classification_project_stats_202

August 12, 2020

[2]:
```
# -*- coding: utf-8 -*-
"""
Created on Mon Aug  3 19:03:01 2020
@author: youss
"""
import os
from typing import Text, Tuple

import matplotlib
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from pandas.plotting import scatter_matrix
import seaborn as sns
import xgboost as xgb
from sklearn.ensemble import GradientBoostingRegressor as gbm
from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import LabelEncoder
from scipy import cluster
from sklearn import preprocessing
from sklearn.cluster import KMeans
from mpl_toolkits.mplot3d import Axes3D
from numpy.random import random
import umap
from sklearn.datasets import load_digits
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LinearRegression
from statsmodels.formula.api import ols
from sklearn.preprocessing import PolynomialFeatures
import statsmodels.api as sm
import pickle
from sklearn import metrics
from sklearn.feature_selection import SelectFromModel
from sklearn.ensemble import RandomForestRegressor
from sklearn.linear_model import LinearRegression
from xgboost.sklearn import XGBClassifier
```

```
from sklearn.model_selection import GridSearchCV
from sklearn.decomposition import PCA
```

0.1 Create the data set

[48]:
```
study_a = pd.read_csv(r"C:\Users\nlaya\Downloads\Study_A.csv")
study_b = pd.read_csv(r"C:\Users\nlaya\Downloads\Study_B.csv")
study_c = pd.read_csv(r"C:\Users\nlaya\Downloads\Study_C.csv")
study_d = pd.read_csv(r"C:\Users\nlaya\Downloads\Study_D.csv")
study_e = pd.read_csv(r"C:\Users\nlaya\Downloads\Study_E.csv")
```

[49]:
```
# Create one dataframe
study = pd.concat([study_a,study_b],ignore_index=True)
study = pd.concat([study,study_c],ignore_index=True)
study = pd.concat([study,study_d],ignore_index=True)
# study_E  = study_e
study
```

[49]:

	Study	Country	PatientID	SiteID	RaterID	AssessmentID	TxGroup	\
0	A	USA	10001	20035	30076	100679	Control	
1	A	USA	10001	20035	30076	101017	Control	
2	A	USA	10001	20035	30076	102177	Control	
3	A	USA	10001	20035	30076	101533	Control	
4	A	USA	10001	20035	30076	100930	Control	
…	…	…	…	…	…	…	…	
20942	D	China	40223	80001	120013	400496	Treatment	
20943	D	China	40223	80001	120013	402261	Treatment	
20944	D	China	40223	80001	120013	400605	Treatment	
20945	D	China	40223	80001	120013	402460	Treatment	
20946	D	China	40223	80001	120013	401180	Treatment	

	VisitDay	P1	P2	…	G9	G10	G11	G12	G13	G14	G15	G16	\
0	0	5	5	…	5	3	3	4	3	3	3	5	
1	11	5	5	…	5	3	3	4	3	3	3	5	
2	18	4	4	…	4	2	2	3	3	2	3	4	
3	25	3	3	…	3	2	2	3	3	2	3	4	
4	39	3	3	…	3	2	2	3	3	2	3	4	
…	…	..	..	…	..	…	…	…	…	…	…	…	
20942	17	4	3	…	3	1	3	5	2	2	4	4	
20943	21	4	3	…	3	1	2	4	2	2	3	3	
20944	28	4	3	…	2	1	3	4	2	2	3	3	
20945	42	4	3	…	3	1	3	5	2	2	4	3	
20946	70	4	3	…	3	1	2	4	2	2	4	3	

	PANSS_Total	LeadStatus
0	107	Assign to CS
1	109	Assign to CS

```
2                91         Passed
3                80       Flagged
4                77       Flagged
…               …          …
20942            79       Flagged
20943            71       Flagged
20944            74       Flagged
20945            77       Flagged
20946            72       Flagged

[20947 rows x 40 columns]
```

0.2 Principal Components

[50]:
```
from sklearn.preprocessing import StandardScaler
features = ['P1', 'P2', 'P3', 'P4', 'P5', 'P6', 'P7', 'N1',
       'N2', 'N3', 'N4', 'N5', 'N6', 'N7', 'G1', 'G2', 'G3', 'G4', 'G5', 'G6',
       'G7', 'G8', 'G9', 'G10', 'G11', 'G12', 'G13', 'G14', 'G15', 'G16']
# Separating out the features
x = study.loc[:, features].values
# Separating out the target
#y = study.loc[:,['PANSS_Total']].values
# Standardizing the features
x = StandardScaler().fit_transform(x)

# Separating out the features
xe = study_e.loc[:, features].values
# Separating out the target
#y = study.loc[:,['PANSS_Total']].values
# Standardizing the features
xe = StandardScaler().fit_transform(xe)
```

[51]:
```
from sklearn.decomposition import PCA
pca = PCA(n_components=5)
principalComponents = pca.fit_transform(x)
principalDf = pd.DataFrame(data = principalComponents
             , columns = ['pca1', 'pca2','pca3','pca4','pca5'])

principalComponentse = pca.fit_transform(xe)
principalDfe = pd.DataFrame(data = principalComponentse
             , columns = ['pca1', 'pca2','pca3','pca4','pca5'])
```

[52]:
```
pca.explained_variance_ratio_.cumsum()
```

[52]:
```
array([0.20784331, 0.35694347, 0.42097308, 0.47340682, 0.51754096])
```

[53]:
```
study_Df = pd.concat([ study[['Study', 'Country', 'PatientID', 'SiteID',␣
↪'RaterID', 'AssessmentID',
      'TxGroup', 'VisitDay','PANSS_Total','LeadStatus']],principalDf], axis =␣
↪1)

def LeadStatus(x):
    if x=='Passed':
        return 2
    elif x=='Assign to CS':
        return 1
    elif x=='Flagged':
        return 0
study_Df['LeadStatus'] = study_Df['LeadStatus'].apply(lambda x : LeadStatus(x))


study_Df
```

[53]:

	Study	Country	PatientID	SiteID	RaterID	AssessmentID	TxGroup	\
0	A	USA	10001	20035	30076	100679	Control	
1	A	USA	10001	20035	30076	101017	Control	
2	A	USA	10001	20035	30076	102177	Control	
3	A	USA	10001	20035	30076	101533	Control	
4	A	USA	10001	20035	30076	100930	Control	
…	…	…	…	…	…	…	…	
20942	D	China	40223	80001	120013	400496	Treatment	
20943	D	China	40223	80001	120013	402261	Treatment	
20944	D	China	40223	80001	120013	400605	Treatment	
20945	D	China	40223	80001	120013	402460	Treatment	
20946	D	China	40223	80001	120013	401180	Treatment	

	VisitDay	PANSS_Total	LeadStatus	pca1	pca2	pca3	\
0	0	107	1	5.593656	-2.556485	-1.238885	
1	11	109	1	5.872074	-2.650186	-1.436511	
2	18	91	2	3.007536	-0.829132	-2.005766	
3	25	80	0	1.311278	-0.279380	-1.049764	
4	39	77	0	0.939654	-0.248050	-0.481266	
…	…	…	…	…	…	…	
20942	17	79	0	1.340655	1.236202	0.407790	
20943	21	71	0	-0.123395	-0.488950	-0.263306	
20944	28	74	0	0.415094	0.255828	0.256294	
20945	42	77	0	0.934756	0.226870	-0.030299	
20946	70	72	0	0.218207	0.042469	-0.266293	

	pca4	pca5
0	-0.335244	1.250182
1	-0.275018	0.864912
2	-0.072055	0.971408

```
3     -0.373288  1.061580
4     -0.714422  1.188067
…           …        …
20942  0.049303  2.095645
20943  0.065781  1.913234
20944  0.551082  1.694367
20945 -0.301250  1.516739
20946  0.095498  1.632240

[20947 rows x 15 columns]
```

[54]:
```
# study = study[['Study', 'Country', 'PatientID', 'SiteID', 'RaterID',␣
 ↪'AssessmentID',
#         'TxGroup', 'VisitDay','PANSS_Total','LeadStatus']+features]

def LeadStatus(x):
    if x=='Passed':
        return 2
    elif x=='Assign to CS':
        return 1
    elif x=='Flagged':
        return 0
study['LeadStatus'] = study['LeadStatus'].apply(lambda x : LeadStatus(x))


study
```

[54]:
```
      Study Country  PatientID  SiteID  RaterID  AssessmentID    TxGroup  \
0         A     USA      10001   20035    30076        100679    Control
1         A     USA      10001   20035    30076        101017    Control
2         A     USA      10001   20035    30076        102177    Control
3         A     USA      10001   20035    30076        101533    Control
4         A     USA      10001   20035    30076        100930    Control
…     …      …         …      …       …            …         …
20942     D   China      40223   80001   120013        400496  Treatment
20943     D   China      40223   80001   120013        402261  Treatment
20944     D   China      40223   80001   120013        400605  Treatment
20945     D   China      40223   80001   120013        402460  Treatment
20946     D   China      40223   80001   120013        401180  Treatment

       VisitDay  P1  P2  …  G9  G10  G11  G12  G13  G14  G15  G16  \
0             0   5   5  …   5    3    3    4    3    3    3    5
1            11   5   5  …   5    3    3    4    3    3    3    5
2            18   4   4  …   4    2    2    3    3    2    3    4
3            25   3   3  …   3    2    2    3    3    2    3    4
4            39   3   3  …   3    2    2    3    3    2    3    4
…         …   ..  ..  …  ..  …  …  …  …  …  …  …  …
```

```
20942        17   4   3  …   3    1    3    5    2    2    4    4
20943        21   4   3  …   3    1    2    4    2    2    3    3
20944        28   4   3  …   2    1    3    4    2    2    3    3
20945        42   4   3  …   3    1    3    5    2    2    4    3
20946        70   4   3  …   3    1    2    4    2    2    4    3

       PANSS_Total  LeadStatus
0              107           1
1              109           1
2               91           2
3               80           0
4               77           0
…              …          …
20942           79           0
20943           71           0
20944           74           0
20945           77           0
20946           72           0

[20947 rows x 40 columns]
```

[55]:
```
# study_E = pd.concat([ study_e[[ 'PatientID', 'SiteID', 'RaterID',␣
 ↪'AssessmentID'
#       , 'VisitDay','PANSS_Total']],principalDfe], axis = 1)
# study_E
```

[56]:
```
study_E  = study_e
```

[57]:
```
#seed(2020)
study_Df = study_Df.reindex(np.random.permutation(study_Df.index))
study_Df
```

[57]:
```
      Study   Country  PatientID  SiteID  RaterID  AssessmentID    TxGroup  \
3377      B   Romania      20126   40018    60021        200657    Control
8508      C     Spain      30510   60023    90239        309472    Control
7572      C     Japan      30392   60116    90099        300265  Treatment
10363     C     China      30732   60069    90222        303368    Control
20322     D     China      40176   80001   120011        400899  Treatment
…     …       …          …       …        …              …
20493     D     China      40190   80001   120032        400419  Treatment
6784      C    Russia      30291   60166    90296        313189    Control
17843     C  Bulgaria      31602   60038    90386        304547  Treatment
869       A       USA      10125   20023    30059        100311    Control
10911     C     Spain      30799   60141    90413        301543    Control

       VisitDay  PANSS_Total  LeadStatus      pca1      pca2      pca3  \
3377         21           91           2  3.309775  1.235642  2.231818
```

```
8508          7           90           2  2.900577 -0.120510  1.623946
7572        170           69           2 -0.594298 -0.729756 -0.586742
10363        16           83           2  1.767063  1.800581 -0.583859
20322       243           65           0 -1.395919  1.051120 -1.886070
…           …             …            …        …         …         …
20493       135           56           1 -2.377687  1.788844  1.550479
6784         47           75           2  0.567513 -0.220081 -1.309871
17843        49           74           2  0.278796 -1.822136  0.065674
869          67           86           0  2.201911 -3.732572 -0.366923
10911       160           31           1 -6.638775 -1.709931  0.218849

            pca4      pca5
3377  -0.441792  1.040025
8508  -1.836030 -0.345550
7572   0.448929  0.138213
10363 -0.373856  0.805457
20322  1.224372 -0.527444
…           …         …
20493  1.827895 -0.658379
6784   0.413861 -1.883736
17843 -1.469751 -0.762392
869   -1.533930  1.534138
10911  0.631837 -0.309546

[20947 rows x 15 columns]
```

0.3 Split data set to a training and a test sets

[58]:
```
# X_train = study_Df.iloc[0:int(20947*0.9),:]
# X_test = study_Df.iloc[int(20947*0.9):20947,:]

# y_train = X_train['LeadStatus']
# X_train.drop(['LeadStatus'],axis=1)
# y_test = X_test['LeadStatus']
# X_test.drop(['LeadStatus'],axis=1)

X_train = study.iloc[0:int(len(study)*0.9),:]
X_test = study.iloc[int(len(study)*0.9):len(study),:]

y_train = X_train['LeadStatus']
X_train.drop(['LeadStatus'],axis=1)
y_test = X_test['LeadStatus']
X_test.drop(['LeadStatus'],axis=1)
```

[58]:
```
      Study Country  PatientID  SiteID  RaterID  AssessmentID    TxGroup  \
18852     D   China      40062   80001   120042        402382    Control
18853     D   China      40062   80001   120042        400384    Control
```

```
18854     D   China      40062   80001   120042        402193    Control
18855     D   China      40062   80001   120042        400174    Control
18856     D   China      40062   80001   120042        401416    Control
…     …     …        …      …       …           …        …
20942     D   China      40223   80001   120013        400496  Treatment
20943     D   China      40223   80001   120013        402261  Treatment
20944     D   China      40223   80001   120013        400605  Treatment
20945     D   China      40223   80001   120013        402460  Treatment
20946     D   China      40223   80001   120013        401180  Treatment

       VisitDay  P1  P2  …  G8  G9  G10  G11  G12  G13  G14  G15  G16  \
18852        15   3   3  …   3   3    3    3    5    3    1    4    3
18853        22   3   3  …   3   3    3    3    5    3    1    4    3
18854        36   3   3  …   2   3    3    3    5    3    1    4    3
18855        64   1   1  …   1   1    2    1    4    2    1    3    2
18856        78   1   1  …   1   1    2    1    4    2    1    3    2
…         …   ..  ..  …  ..  ..  …  …  …  …  …  …  …  …
20942        17   4   3  …   3   3    1    3    5    2    2    4    4
20943        21   4   3  …   2   3    1    2    4    2    2    3    3
20944        28   4   3  …   3   2    1    3    4    2    2    3    3
20945        42   4   3  …   2   3    1    3    5    2    2    4    3
20946        70   4   3  …   2   3    1    2    4    2    2    4    3

       PANSS_Total
18852           78
18853           78
18854           73
18855           53
18856           53
…              …
20942           79
20943           71
20944           74
20945           77
20946           72

[2095 rows x 39 columns]
```

0.4 Tuning XGBOOST parameters

[59]:
```
X_train = X_train[['VisitDay','PANSS_Total']+features]
X_test = X_test[['VisitDay','PANSS_Total']+features]

np.random.seed(42)
rd = np.random.permutation(len(X_train))
X_train = X_train.iloc[rd]
y_train = y_train.iloc[rd]
```

```
# param_test = {
#   'learning_rate':list(np.logspace(-0.01,-0.3,3)),
#    'reg_lambda':list(np.logspace(-0.01,-0.3,3)),
#    'max_depth': [6],
#    'subsample': [0.8],
#    'gamma': list(np.logspace(-0.1,-0.3,2))
#  }
# gsearch = GridSearchCV(estimator = xgb.XGBClassifier( objective= 'multi:
 ↪softmax', eval_metric = 'mlogloss',
#   min_child_weight=6, gamma=0.1, colsample_bytree=0.8, nthread=4,seed=27),
#   param_grid = param_test, cv=5)
# gsearch.fit(X_train,y_train)
# learning_rate = gsearch.best_params_['learning_rate']
# reg_lambda = gsearch.best_params_['reg_lambda']
# max_depth = gsearch.best_params_['max_depth']
# subsample = gsearch.best_params_['subsample']
# print('learning_rate '+str(learning_rate))
# print('reg_lambda '+str(reg_lambda))
# print('max_depth '+str(max_depth))
# print('subsample '+str(subsample))
# gamma = gsearch.best_params_['gamma']
# print(gamma)
```

[60]:
```
# learning_rate = 0.33334
# reg_alpha = 1e-06
# max_depth  = 4
# subsample  = 0.95

#### best score
# learning_rate =  1e-05
# reg_alpha = 1.0
# max_depth = 4
# subsample  = 0.8

# xgbc2
# learning_rate 0.001
# reg_alpha 0.0001
# max_depth 6
# subsample 0.7
```

[61]:
```
#   learning_rate = 0.01, reg_alpha = 0.05, max_depth = 4, subsample = 0.8,
xgbc4 = xgb.XGBClassifier(objective='multi:softprob', learning_rate = 0.001,␣
 ↪reg_alpha = 0.0001 , eval_metric = 'mlogloss',
                          max_depth = 6, subsample = 0.7, min_child_weight=6,␣
 ↪gamma=0.4, colsample_bytree=0.6, nthread=4,seed=27)
xgbc4.fit(X_train, y_train.values)
```

[61]:
```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.6, eval_metric='mlogloss',
              gamma=0.4, gpu_id=-1, importance_type='gain',
              interaction_constraints='', learning_rate=0.001, max_delta_step=0,
              max_depth=6, min_child_weight=6, missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=4, nthread=4,
              num_parallel_tree=1, objective='multi:softprob', random_state=27,
              reg_alpha=0.0001, reg_lambda=1, scale_pos_weight=None, seed=27,
              subsample=0.7, tree_method='exact', validate_parameters=1,
              verbosity=None)
```

[62]:
```
pred_y_ts = xgbc4.predict(X_test)
pred_y_tr = xgbc4.predict(X_train)
```

[63]:
```
print(" Confusion matrix on the training set:")
print(metrics.confusion_matrix(y_train, pred_y_tr))
```

```
 Confusion matrix on the training set:
[[    1     1  1254]
 [    0    47  1912]
 [    0     0 15637]]
```

[64]:
```
print(metrics.confusion_matrix(y_test, pred_y_ts))
m = metrics.confusion_matrix(y_test, pred_y_ts)
(np.sum(m)-np.sum(np.diag(m)))/np.sum(m)
```

```
[[   0    3 1371]
 [   0   17  500]
 [   0    2  202]]
```

[64]:
```
0.8954653937947494
```

[65]:
```
pred_y_ts_prob = xgbc4.predict_proba(X_test)
pred_y_tr_prob = xgbc4.predict_proba(X_train)
np.sum(xgbc4.predict(X_test)==2)
```

[65]:
```
2073
```

[73]:
```
AssessmentID = study_E['AssessmentID']
study_E = study_E[['VisitDay','PANSS_Total']+features]
```

[74]:
```
pred_y_test_prob = xgbc4.predict_proba(study_E)
np.max(pred_y_test_prob[:,0:2],axis=1)
np.sum(xgbc4.predict(X_test)==0)
```

[74]:
```
0
```

[75]:
```
submission = pd.DataFrame(columns=['AssessmentID','LeadStatus'])
submission['AssessmentID'] = AssessmentID
submission['LeadStatus'] = np.max(pred_y_test_prob[:,0:2],axis=1)
submission.to_csv(r"C:\Users\nlaya\Downloads\submission_classification14.
↪csv",index=False)
```

[76]:
```
study_E
```

[76]:

	VisitDay	PANSS_Total	P1	P2	P3	P4	P5	P6	P7	N1	…	G7	G8	G9	\
0	0	70	4	3	5	1	3	4	3	3	…	1	2	3	
1	0	82	3	4	1	3	2	4	1	3	…	1	2	3	
2	38	77	3	4	1	1	1	2	1	3	…	2	3	4	
3	78	75	3	4	1	2	1	1	1	3	…	2	3	3	
4	119	76	3	3	1	1	1	1	1	3	…	2	2	4	
…	…	…	..	..	..	..	..	..	..	..	…	..	..	..	
1957	83	66	3	3	1	1	1	1	1	3	…	1	3	3	
1958	125	60	3	2	1	1	1	1	1	3	…	1	2	3	
1959	168	54	2	2	1	1	1	1	1	3	…	1	1	2	
1960	0	44	1	1	1	1	1	1	1	3	…	1	1	1	
1961	12	43	2	1	1	1	3	2	1	3	…	1	1	2	

	G10	G11	G12	G13	G14	G15	G16
0	3	1	4	1	3	3	4
1	1	4	3	3	1	3	3
2	1	3	3	3	1	2	3
3	1	3	3	3	1	3	3
4	1	3	3	3	2	3	3
…	…	…	…	…	…	…	…
1957	1	3	3	4	1	2	3
1958	1	3	3	3	1	2	3
1959	3	3	3	3	1	2	1
1960	1	3	2	2	2	3	1
1961	1	1	2	1	1	1	1

[1962 rows x 32 columns]

[77]:
```
pred_y_test = xgbc4.predict_proba(study_E)
```

[79]:
```
# ytrain_E = pd.DataFrame()
# ytrain_E['LeadStatus'] = pred_y_test
# #ytrain_E = pd.concat([y_train,ytrain_E],ignore_index=True)
# #ytrain_E.reset_index(drop=True)
# pd.Series.get(ytrain_E,key='LeadStatus')
```

[362]:
```
X_train.to_csv(r"C:\Users\nlaya\Downloads\trainX",index=False)
y_train.to_csv(r"C:\Users\nlaya\Downloads\trainy",index=False)
X_test.to_csv(r"C:\Users\nlaya\Downloads\testX",index=False)
```

```
y_test.to_csv(r"C:\Users\nlaya\Downloads\testy",index=False)
study_E.to_csv(r"C:\Users\nlaya\Downloads\testXE",index=False)
```

```
C:\Users\nlaya\AppData\Local\Continuum\anaconda3\envs\PythonCPU\lib\site-
packages\ipykernel_launcher.py:2: FutureWarning: The signature of
`Series.to_csv` was aligned to that of `DataFrame.to_csv`, and argument 'header'
will change its default value from False to True: please pass an explicit value
to suppress this warning.

C:\Users\nlaya\AppData\Local\Continuum\anaconda3\envs\PythonCPU\lib\site-
packages\ipykernel_launcher.py:4: FutureWarning: The signature of
`Series.to_csv` was aligned to that of `DataFrame.to_csv`, and argument 'header'
will change its default value from False to True: please pass an explicit value
to suppress this warning.
  after removing the cwd from sys.path.
```

[426]:
```
Xtrain = pd.concat([X_train,X_test],ignore_index=True)
ytrain = pd.concat([y_train,y_test],ignore_index=True)

#Xtrain = pd.concat([Xtrain,study_E],ignore_index=True)
#ytrain = pd.concat([ytrain,pd.Series.
 ↪get(ytrain_E,key='LeadStatus')],ignore_index=True)
```

[473]:
```
param_test = {
  'learning_rate':list(np.logspace(-0.01,-0.3,4)),
   'reg_alpha':list(np.logspace(-0.01,-0.3,4)),
   'max_depth': [6],
   'subsample': [0.7],
   'gamma': list(np.logspace(-0.1,-0.3,3))
 }
gsearch = GridSearchCV(estimator = xgb.XGBClassifier( objective= 'multi:
 ↪softmax', eval_metric = 'mlogloss',
  min_child_weight=6, gamma=0.1, colsample_bytree=0.8, nthread=4,seed=27),
  param_grid = param_test, cv=5)
gsearch.fit(Xtrain,ytrain)
learning_rate = gsearch.best_params_['learning_rate']
reg_alpha = gsearch.best_params_['reg_alpha']
max_depth = gsearch.best_params_['max_depth']
subsample = gsearch.best_params_['subsample']
print('learning_rate '+str(learning_rate))
print('reg_lambda '+str(reg_lambda))
print('max_depth '+str(max_depth))
print('subsample '+str(subsample))
gamma = gsearch.best_params_['gamma']
print(gamma)
```

```
learning_rate 0.5011872336272722
```

```
reg_lambda 0.9772372209558107
max_depth 6
subsample 0.7
0.7943282347242815
```

[668]:
```
# xgbc2 X_train, Y_train  learning_rate = 0.01, reg_alpha = 0.05, max_depth =␣
↪4, subsample = 0.8,
# xgbc3 = xgb.XGBClassifier(objective='multi:softmax', learning_rate = 0.01,␣
↪reg_alpha =0.05 ,
#                           max_depth = 4, subsample = 0.8, min_child_weight=6,␣
↪gamma=0.1, colsample_bytree=0.6, nthread=4,seed=27)
# xgbc3.fit(Xtrain, ytrain.values)

xgbc = xgb.XGBClassifier(objective='multi:softmax', learning_rate = 0.001,␣
↪reg_alpha =0.0001 , eval_metric = 'mlogloss',
                         max_depth = 6, subsample = 0.7, min_child_weight=6,␣
↪gamma= 0.1, colsample_bytree=0.7, nthread=4,seed=27)
xgbc.fit(Xtrain, ytrain.values)
```

[668]:
```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.7, eval_metric='mlogloss',
              gamma=0.1, gpu_id=-1, importance_type='gain',
              interaction_constraints='', learning_rate=0.001, max_delta_step=0,
              max_depth=6, min_child_weight=6, missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=4, nthread=4,
              num_parallel_tree=1, objective='multi:softprob', random_state=27,
              reg_alpha=0.0001, reg_lambda=1, scale_pos_weight=None, seed=27,
              subsample=0.7, tree_method='exact', validate_parameters=1,
              verbosity=None)
```

[697]:
```
pred_y_ts = xgbc3.predict(X_test)
#pred_y_tr = xgbc3.predict(X_train)
```

[698]:
```
print(metrics.confusion_matrix(y_test, pred_y_ts))
m = metrics.confusion_matrix(y_test, pred_y_ts)
(np.sum(m)-np.sum(np.diag(m)))/np.sum(m)
```

```
[[  10   24 1340]
 [   5   69  443]
 [   1    4  199]]
```

[698]:
```
0.8673031026252983
```

[678]:
```
pred_y_test_imp1 = xgbc2.predict_proba(study_E)
pred_y_test_prob3 = xgbc3.predict_proba(study_E)
pred_y_test_prob_4 = xgbc4.predict_proba(study_E)
#pred_y_test
```

```
pred_y_test1 = np.max(pred_y_test_imp1[:,0:2],axis=1)

#pred_y_test1 = np.max(pred_y_test1[:,0:2],axis=1)
pred_y_test2 = np.max(pred_y_test_prob3[:,0:2],axis=1)
pred_y_test3 = np.max(pred_y_test_prob_4[:,0:2],axis=1)
(pred_y_test2 + pred_y_test1+ pred_y_test3)/3
#pred_y_test3 - (pred_y_test2 + pred_y_test1+ pred_y_test3)/3
(2*pred_y_test2 + 4*pred_y_test1+ 2*pred_y_test3)/8
```

[678]:
```
array([0.29652205, 0.29368162, 0.28692186, …, 0.28395835, 0.31980938,
       0.30210054], dtype=float32)
```

[691]:
```
(4*pred_y_test2 + 2*pred_y_test1+ 3*pred_y_test3)/9
```

[691]:
```
array([0.2793552 , 0.27439398, 0.2636564 , …, 0.2621557 , 0.3147105 ,
       0.28899604], dtype=float32)
```

[693]:
```
(4*pred_y_test2 + 2*pred_y_test1+ 4*pred_y_test3)/10
```

[693]:
```
array([0.28345308, 0.2788369 , 0.26886553, …, 0.26747397, 0.31606984,
       0.29234895], dtype=float32)
```

[694]:
```
submission2 = pd.DataFrame(columns=['AssessmentID','LeadStatus'])
submission2['AssessmentID'] = AssessmentID
submission2['LeadStatus'] = (4*pred_y_test2 + 2*pred_y_test1+ 4*pred_y_test3)/
 ↪10 #    (3*pred_y_test2 + 9*pred_y_test1)/12
submission2.to_csv(r"C:\Users\nlaya\Downloads\submission_classification12.
 ↪csv",index=False)
```

[454]:
```
try:
    import cPickle as pickle
except ImportError:
    import pickle
```

[455]:
```
with open('xgbc2.pkl', 'wb') as f:
    pickle.dump(xgbc2, f)
```

[456]:
```
with open('xgbc3.pkl', 'wb') as g:
    pickle.dump(xgbc3, g)
```

[558]:
```
pred_y_test3
```

[558]:
```
array([0.2940651 , 0.29292884, 0.28338042, …, 0.28419006, 0.32197493,
       0.2988189 ], dtype=float32)
```

[557]:
```
pred_y_test1
```

[557]:
```
array([0.31830367, 0.31842273, 0.31701568, …, 0.3114323 , 0.3260419 ,
       0.3183532 ], dtype=float32)
```

[564]:
```
(3*pred_y_test2 + pred_y_test1+ pred_y_test3)/5
```

[564]:
```
array([0.25996196, 0.25370473, 0.23882404, …, 0.23770289, 0.3089133 ,
       0.27293682], dtype=float32)
```

[ ]:
```

```

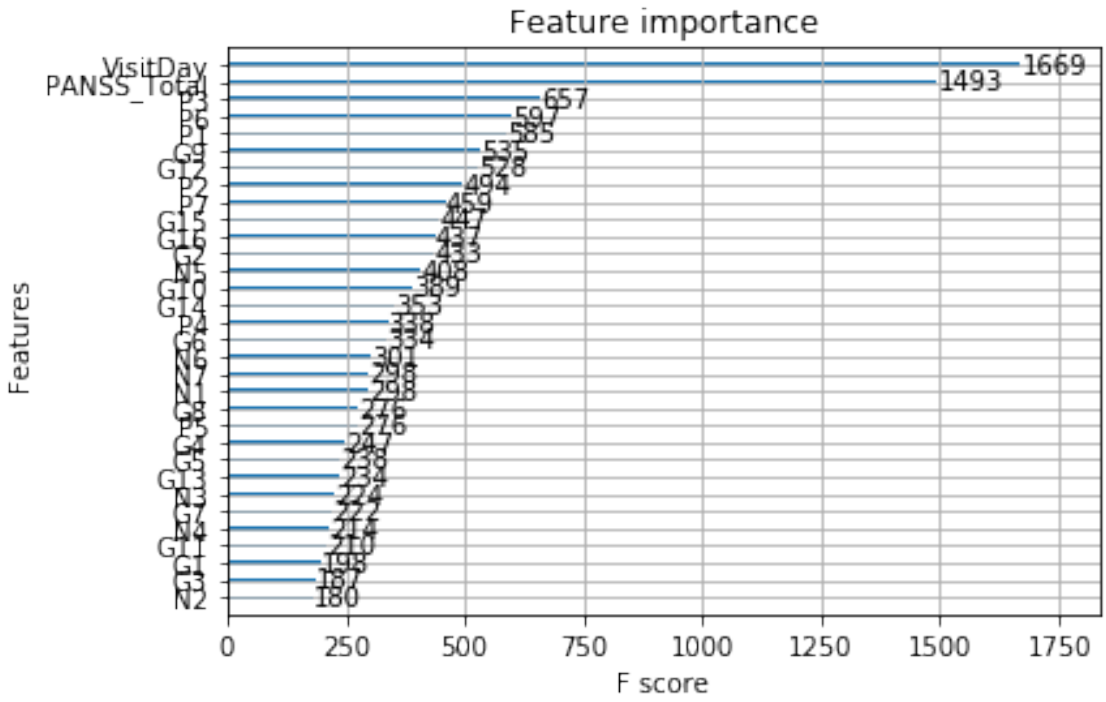
[587]:
```
plt.hist(study_c['LeadStatus'])
#plt.savefig(r'C:\Users\nlaya\Downloads\hist_project.png')
len(study[study['LeadStatus']=='Flagged'])
```

[587]:
```
2630
```

[588]:
```
from xgboost import plot_importance
```

[590]:
```
plot_importance(xgbc2)
```

[590]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1dfca795a88>
```



[643]:
```
def st(x):
    if x=='A':
        return 0
    elif x=='B':
        return 1
    elif x=='C':
        return 2
    elif x=='D':
        return 3

def tx(x):
    if x=='Control':
        return 0
    if x=='Treatment':
        return 1

def LeadStatus(x):
    if x=='Passed':
        return 2
    elif x=='Assign to CS':
        return 1
    elif x=='Flagged':
        return 0
```

```
study_y = study['LeadStatus']
study_X = study.
 ↪drop(['LeadStatus','Country','AssessmentID','Study','PatientID'],axis=1)
#study_X['Study'] = study_X['Study'].apply(lambda x: st(x))
study_X['TxGroup'] = study_X['TxGroup'].apply(lambda x: tx(x))

study_y = study_y.apply(lambda x : LeadStatus(x))

study_test = study_e.copy()
study_test = study_e.drop(['Country','AssessmentID','Study','PatientID'],axis=1)
#study_test['Study'] = study_test['Study'].apply(lambda x: st(x))
study_test['TxGroup'] = study_test['TxGroup'].apply(lambda x: tx(x))

np.random.seed(42)
rd = np.random.permutation(len(X_train))
study_X = study_X.iloc[rd]
study_y = study_y.iloc[rd]

xgbc = xgb.XGBClassifier(objective='multi:softmax', learning_rate = 0.01,␣
 ↪reg_alpha =0.05 , eval_metric = 'mlogloss',
                         max_depth = 4, subsample = 0.7, min_child_weight=6,␣
 ↪gamma= 0.1, colsample_bytree=0.7, nthread=4,seed=27)

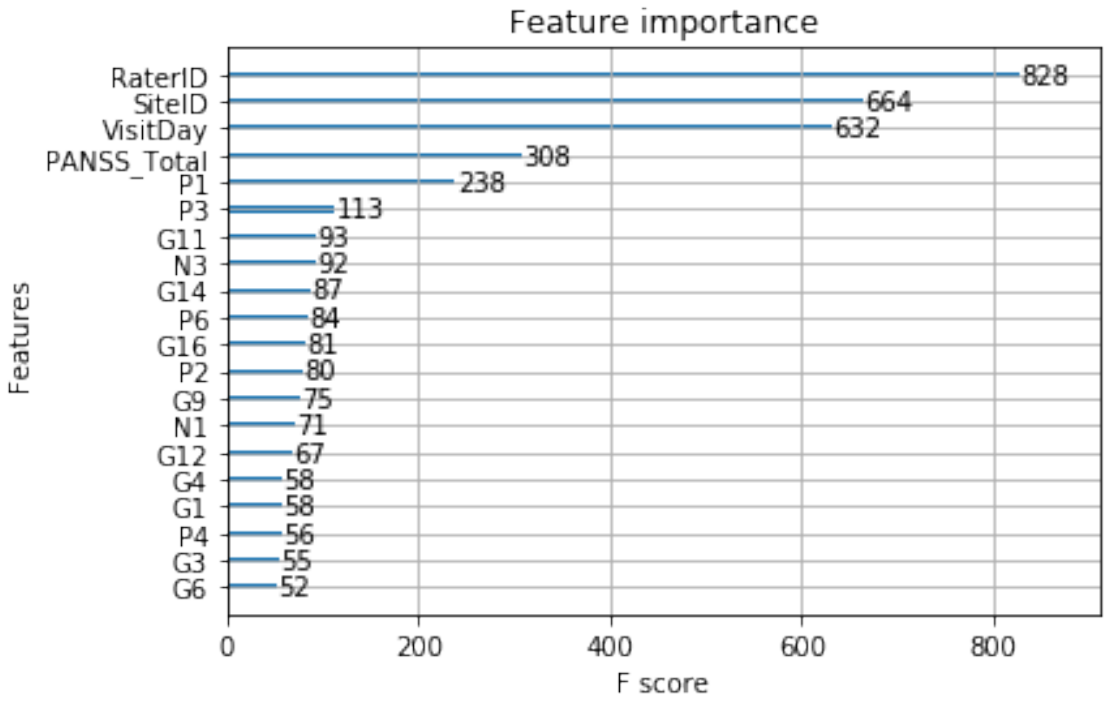
xgb_important_feat = xgbc.fit(study_X,study_y)
```

[649]:
```
xgb_important_feat
```

[649]:
```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.7, eval_metric='mlogloss',
              gamma=0.1, gpu_id=-1, importance_type='gain',
              interaction_constraints='', learning_rate=0.01, max_delta_step=0,
              max_depth=4, min_child_weight=6, missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=4, nthread=4,
              num_parallel_tree=1, objective='multi:softprob', random_state=27,
              reg_alpha=0.05, reg_lambda=1, scale_pos_weight=None, seed=27,
              subsample=0.7, tree_method='exact', validate_parameters=1,
              verbosity=None)
```

[655]:
```
plot_importance(xgb_important_feat, max_num_features=20)
```

[655]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1dfc9997ac8>
```



[645]:
```
pred_y_test_imp = xgb_important_feat.predict_proba(study_test)
```

[646]:
```
pred_y_test = np.max(pred_y_test_imp[:,0:2],axis=1)
```

[647]:
```
pred_y_test_imp
```

[647]:
```
array([[0.29721656, 0.38732508, 0.3154584 ],
       [0.30997065, 0.34321606, 0.34681326],
       [0.3502739 , 0.29297805, 0.356748  ],
       …,
       [0.51256233, 0.20191295, 0.2855247 ],
       [0.3169193 , 0.35818738, 0.32489333],
       [0.36984628, 0.3507609 , 0.27939275]], dtype=float32)
```

[648]:
```
submission3 = pd.DataFrame(columns=['AssessmentID','LeadStatus'])
submission3['AssessmentID'] = AssessmentID
submission3['LeadStatus'] = pred_y_test  #    (3*pred_y_test2 + 9*pred_y_test1)/
↪12
submission3.to_csv(r"C:\Users\nlaya\Downloads\submission_classification13.
↪csv",index=False)
```

[654]:
```
set(study_test['RaterID']) - set(study_X['RaterID'])
```

```
[654]: {150001,
        150002,
        150003,
        150004,
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        150007,
        150009,
        150010,
        150011,
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        150013,
        150014,
        150015,
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        150020,
        150021,
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```

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150121,
150122,
150123,
150124,
150125,
150126,
150127,
150128,
150129,
150130,
150131,
150132,
150133,
150134,
150135,
150136,
150137,
150138,
150139}
```

[656]:
```
xgbc2
```

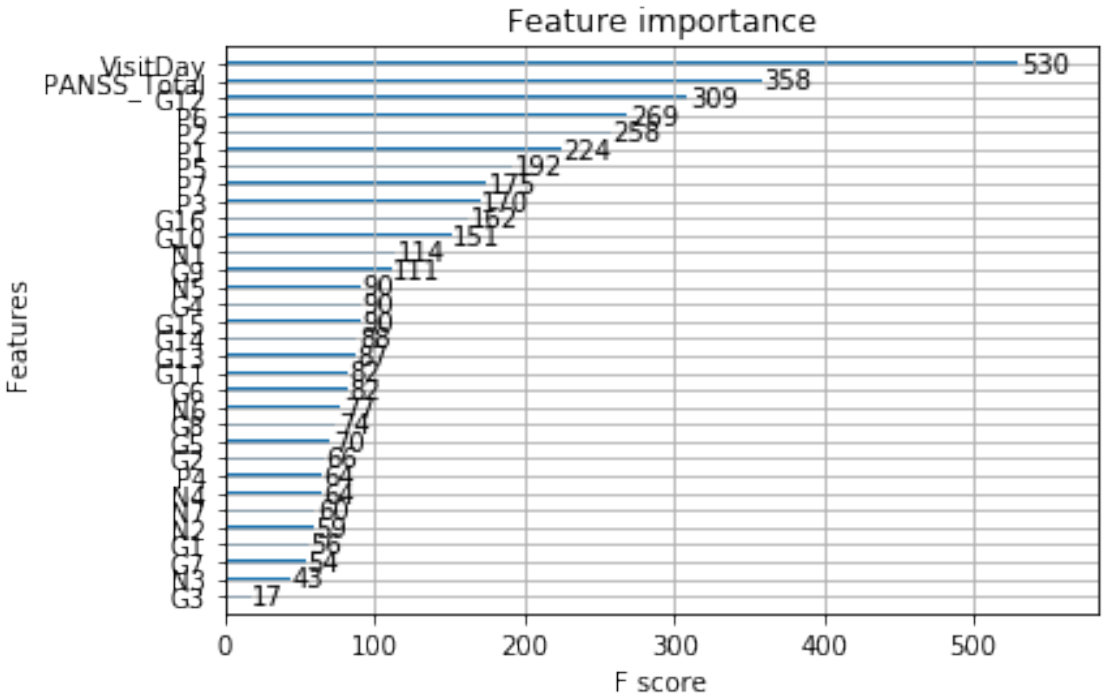
[656]:
```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.8, gamma=0.1, gpu_id=-1,
              importance_type='gain', interaction_constraints='',
              learning_rate=0.001, max_delta_step=0, max_depth=6,
              min_child_weight=6, missing=nan, monotone_constraints='()',
              n_estimators=100, n_jobs=4, nthread=4, num_parallel_tree=1,
              objective='multi:softprob', random_state=27, reg_alpha=0.0001,
              reg_lambda=1, scale_pos_weight=None, seed=27, subsample=0.9,
              tree_method='exact', validate_parameters=1, verbosity=None)
```

[758]:
```
xgbc3
```

[758]:
```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.6, gamma=0.1, gpu_id=-1,
              importance_type='gain', interaction_constraints='',
              learning_rate=0.01, max_delta_step=0, max_depth=4,
              min_child_weight=6, missing=nan, monotone_constraints='()',
              n_estimators=100, n_jobs=4, nthread=4, num_parallel_tree=1,
              objective='multi:softprob', random_state=27, reg_alpha=0.05,
              reg_lambda=1, scale_pos_weight=None, seed=27, subsample=0.8,
              tree_method='exact', validate_parameters=1, verbosity=None)
```

[759]:
```
plot_importance(xgbc3)
```

[759]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1dfcac34248>
```



[766]:
```
s1 = pd.read_csv(r"C:\Users\nlaya\Downloads\submission_classification12_1.csv")
s2 = pd.read_csv(r"C:\Users\nlaya\Downloads\submission_classification12_2.csv")
s3 = pd.read_csv(r"C:\Users\nlaya\Downloads\submission_classification12_3.csv")
s4 = pd.read_csv(r"C:\Users\nlaya\Downloads\submission_classification12_4.csv")
```

[767]:
```
s = (s1['LeadStatus']+s2['LeadStatus']+s3['LeadStatus']+s4['LeadStatus'])/4
s
```

[767]:
```
0       0.280515
1       0.274967
2       0.265064
3       0.261907
4       0.262024
          …
1957    0.262431
1958    0.262163
1959    0.260698
1960    0.316373
1961    0.289971
Name: LeadStatus, Length: 1962, dtype: float64
```

[81]:
```
submission2 = pd.DataFrame(columns=['AssessmentID','LeadStatus'])
submission2['AssessmentID'] = AssessmentID
submission2['LeadStatus'] = s
submission2.to_csv(r"C:\Users\nlaya\Downloads\submission_classification18.
 ↪csv",index=False)
```

[ ]:
```

```