ML_regression_and_classifictation_project

August 11, 2024

Description A fictional stakeholder shared data containing client transaction sums and some features. All the data is stored in the train_dataset.csv file, where transaction sums are under the int_targer field. This field is going to be the target to be predicted in this project. The project has a single goal: to predict the target variable. Nevertheless, it will be divided into several subparts for convenience.

[48]:
```
# importing necessary libraries
import numpy as np
import pandas as pd

from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV

from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import OneHotEncoder

from sklearn.metrics import accuracy_score
from sklearn.metrics import mean_squared_error as MSE
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix

from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import LinearRegression
from statsmodels.regression.linear_model import OLS

from sklearn.decomposition import PCA
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier

from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import GradientBoostingClassifier
from lightgbm import LGBMClassifier
import xgboost as xgb

import plotly.graph_objs as go
```

```python
import matplotlib.pyplot as plt
import seaborn as sns
```

1) Importing data

[3]:
```python
dataset = pd.read_csv('train_dataset.csv')
```

[4]:
```python
dataset.head()
```

[4]:
```
   feature_1  feature_2  feature_3  feature_4  feature_5   feature_6  \
0  -0.043457  -0.027918   1.473594 -10.309556  -1.000000  145.373247
1  -1.535978   0.999851  23.019753  38.430092   1.000000 -110.045207
2  11.567708   0.608310   1.873323   6.412821   0.999995 -280.186852
3   9.220074   0.999864   5.041939 -12.692120  -1.000000  164.773793
4  -3.025434  -0.594711   5.912259 -14.922129  -1.000000    9.546673

    feature_7  feature_8   feature_9  feature_10  …  feature_12  feature_13  \
0    0.001888   2.555947  -64.208613    0.470329  …           B   83.317907
1    2.359228   0.571917 -110.318854   -2.620978  …           D  114.881621
2  133.811870   1.160380 -206.238816   -1.006502  …           B  145.833459
3   85.009772  -1.401234   92.624296    2.712139  …           C   98.150579
4    9.153251  -0.157479 -175.895074   -0.832795  …           C   94.519135

   feature_14  feature_15  feature_16  feature_17  feature_18  feature_19  \
0   85.385030  120.550153   59.736520   64.325558  107.833753   85.853573
1   79.711086   68.505986  116.330797   75.365722  104.229006   90.842232
2  115.159171   64.417992   98.846694   66.381070   82.118547   96.837671
3   78.620349  120.176496  104.297092   89.318362   73.791588   71.870016
4  123.286154   75.458961  111.831234  111.871202   99.733563  100.697358

   feature_20  int_target
0  104.466108       17353
1   95.232654        1214
2  103.887599       16094
3   68.397346       24168
4   97.568328        1105

[5 rows x 21 columns]
```

2. Preliminary data analysis

[5]:
```python
len(dataset.index)
```

[5]: 9000

[6]:
```python
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9000 entries, 0 to 8999
```

```
Data columns (total 21 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   feature_1    9000 non-null   float64
 1   feature_2    9000 non-null   float64
 2   feature_3    9000 non-null   float64
 3   feature_4    9000 non-null   float64
 4   feature_5    9000 non-null   float64
 5   feature_6    9000 non-null   float64
 6   feature_7    9000 non-null   float64
 7   feature_8    9000 non-null   float64
 8   feature_9    9000 non-null   float64
 9   feature_10   9000 non-null   float64
 10  feature_11   9000 non-null   float64
 11  feature_12   9000 non-null   object
 12  feature_13   9000 non-null   float64
 13  feature_14   9000 non-null   float64
 14  feature_15   9000 non-null   float64
 15  feature_16   9000 non-null   float64
 16  feature_17   9000 non-null   float64
 17  feature_18   9000 non-null   float64
 18  feature_19   9000 non-null   float64
 19  feature_20   9000 non-null   float64
 20  int_target   9000 non-null   int64
dtypes: float64(19), int64(1), object(1)
memory usage: 1.4+ MB
```

[6]:
```
dataset.describe()
```

[6]:
```
         feature_1    feature_2    feature_3    feature_4    feature_5  \
count  9000.000000  9000.000000  9000.000000  9000.000000  9000.000000
mean      9.892699     0.051539    13.691801    -5.280291    -0.190470
std      16.005016     0.708241    77.058634    26.814772     0.966878
min     -55.674815    -1.000000     0.002306   -90.266818    -1.000000
25%      -0.590266    -0.652740     0.891789   -24.131903    -1.000000
50%      10.032527     0.108589     2.771781    -6.535842    -0.999996
75%      20.577624     0.750147     8.313018    12.151035     1.000000
max      71.408515     1.000000  4195.458665    96.967006     1.000000

         feature_6    feature_7    feature_8    feature_9   feature_10  \
count  9000.000000  9000.000000  9000.000000  9000.000000  9000.000000
mean     33.328407   353.997548     0.322612   -69.936887    -0.334325
std     193.282240   482.976481     1.928390   130.805512     1.802465
min    -782.730110     0.000032    -8.785694  -562.750841    -6.678488
25%     -88.607265    38.261808    -0.867972  -155.988559    -1.569338
50%      47.154805   169.202144     0.454511   -80.249681    -0.374527
75%     165.882796   476.800547     1.636826    10.046369     0.874218
```

```
max     689.183091  5099.175987     7.563691   454.622574     6.605742

        feature_11   feature_13   feature_14   feature_15   feature_16  \
count  9000.000000  9000.000000  9000.000000  9000.000000  9000.000000
mean      0.328602    99.738087    99.862703    99.764452    99.958384
std       1.949699    19.970516    20.059934    19.816391    20.073887
min      -6.817115    23.296434    21.404151    20.462943    31.695377
25%      -0.997933    86.416262    86.377084    86.184816    86.146061
50%       0.361400    99.753333    99.914720    99.938163    99.956294
75%       1.690059   113.192601   113.550065   113.274773   113.503300
max       7.314190   169.972815   169.211534   176.896232   180.756967

        feature_17   feature_18   feature_19   feature_20    int_target
count  9000.000000  9000.000000  9000.000000  9000.000000   9000.000000
mean    100.053203   100.209235   100.150711    99.819907  14962.016000
std      20.005191    19.839667    20.084744    20.072153   8507.039575
min      25.278459     6.108243    29.523073    28.591199    501.000000
25%      86.513425    86.753705    86.684625    86.163540   7461.750000
50%      99.644334   100.166669   100.179503    99.942090  14878.500000
75%     113.486201   113.389489   113.657307   113.275163  22404.000000
max     182.022092   173.917343   171.521586   178.220128  29631.000000
```

3. Dividing the dataset into target and features as well as into train and test datasets

[6]:
```python
x = dataset.drop(columns=['int_target'])
y = dataset['int_target']
```

[7]:
```python
x_tr,x_t,y_tr,y_t = train_test_split(x,y,test_size=0.3,random_state=42)
```

[39]:
```python
x_tr.head()
```

[39]:
```
      feature_1  feature_2   feature_3  feature_4  feature_5   feature_6  \
7581  -6.077065   0.274977    4.922146 -13.633130   -1.00000  137.750101
8484  13.478385  -0.142569   29.020381  -2.015988   -0.96514 -277.913183
6215  11.137173   0.944967    2.699315 -19.220130   -1.00000  257.743532
6884  27.832998   0.553589    2.006801 -49.907437   -1.00000   18.190559
3647   6.607199   0.312878  561.074357  12.063850    1.00000 -113.262260

       feature_7  feature_8   feature_9  feature_10  feature_11 feature_12  \
7581   36.930724   0.834688  -89.663914   -0.407471   -0.595614          D
8484  181.666863  -0.022423 -182.948151   -2.506720   -3.411167          B
6215  124.036614   1.277240  -86.642872   -0.461344   -0.794835          A
6884  774.675784   0.444103 -156.934461   -1.045558    1.035041          C
3647   43.655079  -1.820279 -202.625263   -3.991031   -1.689960          C

      feature_13  feature_14  feature_15  feature_16  feature_17  feature_18  \
7581   74.966634  108.817839  121.177814  128.620874   77.857225   95.340076
8484   95.358574  139.468850  110.479326  113.688174  108.933680   70.552332
```

```
6215   89.014381  125.106467   93.888226  109.688439  105.704562   90.203266
6884  149.900687  113.287872  100.622504   99.947717   81.521003  118.928950
3647   75.481512  101.213242   92.613375  105.406862  106.978952  111.314922

      feature_19  feature_20
7581   99.516410  106.408905
8484  102.334319  113.123080
6215  109.077749  106.867140
6884  121.942998   98.779535
3647   89.233944  105.230220
```

4. There is one categorical feature in the dataset that has a string format. It will be changed to a numeric format.

[12]:
```python
dataset['feature_12'].value_counts()
```

[12]:
```
feature_12
B    2288
C    2265
D    2230
A    2217
Name: count, dtype: int64
```

[8]:
```python
from sklearn.preprocessing import OneHotEncoder as OHE
ohe = OHE(drop='first', handle_unknown='ignore')
```

[9]:
```python
etr_12 = ohe.fit_transform(x_tr[['feature_12']]).toarray()
```

[10]:
```python
et_12 = ohe.transform(x_t[['feature_12']]).toarray()
```

[11]:
```python
etr_12 = pd.DataFrame(data = etr_12, columns=ohe.categories_[0][1:])
et_12 = pd.DataFrame(data = et_12, columns=ohe.categories_[0][1:])
etr_12.index = x_tr.index
et_12.index = x_t.index
```

[13]:
```python
print(etr_12.head())
print(et_12.head())
```

```
        B    C    D
7581  0.0  0.0  1.0
8484  1.0  0.0  0.0
6215  0.0  0.0  0.0
6884  0.0  1.0  0.0
3647  0.0  1.0  0.0
        B    C    D
7940  0.0  0.0  0.0
1162  0.0  1.0  0.0
582   1.0  0.0  0.0
```

```
4081  0.0  1.0  0.0
8412  0.0  0.0  1.0
```

[12]:

```python
x_tr = pd.concat([x_tr,etr_12],axis=1)
x_tr.drop(columns=['feature_12'],inplace=True)
x_t = pd.concat([x_t,et_12],axis=1)
x_t.drop(columns=['feature_12'],inplace=True)
print(x_tr.head())
print(x_t.head())
```

```
      feature_1  feature_2   feature_3  feature_4  feature_5   feature_6  \
7581  -6.077065   0.274977    4.922146 -13.633130   -1.00000  137.750101
8484  13.478385  -0.142569   29.020381  -2.015988   -0.96514 -277.913183
6215  11.137173   0.944967    2.699315 -19.220130   -1.00000  257.743532
6884  27.832998   0.553589    2.006801 -49.907437   -1.00000   18.190559
3647   6.607199   0.312878  561.074357  12.063850    1.00000 -113.262260

       feature_7  feature_8   feature_9  feature_10  …  feature_14  \
7581   36.930724   0.834688  -89.663914   -0.407471  …  108.817839
8484  181.666863  -0.022423 -182.948151   -2.506720  …  139.468850
6215  124.036614   1.277240  -86.642872   -0.461344  …  125.106467
6884  774.675784   0.444103 -156.934461   -1.045558  …  113.287872
3647   43.655079  -1.820279 -202.625263   -3.991031  …  101.213242

      feature_15  feature_16  feature_17  feature_18  feature_19  feature_20  \
7581  121.177814  128.620874   77.857225   95.340076   99.516410  106.408905
8484  110.479326  113.688174  108.933680   70.552332  102.334319  113.123080
6215   93.888226  109.688439  105.704562   90.203266  109.077749  106.867140
6884  100.622504   99.947717   81.521003  118.928950  121.942998   98.779535
3647   92.613375  105.406862  106.978952  111.314922   89.233944  105.230220

        B    C    D
7581  0.0  0.0  1.0
8484  1.0  0.0  0.0
6215  0.0  0.0  0.0
6884  0.0  1.0  0.0
3647  0.0  1.0  0.0

[5 rows x 22 columns]
      feature_1  feature_2  feature_3  feature_4  feature_5   feature_6  \
7940  21.788966   0.998660   4.177820  83.667049   1.000000 -113.342663
1162  10.043187   0.296065  32.259720  -5.346814  -0.999955  287.185218
582    8.701901   0.636416   7.775502 -20.108899  -1.000000   78.748458
4081   6.182070   0.808258  62.072918  31.335802   1.000000  -59.601221
8412  19.381290  -0.393950   3.424870 -18.088676  -1.000000  475.163917

       feature_7  feature_8   feature_9  feature_10  …  feature_14  \
7940  474.759022   0.249128  129.199477   -5.012149  …  129.395518
```

```
1162  100.865600  -1.152400    2.173456    1.658315  …   60.563411
582    75.723079   0.740615  -62.850303   -0.454813  …  112.716310
4081   38.217993  -0.306800 -277.342478   -3.114036  …  122.854305
8412  375.634383  -1.346684   21.556730   -0.329047  …   99.175725

      feature_15  feature_16  feature_17  feature_18  feature_19  feature_20  \
7940   81.421299  117.976466  107.740527  100.519500  140.581802  118.778455
1162  133.962758   86.688118   91.062096  107.407778   99.737611   99.890741
582   129.104165   79.461983  129.088292  115.548850   91.866696  102.281620
4081  117.988280   81.842686  106.777292   95.309154   78.172080   76.360709
8412   76.437763   75.404877   77.515263  121.018053  132.856019   98.929321

        B    C    D
7940  0.0  0.0  0.0
1162  0.0  1.0  0.0
582   1.0  0.0  0.0
4081  0.0  1.0  0.0
8412  0.0  0.0  1.0

[5 rows x 22 columns]
```

5. The scales of the features differ a lot. One general scaling will be utilized for the features.

[13]:
```
#Considering the data distribution and exisinence of negatve values and␣
↪outliers, StandardScaler was chosen in this case
scaler = StandardScaler()
x_tr_scaled = scaler.fit_transform(x_tr)
x_t_scaled = scaler.transform(x_t)
```

[14]:
```
x_tr_scaled = pd.DataFrame(x_tr_scaled,columns=x_tr.columns)
x_t_scaled = pd.DataFrame(x_t_scaled,columns=x_t.columns)
```

[15]:
```
x_tr_scaled.index = x_tr.index
x_t_scaled.index = x_t.index
```

6. Creating a linear regression model and its assessment using RMSE and other statistical measures.

[16]:
```
linreg = LinearRegression()
linreg.fit(x_tr_scaled,y_tr)
```

[16]:
```
LinearRegression()
```

[17]:
```
y_pred = linreg.predict(x_t_scaled)
MSE(y_t,y_pred)**(1/2)
```

[17]:
```
6800.840397189446
```

[18]:
```
ols = OLS(y_tr,x_tr_scaled)
```

[19]:
```
results = ols.fit()
```

[20]:
```
results.summary()
```

[20]:

Dep. Variable:	int_target	**R-squared (uncentered):**	0.094
Model:	OLS	**Adj. R-squared (uncentered):**	0.091
Method:	Least Squares	**F-statistic:**	29.74
Date:	Sun, 11 Aug 2024	**Prob (F-statistic):**	1.10e-117
Time:	15:21:18	**Log-Likelihood:**	-70031.
No. Observations:	6300	**AIC:**	1.401e+05
Df Residuals:	6278	**BIC:**	1.403e+05
Df Model:	22		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
feature_1	-1174.6468	284.486	-4.129	0.000	-1732.337	-616.956
feature_2	865.3265	207.325	4.174	0.000	458.899	1271.754
feature_3	233.2799	220.647	1.057	0.290	-199.264	665.824
feature_4	-2943.8266	428.817	-6.865	0.000	-3784.454	-2103.199
feature_5	-727.0198	355.453	-2.045	0.041	-1423.828	-30.211
feature_6	-150.5213	302.613	-0.497	0.619	-743.747	442.704
feature_7	-381.3816	268.574	-1.420	0.156	-907.879	145.116
feature_8	-183.7838	295.204	-0.623	0.534	-762.485	394.917
feature_9	2907.6143	369.462	7.870	0.000	2183.343	3631.886
feature_10	255.8017	268.206	0.954	0.340	-269.973	781.577
feature_11	2196.6574	261.298	8.407	0.000	1684.424	2708.890
feature_13	73.9060	205.587	0.359	0.719	-329.115	476.927
feature_14	58.4509	205.508	0.284	0.776	-344.415	461.317
feature_15	-33.0601	205.730	-0.161	0.872	-436.361	370.241
feature_16	42.7527	205.798	0.208	0.835	-360.681	446.186
feature_17	69.7367	205.531	0.339	0.734	-333.174	472.648
feature_18	137.6595	205.569	0.670	0.503	-265.326	540.645
feature_19	7.3568	205.544	0.036	0.971	-395.580	410.294
feature_20	131.7587	205.877	0.640	0.522	-271.830	535.348
B	107.4957	253.574	0.424	0.672	-389.596	604.588
C	28.0881	252.900	0.111	0.912	-467.683	523.859
D	35.1902	253.501	0.139	0.890	-461.759	532.139

Omnibus:	60.221	**Durbin-Watson:**	0.347
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	62.620
Skew:	0.225	**Prob(JB):**	2.52e-14
Kurtosis:	3.189	**Cond. No.**	5.08

Notes:
[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.

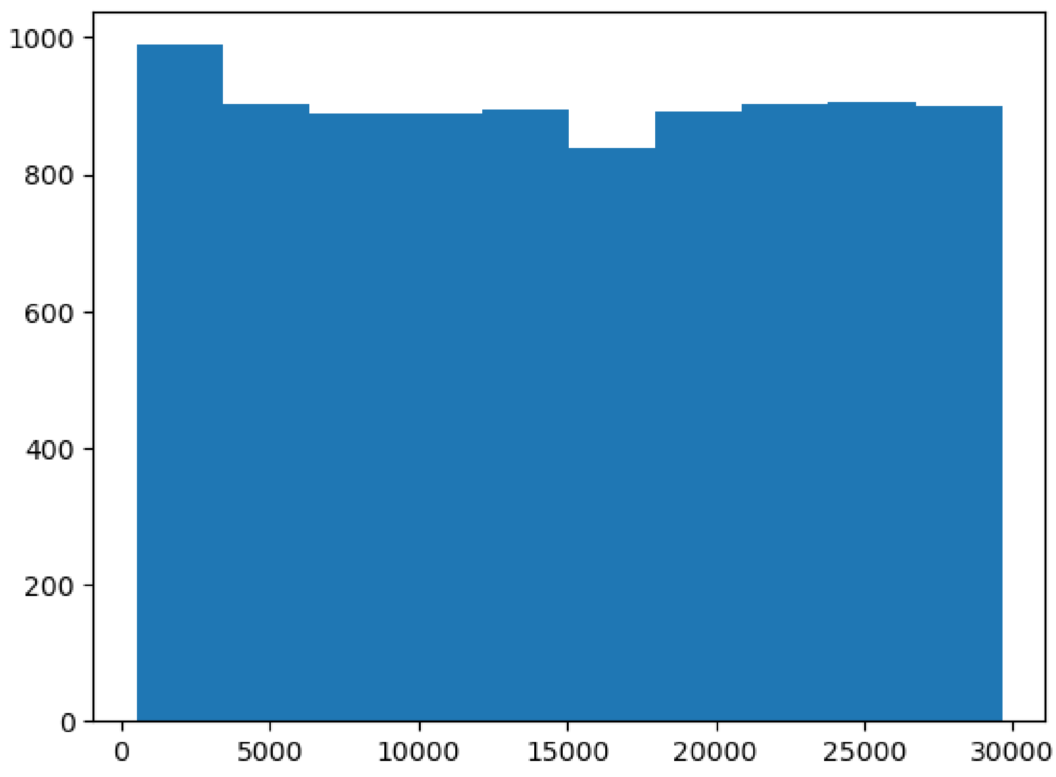
Update of the Task The fictional stakeholder saw the results and thought the RMSE measure was too large: almost half the range of the target variable. The linear regression model might not be of good fit for this task. The target variable could be divided into classes. That is to say we will not consider the absolute sums of transaction, but will look at which class the customer belongs to instead (high revenue, medium revenue, or low revenue). The stakeholder asked to show them how the division is going to be done.

7. Looking at the distribution of the target variable to divide the target into classes.

[60]:
```
y.describe()
```

[60]:
```
count     9000.000000
mean     14962.016000
std       8507.039575
min        501.000000
25%       7461.750000
50%      14878.500000
75%      22404.000000
max      29631.000000
Name: int_target, dtype: float64
```

[21]:
```
plt.hist(dataset.int_target);
```



8. The distribution seems to be uniform: the target variable could be divided into three equal classes. For that respective percentiles have to be calculated (33% and 67%).

[23]:
```
y_33 = np.quantile(y,0.33)
y_67 = np.quantile(y,0.67)
print(y_33,y_67)
```

```
9871.67 20120.66
```

9. The stakeholder agreed to divide the target variable into classes using these percentiles, but they suggested to round the number. That way the division into classes in the target variable will use the following thresholds: 10000 and below will mean the low revenue class, 20000 and above will mean the high revenue class, and everything else will be the medium revenue class.

[23]:
```
# Low revenue class
class_0 = [0 for i in y if i <= 10000]
class_0 = pd.Series(class_0)
class_0.index = y[y<=10000].index
```

[24]:
```
# Medium revenue class
class_1 = [1 for i in y if (i > 10000 and i < 20000)]
class_1 = pd.Series(class_1)
class_1.index = y[y[10000 < y] & y[20000 > y]].index
```

```
C:\Users\azima\AppData\Local\Temp\ipykernel_1360\2887226351.py:4: FutureWarning:
Operation between non boolean Series with different indexes will no longer
return a boolean result in a future version. Cast both Series to object type to
maintain the prior behavior.
  class_1.index = y[y[10000 < y] & y[20000 > y]].index
```

[26]:
```
# High revenue class
class_2 = [2 for i in y if i >= 20000]
class_2 = pd.Series(class_2)
class_2.index = y[y>=20000].index
```

[27]:
```
y_class = pd.concat([class_0,class_1,class_2]).sort_index()
```

[28]:
```
y_class.head()
```

[28]:
```
0    1
1    0
2    1
3    2
4    0
dtype: int64
```

10. Next steps will involve creating a logistic regression model. This model will serve as the baseline and a filter for the features. The created model will have the Lasso regularization with the regularization coefficient of 0.01. The model's performance will be measured using the accuracy metric.

[29]:
```
logreg = LogisticRegression(penalty='l1',C=0.01, solver='liblinear')
```

[30]:
```
y_class_tr = pd.Series([y_class[i] for i in y_tr.index],index=y_tr.index)
y_class_t = pd.Series([y_class[i] for i in y_t.index],index=y_t.index)
```

[31]:
```
y_class_tr.head()
```

[31]:
```
7581    1
8484    0
6215    1
6884    1
3647    0
dtype: int64
```

[32]:
```
y_tr
```

[32]:
```
7581    12868
8484     1895
6215    11398
6884    13635
3647     3505
        …
5734    22641
5191    24348
5390    10498
860     19158
7270    16376
Name: int_target, Length: 6300, dtype: int64
```

[33]:
```
logreg.fit(x_tr_scaled,y_class_tr)
y_class_pred = logreg.predict(x_t_scaled)
accuracy_score(y_class_t,y_class_pred)
```

[33]:
```
0.7355555555555555
```

11. Looking at the resulting feature coefficients of the model

[34]:
```
logreg.coef_, logreg.intercept_
```

[34]:
```
(array([[ 0.3796715 , -0.1871515 ,  0.        ,  1.07461921,  0.08020088,
         -0.22876785,  0.        , -0.01357207, -0.49872147,  0.01267205,
         -0.73448159,  0.        ,  0.        ,  0.        ,  0.        ,
          0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
          0.        ,  0.        ],
        [-0.23148403,  0.        ,  0.        , -0.84576659,  0.        ,
          0.3754246 ,  0.        ,  0.76255836,  0.        , -0.74824977,
          0.48124861,  0.        ,  0.        ,  0.        ,  0.        ,
          0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
```

```
         0.        ,  0.        ],
       [ 0.        ,  0.12522877,  0.        , -0.00989079, -0.17520227,
         0.        , -0.15513951, -0.64849311,  0.37998327,  0.67332255,
         0.09582758,  0.        ,  0.        ,  0.        ,  0.        ,
         0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
         0.        ,  0.        ]]),
 array([-0.85347889, -0.84132347, -0.7702121 ]))
```

12. The features that have coefficients of zero for all the classes should not be as useful. Only the non-zero coefficients will be chosen for future analysis with a new dataset created.

[35]:
```
coef_dict = {logreg.feature_names_in_[i]: 'y' for i in range(len(logreg.
↪feature_names_in_)) if (logreg.coef_[0][i] != 0
            or logreg.coef_[1][i] != 0 or logreg.coef_[2][i] != 0)}
coef_dict
```

[35]:
```
{'feature_1': 'y',
 'feature_2': 'y',
 'feature_4': 'y',
 'feature_5': 'y',
 'feature_6': 'y',
 'feature_7': 'y',
 'feature_8': 'y',
 'feature_9': 'y',
 'feature_10': 'y',
 'feature_11': 'y'}
```

[36]:
```
list(coef_dict)
```

[36]:
```
['feature_1',
 'feature_2',
 'feature_4',
 'feature_5',
 'feature_6',
 'feature_7',
 'feature_8',
 'feature_9',
 'feature_10',
 'feature_11']
```

[37]:
```
x_tr_scaled = x_tr_scaled[list(coef_dict)]
x_t_scaled = x_t_scaled[list(coef_dict)]
x_tr_scaled.head()
```

[37]:
```
      feature_1  feature_2  feature_4  feature_5  feature_6  feature_7  \
7581  -0.991374   0.322929  -0.317627  -0.837569   0.536843  -0.654027
8484   0.222688  -0.265324   0.114265  -0.801533  -1.603270  -0.358543
6215   0.077338   1.266835  -0.525335  -0.837569   1.154649  -0.476197
```

```
6884   1.113866   0.715448  -1.666202  -0.837569  -0.078730   0.852107
3647  -0.203896   0.376326   0.637714   1.229929  -0.755537  -0.640299

      feature_8  feature_9  feature_10  feature_11
7581   0.253938  -0.149507   -0.036008   -0.464830
8484  -0.190346  -0.862272   -1.197150   -1.903308
6215   0.483335  -0.126424   -0.065806   -0.566612
6884   0.051478  -0.663507   -0.388948    0.368279
3647  -1.122266  -1.012620   -2.018156   -1.023936
```

13. Looking at the predictive ability of the remaining features. In order to dot that principal component analysis will be utilised with visualizing the components on a graph against the target.

[42]:
```
# Taking all of the features to assess how much of variance is influenced by␣
↪each feature.
pca = PCA(n_components = len(coef_dict))
```

[39]:
```
data_pca = pca.fit_transform(x_tr_scaled)
data_pca.shape
```

[39]:
```
(6300, 10)
```

[40]:
```
pca.explained_variance_ratio_
```

[40]:
```
array([0.28700352, 0.17523067, 0.12405576, 0.10048613, 0.09608016,
       0.08450172, 0.06252189, 0.0355892 , 0.02251423, 0.01201671])
```

[43]:
```
# The first two features could be left as the most influential ones, but the␣
↪first three components will also be checked
pca_new = PCA(n_components=2)
data_new = pca_new.fit_transform(x_tr_scaled)
```

[44]:
```
data_new
```

[44]:
```
array([[-0.00776042, -0.52236894],
       [-1.28566659,  1.35763105],
       [ 0.6210337 , -0.2135601 ],
       …,
       [-1.79237927,  1.23449541],
       [ 1.5703436 , -0.2720664 ],
       [ 0.35846336, -1.79997616]])
```

[45]:
```
pca_new.explained_variance_ratio_
```

[45]:
```
array([0.28700352, 0.17523067])
```

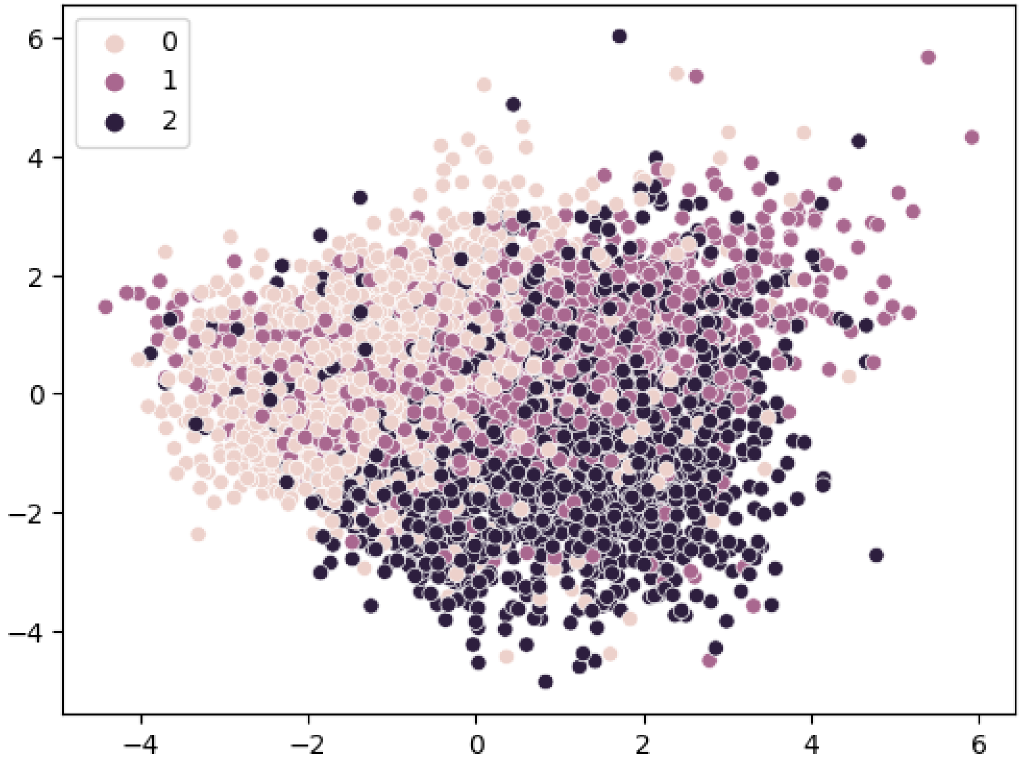
[46]:
```
data_new
```

[46]: array([[-0.00776042, -0.52236894],
       [-1.28566659, 1.35763105],
       [0.6210337 , -0.2135601],
       …,
       [-1.79237927, 1.23449541],
       [1.5703436 , -0.2720664],
       [0.35846336, -1.79997616]])

[47]:
```
data_new[:,0]
```

[47]: array([-0.00776042, -1.28566659, 0.6210337 , …, -1.79237927,
        1.5703436 , 0.35846336])

[49]:
```
sns.scatterplot(x=data_new[:,0],y=data_new[:,1],hue=y_class_tr);
```



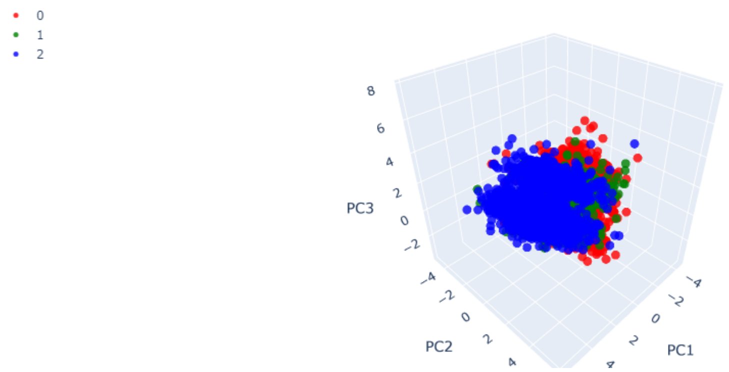
[50]:
```
# Additional PCA visualization with the first three components
pca_newer = PCA(n_components=3)
data_newer = pca_newer.fit_transform(x_tr_scaled)
```

[51]:
```
trace_pca0 = go.Scatter3d(
    x = data_newer[y_class_tr==0,0],
    y = data_newer[y_class_tr==0,1],
```

```python
    z = data_newer[y_class_tr==0,2],
    mode='markers',
    marker = dict(
        size = 5,
        color = 'red',
        opacity = 0.8
    ),
    name='0'
)
trace_pca1 = go.Scatter3d(
    x = data_newer[y_class_tr==1,0],
    y = data_newer[y_class_tr==1,1],
    z = data_newer[y_class_tr==1,2],
    mode='markers',
    marker = dict(
        size = 5,
        color = 'green',
        opacity = 0.8
    ),
    name='1'
)
trace_pca2 = go.Scatter3d(
    x = data_newer[y_class_tr==2,0],
    y = data_newer[y_class_tr==2,1],
    z = data_newer[y_class_tr==2,2],
    mode='markers',
    marker = dict(
        size = 5,
        color = 'blue',
        opacity = 0.8
    ),
    name='2'
)
```

[52]:
```python
layout = go.Layout(
    scene = dict(
        xaxis = dict(title='PC1'),
        yaxis = dict(title='PC2'),
        zaxis = dict(title='PC3'),
    ),
    margin = dict(l=0,r=0,b=0,t=0),
    legend=dict(x=0,y=1)
)
```

[53]:
```python
fig = go.Figure(data=[trace_pca0,trace_pca1,trace_pca2], layout=layout)
fig.show()
```



[54]:
```
y_class_tr
```

[54]:
```
7581    1
8484    0
6215    1
6884    1
3647    0
        ..
5734    2
5191    2
5390    1
860     1
7270    1
Length: 6300, dtype: int64
```

[55]:
```
# Preparing data for further analysis
data_new = pd.DataFrame(data_new,columns=['new1','new2'])
data_new
```

[55]:

	new1	new2
0	-0.007760	-0.522369
1	-1.285667	1.357631
2	0.621034	-0.213560
3	1.625722	1.655920
4	-2.012947	0.609353
…	…	…
6295	-0.444403	-2.869545
6296	1.763569	-0.188656
6297	-1.792379	1.234495
6298	1.570344	-0.272066
6299	0.358463	-1.799976

[6300 rows x 2 columns]

[56]:
```
data_new.index = x_tr_scaled.index
```

[57]:
```
data_newer = pd.DataFrame(data_newer,columns=['newer1','newer2','newer_3'])
data_newer.tail(5)
```

[57]:

	newer1	newer2	newer_3
6295	-0.444403	-2.869545	1.014904
6296	1.763569	-0.188656	-0.132870
6297	-1.792379	1.234495	-2.255040
6298	1.570344	-0.272066	-0.126920
6299	0.358463	-1.799976	-0.661736

[58]:
```
data_newer.index = x_tr_scaled.index
```

14. Now that the main feature are chosen, a more complex model could be built. For that models based on trees will be utilised. The models will be assessed based on the accuracy metric.

[59]:
```
# Trying two types of models with trees
tree_new = DecisionTreeClassifier(random_state = 42)
forest_new = RandomForestClassifier(random_state=42)
```

[60]:
```
params_tree = {'max_depth': np.arange(3,7),
               'max_features': [1,2,3,4]}
search_tree =␣
 ↪GridSearchCV(estimator=tree_new,param_grid=params_tree,scoring='accuracy',cv=3)
```

[61]:
```
# Looking at the initial dataset (prior to the PCA)
search_tree.fit(x_tr_scaled,y_class_tr)
```

[61]:
```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(random_state=42),
             param_grid={'max_depth': array([3, 4, 5, 6]),
                         'max_features': [1, 2, 3, 4]},
             scoring='accuracy')
```

[62]:
```
y_class_pred = search_tree.predict(x_t_scaled)
accuracy_score(y_class_t,y_class_pred)
```

[62]: 0.7307407407407407

[63]:
```
# Now trying the data after the PCA
search_tree.fit(data_new,y_class_tr)
```

[63]:
```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(random_state=42),
             param_grid={'max_depth': array([3, 4, 5, 6]),
                         'max_features': [1, 2, 3, 4]},
             scoring='accuracy')
```

[64]:
```
data_new_t = pca_new.transform(x_t_scaled)
data_new_t = pd.DataFrame(data_new_t,columns=['new1','new2'])
data_new_t.index = x_t_scaled.index
```

[65]:
```
y_class_pred = search_tree.predict(data_new_t)
accuracy_score(y_class_t,y_class_pred)
```

[65]:
```
0.6170370370370370
```

[66]:
```
search_tree.fit(data_newer,y_class_tr)
data_newer_t = pca_newer.transform(x_t_scaled)
data_newer_t = pd.DataFrame(data_newer_t,columns=['newer1','newer2','newer_3'])
data_newer_t.index = x_t_scaled.index
y_class_pred = search_tree.predict(data_newer_t)
accuracy_score(y_class_t,y_class_pred)
```

[66]:
```
0.6381481481481481
```

Obvously, the model with a greater number of features gave the higher accuracy of the predictions since the majority of the features have comparable predictive abilities and taking away a large part of the features is not correct. Consecutively, the data that will be used further is the data prior to the PCA so that the results are more accurate.

[67]:
```
params_forest = {'n_estimators' : [100,200],
                'max_depth': np.arange(3,7),
                'max_features': [1,2,3,4]}
search_forest =␣
 ↪GridSearchCV(estimator=forest_new,param_grid=params_forest,scoring='accuracy',cv=3)
```

[68]:
```
search_forest.fit(x_tr_scaled,y_class_tr)
```

[68]:
```
GridSearchCV(cv=3, estimator=RandomForestClassifier(random_state=42),
             param_grid={'max_depth': array([3, 4, 5, 6]),
                         'max_features': [1, 2, 3, 4],
                         'n_estimators': [100, 200]},
             scoring='accuracy')
```

[69]:
```
y_class_pred = search_forest.predict(x_t_scaled)
accuracy_score(y_class_t,y_class_pred)
```

[69]:
```
0.7685185185185185
```

15. Trying using other types of model. This time it will be a SVM model and its accuracy will be evaluated.

[70]:
```
svc = SVC(kernel='poly',probability=True)
```

[71]:
```
params_svc = {'degree': range(2,7), 'C': [0.1,1,10]}
```

```
svc_search =␣
↪GridSearchCV(estimator=svc,param_grid=params_svc,scoring='accuracy',cv=3)
```

[72]:
```
svc_search.fit(x_tr_scaled,y_class_tr)
```

[72]:
```
GridSearchCV(cv=3, estimator=SVC(kernel='poly', probability=True),
             param_grid={'C': [0.1, 1, 10], 'degree': range(2, 7)},
             scoring='accuracy')
```

[73]:
```
y_class_pred = svc_search.predict(x_t_scaled)
accuracy_score(y_class_t,y_class_pred)
```

[73]:
```
0.81
```

16. Trying using other types of model. This time it will be a KNN model and its accuracy will be evaluated.

[74]:
```
knn = KNeighborsClassifier()
params = {'n_neighbors':range(2,21)}
knn_search = GridSearchCV(estimator=knn, param_grid=params, scoring='accuracy',␣
↪cv=3)
knn_search.fit(x_tr_scaled,y_class_tr)
```

[74]:
```
GridSearchCV(cv=3, estimator=KNeighborsClassifier(),
             param_grid={'n_neighbors': range(2, 21)}, scoring='accuracy')
```

[75]:
```
y_class_pred = knn_search.predict(x_t_scaled)
accuracy_score(y_class_t,y_class_pred)
```

[75]:
```
0.8107407407407408
```

17. The last two model have showed good results in terms of accurace, but the random forest model has also showed a decent score. Next, boosting could be used where appropriate.

[76]:
```
ada_boost0 = AdaBoostClassifier(n_estimators=100,learning_rate=0.
↪1,random_state=42)
ada_boost0.fit(x_tr_scaled,y_class_tr)
y_pred = ada_boost0.predict(x_t_scaled)
accuracy_score(y_class_t,y_pred)
```

[76]:
```
0.7025925925925925
```

[77]:
```
ada_boost = AdaBoostClassifier(estimator=search_forest.
↪best_estimator_,n_estimators=100,learning_rate=0.1,random_state=42)
```

[78]:
```
ada_boost.fit(x_tr_scaled,y_class_tr)
```

[78]:
```
AdaBoostClassifier(estimator=RandomForestClassifier(max_depth=6, max_features=4,
                                                    n_estimators=200,
```

```
                                                  random_state=42),
                                  learning_rate=0.1, n_estimators=100, random_state=42)
```

[79]:
```
y_pred = ada_boost.predict(x_t_scaled)
accuracy_score(y_class_t,y_pred)
```

[79]: 0.8225925925925925

[80]:
```
gbc = GradientBoostingClassifier(init=search_forest.
 ↪best_estimator_,n_estimators=100,learning_rate=0.
 ↪1,max_depth=5,random_state=42)
gbc.fit(x_tr_scaled, y_class_tr)
prediction = gbc.predict(x_t_scaled)
accuracy_score(y_class_t,prediction)
```

[80]: 0.8125925925925926

[81]:
```
gbc2 = GradientBoostingClassifier(init=knn_search.
 ↪best_estimator_,n_estimators=100,learning_rate=0.
 ↪1,max_depth=5,random_state=42)
gbc2.fit(x_tr_scaled, y_class_tr)
prediction = gbc2.predict(x_t_scaled)
accuracy_score(y_class_t,prediction)
```

[81]: 0.8103703703703704

[82]:
```
gbc3 = GradientBoostingClassifier(init=svc_search.
 ↪best_estimator_,n_estimators=100,learning_rate=0.
 ↪1,max_depth=5,random_state=42)
gbc3.fit(x_tr_scaled, y_class_tr)
prediction = gbc3.predict(x_t_scaled)
accuracy_score(y_class_t,prediction)
```

[82]: 0.812962962962963

[83]:
```
gbc4 = GradientBoostingClassifier(n_estimators=100,learning_rate=0.
 ↪1,max_depth=5,random_state=42)
gbc4.fit(x_tr_scaled, y_class_tr)
prediction = gbc4.predict(x_t_scaled)
accuracy_score(y_class_t,prediction)
```

[83]: 0.8137037037037037

[84]:
```
xgb = xgb.XGBClassifier(n_estimators=100,learning_rate=0.
 ↪1,max_depth=5,reg_lambda=1,random_state=42)
xgb.fit(x_tr_scaled, y_class_tr)
prediction = xgb.predict(x_t_scaled)
accuracy_score(y_class_t,prediction)
```

[84]: 0.8107407407407408

[85]:
```
lgbm = LGBMClassifier(n_estimators=200,learning_rate=0.
↪01,reg_lambda=1,max_depth=5,random_state=42)
lgbm.fit(x_tr_scaled, y_class_tr)
prediction = lgbm.predict(x_t_scaled)
```

```
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of
testing was 0.001217 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 2549
[LightGBM] [Info] Number of data points in the train set: 6300, number of used
features: 10
[LightGBM] [Info] Start training from score -1.076944
[LightGBM] [Info] Start training from score -1.105781
[LightGBM] [Info] Start training from score -1.113484
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
```

```
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
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num_leaves OR 2^max_depth > num_leaves. (num_leaves=31).
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[86]:
```
accuracy_score(y_class_t,prediction)
```

```
[86]: 0.7907407407407407
```

Conclusion As can be seen the best model overall was one of the AdaBoost models that used a random forest as one of its arguments. Achieved accuracy is slightly above 82%.