# 4_3_Models

April 20, 2020

## 1 FE + Dimension Reduction + Standardization + ML Classification Model

1. No oversampling techniques applied
2. 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 StandardScaler
import tqdm
# Dimension reduction
```

```python
from sklearn.decomposition import PCA
```

# 3 2. Read train data

[2]:
```python
# 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]:
```python
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. Apply Feature Engg

[4]:
```
# We already saw in 2_FE.ipynb file that we created a feat_enng function. We␣
↪just put it here

def feature_engg(df, if_test = False):
    '''
    Perform Feature Engg in Basic Stats, Trigometrics, Hyperbolic and␣
↪Exponential Function

    Parameters:
    df: Pass DataFrame (all features much be in numric values)
    if_test: If the DataFrame is test data or train data. Ig it is test data,␣
↪put if_test=True

    Return:
    DataFrame with feature engineering appended
    '''

    if if_test:
        temp = df.drop(['id'], axis=1)
    else:
        temp = df.drop(['id','target'], axis=1)

    # Mean and Std FE
    df['mean'] = np.mean(temp, axis=1)
    df['std'] = np.std(temp, axis=1)

    # Trigometric FE
    sin_temp = np.sin(temp)
    cos_temp = np.cos(temp)
    tan_temp = np.tan(temp)
    df['mean_sin'] = np.mean(sin_temp, axis=1)
    df['mean_cos'] = np.mean(cos_temp, axis=1)
    df['mean_tan'] = np.mean(tan_temp, axis=1)

    # Hyperbolic FE
    sinh_temp = np.sinh(temp)
    cosh_temp = np.cosh(temp)
    tanh_temp = np.tanh(temp)
    df['mean_sinh'] = np.mean(sin_temp, axis=1)
    df['mean_cosh'] = np.mean(cos_temp, axis=1)
    df['mean_tanh'] = np.mean(tan_temp, axis=1)

    # Exponents FE
    exp_temp = np.exp(temp)
    expm1_temp = np.expm1(temp)
```

```
    exp2_temp = np.exp2(temp)
    df['mean_exp'] = np.mean(exp_temp, axis=1)
    df['mean_expm1'] = np.mean(expm1_temp, axis=1)
    df['mean_exp2'] = np.mean(exp2_temp, axis=1)

    # Polynomial FE
    # X**2
    df['mean_x2'] = np.mean(np.power(temp,2), axis=1)
    # X**3
    df['mean_x3'] = np.mean(np.power(temp,3), axis=1)
    # X**4
    df['mean_x4'] = np.mean(np.power(temp,4), axis=1)

    return df
```

[5]:
```
df_train = feature_engg(df_train)
df_train.head(5)
```

[5]:
```
   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  ...

   mean_tan  mean_sinh  mean_cosh  mean_tanh  mean_exp  mean_expm1  mean_exp2  \
0 -0.315591  -0.010536   0.537968  -0.315591  1.760647    0.760647   1.315869
1  0.607457   0.075490   0.611600   0.607457  1.712292    0.712292   1.324817
2  0.104777  -0.005509   0.599358   0.104777  1.749107    0.749107   1.313960
3  0.891722   0.046067   0.645721   0.891722  1.752101    0.752101   1.326229
4  0.274261   0.059548   0.643508   0.274261  1.861741    0.861741   1.377569

    mean_x2   mean_x3   mean_x4
0  1.182425  0.015243  3.584848
1  0.976056  0.047272  2.766570
2  1.023024  0.266454  3.092631
3  0.887980  0.371308  2.553467
4  0.901115  0.613952  2.671541

[5 rows x 316 columns]
```

[6]:
```
df_test = feature_engg(df_test, True)
df_test.head(5)
```

[6]:
```
    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  …

   mean_tan  mean_sinh  mean_cosh  mean_tanh  mean_exp  mean_expm1  mean_exp2  \
0  0.565830   0.094378   0.609398   0.565830  1.904397    0.904397   1.404195
1 -1.641918  -0.018425   0.570495  -1.641918  1.642217    0.642217   1.265487
2 -0.516155  -0.012641   0.611053  -0.516155  1.517775    0.517775   1.214393
3 -0.816079   0.002689   0.610619  -0.816079  1.566765    0.566765   1.243412
4 -1.547172   0.067329   0.611907  -1.547172  1.849024    0.849024   1.374870

    mean_x2   mean_x3   mean_x4
0  0.985912  0.477020  2.913247
1  1.094274 -0.128315  3.281111
2  0.994294 -0.330590  3.062801
3  0.956136 -0.076546  2.382968
4  0.988710  0.371320  3.079160

[5 rows x 315 columns]
```

## 5 4. Take train and test values from DataFrame

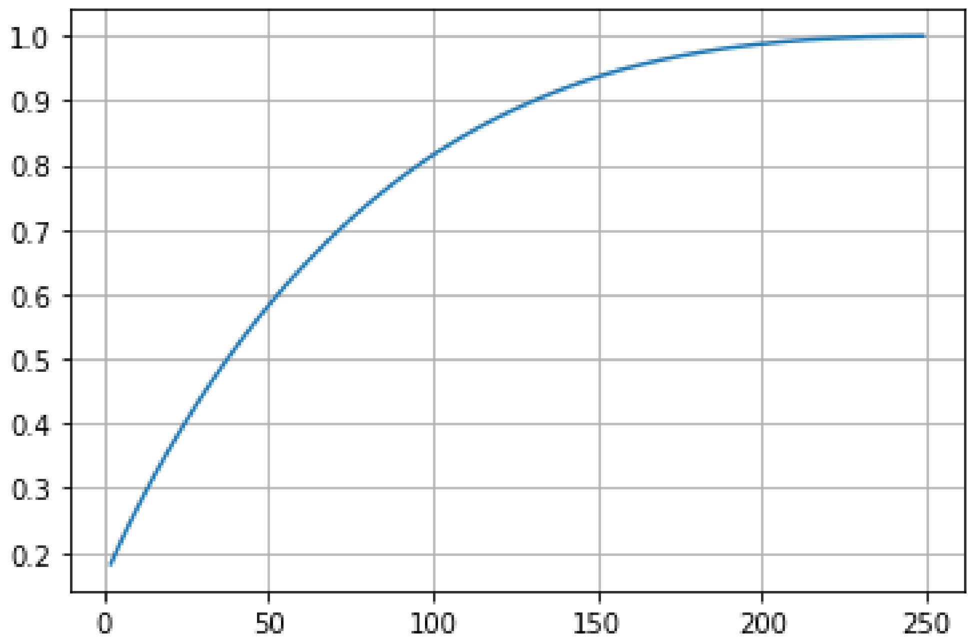
[7]:
```
# Take separate for features value
tr_X = df_train.drop(['id','target'], axis=1)
# Take separate for class value
tr_y = df_train['target'].values
# Take test feature value
ts_X = df_test.drop(['id'], axis=1)
```

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

## 6 5. PCA - Principal Components Analysis

[8]:
```
exp_rat = []
for i in range(2,min(tr_X.shape[0],tr_X.shape[1])):
    pca = PCA(n_components=i)
    pca.fit(tr_X,tr_y)
    exp_rat.append(np.sum(pca.explained_variance_ratio_))
```

[9]:
```
plt.plot(np.arange(2,min(tr_X.shape[0],tr_X.shape[1])),exp_rat)
plt.grid()
plt.show()
```




Let take n_components = 100 which retain 80-85% data

[10]:
```
# Fit and transform on train data and transform on cv and test data
pca = PCA(n_components=100)
tr_X = pca.fit_transform(tr_X,tr_y)
ts_X = pca.transform(ts_X)
```

# 7 6. Standardization

[11]:
```
stand_vec = StandardScaler()
tr_X = stand_vec.fit_transform(tr_X)
pd.DataFrame(tr_X).head(5)
```

[11]:

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | \ |
|---|---|---|---|---|---|---|---|---|
| 0 | -0.166673 | 0.716303 | 1.061006 | 0.283135 | 0.765347 | 1.253518 | -1.967637 | |
| 1 | 0.031105 | 0.688296 | -0.679376 | -1.075485 | 1.484971 | -1.484536 | -0.954770 | |
| 2 | -0.037655 | 0.759798 | 0.240590 | -1.494130 | 0.680533 | -1.507534 | -1.475887 | |
| 3 | 0.089884 | -0.794913 | 0.652919 | -0.124737 | -1.415833 | 0.182715 | 1.361817 | |
| 4 | -0.048058 | 0.464460 | 0.932549 | 0.062235 | 1.730730 | -0.003666 | -1.875208 | |

| | 7 | 8 | 9 | … | 90 | 91 | 92 | 93 | \ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.739057 | -1.551768 | 2.025589 | … | -0.595692 | -0.318748 | -1.337064 | 2.628657 | |
| 1 | -1.640496 | 0.533955 | -1.032526 | … | 1.414106 | -0.001174 | 0.156322 | 0.900612 | |
| 2 | 1.563435 | -0.133188 | 1.023150 | … | 1.752939 | 1.005274 | -0.664277 | 0.933295 | |
| 3 | -0.364036 | 1.076568 | -0.197581 | … | 0.693881 | 0.713162 | -0.981445 | -1.106564 | |

```
4  0.016811  0.794978  1.687170  … -1.366679 -0.379423  0.101277 -0.234361

         94        95        96        97        98        99
0  0.170896  1.266913 -0.725125 -0.328609 -0.029965 -0.067125
1 -0.065687  0.146486  0.987334  0.269771 -1.352687  0.748062
2  0.279115  0.701745  0.674709 -0.358302 -1.274508 -1.814593
3 -1.178461  0.141677 -2.065266 -1.978613 -1.559254 -0.184509
4 -1.180351 -0.475823 -1.364242  0.418845 -0.064071 -0.862030

[5 rows x 100 columns]
```

[12]:
```python
ts_X = stand_vec.transform(ts_X)
pd.DataFrame(ts_X).head(5)
```

[12]:
```
          0         1         2         3         4         5         6  \
0  0.019110  0.276096 -0.061850 -0.436308  0.152002 -0.063529  0.282660
1 -0.361623 -0.459394  0.611061 -0.043825 -0.601051 -0.794353 -0.333588
2 -0.174794  0.385567 -0.876048  0.592629  0.129279 -0.328676 -0.401293
3 -0.220446  0.983462 -0.596268  0.007514 -0.104571  0.285299 -0.541471
4 -0.327378 -0.630620 -1.088273 -1.305239 -0.065958  0.116384 -0.027180

          7         8         9  …        90        91        92        93  \
0 -0.963953  0.269206  0.077995  … -0.743524 -0.357727 -0.367373 -0.832358
1  0.045550  0.197833  0.466416  … -1.227608 -0.117458 -0.640373 -0.619610
2  1.146829 -0.305653 -0.500269  …  0.998926  1.647119 -0.347204 -0.904379
3  0.045604 -0.163915  0.472175  …  1.487871  0.153404 -0.337140 -1.482203
4  0.027114 -0.500452 -0.846949  …  0.249169  0.517964  0.206816 -0.102744

         94        95        96        97        98        99
0 -1.211555  0.123960 -1.542254  0.698954  0.393598 -0.215651
1  0.566481  0.970761 -0.286684  1.293203 -0.134996 -0.749521
2  0.172312 -0.845432 -1.661443  1.292290  2.376381 -0.957758
3 -0.039025 -1.118181 -0.131397  0.612306 -0.730028 -0.996033
4 -0.936385  1.129054 -0.643586  0.104072 -0.879719  0.345509

[5 rows x 100 columns]
```

# 8 7. Apply ML Models (with hyperparameter)

[13]:
```python
def hyperparameter_model(models, params):
    '''
    Hyperparameter tuning with StratifiedKFold follow by GridSearchCV follow by␣
 ↪CalibratedClassifier

    Parameters:
    models: Instance of the model
```

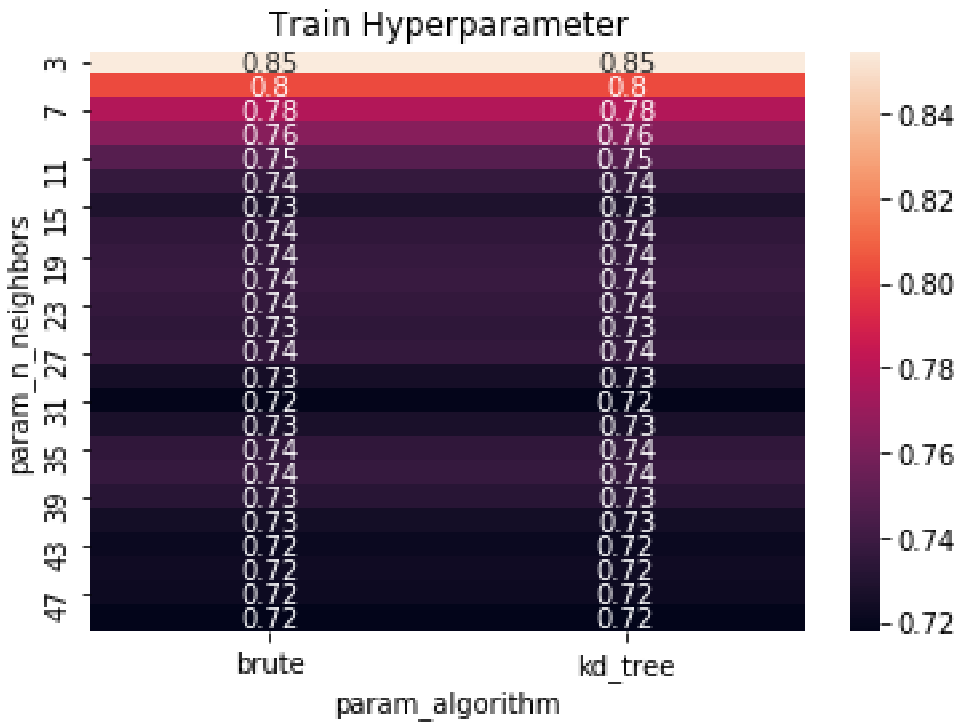
```
    params: list of parameters with value fr tuning (dict)

    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
```

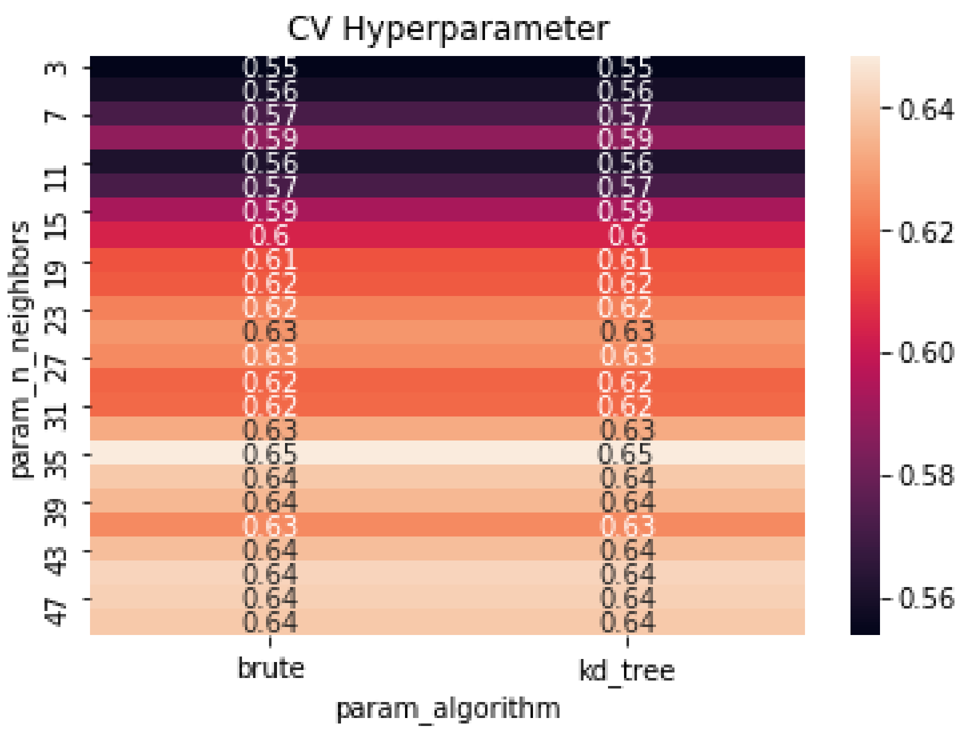
# 9 7.1 kNN

[14]:
```
# Import KNN
from sklearn.neighbors import KNeighborsClassifier
```

[15]:
```
# 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)
```

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


Train Hyperparameter
param_n_neighbors
param_algorithm
brute
kd_tree


CV Hyperparameter
param_n_neighbors
param_algorithm
brute
kd_tree

[17]:
```python
print(knn_clf.best_params_)
```

```
{'algorithm': 'kd_tree', 'n_neighbors': 35}
```

[18]:
```python
clf = CalibratedClassifierCV(knn_clf, cv=3)
clf.fit(tr_X,tr_y)
```

[18]:
```
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,
```

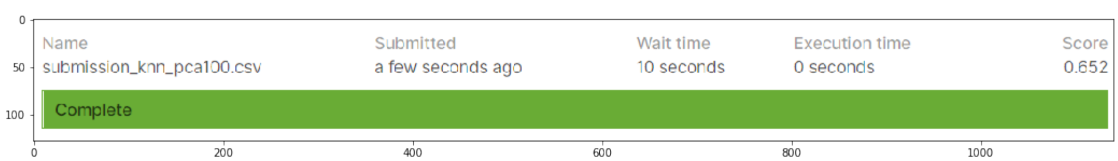
```
49]},
                                                    pre_dispatch='2*n_jobs',
                                                    refit=True,
                                                    return_train_score=True,
                                                    scoring='roc_auc',
                                                    verbose=0),
                       cv=3, method='sigmoid')
```

# 10 7.1.1 Kaggle Score

[19]:
```
# 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_pca100.csv', index=False)
```

[20]:
```
image = plt.imread(data_dir+'/submission_knn_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[20]:
```
<matplotlib.image.AxesImage at 0x209091d11c8>
```




## 10.1 7.2 Logistic Regression

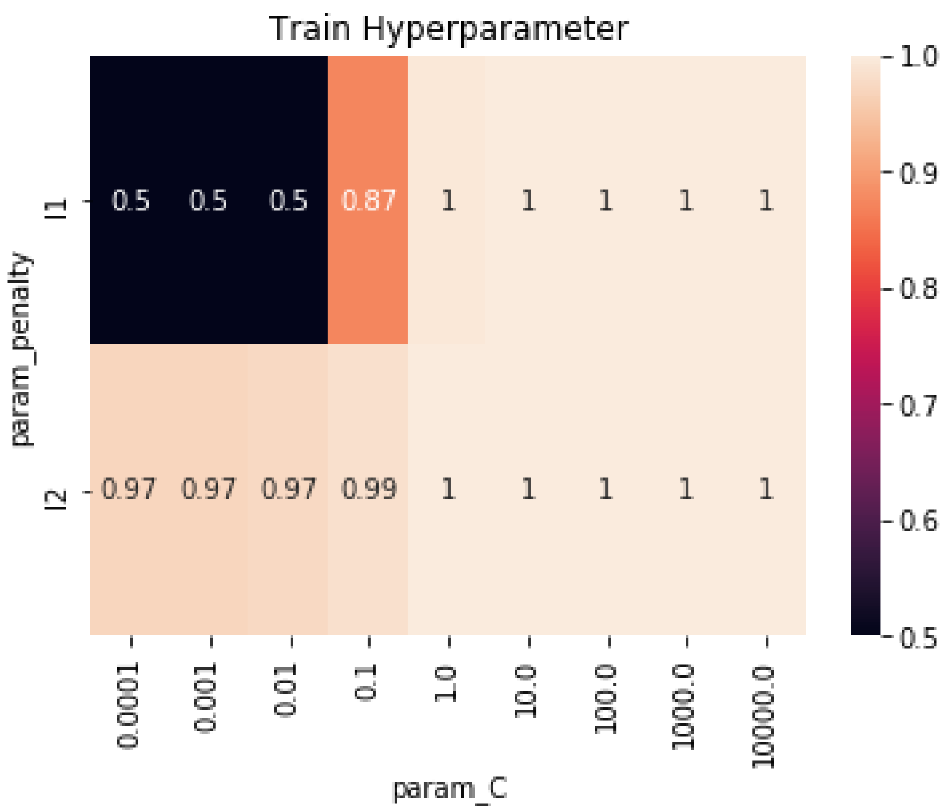
[21]:
```
# Import Logistic Regression
from sklearn.linear_model import LogisticRegression
```

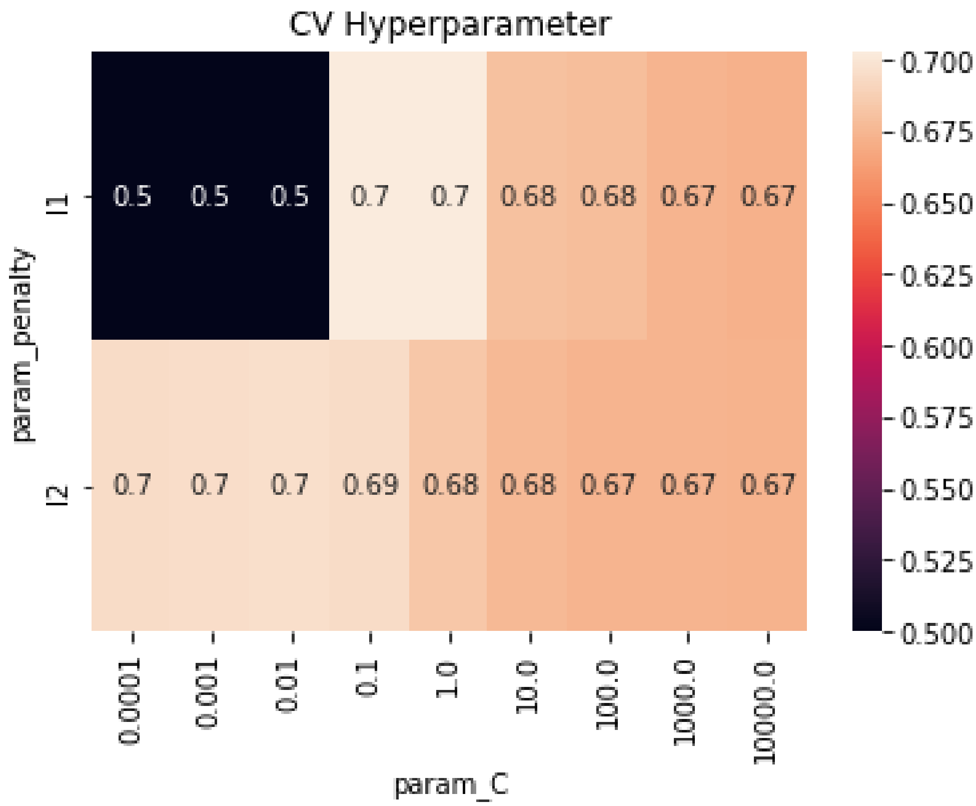
[22]:
```
# LogisticRegression (See Docs: https://scikit-learn.org/stable/modules/
↪generated/sklearn.linear_model.LogisticRegression.html)

# 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)
```

[23]:

```
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()
```






[24]:
```
print(log_clf.best_params_)
```

```
{'C': 0.1, 'penalty': 'l1', 'solver': 'liblinear'}
```

[25]:
```
clf = CalibratedClassifierCV(log_clf, cv=3)
clf.fit(tr_X,tr_y)
```

[25]:
```
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,
```

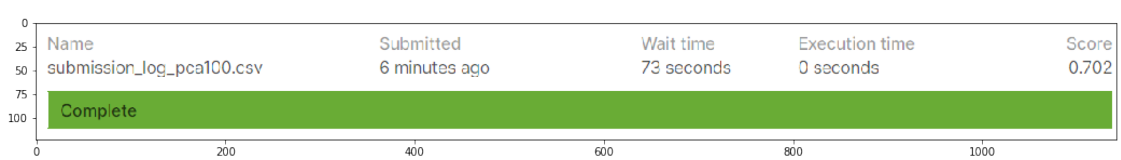
```
solver='lbfgs',
tol=0.0001,
verbose=0,
warm_start=False),
                                                   iid='deprecated',
                                                   n_jobs=None,
                                                   param_grid={'C': [0.0001,
                                                                     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')
```

# 11 7.2.1 Kaggle Score

[26]:
```
# 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_pca100.csv', index=False)
```

[27]:
```
image = plt.imread(data_dir+'/submission_log_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[27]: <matplotlib.image.AxesImage at 0x2090934f388>

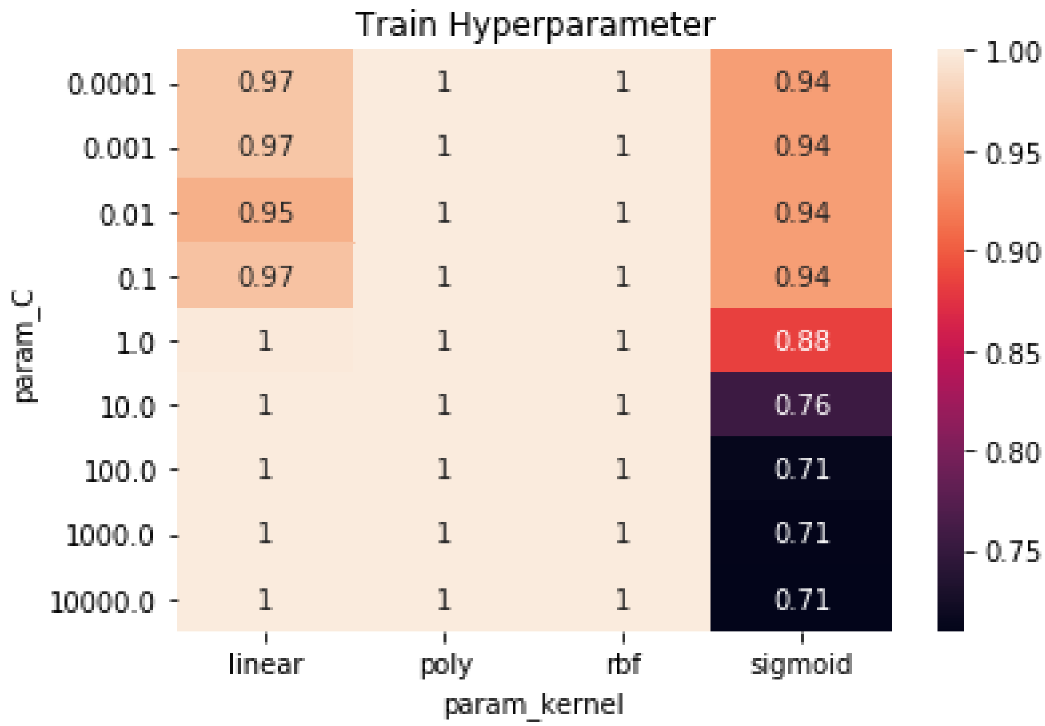


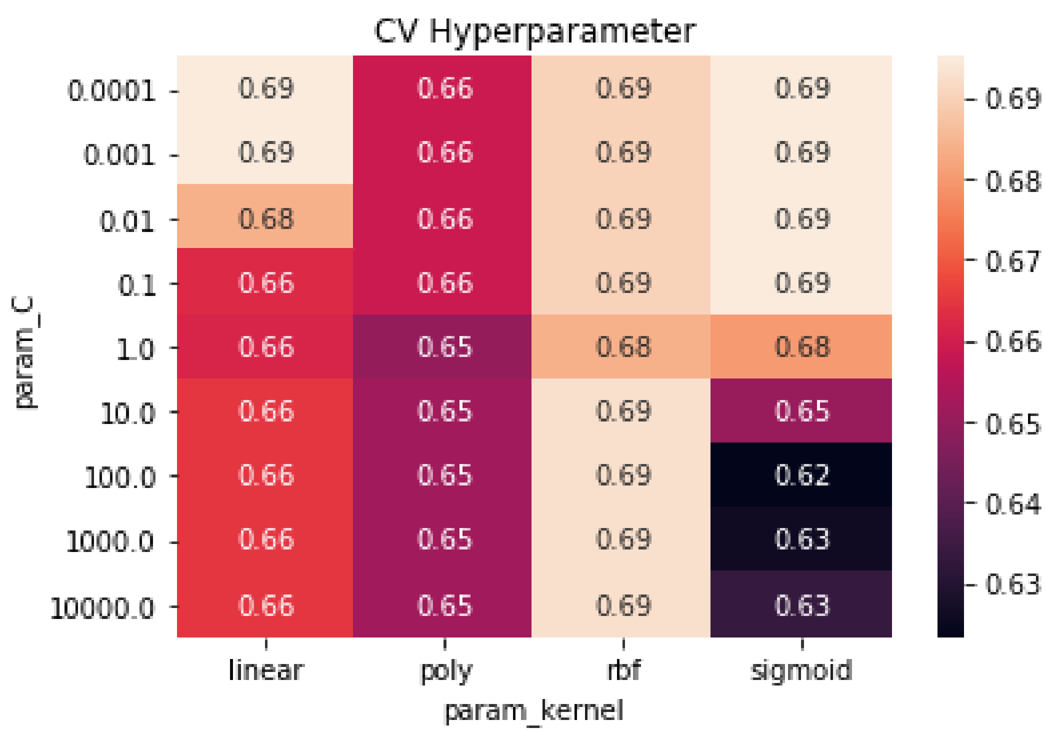
# 12 7.3 SVC

[28]:
```
# Import SVC
from sklearn.svm import SVC
```

[29]:
```
# SVC (See Docs: https://scikit-learn.org/stable/modules/generated/sklearn.svm.
↪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)
```

[30]:
```
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()
```


Train Hyperparameter
0.0001
0.001
0.01
0.1
1.0
10.0
100.0
1000.0
10000.0
param_C
linear
poly
rbf
sigmoid
param_kernel
0.97
0.97
0.95
0.97
1
0.94
0.94
0.94
0.94
0.88
0.76
0.71
0.71
0.71
1.00
0.95
0.90
0.85
0.80
0.75


CV Hyperparameter
0.0001
0.001
0.01
0.1
1.0
10.0
100.0
1000.0
10000.0
param_C
linear
poly
rbf
sigmoid
param_kernel
0.69
0.66
0.68
0.65
0.62
0.63
0.69
0.68
0.67
0.66
0.65
0.64
0.63

[31]:
```
print(svc_clf.best_params_)
```

```
{'C': 0.0001, 'kernel': 'sigmoid'}
```

[32]:
```
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)
```

[32]:
```
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),
```

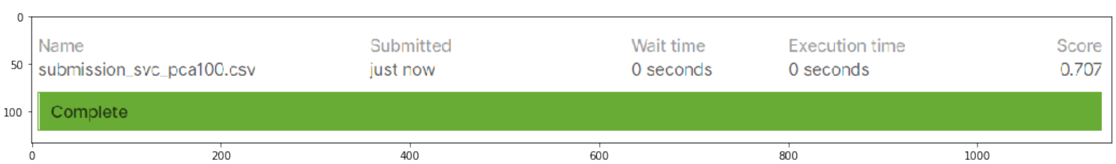
```
cv=3, method='sigmoid')
```

# 13 7.3.1 Kaggle Score

[33]:
```
# 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_pca100.csv', index=False)
```

[34]:
```
image = plt.imread(data_dir+'/submission_svc_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[34]: <matplotlib.image.AxesImage at 0x209006f2908>



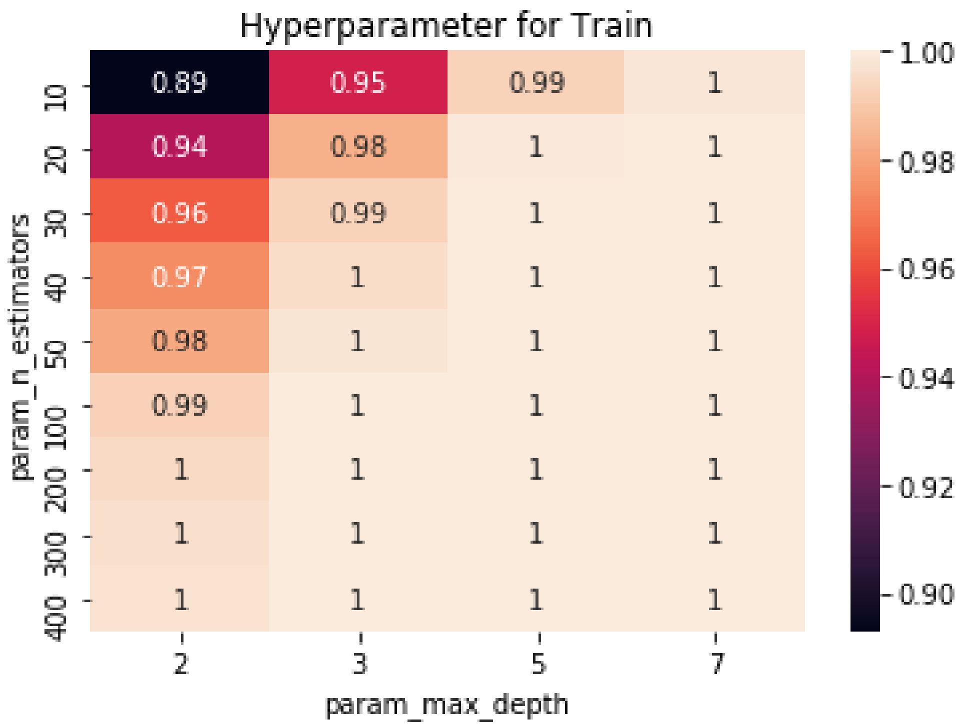

# 14 7.4 RandomForest

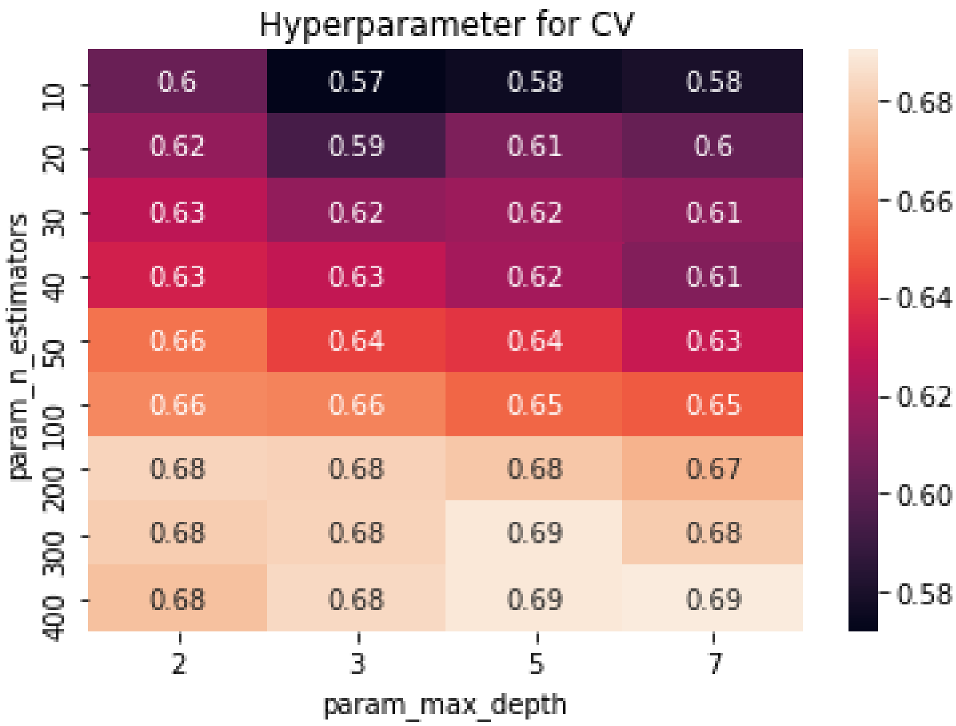
[35]:
```
# Impoer Random Forest
from sklearn.ensemble import RandomForestClassifier
```

[36]:
```
# 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)
```

[37]:
```
# 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()
```






[38]:
```
print(rf_clf.best_params_)
```

```
{'max_depth': 7, 'n_estimators': 400}
```

[39]:
```
# Calibrate the model
clf = CalibratedClassifierCV(rf_clf, cv=3)
clf.fit(tr_X, tr_y)
```

[39]:
```
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')
```

# 15 7.4.1 Kaggle Score

[40]:

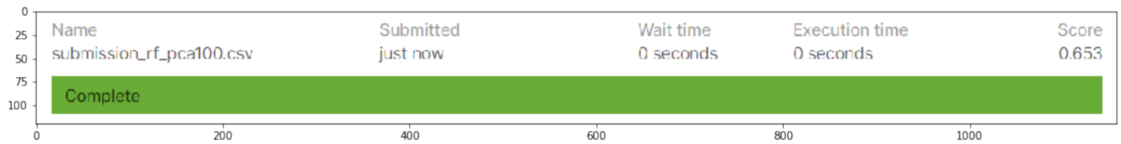
```
# Create a submission file format to submit in kaggle
temp_id = df_test['id']
rf_csv = clf.predict_proba(ts_X)[:,1]
rf_df = pd.DataFrame(np.column_stack((temp_id,rf_csv)), columns=['id','target'])
rf_df['id'] = rf_df['id'].astype('int32')
rf_df.to_csv(data_dir+'/submission_rf_pca100.csv', index=False)
```

[41]:

```
image = plt.imread(data_dir+'/submission_rf_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[41]:

```
<matplotlib.image.AxesImage at 0x209023dc1c8>
```

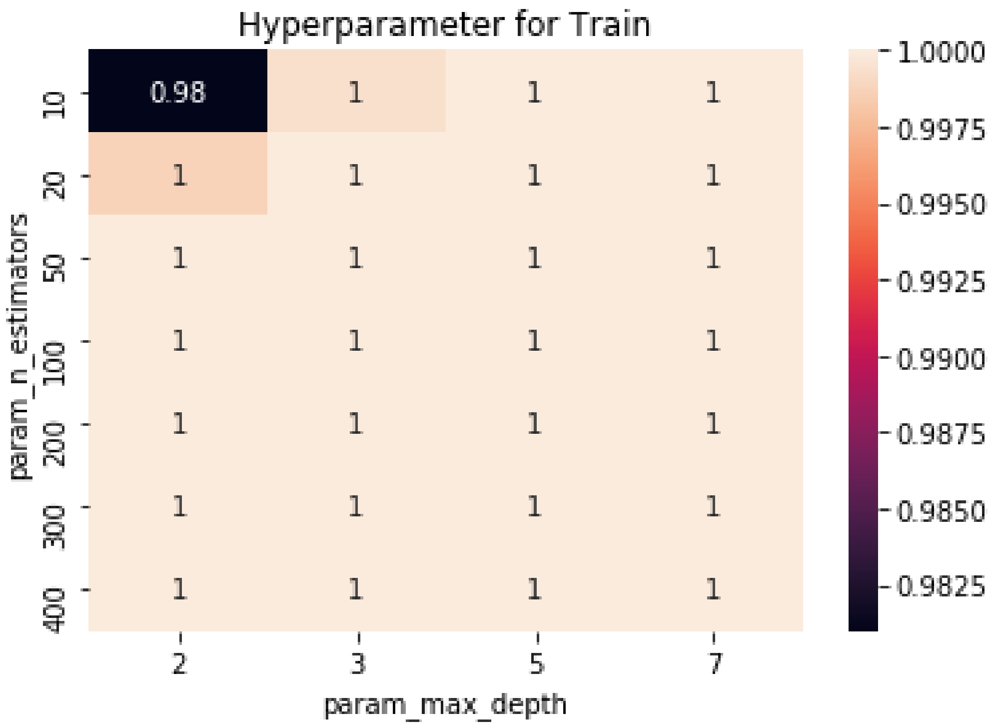


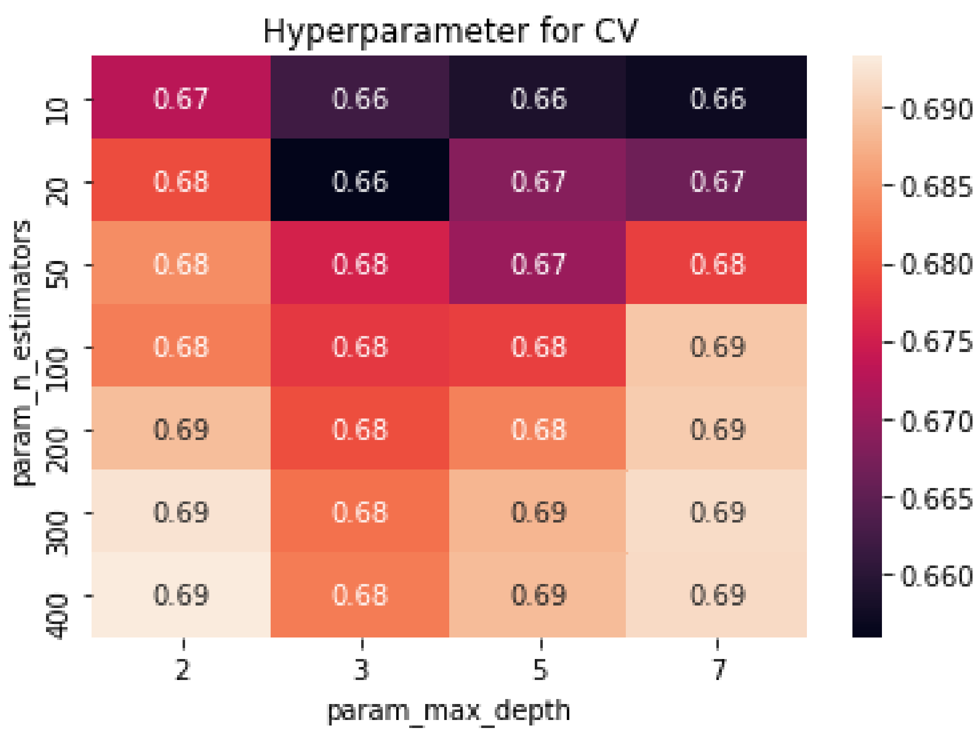

# 16 7.5 XGBoost

[42]:
```
# Import Xgboost
from xgboost import XGBClassifier
```

[43]:
```
# 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)
```

[44]:
```
# 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()
```


Hyperparameter for Train
param_n_estimators
param_max_depth


Hyperparameter for CV
param_n_estimators
param_max_depth

[45]:
```python
print(xgb_clf.best_params_)
```

```
{'max_depth': 2, 'n_estimators': 400}
```

[46]:
```python
# Calibrate the model
clf = CalibratedClassifierCV(xgb_clf, cv=3)
clf.fit(tr_X, tr_y)
```

[46]:
```
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,
```

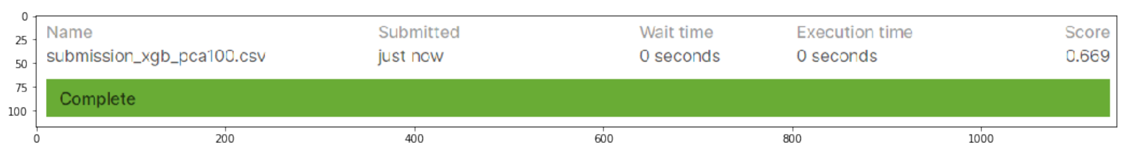
```
                                                        scoring='roc_auc',
                                                        verbose=0),
                                cv=3, method='sigmoid')
```

# 17 7.5.1 Kaggle Score

[47]:
```
# 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_pca100.csv', index=False)
```

[48]:
```
image = plt.imread(data_dir+'/submission_xgb_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[48]: <matplotlib.image.AxesImage at 0x2090ae87a88>




# 18 7.6 Stacking Classifier

[49]:
```
# Import Stacking Classifier
from mlxtend.classifier import StackingClassifier
```

[50]:
```
# StackClassifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/StackingClassifier/#methods)

# Classifier 1: Logistic Regression with best params
clf1 = LogisticRegression(C = 0.1, 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=0.0001, kernel='sigmoid', random_state=42,␣
 ↪class_weight='balanced', probability=True)
```

```python
clf2.fit(tr_X,tr_y)
clf2 = CalibratedClassifierCV(clf2, cv=3)

# Classifier 3: XGBoost with best params
clf3 = XGBClassifier(max_depth=2, n_estimators=400, 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=7, n_estimators=400)
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)
```

[50]:
```
StackingClassifier(average_probas=False,
classifiers=[CalibratedClassifierCV(base_estimator=LogisticRegression(C=0.1,
          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='si…
meta_classifier=CalibratedClassifierCV(base_estimator=LogisticRegression(C=0.1,
            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',
```

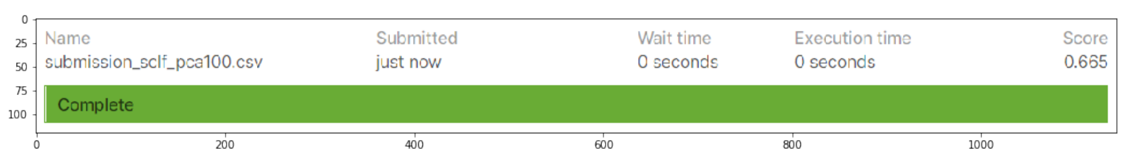
```
                random_state=42,
                solver='liblinear',
                tol=0.0001,
                verbose=0,
                warm_start=False),
                                                    cv=3,
                                                    method='sigmoid'),
                store_train_meta_features=False, use_clones=True,
                use_features_in_secondary=False, use_probas=True, verbose=0)
```

## 19 7.6.1 Kaggle score

[51]:
```python
# 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_pca100.csv', index=False)
```

[52]:
```python
image = plt.imread(data_dir+'/submission_sclf_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[52]:
```
<matplotlib.image.AxesImage at 0x2090ae78fc8>
```




## 20 7.7 Voting Classifier (Without Stack Classifier + no weights)

[53]:
```python
# Import Voting Classifier
from mlxtend.classifier import EnsembleVoteClassifier
```

[54]:
```python
# 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)
```

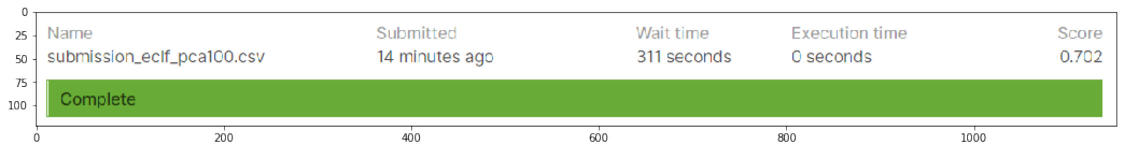
```
[54]: EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
      ssion(C=0.1,
            class_weight='balanced',
            dual=False,
            fit_intercept=True,
            intercept_scaling=1,
            l1_ratio=None,
            max_iter=100,
            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'),
                                  CalibratedClassi…
                max_depth=7,
                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=400,
                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)
```

# 21 7.7.1 Kaggle Score

```
[55]: # 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_pca100.csv', index=False)
```

[56]:
```
image = plt.imread(data_dir+'/submission_eclf_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[56]:
```
<matplotlib.image.AxesImage at 0x2090e4be508>
```




# 22 7.8 Voting Classifier (With Stack Classifier + no weights)

[57]:
```
# 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)
```

[57]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=0.1,
      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'),
                             CalibratedClassi…
                                        fit_intercept=True,
                                        intercept_scaling=1,
                                        l1_ratio=None,
                                        max_iter=100,
                                        multi_class='auto',
                                        n_jobs=None,
                                        penalty='l1',
```

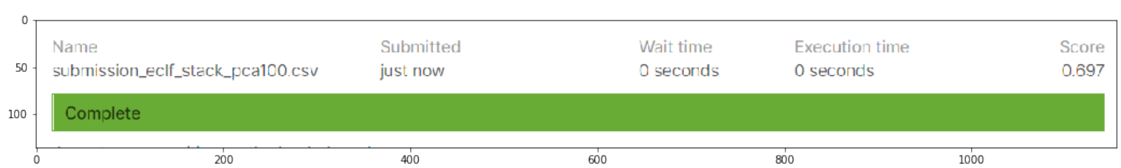
```
                                                    random_state=42,
                                                    solver='liblinear',
                                                    tol=0.0001,
                                                    verbose=0,
                                                    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)
```

# 23 7.8.1 Kaggle Score

[58]:
```
# 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_pca100.csv', index=False)
```

[59]:
```
image = plt.imread(data_dir+'/submission_eclf_stack_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[59]: <matplotlib.image.AxesImage at 0x2090e871408>




# 24 7.9 Voting Classifier (without Stack Classifier + weights)

[60]:
```
# Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4], weights=[0.3,0.3,0.
↪15,0.25])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

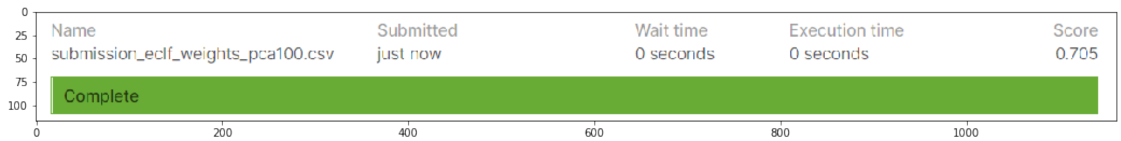
[60]:
```
EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=0.1,
      class_weight='balanced',
      dual=False,
      fit_intercept=True,
      intercept_scaling=1,
      l1_ratio=None,
      max_iter=100,
      multi_class='auto',
      n_jobs=None,
      penalty='l1',
      random_state=42,
      solver='liblinear',
      tol=0.0001,
      verbose=0,
      warm_start=False),
                                               cv=3, method='sigmoid'),
                             CalibratedClassi…
          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=400,
          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=[0.3, 0.3, 0.15, 0.25])
```

# 7.9.1 Kaggle Score

[61]:
```
# 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_pca100.csv', index=False)
```

```
[62]: image = plt.imread(data_dir+'/submission_eclf_weights_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

```
[62]: <matplotlib.image.AxesImage at 0x2090eaa8388>
```




# 25 7.10 Voting Classifier (with Stack Classifier + weights)

```
[63]: # Voting Classifier (See Docs: http://rasbt.github.io/mlxtend/user_guide/
 ↪classifier/EnsembleVoteClassifier/)
eclf = EnsembleVoteClassifier(clfs=[clf1,clf2,clf3,clf4,sclf], weights=[0.3,0.
 ↪3,0.1,0.1,0.2])
# Fit the train data
eclf.fit(tr_X,tr_y)
```

```
[63]: EnsembleVoteClassifier(clfs=[CalibratedClassifierCV(base_estimator=LogisticRegre
ssion(C=0.1,
      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'),
                             CalibratedClassi…
                                         intercept_scaling=1,
                                         l1_ratio=None,
                                         max_iter=100,
                                         multi_class='auto',
                                         n_jobs=None,
                                         penalty='l1',
```

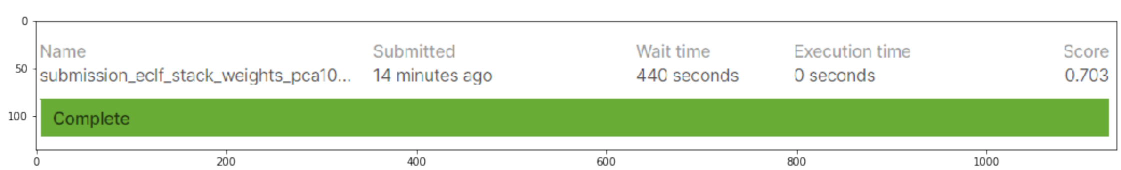
```
                                                    random_state=42,
                                                    solver='liblinear',
                                                    tol=0.0001,
                                                    verbose=0,
                                                    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=[0.3, 0.3, 0.1, 0.1, 0.2])
```

## 26 7.10.1 Kaggle Score

[64]:
```python
# 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_pca100.csv',␣
 ↪index=False)
```

[65]:
```python
image = plt.imread(data_dir+'/submission_eclf_stack_weights_pca100.png')
plt.figure(figsize=(18,5))
plt.imshow(image)
```

[65]: <matplotlib.image.AxesImage at 0x2090abe0588>




## 27 6. Summary of All Models

[66]:
```python
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': 35}",0.652])
```

```
x.add_row(['Logistic Regression','AF',r"{'C': 0.1, 'penalty': 'l1', 'solver':␣
 ↪'liblinear'}",0.702])
x.add_row(['SVC','AF',r"{'C': 0.0001, 'kernel': 'sigmoid'}",0.707])
x.add_row(['RandomForest','AF',r"{'max_depth': 7, 'n_estimators': 400}",0.653])
x.add_row(['XGBoost','AF',r"{'max_depth': 2, 'n_estimators': 400}",0.669])
x.add_row(['Stacking Classifier','AF','-',0.665])
x.add_row(['Voting Classifier(No stacking + no weights)','AF',"-",0.702])
x.add_row(['Voting Classifier(stacking + no weights)','AF',"-",0.697])
x.add_row(['Voting Classifier(no stacking + weights)','AF',"-",0.705])
x.add_row(['Voting Classifier(stacking + weights)','AF',"-",0.703])
print(x)
```

```
+---------------------------------------------+----------+----------------------
------------------------------+------------+
|                    Model                    | Features |
Hyperparameter                                | Test Score |
+---------------------------------------------+----------+----------------------
------------------------------+------------+
|                     knn                     |    AF    |    {'algorithm':
'kd_tree', 'n_neighbors': 35}      |   0.652    |
|             Logistic Regression             |    AF    | {'C': 0.1, 'penalty':
'l1', 'solver': 'liblinear'} |   0.702    |
|                     SVC                     |    AF    |         {'C': 0.0001,
'kernel': 'sigmoid'}           |   0.707    |
|                 RandomForest                |    AF    |       {'max_depth':
7, 'n_estimators': 400}          |   0.653    |
|                   XGBoost                   |    AF    |       {'max_depth':
2, 'n_estimators': 400}          |   0.669    |
|             Stacking Classifier             |    AF    |
-                                           |   0.665    |
| Voting Classifier(No stacking + no weights) |    AF    |
-                                           |   0.702    |
|   Voting Classifier(stacking + no weights)  |    AF    |
-                                           |   0.697    |
|   Voting Classifier(no stacking + weights)  |    AF    |
-                                           |   0.705    |
|    Voting Classifier(stacking + weights)    |    AF    |
-                                           |   0.703    |
+---------------------------------------------+----------+----------------------
------------------------------+------------+
```

Notation: 1. AF: All features

```
[ ]:
```