4_2_Models

April 20, 2020

1 Normalization + ML Classification Model with/without Top Features

1. No oversampling techniques applied
2. No feature engineering applied

2 1. Import Necessary Libraries

[1]:
```
# For Computational and random seed purpose
import numpy as np
np.random.seed(42)
# To read csv file
import pandas as pd
# To Split data into train and cv data
from sklearn.model_selection import train_test_split
# To compute AUROC score
# For AUROC Score (Ref: https://scikit-learn.org/stable/modules/generated/
 ↪sklearn.metrics.roc_auc_score.html)
from sklearn.metrics import  roc_curve, auc
# For Hyperparameter and CV Fold
from sklearn.model_selection import GridSearchCV, RepeatedStratifiedKFold,␣
 ↪cross_val_score
# For plot AUROC graph
import matplotlib.pyplot as plt
# Data is umbalance, we need Calibrated Model to ive confidence probabilities␣
 ↪result
from sklearn.calibration import CalibratedClassifierCV
# For heatmap
import seaborn as sns
# To ignore warninga
import warnings
warnings.filterwarnings('ignore')
# To stndardize the data
from sklearn.preprocessing import MinMaxScaler
import tqdm
```

3 2. Read train data

[2]:
```
# Locate parent directory
data_dir = "./"

# Read csv file and display top 5 rows
df_train = pd.read_csv(data_dir+'/train.csv')
df_train.head(5)
```

[2]:
```
   id  target      0      1      2      3      4      5      6      7  …  \
0   0     1.0 -0.098  2.165  0.681 -0.614  1.309 -0.455 -0.236  0.276  …
1   1     0.0  1.081 -0.973 -0.383  0.326 -0.428  0.317  1.172  0.352  …
2   2     1.0 -0.523 -0.089 -0.348  0.148 -0.022  0.404 -0.023 -0.172  …
3   3     1.0  0.067 -0.021  0.392 -1.637 -0.446 -0.725 -1.035  0.834  …
4   4     1.0  2.347 -0.831  0.511 -0.021  1.225  1.594  0.585  1.509  …

      290    291    292    293    294    295    296    297    298    299
0  0.867  1.347  0.504 -0.649  0.672 -2.097  1.051 -0.414  1.038 -1.065
1 -0.165 -1.695 -1.257  1.359 -0.808 -1.624 -0.458 -1.099 -0.936  0.973
2  0.013  0.263 -1.222  0.726  1.444 -1.165 -1.544  0.004  0.800 -1.211
3 -0.404  0.640 -0.595 -0.966  0.900  0.467 -0.562 -0.254 -0.533  0.238
4  0.898  0.134  2.415 -0.996 -1.006  1.378  1.246  1.478  0.428  0.253

[5 rows x 302 columns]
```

[3]:
```
df_test = pd.read_csv(data_dir+'/test.csv')
df_test.head(5)
```

[3]:
```
    id      0      1      2      3      4      5      6      7      8  …  \
0  250  0.500 -1.033 -1.595  0.309 -0.714  0.502  0.535 -0.129 -0.687  …
1  251  0.776  0.914 -0.494  1.347 -0.867  0.480  0.578 -0.313  0.203  …
2  252  1.750  0.509 -0.057  0.835 -0.476  1.428 -0.701 -2.009 -1.378  …
3  253 -0.556 -1.855 -0.682  0.578  1.592  0.512 -1.419  0.722  0.511  …
4  254  0.754 -0.245  1.173 -1.623  0.009  0.370  0.781 -1.763 -1.432  …

      290    291    292    293    294    295    296    297    298    299
0 -0.088 -2.628 -0.845  2.078 -0.277  2.132  0.609 -0.104  0.312  0.979
1 -0.683 -0.066  0.025  0.606 -0.353 -1.133 -3.138  0.281 -0.625 -0.761
2 -0.094  0.351 -0.607 -0.737 -0.031  0.701  0.976  0.135 -1.327  2.463
3 -0.336 -0.787  0.255 -0.031 -0.836  0.916  2.411  1.053 -1.601 -1.529
4  2.184 -1.090  0.216  1.186 -0.143  0.322 -0.068 -0.156 -1.153  0.825

[5 rows x 301 columns]
```

4 3. Take train and test values from DataFrame

[4]:
```
# Take separate for features value
tr_X = df_train.drop(['id','target'], axis=1)
# Take separate for class value
tr_y = df_train['target'].values
# Take test feature value
ts_X = df_test.drop(['id'], axis=1)
```

Note: Don't worry about splitting train data into train and cv. I apply Stratify CV technique while modelling

5 4. Standardization

[5]:
```
stand_vec = MinMaxScaler()
tr_X = stand_vec.fit_transform(tr_X)
pd.DataFrame(tr_X).head(5)
```

[5]:

	0	1	2	3	4	5	6	\
0	0.454564	0.952523	0.538081	0.340156	0.708798	0.423909	0.496197	
1	0.695866	0.365981	0.356790	0.523392	0.391074	0.560837	0.751177	
2	0.367581	0.531215	0.362753	0.488694	0.465337	0.576268	0.534770	
3	0.488334	0.543925	0.488840	0.140741	0.387781	0.376020	0.351503	
4	0.954973	0.392523	0.509116	0.455750	0.693433	0.787336	0.644875	

	7	8	9	…	290	291	292	293	\
0	0.591415	0.098864	0.786842	…	0.647557	0.722731	0.593665	0.358949	
1	0.603498	0.525000	0.389098	…	0.465514	0.142639	0.273075	0.755630	
2	0.520191	0.550189	0.478195	…	0.496913	0.516018	0.279447	0.630581	
3	0.680127	0.619508	0.495301	…	0.423355	0.587910	0.393592	0.296326	
4	0.787440	0.521970	0.856955	…	0.653025	0.491419	0.941562	0.290399	

	294	295	296	297	298	299
0	0.718121	0.157182	0.627768	0.437245	0.630322	0.388295
1	0.449664	0.233435	0.370698	0.310441	0.337487	0.713283
2	0.858153	0.307432	0.185690	0.514624	0.595016	0.365014
3	0.759478	0.570530	0.352981	0.466864	0.397270	0.596077
4	0.413749	0.717395	0.660988	0.787486	0.539831	0.598469

[5 rows x 300 columns]

[6]:
```
ts_X = stand_vec.transform(ts_X)
pd.DataFrame(ts_X).head(5)
```

[6]:

	0	1	2	3	4	5	6	\
0	0.576955	0.354766	0.150281	0.520078	0.338760	0.593650	0.635820	
1	0.633442	0.718692	0.337877	0.722417	0.310774	0.589748	0.643607	

```
2  0.832788  0.642991  0.412336  0.622612  0.382294  0.757893  0.411988
3  0.360827  0.201121  0.305844  0.572515  0.760563  0.595424  0.281963
4  0.628940  0.502056  0.621912  0.143470  0.471008  0.570238  0.680369

          7         8         9    …       290       291       292       293  \
0  0.527027  0.394129  0.686466  …  0.479097 -0.035278  0.348079  0.897669
1  0.497774  0.562689  0.698684  …  0.374140  0.453280  0.506463  0.606875
2  0.228140  0.263258  0.475188  …  0.478038  0.532799  0.391407  0.341565
3  0.662321  0.621023  0.550376  …  0.435350  0.315789  0.548334  0.481035
4  0.267250  0.253030  0.268985  …  0.879873  0.258009  0.541234  0.721454

        294       295       296       297       298       299
0  0.545982  0.838949  0.552470  0.494632  0.522623  0.714240
1  0.532197  0.312591 -0.085860  0.565902  0.383623  0.436772
2  0.590604  0.608254  0.614991  0.538874  0.279484  0.950885
3  0.444586  0.642915  0.859455  0.708812  0.238837  0.314304
4  0.570288  0.547155  0.437138  0.485006  0.305296  0.689683

[5 rows x 300 columns]
```

6 5. Apply ML Models (with hyperparameter)

[7]:
```python
def hyperparameter_model(models, params):
    '''
    Hyperparameter tuning with StratifiedKFold follow by GridSearchCV follow by␣
 ↪CalibratedClassifier

    Parameters:
    models: Instance of the model
    params: list of parameters with value fr tuning (dict)

    Return:
    grid_clf: return gridsearch model
    '''
    # Random shuffle after every iteration with stratify
    str_cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=5, random_state=42)
    # Find the right hyperparameter for the model
    grid_clf = GridSearchCV(models, params, cv=str_cv, return_train_score=True,␣
 ↪scoring='roc_auc')
    # Fit on train data
    grid_clf.fit(tr_X, tr_y)
    return grid_clf

def plot_feature_importance(model, model_name, top_n = 10):
    '''
    Compute ROC curve and ROC area for each class
```

```
    Parameters:
    try_true: train true label
    try_pred: train predict probabilities value
    cvy_true: cv true label
    cvy_pred: cv predict probabilities value
    n_classes: number of unique classes

    Return:
    Plot of ROC Curve for train and cv data
    '''
    column_name = df_train.drop(['id','target'], axis=1).columns
    if model_name == 'log_model':
        feat_imp_coef = model.coef_.ravel()
    else:
        feat_imp_coef = model.feature_importances_
    temp = pd.DataFrame(data=np.column_stack((column_name, feat_imp_coef)),␣
↪columns=['col_name','coef'])
    temp = temp.sort_values(by='coef', ascending=False).reset_index()
    df = temp
    temp = temp[:top_n]
    plt.figure(figsize=(20,5))
    sns.barplot(data=temp, y='coef', x='col_name', order=temp['col_name'])
    plt.grid()
    plt.show()
    return df
```

[8]:
```
def forward_selection_model(model, top_n=10):
    top_column = []
    exist_score = 0
    for n in range(top_n):
        print('for {} feature'.format(n+1))
        flag = 0
        for i in tqdm.tqdm_notebook(range(tr_X.shape[1])):
            # Finding for first top feature
            if len(top_column) == 0:
                str_cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=5,␣
↪random_state=42)
                score = cross_val_score(model,tr_X[:
↪,[i]],tr_y,cv=str_cv,scoring='roc_auc')
                if exist_score < np.mean(score):
                    top_current = i
                    exist_score = np.mean(score)
                    flag = 1
            # Excluded apart from top column
            elif i not in top_column:
```

```
                str_cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=5,␣
↪random_state=42)
                score = cross_val_score(model,tr_X[:,np.
↪concatenate((top_column,[i]))],tr_y,cv=str_cv,scoring='roc_auc')
                if exist_score < np.mean(score):
                    top_current = i
                    exist_score = np.mean(score)
                    flag = 1

        if flag == 1:
            print('Current top feature {} and score: {}'.
↪format(top_current,exist_score))
            print('Appended to top column')
            top_column.append(top_current)
            print(top_column)
        else:
            break
    return top_column
```

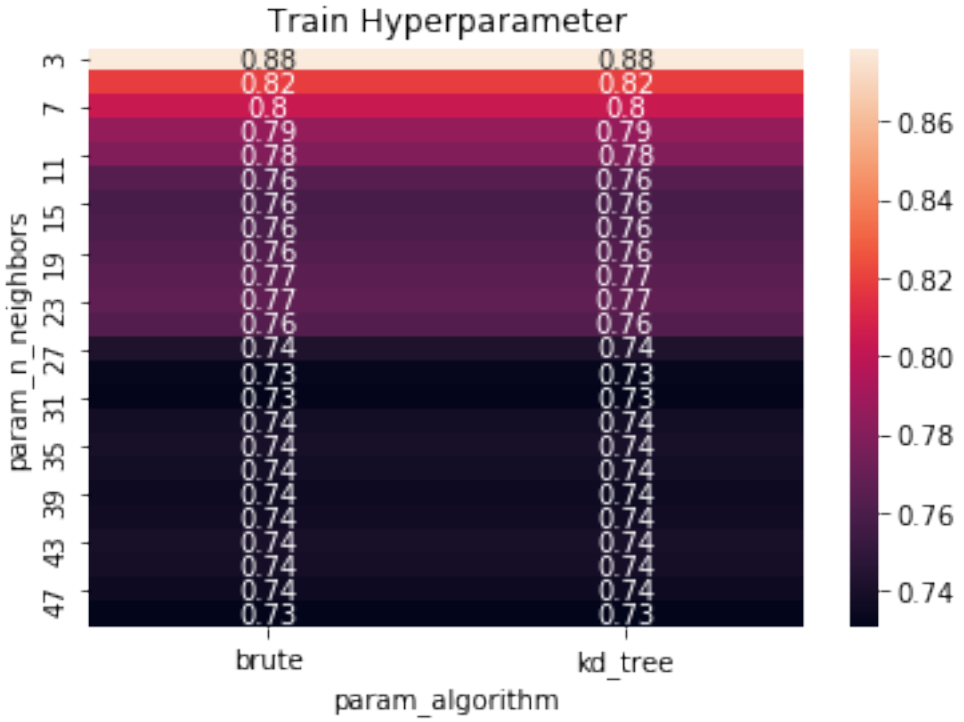
7 5.1 kNN

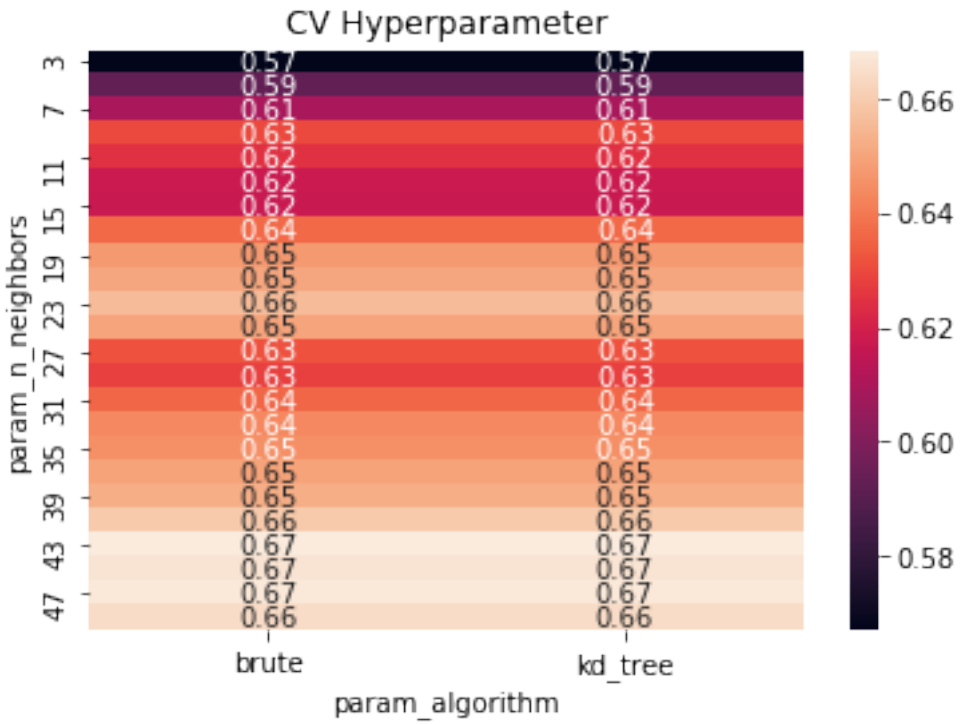
[9]:
```
# Import KNN
from sklearn.neighbors import KNeighborsClassifier
```

[10]:
```
# kNN (See Docs: https://scikit-learn.org/stable/modules/generated/sklearn.
↪neighbors.KNeighborsClassifier.html)

# List of params
params = {'n_neighbors':np.arange(3,51,2).tolist(), 'algorithm': ['kd_tree',␣
↪'brute']}
# Instance of knn model
knn_model = KNeighborsClassifier()
# Call hyperparameter for find the best params as possible
knn_clf = hyperparameter_model(knn_model, params)
```

[11]:
```
cv_pvt = pd.pivot_table(pd.DataFrame(knn_clf.cv_results_),␣
↪values='mean_test_score', index='param_n_neighbors', \
                    columns='param_algorithm')
tr_pvt = pd.pivot_table(pd.DataFrame(knn_clf.cv_results_),␣
↪values='mean_train_score', index='param_n_neighbors', \
                    columns='param_algorithm')

plt.title('Train Hyperparameter')
sns.heatmap(tr_pvt, annot=True)
plt.show()
```

```
plt.title('CV Hyperparameter')
sns.heatmap(cv_pvt, annot=True)
plt.show()
```





[12]:
```
print(knn_clf.best_params_)
```

```
{'algorithm': 'kd_tree', 'n_neighbors': 43}
```

[13]:
```
clf = CalibratedClassifierCV(knn_clf, cv=3)
clf.fit(tr_X,tr_y)
```

[13]:
```
CalibratedClassifierCV(base_estimator=GridSearchCV(cv=RepeatedStratifiedKFold(n_
repeats=5, n_splits=10, random_state=42),
                                                   error_score=nan,
estimator=KNeighborsClassifier(algorithm='auto',
  leaf_size=30,
  metric='minkowski',
  metric_params=None,
  n_jobs=None,
  n_neighbors=5,
  p=2,
  weights='uniform'),
                                                   iid='deprecated',
                                                   n_jobs=None,
                                                   param_grid={'algorithm':

['kd_tree',
'brute'],
```

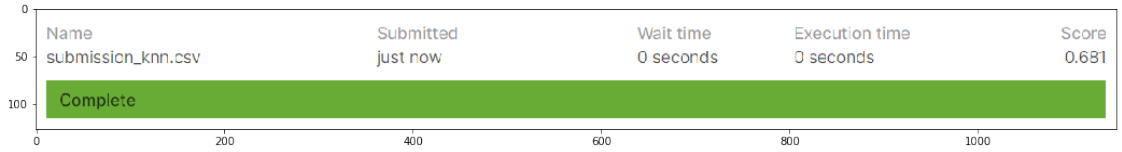
```
                                                                'n_neighbors':
[3,
5,
7,
9,
11,
13,
15,
17,
19,
21,
23,
25,
27,
29,
31,
33,
35,
37,
39,
41,
43,
45,
47,
49]},
                                                      pre_dispatch='2*n_jobs',
                                                      refit=True,
                                                      return_train_score=True,
                                                      scoring='roc_auc',
                                                      verbose=0),
                         cv=3, method='sigmoid')
```

8 5.1.1 Kaggle Score without top features

[14]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
knn_csv = clf.predict_proba(ts_X)[:,1]
knn_df = pd.DataFrame(np.column_stack((temp_id,knn_csv)),␣
 ↪columns=['id','target'])
knn_df['id'] = knn_df['id'].astype('int32')
knn_df.to_csv(data_dir+'/submission_knn.csv', index=False)
```

[15]:
```
image = plt.imread(data_dir+'/submission_knn.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[15]: <matplotlib.image.AxesImage at 0x2394322ac08>

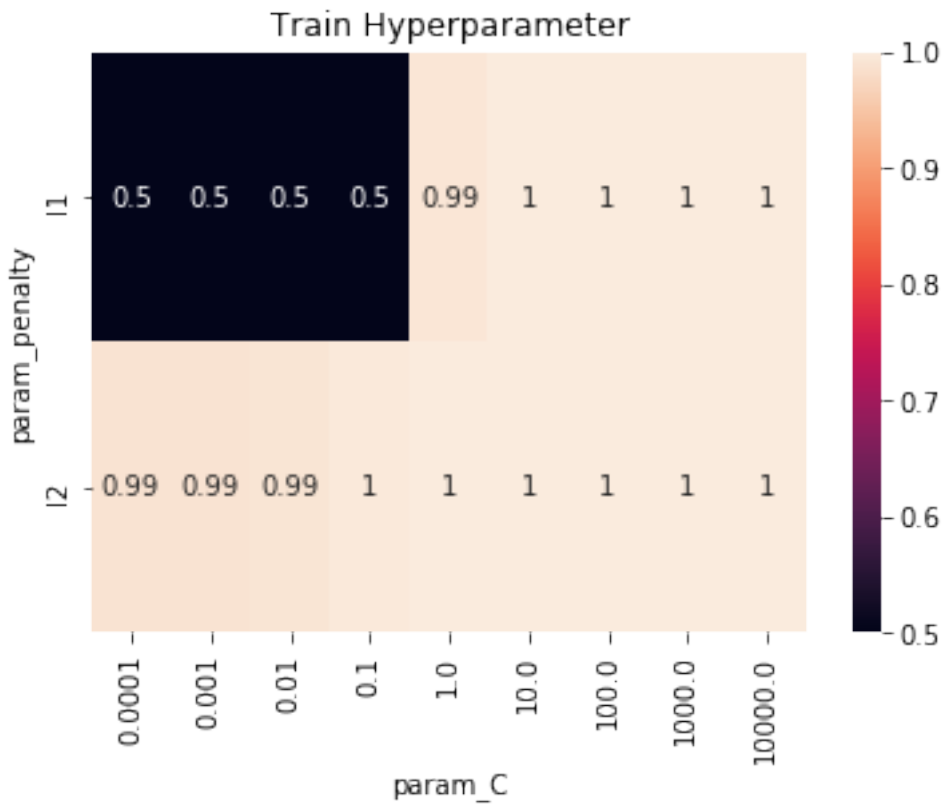


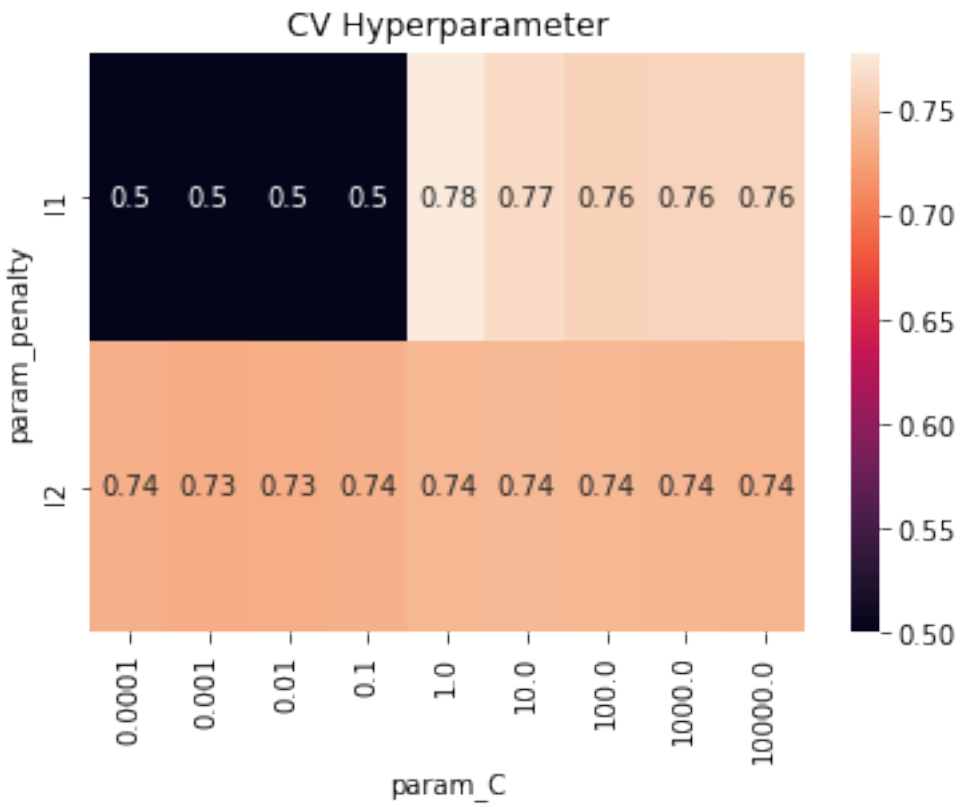
8.1 5.2 Logistic Regression

[16]:
```
# Import Logistic Regression
from sklearn.linear_model import LogisticRegression
```

[17]:
```
# LogisticRegression (See Docs: https://scikit-learn.org/stable/modules/
 ↪generated/sklearn.linear_model.LogisticRegression.html)

# List of hyperparameter that has to be tuned
params = {'penalty':['l1', 'l2', 'elasticnet'], 'C':[10**i for i in␣
 ↪range(-4,5)], 'solver':['liblinear','sag']}
# Instance of Logsitic Regression
log_model = LogisticRegression(random_state=42, class_weight='balanced')
# Call hyperparameter to get the best parameters of this model
log_clf = hyperparameter_model(log_model, params)
```

[18]:
```
cv_pvt = pd.pivot_table(pd.DataFrame(log_clf.cv_results_),␣
 ↪values='mean_test_score', index='param_penalty', \
                      columns='param_C')
tr_pvt = pd.pivot_table(pd.DataFrame(log_clf.cv_results_),␣
 ↪values='mean_train_score', index='param_penalty', \
                      columns='param_C')

plt.title('Train Hyperparameter')
sns.heatmap(tr_pvt, annot=True)
plt.show()

plt.title('CV Hyperparameter')
sns.heatmap(cv_pvt, annot=True)
plt.show()
```


Train Hyperparameter
param_penalty
l1
l2
0.5 0.5 0.5 0.5 0.99 1 1 1 1
0.99 0.99 0.99 1 1 1 1 1 1
0.0001
0.001
0.01
0.1
1.0
10.0
100.0
1000.0
10000.0
param_C
1.0
0.9
0.8
0.7
0.6
0.5



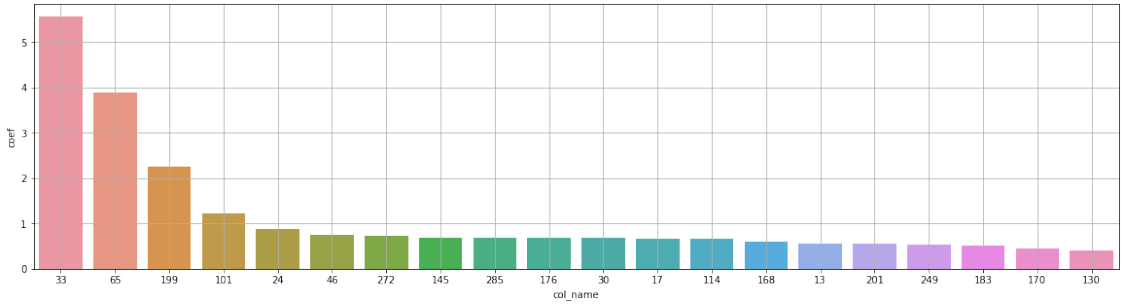
[19]:
```
print(log_clf.best_params_)
```

```
{'C': 1, 'penalty': 'l1', 'solver': 'liblinear'}
```

[20]:
```
log_model = LogisticRegression(**log_clf.best_params_, class_weight='balanced',␣
↪random_state=42)
log_model.fit(tr_X, tr_y)
```

[20]:
```
LogisticRegression(C=1, class_weight='balanced', dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='auto', n_jobs=None, penalty='l1',
                   random_state=42, solver='liblinear', tol=0.0001, verbose=0,
                   warm_start=False)
```

[21]:
```
df = plot_feature_importance(log_model, 'log_model', 20)
```



[22]:
```
clf = CalibratedClassifierCV(log_clf, cv=3)
clf.fit(tr_X,tr_y)
```

[22]:
```
CalibratedClassifierCV(base_estimator=GridSearchCV(cv=RepeatedStratifiedKFold(n_
repeats=5, n_splits=10, random_state=42),
                                                   error_score=nan,
estimator=LogisticRegression(C=1.0,
class_weight='balanced',
dual=False,
fit_intercept=True,
intercept_scaling=1,
l1_ratio=None,
max_iter=100,
multi_class='auto',
n_jobs=None,
penalty='l2',
random_state=42,
solver='lbfgs',
tol=0.0001,
verbose=0,
warm_start=False),
                                                   iid='deprecated',
                                                   n_jobs=None,
                                                   param_grid={'C': [0.0001,
                                                                     0.001,
                                                                     0.01, 0.1,
                                                                     1, 10, 100,
                                                                     1000,
                                                                     10000],
                                                               'penalty': ['l1',
                                                                           'l2',
'elasticnet'],
                                                               'solver':
['liblinear',
'sag']},
```

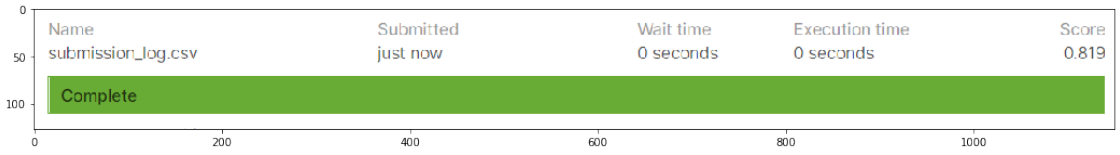
```
                                                    pre_dispatch='2*n_jobs',
                                                    refit=True,
                                                    return_train_score=True,
                                                    scoring='roc_auc',
                                                    verbose=0),
                                cv=3, method='sigmoid')
```

9 5.2.1 Kaggle Score without top features

[23]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
log_csv = clf.predict_proba(ts_X)[:,1]
log_df = pd.DataFrame(np.column_stack((temp_id,log_csv)),␣
 ↪columns=['id','target'])
log_df['id'] = log_df['id'].astype('int32')
log_df.to_csv(data_dir+'/submission_log.csv', index=False)
```

[24]:
```
image = plt.imread(data_dir+'/submission_log.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[24]:
```
<matplotlib.image.AxesImage at 0x2394308d888>
```



10 5.2.2 Kaggle Score Using top 10 features based on Logistic Regression Model

[25]:
```
top_column = forward_selection_model(log_model)
```

```
for 1 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 33 and score: 0.7347222222222222
Appended to top column
[33]
for 2 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 65 and score: 0.7876388888888887
Appended to top column
[33, 65]
for 3 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 217 and score: 0.8027777777777777
Appended to top column
[33, 65, 217]
for 4 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 91 and score: 0.8190277777777777
Appended to top column
[33, 65, 217, 91]
for 5 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 117 and score: 0.8458333333333334
Appended to top column
[33, 65, 217, 91, 117]
for 6 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 194 and score: 0.852638888888889
Appended to top column
[33, 65, 217, 91, 117, 194]
for 7 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 199 and score: 0.8573611111111111
Appended to top column
[33, 65, 217, 91, 117, 194, 199]
for 8 feature
```

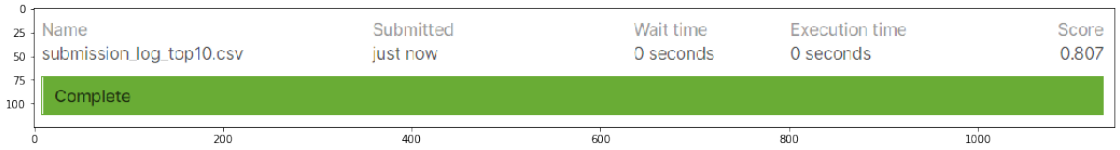
```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 80 and score: 0.8698611111111112
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80]
for 9 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 127 and score: 0.875
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127]
for 10 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 226 and score: 0.8791666666666669
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226]
```

[26]:
```
# Store the top column name into set
log_top10_feat = set(top_column)
# Fit Logistic Regression on top features only
log_model_top = LogisticRegression(**log_clf.best_params_,␣
 ↪class_weight='balanced', random_state=42)
log_model_top.fit(tr_X[:,top_column],tr_y)
# Calibrate it in top features only
clf = CalibratedClassifierCV(log_model_top, cv=3)
clf.fit(tr_X[:,top_column],tr_y)
# Predict the probabilities of 1
ts_pred = clf.predict_proba(ts_X[:,top_column])[:,1]
```

[27]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
df_tspred = pd.DataFrame(np.column_stack((temp_id,ts_pred)),␣
 ↪columns=['id','target'])
df_tspred['id'] = df_tspred['id'].astype('int32')
df_tspred.to_csv(data_dir+'/submission_log_top10.csv', index=False)
```

[28]:
```
image = plt.imread(data_dir+'/log_csv_top10.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[28]:
```
<matplotlib.image.AxesImage at 0x23943841f08>
```



11 5.2.3 Kaggle Score Using top 20 features based on Logistic Regression Model

[29]:
```
top_column = forward_selection_model(log_model,20)
```

```
for 1 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 33 and score: 0.7347222222222222
Appended to top column
[33]
for 2 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 65 and score: 0.7876388888888887
Appended to top column
[33, 65]
for 3 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 217 and score: 0.8027777777777777
Appended to top column
[33, 65, 217]
for 4 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 91 and score: 0.8190277777777777
Appended to top column
[33, 65, 217, 91]
for 5 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 117 and score: 0.8458333333333334
Appended to top column
[33, 65, 217, 91, 117]
for 6 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 194 and score: 0.852638888888889
Appended to top column
[33, 65, 217, 91, 117, 194]
for 7 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 199 and score: 0.8573611111111111
Appended to top column
[33, 65, 217, 91, 117, 194, 199]
for 8 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 80 and score: 0.8698611111111112
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80]
for 9 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 127 and score: 0.875
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127]
for 10 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 226 and score: 0.8791666666666669
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226]
for 11 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 43 and score: 0.8875
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43]
for 12 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 170 and score: 0.8933333333333333
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170]
for 13 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 82 and score: 0.8973611111111112
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82]
for 14 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 183 and score: 0.9002777777777777
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183]
for 15 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 168 and score: 0.9018055555555555
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168]
for 16 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 108 and score: 0.9033333333333333
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168, 108]
for 17 feature
```

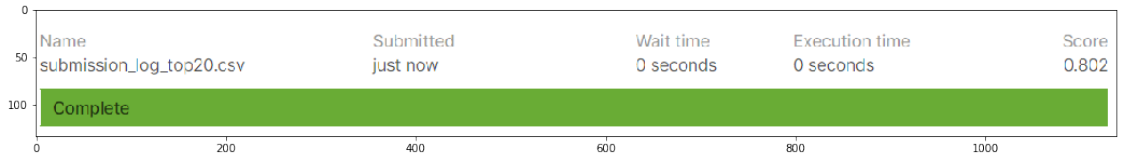
```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 114 and score: 0.9054166666666665
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168, 108, 114]
for 18 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 63 and score: 0.90875
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168, 108, 114,
63]
for 19 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 101 and score: 0.9105555555555557
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168, 108, 114,
63, 101]
for 20 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 198 and score: 0.9113888888888888
Appended to top column
[33, 65, 217, 91, 117, 194, 199, 80, 127, 226, 43, 170, 82, 183, 168, 108, 114,
63, 101, 198]
```

[30]:
```
# Store the top column name into set
log_top20_feat = set(top_column)
# Fit Logistic Regression on top features only
log_model_top = LogisticRegression(**log_clf.best_params_,␣
 ↪class_weight='balanced', random_state=42)
log_model_top.fit(tr_X[:,top_column],tr_y)
# Calibrate it in top features only
clf = CalibratedClassifierCV(log_model_top, cv=3)
clf.fit(tr_X[:,top_column],tr_y)
# Predict the probabilities of 1
ts_pred = clf.predict_proba(ts_X[:,top_column])[:,1]
```

[31]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
df_tspred = pd.DataFrame(np.column_stack((temp_id,ts_pred)),␣
 ↪columns=['id','target'])
df_tspred['id'] = df_tspred['id'].astype('int32')
df_tspred.to_csv(data_dir+'/submission_log_top20.csv', index=False)
```

[32]:
```
image = plt.imread(data_dir+'/log_csv_top20.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[32]:
```
<matplotlib.image.AxesImage at 0x239430ee4c8>
```



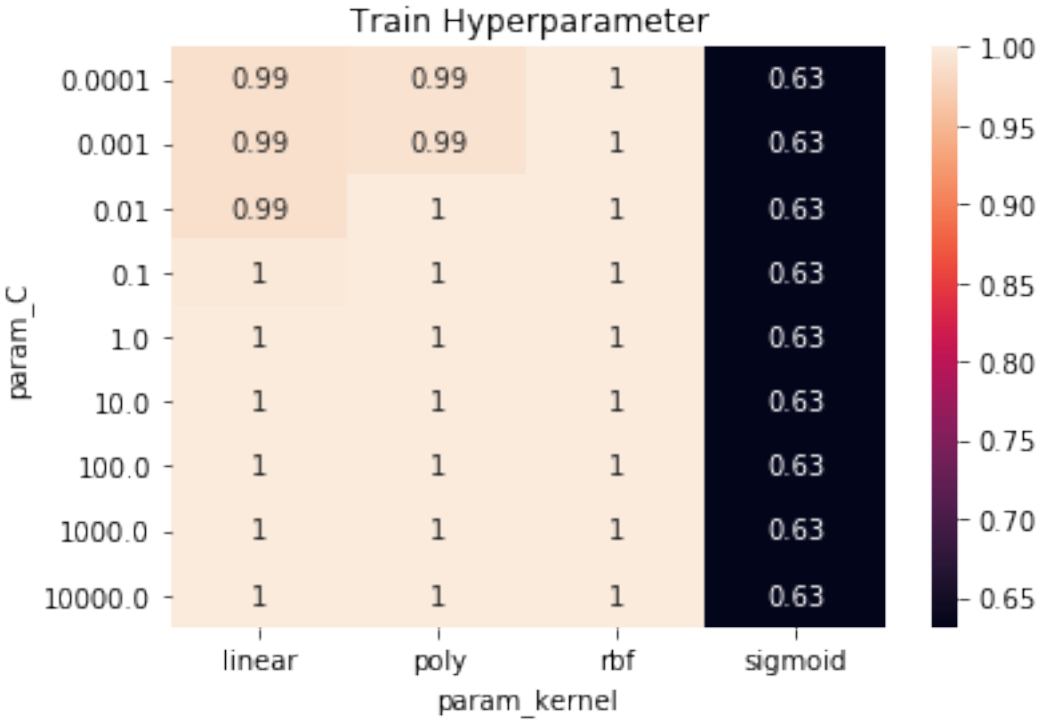
12 5.3 SVC

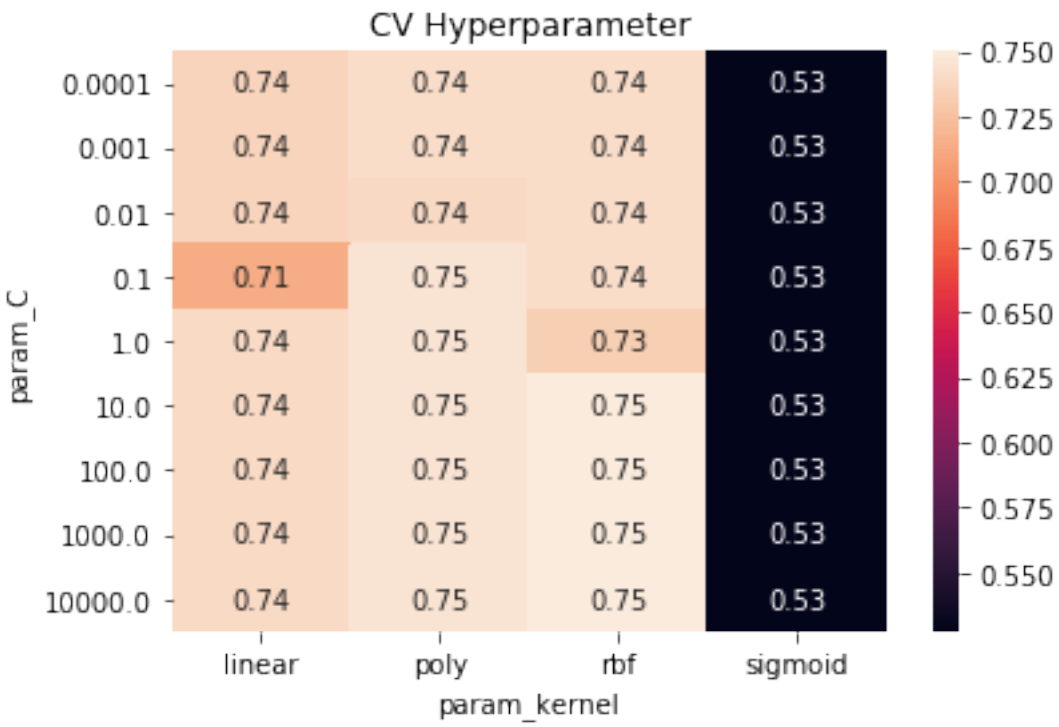
[33]:
```
# Import SVC
from sklearn.svm import SVC
```

[34]:
```
# SVC (See Docs: https://scikit-learn.org/stable/modules/generated/sklearn.sum.
 ↪SVC.html)

# List of hyperparameter that has to be tuned
params = {'C':[10**i for i in range(-4,5)], 'kernel':
 ↪['linear','poly','sigmoid','rbf']}
# Instance of SVC
svc_model = SVC(class_weight='balanced', random_state=42, probability=True)
# Call hyperparameter to find the best parameters
svc_clf = hyperparameter_model(svc_model, params)
```

[35]:
```
cv_pvt = pd.pivot_table(pd.DataFrame(svc_clf.cv_results_),␣
 ↪values='mean_test_score', index='param_C', \
                    columns='param_kernel')
tr_pvt = pd.pivot_table(pd.DataFrame(svc_clf.cv_results_),␣
 ↪values='mean_train_score', index='param_C', \
                    columns='param_kernel')

plt.title('Train Hyperparameter')
sns.heatmap(tr_pvt, annot=True)
```

```
plt.show()

plt.title('CV Hyperparameter')
sns.heatmap(cv_pvt, annot=True)
plt.show()
```





[36]:
```
print(svc_clf.best_params_)
```

```
{'C': 10, 'kernel': 'rbf'}
```

[37]:
```
svc_model = SVC(**svc_clf.best_params_, class_weight='balanced',␣
↪random_state=42, probability=True)
svc_model.fit(tr_X, tr_y)

clf = CalibratedClassifierCV(svc_clf, cv=3)
clf.fit(tr_X,tr_y)
```

[37]:
```
CalibratedClassifierCV(base_estimator=GridSearchCV(cv=RepeatedStratifiedKFold(n_
repeats=5, n_splits=10, random_state=42),
                                                   error_score=nan,
                                                   estimator=SVC(C=1.0,
break_ties=False,
                                                                 cache_size=200,
class_weight='balanced',
                                                                 coef0=0.0,
decision_function_shape='ovr',
                                                                 degree=3,
                                                                 gamma='scale',
                                                                 kernel='rbf',
```

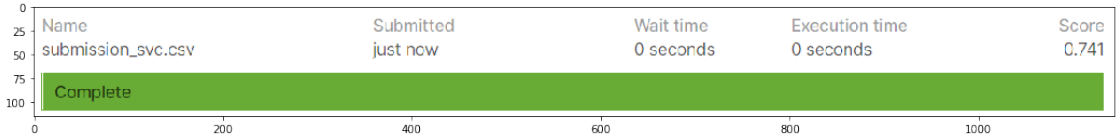
```
                                                                  max_iter=-1,
probability=True,
random_state=42,
                                                                  shrinking=True,
                                                                  tol=0.001,
                                                                  verbose=False),
                                                    iid='deprecated',
                                                    n_jobs=None,
                                                    param_grid={'C': [0.0001,
                                                                      0.001,
                                                                      0.01, 0.1,
                                                                      1, 10, 100,
                                                                      1000,
                                                                      10000],
                                                                'kernel':
['linear',
'poly',
'sigmoid',
'rbf']},
                                                    pre_dispatch='2*n_jobs',
                                                    refit=True,
                                                    return_train_score=True,
                                                    scoring='roc_auc',
                                                    verbose=0),
                         cv=3, method='sigmoid')
```

13 5.3.1 Kaggle Score without top features

[38]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
svc_csv = clf.predict_proba(ts_X)[:,1]
svc_df = pd.DataFrame(np.column_stack((temp_id,svc_csv)),␣
 ↪columns=['id','target'])
svc_df['id'] = svc_df['id'].astype('int32')
svc_df.to_csv(data_dir+'/submission_svc.csv', index=False)
```

[39]:
```
image = plt.imread(data_dir+'/submission_svc.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[39]:
```
<matplotlib.image.AxesImage at 0x239437b6748>
```



14 5.3.2 Kaggle Score Using top 10 features based on SVC Model

[40]:
```
top_column = forward_selection_model(svc_model)
```

```
for 1 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 33 and score: 0.708888888888889
Appended to top column
[33]
for 2 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 167 and score: 0.7570833333333334
Appended to top column
[33, 167]
for 3 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 116 and score: 0.7616666666666666
Appended to top column
[33, 167, 116]
for 4 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 70 and score: 0.7881944444444444
Appended to top column
[33, 167, 116, 70]
for 5 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 293 and score: 0.8234722222222223
Appended to top column
```

```
[33, 167, 116, 70, 293]
for 6 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 43 and score: 0.8543055555555558
Appended to top column
[33, 167, 116, 70, 293, 43]
for 7 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 157 and score: 0.8663888888888889
Appended to top column
[33, 167, 116, 70, 293, 43, 157]
for 8 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 103 and score: 0.8681944444444444
Appended to top column
[33, 167, 116, 70, 293, 43, 157, 103]
for 9 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

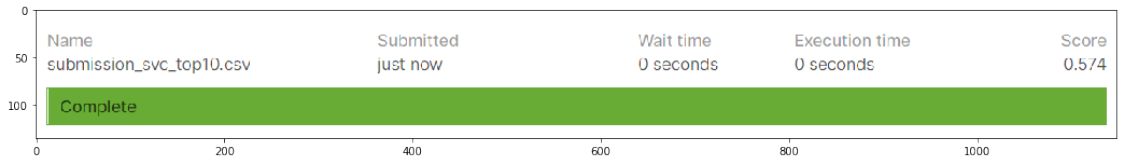
[41]:
```
# Store the top column name into set
svc_top10_feat = set(top_column)
# Fit SVC on top features only
svc_model_top = SVC(**svc_clf.best_params_, class_weight='balanced',␣
 ↪random_state=42, probability=True)
svc_model_top.fit(tr_X[:,top_column],tr_y)
# Calibrate it in top features only
clf = CalibratedClassifierCV(svc_model_top, cv=3)
clf.fit(tr_X[:,top_column],tr_y)
# Predict the probabilities of 1
ts_pred = clf.predict_proba(ts_X[:,top_column])[:,1]
```

[42]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
df_tspred = pd.DataFrame(np.column_stack((temp_id,ts_pred)),␣
 ↪columns=['id','target'])
```

```
df_tspred['id'] = df_tspred['id'].astype('int32')
df_tspred.to_csv(data_dir+'/submission_svc_top10.csv', index=False)
```

[43]:
```
image = plt.imread(data_dir+'/svc_csv_top10.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[43]:
```
<matplotlib.image.AxesImage at 0x23943812c48>
```



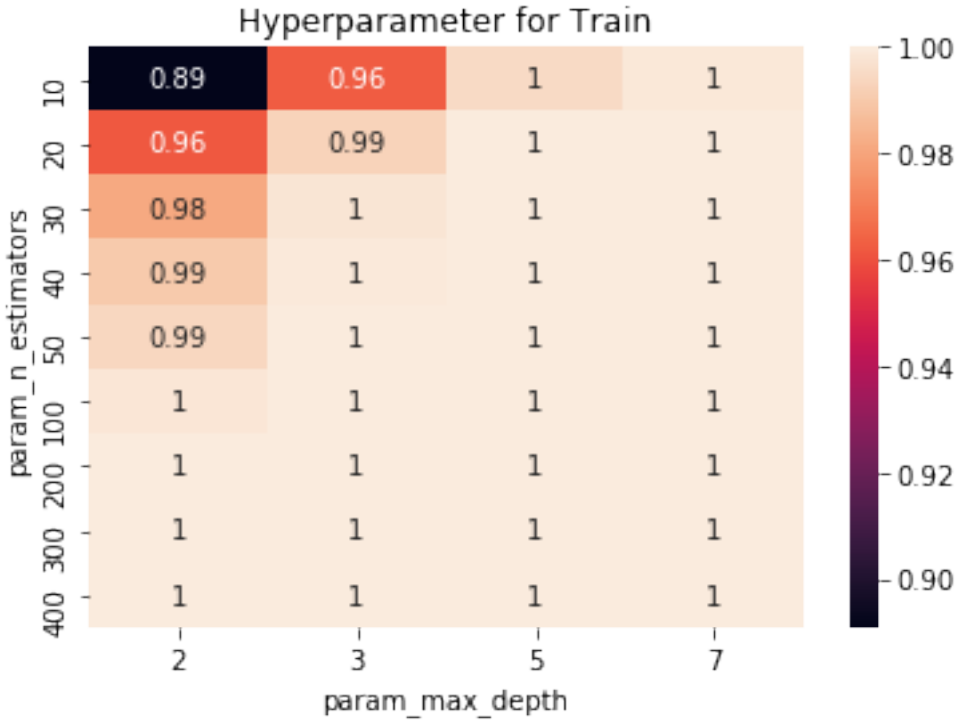
15 5.4 RandomForest

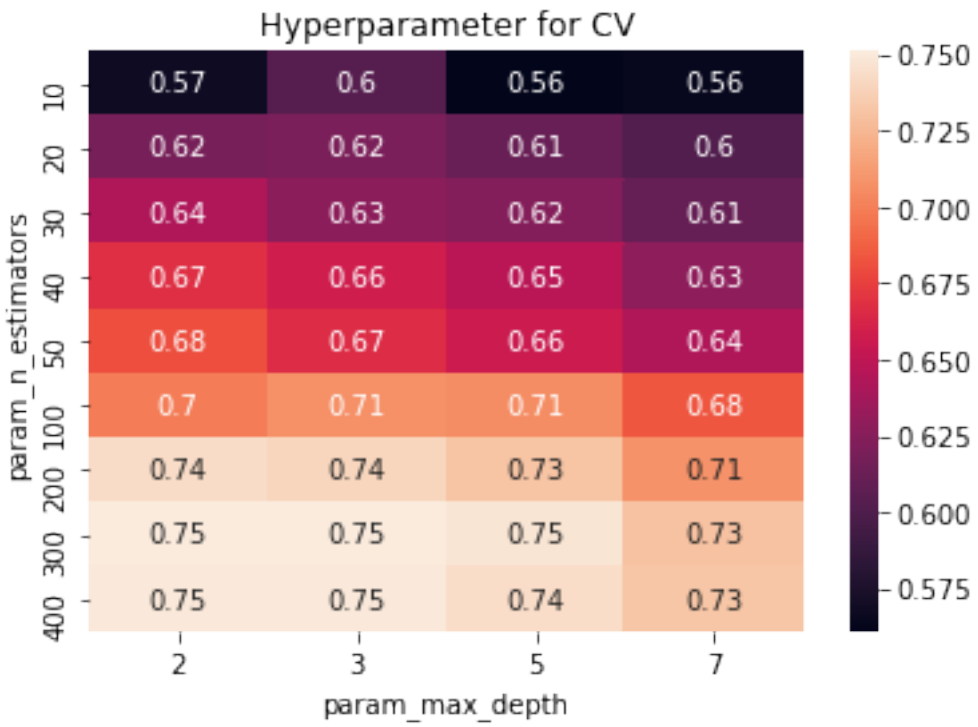
[44]:
```
# Impoer Random Forest
from sklearn.ensemble import RandomForestClassifier
```

[45]:
```
# RandomForest (See Docs: https://scikit-learn.org/stable/modules/generated/
 ↪sklearn.ensemble.RandomForestClassifier.html)

# List of hyperparameter that has t be tuned
params = {'n_estimators':[10,20,30,40,50,100,200,300,400],'max_depth':[2,3,5,7]}
# Instance of randomforest
rf_model = RandomForestClassifier(random_state=42)
# Perform GridSearchCV to find best parameters
rf_clf = hyperparameter_model(rf_model, params)
```

[46]:
```
# Ref: https://stackoverflow.com/questions/48791709/
 ↪how-to-plot-a-heat-map-on-pivot-table-after-grid-search

# Plotting of hyperpameter of train and cv score
pvt_tr = pd.pivot_table(pd.DataFrame(rf_clf.cv_results_),␣
 ↪values='mean_train_score', index='param_n_estimators',␣
 ↪columns='param_max_depth')
pvt_cv = pd.pivot_table(pd.DataFrame(rf_clf.cv_results_),␣
 ↪values='mean_test_score', index='param_n_estimators',␣
 ↪columns='param_max_depth')
plt.figure(1)
plt.title('Hyperparameter for Train')
sns.heatmap(pvt_tr, annot=True)
plt.figure(2)
```

```
plt.title('Hyperparameter for CV')
sns.heatmap(pvt_cv, annot=True)
plt.show()
```





[47]:
```
print(rf_clf.best_params_)
```

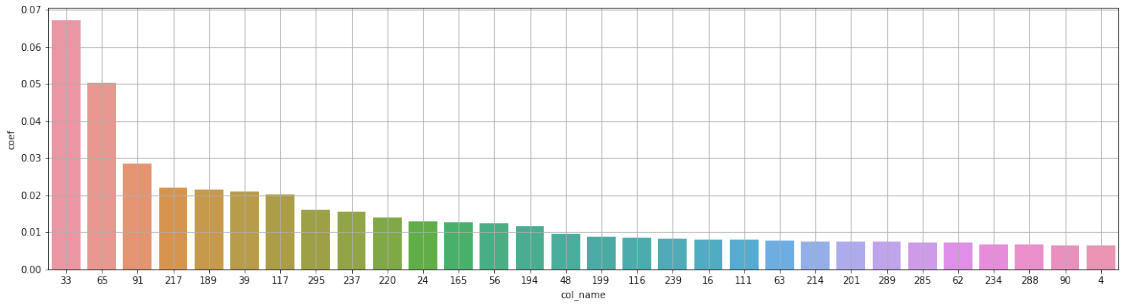
```
{'max_depth': 2, 'n_estimators': 300}
```

[48]:
```
# Instance of randomforest with best parameters
rf_model = RandomForestClassifier(**rf_clf.best_params_, random_state=42)
# Fit the model
rf_model.fit(tr_X,tr_y)
# Calibrate the model
clf = CalibratedClassifierCV(rf_clf, cv=3)
clf.fit(tr_X, tr_y)
```

[48]:
```
CalibratedClassifierCV(base_estimator=GridSearchCV(cv=RepeatedStratifiedKFold(n_
repeats=5, n_splits=10, random_state=42),
                                                   error_score=nan,
estimator=RandomForestClassifier(bootstrap=True,
    ccp_alpha=0.0,
    class_weight=None,
    criterion='gini',
    max_depth=None,
    max_features='auto',
    max_leaf_nodes=None,
    max_samples=None,
```

```
    min_impurity_decrease=0.0,
    min_impurity_split=N…
    min_samples_split=2,
    min_weight_fraction_leaf=0.0,
    n_estimators=100,
    n_jobs=None,
    oob_score=False,
    random_state=42,
    verbose=0,
    warm_start=False),
                                                    iid='deprecated',
                                                    n_jobs=None,
                                                    param_grid={'max_depth': [2,
                                                                              3,
                                                                              5,
                                                                              7],
                                                                'n_estimators':
[10,
20,
30,
40,
50,
100,
200,
300,
400]},
                                                    pre_dispatch='2*n_jobs',
                                                    refit=True,
                                                    return_train_score=True,
                                                    scoring='roc_auc',
                                                    verbose=0),
                        cv=3, method='sigmoid')
```

[49]:
```
# Plot the feature importance based on this model
df = plot_feature_importance(rf_model, 'rf',30)
```

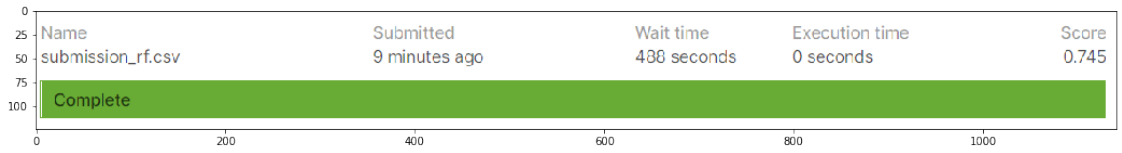


16 5.4.1 Kaggle Score without top features

[50]:
```
# Create a submission file format to submit in kaggle
temp_id = df_test['id']
rf_csv = clf.predict_proba(ts_X)[:,1]
rf_df = pd.DataFrame(np.column_stack((temp_id,rf_csv)), columns=['id','target'])
rf_df['id'] = rf_df['id'].astype('int32')
rf_df.to_csv(data_dir+'/submission_rf.csv', index=False)
```

[51]:
```
image = plt.imread(data_dir+'/submission_rf.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[51]: <matplotlib.image.AxesImage at 0x23940d2e188>



17 5.4.2 Kaggle Score Using top 10 features based on Random-Forest Model

[52]:
```
top_column = forward_selection_model(rf_model)
```

```
for 1 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 33 and score: 0.71
Appended to top column
[33]
for 2 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 65 and score: 0.7651388888888888
Appended to top column
[33, 65]
for 3 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 91 and score: 0.7865277777777777
Appended to top column
[33, 65, 91]
for 4 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 199 and score: 0.7890277777777779
Appended to top column
[33, 65, 91, 199]
for 5 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 217 and score: 0.8052777777777779
Appended to top column
[33, 65, 91, 199, 217]
for 6 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 214 and score: 0.8094444444444444
Appended to top column
[33, 65, 91, 199, 217, 214]
for 7 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 189 and score: 0.8162500000000001
Appended to top column
[33, 65, 91, 199, 217, 214, 189]
for 8 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 132 and score: 0.8291666666666667
Appended to top column
[33, 65, 91, 199, 217, 214, 189, 132]
for 9 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

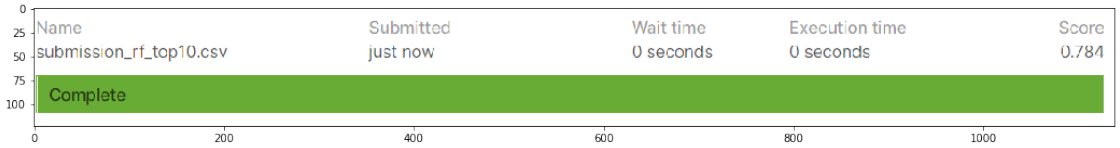
[53]:
```
# Store the top column name into set
rf_top10_feat = set(top_column)
```

[54]:
```
# Fit RF on top features only
rf_model_top = RandomForestClassifier(**rf_clf.best_params_, random_state=42)
rf_model_top.fit(tr_X[:,top_column],tr_y)
# Calibrate it in top features only
clf = CalibratedClassifierCV(rf_model_top, cv=3)
clf.fit(tr_X[:,top_column],tr_y)
# Predict the probabilities of 1
ts_pred = clf.predict_proba(ts_X[:,top_column])[:,1]
```

[55]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
df_tspred = pd.DataFrame(np.column_stack((temp_id,ts_pred)),␣
 ↪columns=['id','target'])
df_tspred['id'] = df_tspred['id'].astype('int32')
df_tspred.to_csv(data_dir+'/submission_rf_top10.csv', index=False)
```

[56]:
```
image = plt.imread(data_dir+'/rf_csv_top10.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[56]:
```
<matplotlib.image.AxesImage at 0x239430ef188>
```



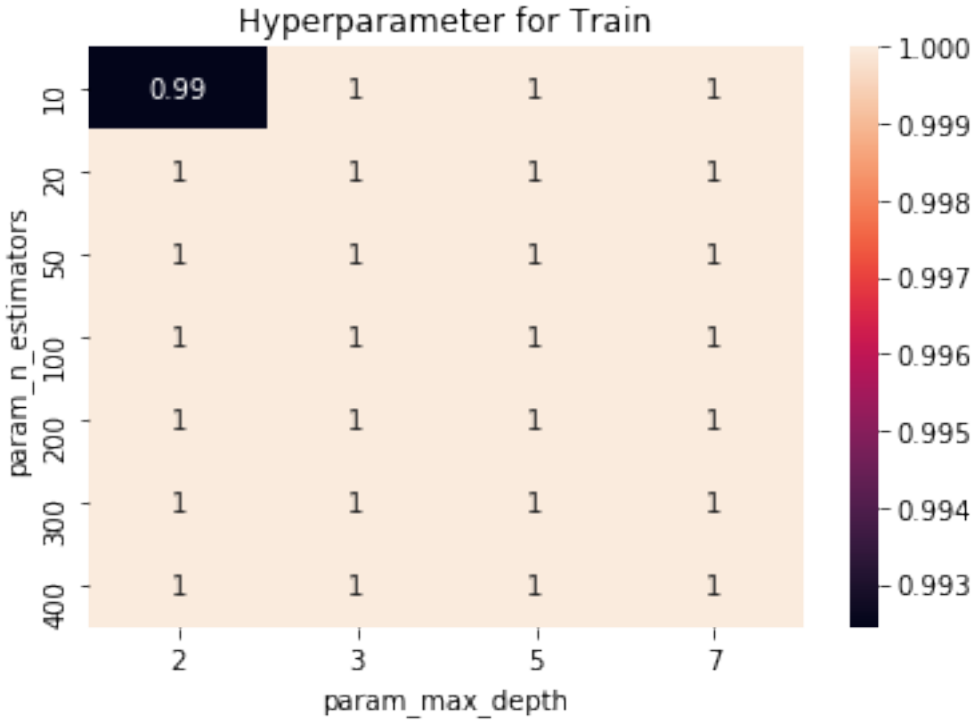
18 5.5 XGBoost

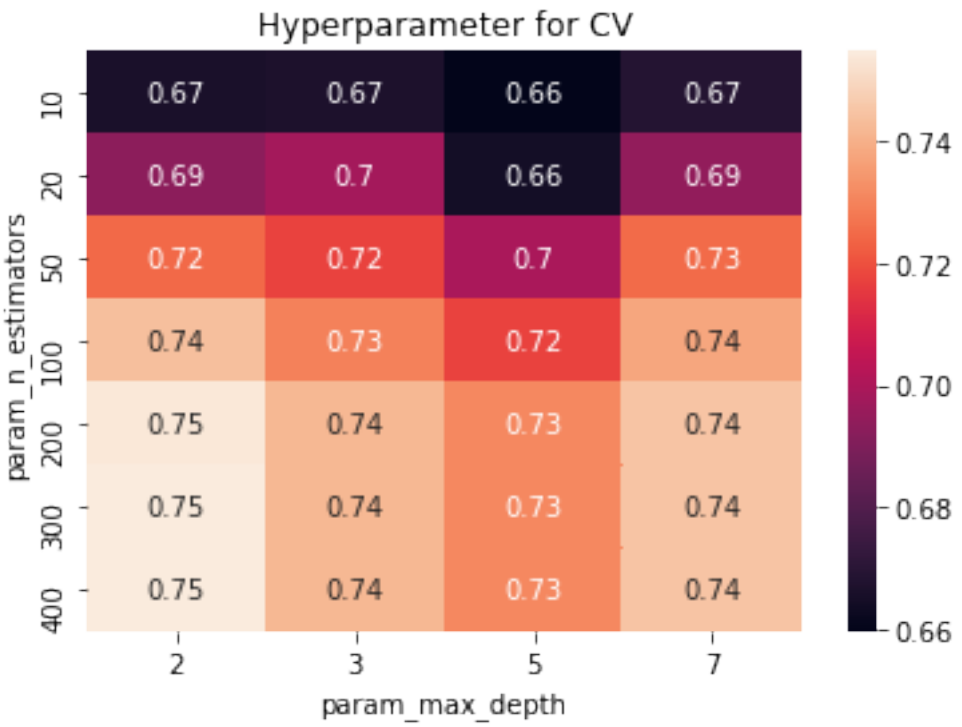
[57]:
```
# Import Xgboost
from xgboost import XGBClassifier
```

[58]:
```
# Xgboost (See Docs: https://xgboost.readthedocs.io/en/latest/python/python_api.
 ↪html)

# List of hyperparameter that has to be tuned
```

```
params = {'max_depth':[2,3,5,7], 'n_estimators':[10,20,50,100,200,300,400]}
# Instance of XGBoost Model
xgb_model = XGBClassifier(scale_pos_weight=0.5)
# Call hyperparameter to find the best parameters
xgb_clf = hyperparameter_model(xgb_model, params)
```

[59]:
```
# Ref: https://stackoverflow.com/questions/48791709/
 ↪how-to-plot-a-heat-map-on-pivot-table-after-grid-search

# Plotting of hyperpameter of train and cv score
pvt_tr = pd.pivot_table(pd.DataFrame(xgb_clf.cv_results_),␣
 ↪values='mean_train_score', index='param_n_estimators',␣
 ↪columns='param_max_depth')
pvt_cv = pd.pivot_table(pd.DataFrame(xgb_clf.cv_results_),␣
 ↪values='mean_test_score', index='param_n_estimators',␣
 ↪columns='param_max_depth')
plt.figure(1)
plt.title('Hyperparameter for Train')
sns.heatmap(pvt_tr, annot=True)
plt.figure(2)
plt.title('Hyperparameter for CV')
sns.heatmap(pvt_cv, annot=True)
plt.show()
```

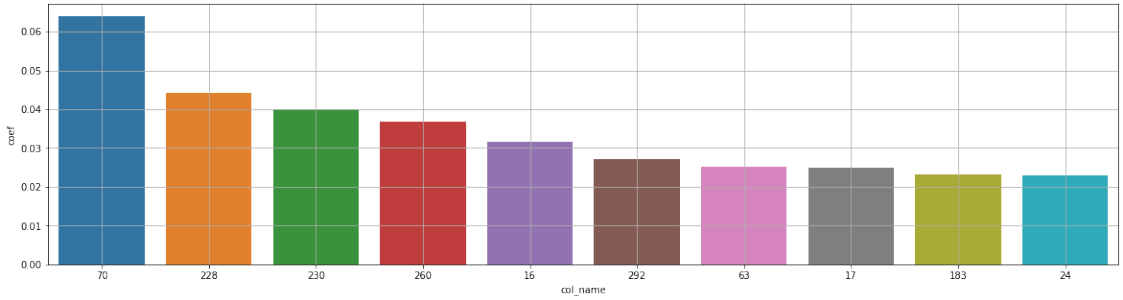




[60]:
```
print(xgb_clf.best_params_)
```

```
{'max_depth': 2, 'n_estimators': 300}
```

[61]:
```
# Instance of randomforest with best parameters
xgb_model = XGBClassifier(**xgb_clf.best_params_, random_state=42,␣
 ↪scale_pos_weight=0.5)
# Fit the model
xgb_model.fit(tr_X,tr_y)

# Instance of XGBoost model with best parameters
df = plot_feature_importance(xgb_model, 'xgb',10)
```



[62]:
```
# Calibrate the model
clf = CalibratedClassifierCV(xgb_clf, cv=3)
clf.fit(tr_X, tr_y)
```

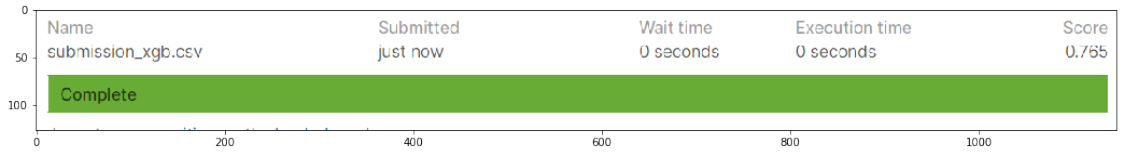
[62]:
```
CalibratedClassifierCV(base_estimator=GridSearchCV(cv=RepeatedStratifiedKFold(n_
repeats=5, n_splits=10, random_state=42),
                                                   error_score=nan,
estimator=XGBClassifier(base_score=None,
booster=None,
colsample_bylevel=None,
colsample_bynode=None,
colsample_bytree=None,
gamma=None,
gpu_id=None,
importance_type='gain',
interaction_constraints=None,
learning_rate=None,
                                                                        m…
random_state=None,
reg_alpha=None,
reg_lambda=None,
scale_pos_weight=0.5,
subsample=None,
tree_method=None,
validate_parameters=False,
verbosity=None),
                                                   iid='deprecated',
                                                   n_jobs=None,
                                                   param_grid={'max_depth': [2,
                                                                             3,
                                                                             5,
                                                                             7],
                                                               'n_estimators':
[10,
20,
50,
100,
200,
300,
400]},
                                                   pre_dispatch='2*n_jobs',
                                                   refit=True,
                                                   return_train_score=True,
                                                   scoring='roc_auc',
                                                   verbose=0),
                       cv=3, method='sigmoid')
```

19 5.5.1 Kaggle Score without top features

[63]:
```
# Create submission file format to submit in Kaggle
temp_id = df_test['id']
xgb_csv = clf.predict_proba(ts_X)[:,1]
xgb_df = pd.DataFrame(np.column_stack((temp_id,xgb_csv)),␣
 ↪columns=['id','target'])
xgb_df['id'] = xgb_df['id'].astype('int32')
xgb_df.to_csv(data_dir+'/submission_xgb.csv', index=False)
```

[64]:
```
image = plt.imread(data_dir+'/submission_xgb.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[64]:
```
<matplotlib.image.AxesImage at 0x23954828048>
```



20 5.5.2 Using top 10 features of this model

[65]:
```
top_column = forward_selection_model(xgb_model)
```

```
for 1 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 91 and score: 0.6425
Appended to top column
[91]
for 2 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 120 and score: 0.7105555555555556
Appended to top column
[91, 120]
for 3 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 33 and score: 0.7479166666666666
Appended to top column
[91, 120, 33]
for 4 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 108 and score: 0.7793055555555555
Appended to top column
[91, 120, 33, 108]
for 5 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 141 and score: 0.8012500000000001
Appended to top column
[91, 120, 33, 108, 141]
for 6 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 246 and score: 0.83
Appended to top column
[91, 120, 33, 108, 141, 246]
for 7 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 146 and score: 0.8494444444444446
Appended to top column
[91, 120, 33, 108, 141, 246, 146]
for 8 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

```
Current top feature 95 and score: 0.8691666666666668
Appended to top column
[91, 120, 33, 108, 141, 246, 146, 95]
for 9 feature
```

```
HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))


Current top feature 230 and score: 0.8737500000000001
Appended to top column
[91, 120, 33, 108, 141, 246, 146, 95, 230]
for 10 feature

HBox(children=(FloatProgress(value=0.0, max=300.0), HTML(value='')))
```

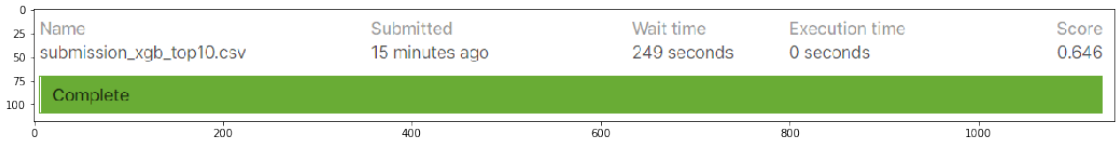
[66]:
```
# Store the top column name into set
xgb_top10_feat = set(top_column)
```

[67]:
```
# Fit RF on top features only
xgb_model_top = XGBClassifier(**xgb_clf.best_params_, random_state=42,␣
 ↪scale_pos_weight=0.5)
xgb_model_top.fit(tr_X[:,top_column],tr_y)
# Calibrate it in top features only
clf = CalibratedClassifierCV(xgb_model_top, cv=3)
clf.fit(tr_X[:,top_column],tr_y)
# Predict the probabilities of 1
ts_pred = clf.predict_proba(ts_X[:,top_column])[:,1]
```

[68]:
```
# Create a submssion format to make submission in Kaggle
temp_id = df_test['id']
df_tspred = pd.DataFrame(np.column_stack((temp_id,ts_pred)),␣
 ↪columns=['id','target'])
df_tspred['id'] = df_tspred['id'].astype('int32')
df_tspred.to_csv(data_dir+'/submission_xgb_top10.csv', index=False)
```

[69]:
```
image = plt.imread(data_dir+'/xgb_csv_top10.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[69]:
```
<matplotlib.image.AxesImage at 0x23954431248>
```



21 5.6 Stacking Classifier

[70]:
```
# Combined all top features of all models
# Ref: https://www.geeksforgeeks.org/union-function-python/
comb_top_feat = list(log_top20_feat.union(svc_top10_feat, rf_top10_feat,␣
↪xgb_top10_feat))
```

[71]:
```
# Import Stacking Classifier
from mlxtend.classifier import StackingClassifier
```

[72]:
```
# StackClassifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
↪classifier/StackingClassifier/#methods)

# Classifier 1: Logistic Regression with best params
clf1 = LogisticRegression(C = 1, penalty = 'l1', solver = 'liblinear',␣
↪class_weight='balanced', random_state=42)
clf1.fit(tr_X,tr_y)
clf1 = CalibratedClassifierCV(clf1, cv=3)

# Classifier 2: SVC with best params
clf2 = SVC(C=10, kernel='rbf', random_state=42, class_weight='balanced',␣
↪probability=True)
clf2.fit(tr_X,tr_y)
clf2 = CalibratedClassifierCV(clf2, cv=3)

# Classifier 3: XGBoost with best params
clf3 = XGBClassifier(max_depth=2, n_estimators=300, scale_pos_weight=0.5)
clf3.fit(tr_X,tr_y)
clf3 = CalibratedClassifierCV(clf3, cv=3)

# Classifier 4: RF with best params
clf4 = RandomForestClassifier(max_depth=2, n_estimators=300)
clf4.fit(tr_X,tr_y)
clf4 = CalibratedClassifierCV(clf4, cv=3)

# Stack Classifier
sclf = StackingClassifier(classifiers=[clf1,clf2,clf3,clf4],␣
↪meta_classifier=clf1, use_probas=True)

# Fit the model
sclf.fit(tr_X, tr_y)
```

[72]:
```
StackingClassifier(average_probas=False,
classifiers=[CalibratedClassifierCV(base_estimator=LogisticRegression(C=1,
          class_weight='balanced',
          dual=False,
          fit_intercept=True,
```

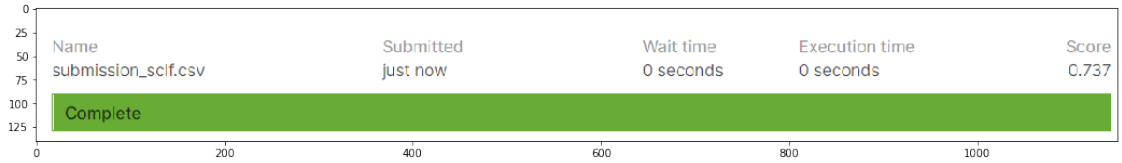
```
            intercept_scaling=1,
            l1_ratio=None,
            max_iter=100,
            multi_class='auto',
            n_jobs=None,
            penalty='l1',
            random_state=42,
            solver='liblinear',
            tol=0.0001,
            verbose=0,
            warm_start=False),
                                                        cv=3, method='sigm…
meta_classifier=CalibratedClassifierCV(base_estimator=LogisticRegression(C=1,
               class_weight='balanced',
               dual=False,
               fit_intercept=True,
               intercept_scaling=1,
               l1_ratio=None,
               max_iter=100,
               multi_class='auto',
               n_jobs=None,
               penalty='l1',
               random_state=42,
               solver='liblinear',
               tol=0.0001,
               verbose=0,
               warm_start=False),
                                                           cv=3,
                                                           method='sigmoid'),
                     store_train_meta_features=False, use_clones=True,
                     use_features_in_secondary=False, use_probas=True, verbose=0)
```

22 5.6.1 Kaggle score without top features

[73]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
sclf_csv = sclf.predict_proba(ts_X)[:,1]
sclf_df = pd.DataFrame(np.column_stack((temp_id,sclf_csv)),␣
 ↪columns=['id','target'])
sclf_df['id'] = sclf_df['id'].astype('int32')
sclf_df.to_csv(data_dir+'/submission_sclf.csv', index=False)
```

[74]:
```
image = plt.imread(data_dir+'/submission_sclf.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[74]: <matplotlib.image.AxesImage at 0x239541fe7c8>



23 5.6.2 Using Top features

[75]:
```
# Fit the model
scif.fit(tr_X[:,comb_top_feat], tr_y)
```

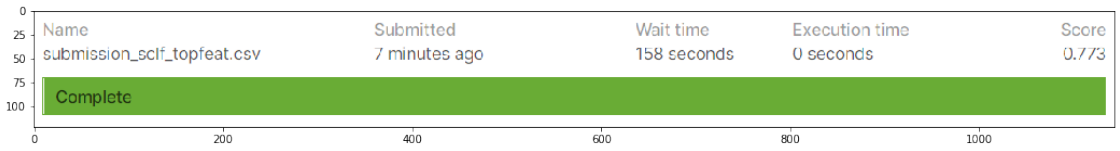
[75]:
```
StackingClassifier(average_probas=False,
classifiers=[CalibratedClassifierCV(base_estimator=LogisticRegression(C=1,
          class_weight='balanced',
          dual=False,
          fit_intercept=True,
          intercept_scaling=1,
          l1_ratio=None,
          max_iter=100,
          multi_class='auto',
          n_jobs=None,
          penalty='l1',
          random_state=42,
          solver='liblinear',
          tol=0.0001,
          verbose=0,
          warm_start=False),
                                                          cv=3, method='sigm…
meta_classifier=CalibratedClassifierCV(base_estimator=LogisticRegression(C=1,
             class_weight='balanced',
             dual=False,
             fit_intercept=True,
             intercept_scaling=1,
             l1_ratio=None,
             max_iter=100,
             multi_class='auto',
             n_jobs=None,
             penalty='l1',
             random_state=42,
             solver='liblinear',
             tol=0.0001,
             verbose=0,
```

```
                warm_start=False),
                                                        cv=3,
                                                        method='sigmoid'),
                      store_train_meta_features=False, use_clones=True,
                      use_features_in_secondary=False, use_probas=True, verbose=0)
```

[76]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
sclf_csv = sclf.predict_proba(ts_X[:, comb_top_feat])[:,1]
sclf_df = pd.DataFrame(np.column_stack((temp_id,sclf_csv)),␣
 ↪columns=['id','target'])
sclf_df['id'] = sclf_df['id'].astype('int32')
sclf_df.to_csv(data_dir+'/submission_sclf_topfeat.csv', index=False)
```

[78]:
```
image = plt.imread(data_dir+'/sclf_topfeat.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[78]:
```
<matplotlib.image.AxesImage at 0x239547174c8>
```



24 5.7 Voting Classifier (Without Stack Classifier + no weights)

[79]:
```
# Import Voting Classifier
from mlxtend.classifier import EnsembleVoteClassifier
```

[80]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1, clf2,clf3,clf4])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

[80]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
```

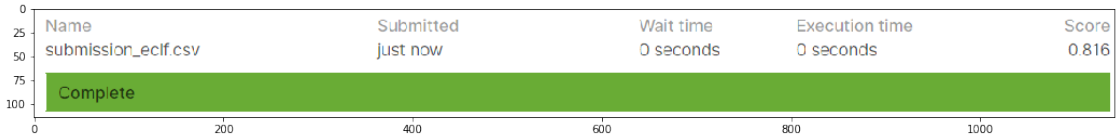
```
            max_iter=100,
            multi_class='auto',
            n_jobs=None,
            penalty='l1',
            random_state=42,
            solver='liblinear',
            tol=0.0001,
            verbose=0,
            warm_start=False),
                                                        cv=3, method='sigmoid'),
                               CalibratedClassifi…
        max_depth=2,
        max_features='auto',
        max_leaf_nodes=None,
        max_samples=None,
        min_impurity_decrease=0.0,
        min_impurity_split=None,
        min_samples_leaf=1,
        min_samples_split=2,
        min_weight_fraction_leaf=0.0,
        n_estimators=300,
        n_jobs=None,
        oob_score=False,
        random_state=None,
        verbose=0,
        warm_start=False),
                                                        cv=3, method='sigmoid')],
                      refit=True, verbose=0, voting='hard', weights=None)
```

25 5.7.1 Kaggle Score without top features

[81]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X)[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf.csv', index=False)
```

[82]:
```
image = plt.imread(data_dir+'/submission_eclf.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[82]:
```
<matplotlib.image.AxesImage at 0x2394d1d85c8>
```



26 5.7.2 Kaggle Score using top features

[83]:
```
# Fit the model
eclf.fit(tr_X[:,comb_top_feat], tr_y)
```

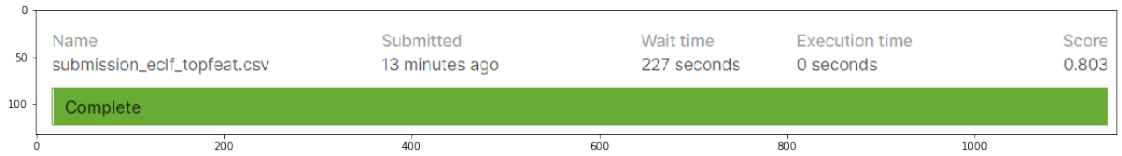
[83]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                                    cv=3, method='sigmoid'),
                          CalibratedClassifi…
    max_depth=2,
    max_features='auto',
    max_leaf_nodes=None,
    max_samples=None,
    min_impurity_decrease=0.0,
    min_impurity_split=None,
    min_samples_leaf=1,
    min_samples_split=2,
    min_weight_fraction_leaf=0.0,
    n_estimators=300,
    n_jobs=None,
    oob_score=False,
    random_state=None,
    verbose=0,
    warm_start=False),
                                                    cv=3, method='sigmoid')],
```

```
                                refit=True, verbose=0, voting='hard', weights=None)
```

[84]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X[:,comb_top_feat])[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_topfeat.csv', index=False)
```

[85]:
```
image = plt.imread(data_dir+'/eclf_topfeat.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[85]:
```
<matplotlib.image.AxesImage at 0x23954f58a48>
```



27 5.8 Voting Classifier (With Stack Classifier + no weights)

[86]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1, clf2,clf3,clf4,sclf])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

[86]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
```

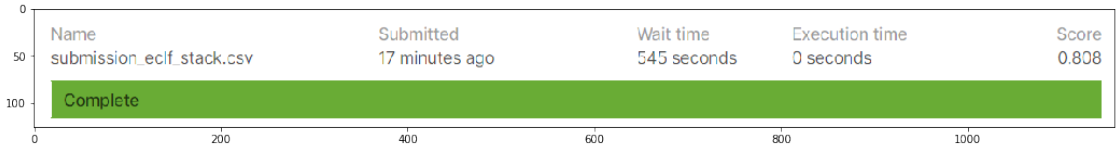
```
        verbose=0,
        warm_start=False),
                                                cv=3, method='sigmoid'),
                            CalibratedClassifi…
                                        fit_intercept=True,
                                        intercept_scaling=1,
                                        l1_ratio=None,
                                        max_iter=100,
                                        multi_class='auto',
                                        n_jobs=None,
                                        penalty='l1',
                                        random_state=42,
                                        solver='liblinear',
                                        tol=0.0001,
                                        verbose=0,
                                        warm_start=False),
         cv=3,
         method='sigmoid'),
                                                store_train_meta_features=False,
                                                use_clones=True,
                                                use_features_in_secondary=False,
                                                use_probas=True, verbose=0)],
                        refit=True, verbose=0, voting='hard', weights=None)
```

28 5.8.1 Kaggle Score without top features

[87]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X)[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_stack.csv', index=False)
```

[88]:
```
image = plt.imread(data_dir+'/submission_eclf_stack.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[88]:
```
<matplotlib.image.AxesImage at 0x23954f34708>
```



29 5.8.2 Kaggle Score using top features

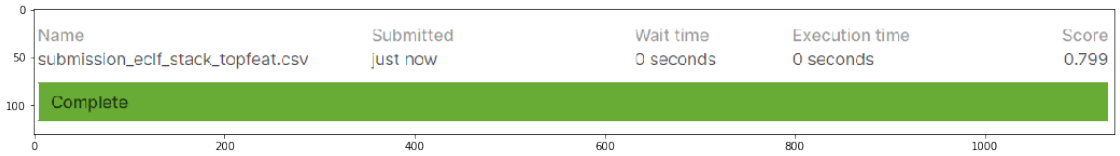
[89]:
```
# Fit the model
eclf.fit(tr_X[:,comb_top_feat], tr_y)
```

[89]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                                cv=3, method='sigmoid'),
                           CalibratedClassifi…
                                      fit_intercept=True,
                                      intercept_scaling=1,
                                      l1_ratio=None,
                                      max_iter=100,
                                      multi_class='auto',
                                      n_jobs=None,
                                      penalty='l1',
                                      random_state=42,
                                      solver='liblinear',
                                      tol=0.0001,
                                      verbose=0,
                                      warm_start=False),
       cv=3,
       method='sigmoid'),
                                             store_train_meta_features=False,
                                             use_clones=True,
                                             use_features_in_secondary=False,
                                             use_probas=True, verbose=0)],
                    refit=True, verbose=0, voting='hard', weights=None)
```

[90]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X[:,comb_top_feat])[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_stack_topfeat.csv', index=False)
```

[92]:
```
image = plt.imread(data_dir+'/submission_eclf_stack_topfeat.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[92]: <matplotlib.image.AxesImage at 0x239553d3408>



30 5.9 Voting Classifier (without Stack Classifier + weights)

[93]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4], weights=[0.4,0.2,0.
↪2,0.2])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

[93]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
```

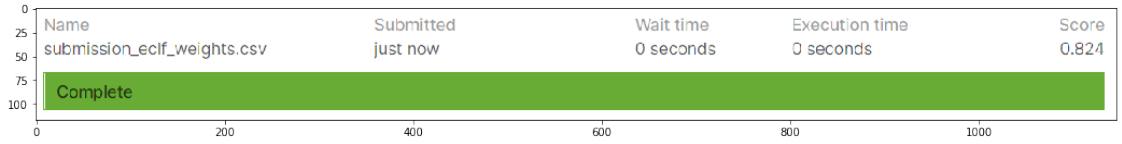
```
        warm_start=False),
                                                    cv=3, method='sigmoid'),
                           CalibratedClassifi…
            max_features='auto',
            max_leaf_nodes=None,
            max_samples=None,
            min_impurity_decrease=0.0,
            min_impurity_split=None,
            min_samples_leaf=1,
            min_samples_split=2,
            min_weight_fraction_leaf=0.0,
            n_estimators=300,
            n_jobs=None,
            oob_score=False,
            random_state=None,
            verbose=0,
            warm_start=False),
                                                    cv=3, method='sigmoid')],
                      refit=True, verbose=0, voting='hard',
                      weights=[0.4, 0.2, 0.2, 0.2])
```

5.9.1 Kaggle Score without top features

[94]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X)[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_weights.csv', index=False)
```

[95]:
```
image = plt.imread(data_dir+'/submission_eclf_weights.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[95]:
```
<matplotlib.image.AxesImage at 0x239552c52c8>
```



31 5.9.2 Kaggle Score using top features

[96]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4], weights=[0.4,0.2,0.
 ↪2,0.2])
# Fit the train data
eclf.fit(tr_X[:,comb_top_feat],tr_y)
```

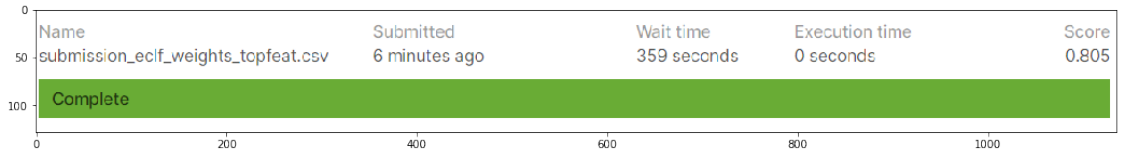
[96]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                                    cv=3, method='sigmoid'),
                           CalibratedClassifi…
          max_features='auto',
          max_leaf_nodes=None,
          max_samples=None,
          min_impurity_decrease=0.0,
          min_impurity_split=None,
          min_samples_leaf=1,
          min_samples_split=2,
          min_weight_fraction_leaf=0.0,
          n_estimators=300,
          n_jobs=None,
          oob_score=False,
          random_state=None,
          verbose=0,
          warm_start=False),
                                                    cv=3, method='sigmoid')],
                    refit=True, verbose=0, voting='hard',
                    weights=[0.4, 0.2, 0.2, 0.2])
```

[97]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
```

```
eclf_csv = eclf.predict_proba(ts_X[:,comb_top_feat])[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_weights_topfeat.csv', index=False)
```

[98]:
```
image = plt.imread(data_dir+'/submission_eclf_weights_topfeat.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[98]:
```
<matplotlib.image.AxesImage at 0x239573ffe48>
```



32 5.10 Voting Classifier (with Stack Classifier + weights)

[99]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4,sclf], weights=[0.4,0.
↪1,0.1,0.2,0.2])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

[99]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                                    cv=3, method='sigmoid'),
```

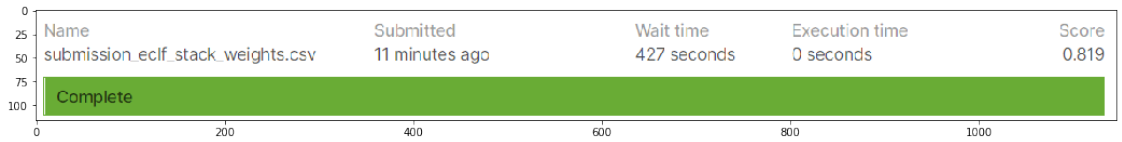
```
                            CalibratedClassifi…
                                        intercept_scaling=1,
                                        l1_ratio=None,
                                        max_iter=100,
                                        multi_class='auto',
                                        n_jobs=None,
                                        penalty='l1',
                                        random_state=42,
                                        solver='liblinear',
                                        tol=0.0001,
                                        verbose=0,
                                        warm_start=False),
        cv=3,
        method='sigmoid'),
                                                store_train_meta_features=False,
                                                use_clones=True,
                                                use_features_in_secondary=False,
                                                use_probas=True, verbose=0)],
                        refit=True, verbose=0, voting='hard',
                        weights=[0.4, 0.1, 0.1, 0.2, 0.2])
```

33 5.10.1 Kaggle Score without top features

[100]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X)[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_stack_weights.csv', index=False)
```

[101]:
```
image = plt.imread(data_dir+'/submission_eclf_stack_weights.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[101]:
```
<matplotlib.image.AxesImage at 0x2395779bd88>
```



34 5.10.2 Kaggle Score using top features

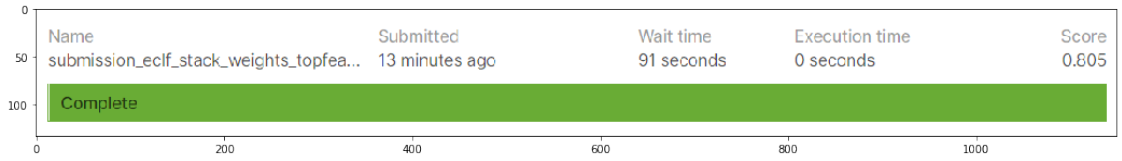
[102]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4,sclf], weights=[0.4,0.
 ↪1,0.1,0.2,0.2])
# Fit the train data
eclf.fit(tr_X[:,comb_top_feat],tr_y)
```

[102]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                                cv=3, method='sigmoid'),
                           CalibratedClassifi…
                                       intercept_scaling=1,
                                       l1_ratio=None,
                                       max_iter=100,
                                       multi_class='auto',
                                       n_jobs=None,
                                       penalty='l1',
                                       random_state=42,
                                       solver='liblinear',
                                       tol=0.0001,
                                       verbose=0,
                                       warm_start=False),
       cv=3,
       method='sigmoid'),
                                              store_train_meta_features=False,
                                              use_clones=True,
                                              use_features_in_secondary=False,
                                              use_probas=True, verbose=0)],
                    refit=True, verbose=0, voting='hard',
                    weights=[0.4, 0.1, 0.1, 0.2, 0.2])
```

[103]:
```
# Create a submission file format to submit in Kaggle
temp_id = df_test['id']
eclf_csv = eclf.predict_proba(ts_X[:,comb_top_feat])[:,1]
eclf_df = pd.DataFrame(np.column_stack((temp_id,eclf_csv)),␣
 ↪columns=['id','target'])
eclf_df['id'] = eclf_df['id'].astype('int32')
eclf_df.to_csv(data_dir+'/submission_eclf_stack_weights_topfeat.csv',␣
 ↪index=False)
```

[104]:
```
image = plt.imread(data_dir+'/submission_eclf_stack_weights_topfeat.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[104]:
```
<matplotlib.image.AxesImage at 0x23957531188>
```



35 6. Summary of All Models

[107]:
```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ['Model','Features','Hyperparameter','Test Score']
x.add_row(['knn','AF',r"{'algorithm': 'kd_tree', 'n_neighbors': 43}",0.681])
x.add_row(['Logistic Regression','AF',r"{'C': 1, 'penalty': 'l1', 'solver':␣
 ↪'liblinear'}",0.819])
x.add_row(['Logistic Regression','top10',r"{'C': 1, 'penalty': 'l1', 'solver':␣
 ↪'liblinear'}",0.807])
x.add_row(['Logistic Regression','top20',r"{'C': 1, 'penalty': 'l1', 'solver':␣
 ↪'liblinear'}",0.802])
x.add_row(['SVC','AF',r"{'C': 10, 'kernel': 'rbf'}",0.741])
x.add_row(['SVC','top10',r"{'C': 10, 'kernel': 'rbf'}",0.574])
x.add_row(['RandomForest','AF',r"{'max_depth': 2, 'n_estimators': 300}",0.745])
x.add_row(['RandomForest','top10',r"{'max_depth': 2, 'n_estimators': 300}",0.
 ↪784])
x.add_row(['XGBoost','AF',r"{'max_depth': 2, 'n_estimators': 300}",0.765])
x.add_row(['XGBoost','top10',r"{'max_depth': 2, 'n_estimators': 300}",0.646])
x.add_row(['Stacking Classifier','AF','-',0.737])
x.add_row(['Stacking Classifier','topfeatures','-',0.773])
x.add_row(['Voting Classifier(No stacking + no weights)','AF',"-",0.816])
```

```
x.add_row(['Voting Classifier(No stacking + no weights)','topfeatures',"-",0.
↪803])
x.add_row(['Voting Classifier(stacking + no weights)','AF',"-",0.808])
x.add_row(['Voting Classifier(stacking + no weights)','topfeatures',"-",0.799])
x.add_row(['Voting Classifier(no stacking + weights)','AF',"-",0.824])
x.add_row(['Voting Classifier(no stacking + weights)','topfeatures',"-",0.805])
x.add_row(['Voting Classifier(stacking + weights)','AF',"-",0.819])
x.add_row(['Voting Classifier(stacking + weights)','topfeatures',"-",0.805])
print(x)
```

```
+-------------------------------------------+------------+------------------
--------------------------------+------------+
|                   Model                   |   Features   |
Hyperparameter                  | Test Score |
+-------------------------------------------+------------+------------------
--------------------------------+------------+
|                    knn                    |      AF      |   {'algorithm':
'kd_tree', 'n_neighbors': 43}    |   0.681    |
|            Logistic Regression            |      AF      | {'C': 1,
'penalty': 'l1', 'solver': 'liblinear'} |   0.819    |
|            Logistic Regression            |    top10     | {'C': 1,
'penalty': 'l1', 'solver': 'liblinear'} |   0.807    |
|            Logistic Regression            |    top20     | {'C': 1,
'penalty': 'l1', 'solver': 'liblinear'} |   0.802    |
|                    SVC                    |      AF      |            {'C':
10, 'kernel': 'rbf'}            |   0.741    |
|                    SVC                    |    top10     |            {'C':
10, 'kernel': 'rbf'}            |   0.574    |
|                RandomForest               |      AF      |      {'max_depth':
2, 'n_estimators': 300}       |   0.745    |
|                RandomForest               |    top10     |      {'max_depth':
2, 'n_estimators': 300}       |   0.784    |
|                 XGBoost                   |      AF      |      {'max_depth':
2, 'n_estimators': 300}       |   0.765    |
|                 XGBoost                   |    top10     |      {'max_depth':
2, 'n_estimators': 300}       |   0.646    |
|            Stacking Classifier            |      AF      |
-                         |   0.737    |
|            Stacking Classifier            | topfeatures |
-                         |   0.773    |
| Voting Classifier(No stacking + no weights) |      AF      |
-                         |   0.816    |
| Voting Classifier(No stacking + no weights) | topfeatures |
-                         |   0.803    |
|   Voting Classifier(stacking + no weights)  |      AF      |
-                         |   0.808    |
|   Voting Classifier(stacking + no weights)  | topfeatures |
```

```
-                          |   0.799    |
|   Voting Classifier(no stacking + weights)  |      AF     |
-                          |   0.824    |
|   Voting Classifier(no stacking + weights)  | topfeatures |
-                          |   0.805    |
|    Voting Classifier(stacking + weights)    |      AF     |
-                          |   0.819    |
|    Voting Classifier(stacking + weights)    | topfeatures |
-                          |   0.805    |
+---------------------------------------------+-------------+-------------------
------------------------------+------------+
```

Notation: 1. AF: All features 2. top10: Find top 10 features using forward feature selections of that model 3. top20: Find top 20 features using forward feature selections of that model 4. topfeatures: combining all the top features generated using forward feature selection of that model.

[ ]: