77      0.93      0.84       983
         1.0       0.75      0.41      0.53       477

    accuracy                           0.76      1460
   macro avg       0.76      0.67      0.69      1460
weighted avg       0.76      0.76      0.74      1460

Linear discriminant analysis - training results
Confusion Matrix (Accuracy 0.8303)

       Prediction
Actual    0    1
     0 3663  298
     1  693 1185
Linear discriminant analysis - validation results
Confusion Matrix (Accuracy 0.7623)

       Prediction
Actual   0   1
     0 918  65
     1 282 195
```

5 Support Vector Machine

[202]:
```
from sklearn.svm import SVC
clf = SVC(kernel = 'linear', probability = True)
clf.fit(x_train, y_train)
y_pred_clf = clf.predict(x_test)
print(classification_report(y_test, y_pred_clf))
confusionMatrices(clf, 'Support Vector Machine')
```

```
              precision    recall  f1-score   support

         0.0       0.93      0.95      0.94       983
         1.0       0.90      0.86      0.88       477

    accuracy                           0.92      1460
   macro avg       0.92      0.91      0.91      1460
weighted avg       0.92      0.92      0.92      1460

Support Vector Machine - training results
Confusion Matrix (Accuracy 1.0000)

       Prediction
Actual    0    1
```

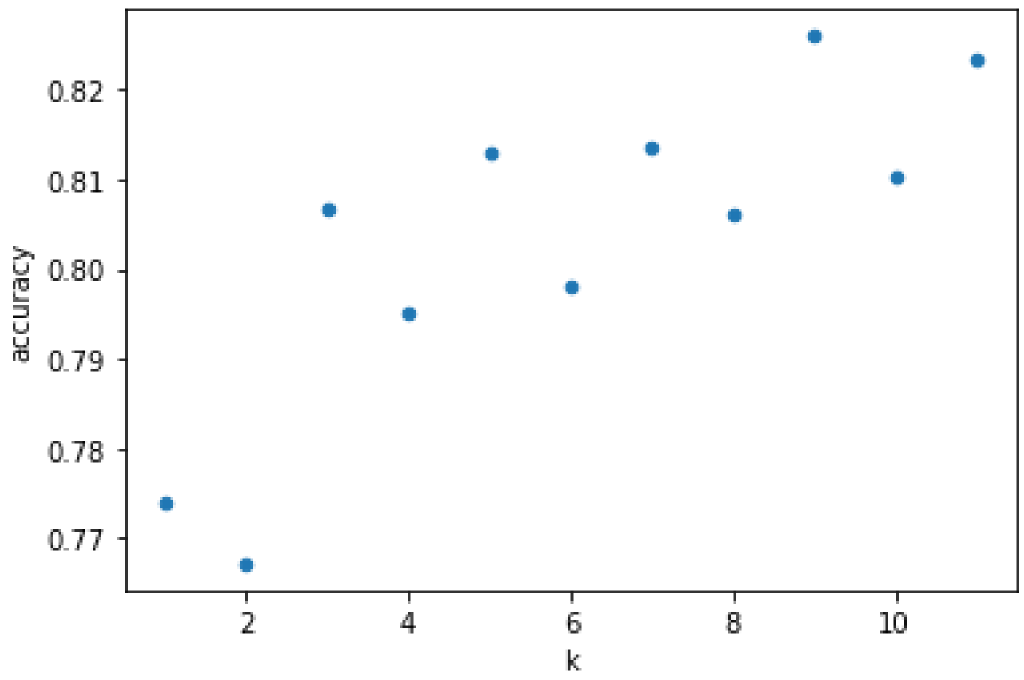
```
     0 3961    0
     1    0 1878
Support Vector Machine - validation results
Confusion Matrix (Accuracy 0.9240)

       Prediction
Actual   0   1
     0 938  45
     1  66 411
```

6 K Nearest Neighbors

[203]:
```
from sklearn.neighbors import NearestNeighbors, KNeighborsClassifier
```

[204]:
```
results = []
for k in range(1,12):
    knn = KNeighborsClassifier(n_neighbors=k).fit(x_train, y_train)
    results.append({
        'k': k,
        'accuracy': accuracy_score(y_test, knn.predict(x_test))
    })
results = pd.DataFrame(results)
results.plot.scatter(x='k', y='accuracy')
results
```

[204]:
```
     k  accuracy
0    1  0.773973
1    2  0.767123
2    3  0.806849
3    4  0.795205
4    5  0.813014
5    6  0.797945
6    7  0.813699
7    8  0.806164
8    9  0.826027
9   10  0.810274
10  11  0.823288
```



[205]:
```python
knn1 = KNeighborsClassifier(n_neighbors = 9).fit(x_train, y_train)
y_pred_knn = knn1.predict(x_test)
print(classification_report(y_test, y_pred_knn))
confusionMatrices(knn1, 'K Nearest Neighbors')
```

```
              precision    recall  f1-score   support

         0.0       0.81      0.97      0.88       983
         1.0       0.89      0.53      0.67       477

    accuracy                           0.83      1460
   macro avg       0.85      0.75      0.77      1460
weighted avg       0.84      0.83      0.81      1460

K Nearest Neighbors - training results
Confusion Matrix (Accuracy 0.8582)

       Prediction
Actual    0    1
     0 3847  114
     1  714 1164
K Nearest Neighbors - validation results
Confusion Matrix (Accuracy 0.8260)

       Prediction
```

```
Actual    0    1
     0  952   31
     1  223  254
```

7 Logisitic Regression

[206]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score,recall_score
from sklearn.metrics import classification_report

classifier = LogisticRegression()
classifier.fit(x_train,y_train)
y_pred = classifier.predict(x_test)
print('accuracy %2.2f ' % accuracy_score(y_test, classifier.predict(x_test)))
y_pred = classifier.predict(x_test)
print(classification_report(y_test, y_pred))
confusionMatrices(classifier, 'Logistic regression')
```

```
accuracy 0.93
              precision    recall  f1-score   support

         0.0       0.93      0.96      0.95       983
         1.0       0.91      0.86      0.88       477

    accuracy                           0.93      1460
   macro avg       0.92      0.91      0.91      1460
weighted avg       0.93      0.93      0.93      1460

Logistic regression - training results
Confusion Matrix (Accuracy 0.9985)

       Prediction
Actual     0     1
     0  3956     5
     1     4  1874
Logistic regression - validation results
Confusion Matrix (Accuracy 0.9260)

       Prediction
Actual    0    1
     0  942   41
     1   67  410
```

```
/Users/kevoncambridge/opt/anaconda3/lib/python3.8/site-
packages/sklearn/linear_model/_logistic.py:814: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

8 Decision Tree

[207]:
```
classTree = DecisionTreeClassifier()
classTree.fit(x_train, y_train)

#parameters

param_grid = {
    'max_depth': [10, 20, 30, 40],
    'min_samples_split': [20, 40, 60, 80, 100],
    'min_impurity_decrease': [0, 0.0005, 0.001, 0.005, 0.01],
}


gridSearch = GridSearchCV(DecisionTreeClassifier(random_state=1), param_grid,␣
 ↪cv=5, n_jobs=-1)
gridSearch.fit(x_train, y_train)
print('Initial score: ', gridSearch.best_score_)
print('Initial parameters: ', gridSearch.best_params_)

param_grid = {
    'max_depth': list(range(2, 16)),
    'min_samples_split': [96, 97, 98, 99, 100, 101, 102, 103],
    'min_impurity_decrease': [0, 0.0005, 0.001, 0.005, 0.01],
}

gridSearch = GridSearchCV(DecisionTreeClassifier(), param_grid, cv=5, n_jobs=-1)
gridSearch.fit(x_train, y_train)
print('Improved score: ', gridSearch.best_score_)
print('Improved parameters: ', gridSearch.best_params_)




classTree = gridSearch.best_estimator_
y_pred_classTree = classTree.predict(x_test)
print(classification_report(y_test, y_pred))
confusionMatrices(classTree, 'Decision tree')
```

```
Initial score:  0.885598830862415
Initial parameters:  {'max_depth': 20, 'min_impurity_decrease': 0.001,
'min_samples_split': 20}
Improved score:  0.8837145355730065
Improved parameters:  {'max_depth': 13, 'min_impurity_decrease': 0.0005,
'min_samples_split': 96}
              precision    recall  f1-score   support

         0.0       0.93      0.96      0.95       983
         1.0       0.91      0.86      0.88       477

    accuracy                           0.93      1460
   macro avg       0.92      0.91      0.91      1460
weighted avg       0.93      0.93      0.93      1460

Decision tree - training results
Confusion Matrix (Accuracy 0.9032)

       Prediction
Actual    0    1
     0 3785  176
     1  389 1489
Decision tree - validation results
Confusion Matrix (Accuracy 0.8836)

       Prediction
Actual   0   1
     0 927  56
     1 114 363
```

9 Bagging

[208]:
```python
from sklearn.ensemble import BaggingClassifier

bagging = BaggingClassifier(classTree, max_samples=0.5, max_features=0.5)
bagging.fit(x_train, y_train)
y_pred_bag = bagging.predict(x_test)
print('accuracy %2.2f ' % accuracy_score(y_test, bagging.predict(x_test)))
print(classification_report(y_test, y_pred_bag))
confusionMatrices(bagging, 'Bagging')
```

```
accuracy 0.87
              precision    recall  f1-score   support

         0.0       0.86      0.97      0.91       983
         1.0       0.92      0.66      0.77       477

    accuracy                           0.87      1460
```

```
   macro avg       0.89      0.82      0.84      1460
weighted avg       0.88      0.87      0.87      1460

Bagging - training results
Confusion Matrix (Accuracy 0.9041)

       Prediction
Actual    0    1
     0 3885   76
     1  484 1394
Bagging - validation results
Confusion Matrix (Accuracy 0.8726)

       Prediction
Actual   0   1
     0 957  26
     1 160 317
```

10 AdaBoost

[209]:
```
from sklearn.ensemble import AdaBoostClassifier
adaboost = AdaBoostClassifier(n_estimators=100, base_estimator=classTree)
adaboost.fit(x_train, y_train)
y_pred_ada = adaboost.predict(x_test)
print('accuracy %2.2f ' % accuracy_score(y_test, adaboost.predict(x_test)))
print(classification_report(y_test, y_pred_ada))
confusionMatrices(adaboost, 'AdaBoost')
```

```
accuracy 0.90
              precision    recall  f1-score   support

         0.0       0.90      0.95      0.92       983
         1.0       0.88      0.79      0.83       477

    accuracy                           0.90      1460
   macro avg       0.89      0.87      0.88      1460
weighted avg       0.89      0.90      0.89      1460

AdaBoost - training results
Confusion Matrix (Accuracy 1.0000)

       Prediction
Actual    0    1
     0 3961    0
     1    0 1878
AdaBoost - validation results
Confusion Matrix (Accuracy 0.8952)
```

```
       Prediction
Actual   0   1
     0 930  53
     1 100 377
```

11 Random Forest

[210]:
```
from sklearn.ensemble import RandomForestClassifier

rfModel = RandomForestClassifier(max_features=3, min_samples_split=300,
 random_state=0, n_estimators=100, criterion='entropy')
rfModel.fit(x_train, y_train)

y_pred_rf = rfModel.predict(x_test)
print('accuracy %2.2f ' % accuracy_score(y_test, rfModel.predict(x_test)))
print(classification_report(y_test, y_pred_rf))
confusionMatrices(rfModel, 'Random Forest')
```

```
accuracy 0.69
              precision    recall  f1-score   support

         0.0       0.69      1.00      0.81       983
         1.0       1.00      0.06      0.12       477

    accuracy                           0.69      1460
   macro avg       0.84      0.53      0.47      1460
weighted avg       0.79      0.69      0.59      1460

Random Forest - training results
Confusion Matrix (Accuracy 0.8328)

       Prediction
Actual    0    1
     0 3961    0
     1  976  902
Random Forest - validation results
Confusion Matrix (Accuracy 0.6938)

       Prediction
Actual   0   1
     0 983   0
     1 447  30
```

12 Naive Bayes

[211]:
```
from sklearn.naive_bayes import MultinomialNB
nb = MultinomialNB(alpha=0.01)
nb.fit(x_train, y_train)

y_pred_nb = nb.predict(x_test)
print('accuracy %2.2f ' % accuracy_score(y_test, nb.predict(x_test)))
print(classification_report(y_test, y_pred_nb))
confusionMatrices(nb, 'Naive Bayes')
```

```
accuracy 0.93
              precision    recall  f1-score   support

         0.0       0.96      0.94      0.95       983
         1.0       0.87      0.92      0.90       477

    accuracy                           0.93      1460
   macro avg       0.92      0.93      0.92      1460
weighted avg       0.93      0.93      0.93      1460

Naive Bayes - training results
Confusion Matrix (Accuracy 1.0000)

       Prediction
Actual    0    1
     0 3961    0
     1    0 1878
Naive Bayes - validation results
Confusion Matrix (Accuracy 0.9301)

       Prediction
Actual   0   1
     0 920  63
     1  39 438
```

13 Neural Network

[212]:
```
from sklearn.neural_network import MLPClassifier
from sklearn.preprocessing import MinMaxScaler

#scaleInput = MinMaxScaler()
#scaleInput.fit(x_train * 1.0)

from sklearn.preprocessing import MaxAbsScaler
scaleInput = MaxAbsScaler().fit(X)
```

```
neuralNet = MLPClassifier(hidden_layer_sizes=(10),
                          activation='logistic',
                          solver='lbfgs',
                          max_iter=3000,
                          random_state=1)
neuralNet.fit(scaleInput.transform(x_train), y_train)
```

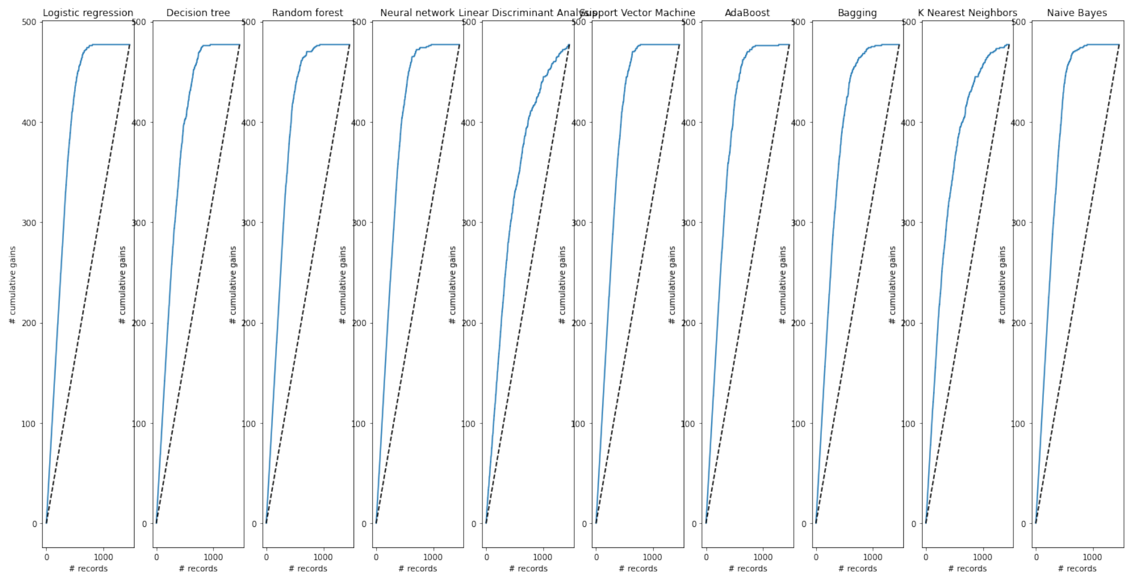
```
[212]: MLPClassifier(activation='logistic', hidden_layer_sizes=10, max_iter=3000,
                     random_state=1, solver='lbfgs')
```

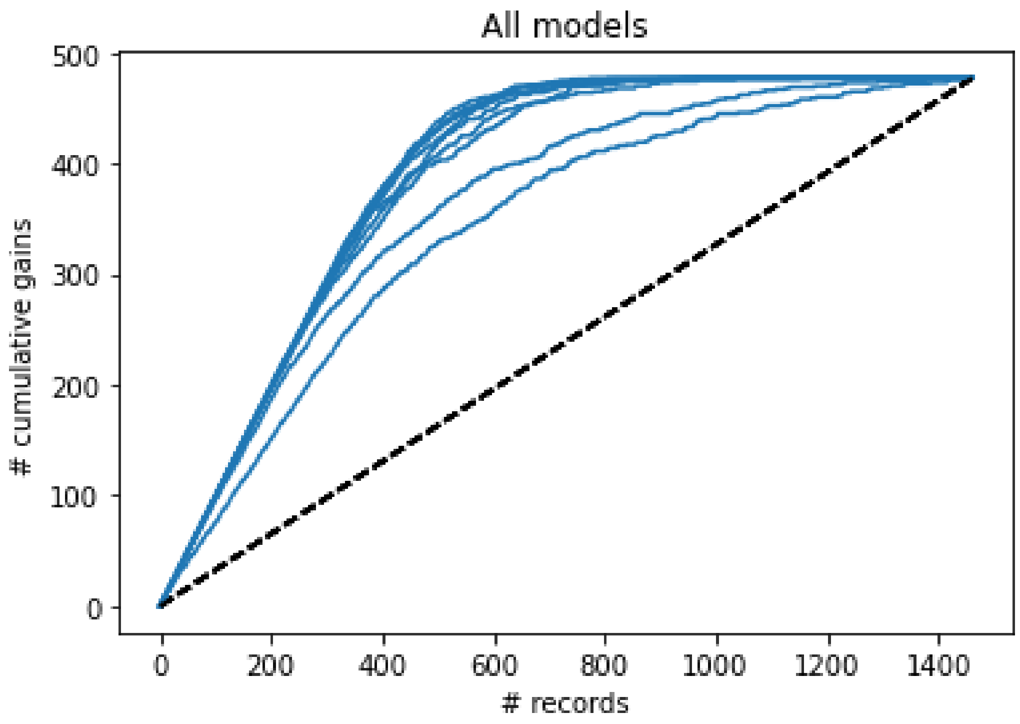
```
[213]: y_pred_nn = neuralNet.predict(x_test)
       print('accuracy %2.2f ' % accuracy_score(y_test, neuralNet.predict(x_test)))
       print(classification_report(y_test, y_pred_nn))
       confusionMatrices(neuralNet, 'Neural Network')
```

```
accuracy 0.91
              precision    recall  f1-score   support

         0.0       0.93      0.94      0.94       983
         1.0       0.87      0.86      0.87       477

    accuracy                           0.91      1460
   macro avg       0.90      0.90      0.90      1460
weighted avg       0.91      0.91      0.91      1460

Neural Network - training results
Confusion Matrix (Accuracy 0.9993)

       Prediction
Actual    0    1
     0 3958    3
     1    1 1877
Neural Network - validation results
Confusion Matrix (Accuracy 0.9130)

       Prediction
Actual   0   1
     0 923  60
     1  67 410
```

```
[230]: fig, axes = plt.subplots(nrows=1, ncols=10, figsize=(24, 12))

       def modelGainsChart(model, title, ax=None):
           result = pd.DataFrame({
               'actual': y_test,
               'prob': model.predict_proba(x_test)[:, 1]
           })
```

```
    result = result.sort_values(by=['prob'], ascending=False).
↪reset_index(drop=True)
    ax = gainsChart(result.actual, ax=ax)
    ax.set_title(title)
    return ax

modelGainsChart(classifier, 'Logistic regression', axes[0])
modelGainsChart(classTree, 'Decision tree', axes[1])
modelGainsChart(rfModel, 'Random forest', axes[2])
modelGainsChart(neuralNet, 'Neural network', axes[3])
modelGainsChart(ldaModel, 'Linear Discriminant Analysis', axes[4])
modelGainsChart(clf, 'Support Vector Machine', axes[5])
modelGainsChart(adaboost, 'AdaBoost', axes[6])
modelGainsChart(bagging, 'Bagging', axes[7])
modelGainsChart(knn1, 'K Nearest Neighbors', axes[8])
modelGainsChart(nb, 'Naive Bayes', axes[9])

ax = modelGainsChart(classifier, 'Logistic regression')
modelGainsChart(classTree, 'Decision tree', ax)
modelGainsChart(rfModel, 'Random forest', ax)
modelGainsChart(neuralNet, 'Neural network', ax)
modelGainsChart(ldaModel, 'Linear Discriminant Analysis', ax)
modelGainsChart(clf, 'Support Vector Machine', ax)
modelGainsChart(adaboost, 'AdaBoost', ax)
modelGainsChart(bagging, 'Bagging', ax)
modelGainsChart(knn1, 'K Nearest Neighbors', ax)
modelGainsChart(nb, 'Naive Bayes', ax)
ax.set_title('All models')
plt.show()
```




All models
# cumulative gains
# records
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400

```
[ ]:
```