StackOverflow_Model

June 29, 2019

In [1]:
```
# general purpose packages
import pandas as pd
import numpy as np
import os
from datetime import datetime
import pickle

# visualization related packages
import matplotlib.pyplot as plt
import seaborn as sns
sns.set()

from sklearn.model_selection import GridSearchCV

# Classifier Evaluation
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_recall_fscore_support
from sklearn.metrics import hamming_loss
from sklearn.metrics import accuracy_score
from sklearn.metrics import make_scorer
from sklearn.metrics import f1_score

# data preprocessing
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import normalize

from sklearn.feature_extraction.text import CountVectorizer
from wordcloud import WordCloud

# Model related packages
from sklearn.linear_model import SGDClassifier
from sklearn.linear_model import LogisticRegression
#from sklearn.linear_model import
from sklearn.multiclass import OneVsRestClassifier

# Presenting Results
from prettytable import PrettyTable
```

```
# for loading the sparse matrix features
import scipy.sparse
```

1 Configs

In [2]:
```
# set sample size
sample_size = -1 # set -1 for full size

# path for train, test
df_train_label_path = './data/Final_train_df_label.csv'
df_test_label_path = './data/Final_test_df_label.csv'
# path of final features frames
final_train_feat_path = './data/train_feat_sparse_matrix.npz'
final_test_feat_path = './data/test_feat_sparse_matrix.npz'
```

2 Util Functions

In [3]:
```
def evaluate_model(model, X, y, title_suffix=str()):

    # get prediction and its probability
    predicted_labels = model.predict(X)
    #predicted_probs = model.predict_proba(X)

    # get evaluation scores (micro averaged)
    micro_eval_array = precision_recall_fscore_support(y, predicted_labels,
                                                        average='micro')[0:-1]


    # get evaluation scores (macro averaged)
    macro_eval_array = precision_recall_fscore_support(y, predicted_labels,
                                                        average='macro')[0:-1]

    eval_df = pd.DataFrame([micro_eval_array, macro_eval_array],
                           columns=['Precision', 'Recall', 'F1_Score'])
    eval_df.index = ['Micro-Averaged', 'Macro-Averaged']

    # convert it to percentage
    eval_df *= 100.0

    # plot the classification report
    sns.heatmap(eval_df, annot=True, annot_kws={'size': 16}, fmt='.4f', cmap='YlGnBu',
                cbar_kws={'label': 'Percentage', 'format':'%.2f'})
    plt.yticks(rotation=0)
    plt.xticks(rotation=90)

    plt.xlabel('Metrics')
```

```
    plt.ylabel('Average Type')
    plt.title('Classification Report -' + title_suffix)
    plt.show()

    # get the performace metrics
    micro_f1_score = '{0:.4f}'.format(eval_df.loc['Micro-Averaged', 'F1_Score'])
    macro_f1_score = '{0:.4f}'.format(eval_df.loc['Macro-Averaged', 'F1_Score'])

    # get accuracy & haming loss
    accuracy = accuracy_score(y, predicted_labels)
    ham_loss = hamming_loss(y, predicted_labels)

    print('Accuracy : %f \t Hamming loss : %f'%(accuracy, ham_loss,))

    return (ham_loss, micro_f1_score,)
```

3 Data

```
In [4]: # Read label inforamtion
        df_train = pd.read_csv(df_train_label_path, index_col=False)
        df_test = pd.read_csv(df_test_label_path, index_col=False)

        # read featue data
        X_train = scipy.sparse.load_npz(final_train_feat_path)
        X_test = scipy.sparse.load_npz(final_test_feat_path)

        if sample_size > 0:
            # set sample for train
            df_train = df_train.iloc[0:sample_size]
            df_train = df_train.reset_index(drop=True)
            # set sample for test
            df_test = df_test.iloc[0:sample_size]
            df_test = df_test.reset_index(drop=True)
            # sample features
            X_train = X_train[0:sample_size, :]
            X_test = X_test[0:sample_size, :]



        print('Shape of train features shape :', X_train.shape)
        print('Shape of features shape :', X_test.shape)
```

```
Shape of train features shape : (210000, 12526)
Shape of features shape : (90000, 12526)
```

```
In [5]: # load the label names from the pickle file
        #load model from disk
```

```
pickle_in = open("./data/so_multilabels.pkl","rb")
labels_list = pickle.load(pickle_in)
pickle_in.close()
print('Multilabel list', labels_list[30:40])
```

```
Multilabel list ['application', 'architecture', 'arraylist', 'arrays', 'asp-classic', 'asp.net',
```

3.1 Convert labels to One Hot Encoded Format

In [6]:
```
vectorizer = CountVectorizer(tokenizer=lambda x: x.split(), binary='true')
vectorizer.fit([' '.join(labels_list)])
label_names_list = list(vectorizer.get_feature_names())
```

In [7]:
```
# transform the feature columns
y_train = vectorizer.transform(df_train['Tags'])
y_test = vectorizer.transform(df_test['Tags'])

# prepare train test features data frames
y_train = pd.DataFrame(y_train.toarray(), columns=label_names_list)
y_test = pd.DataFrame(y_test.toarray(), columns=label_names_list)

# sample y_train
y_train.head()
```

Out[7]:
```
   .htaccess  .net  .net-3.5  .net-4.0  2010  3d  abstract-algebra  \
0          0     0         0         0     0   0                 0
1          0     0         0         0     0   0                 0
2          0     0         0         0     0   0                 0
3          0     0         0         0     0   0                 0
4          0     0         0         0     0   0                 0

   actionscript  actionscript-3  active-directory       ...         wpf  xaml  \
0             0               0                 0       ...           0     0
1             0               0                 0       ...           0     0
2             0               0                 0       ...           0     0
3             0               0                 0       ...           0     0
4             0               0                 0       ...           0     0

   xcode  xcode4  xhtml  xml  xpath  xslt  youtube  zend-framework
0      0       0      0    0      0     0        0               0
1      0       0      0    0      0     0        0               0
2      0       0      0    0      0     0        0               0
3      0       0      0    0      0     0        0               0
4      0       0      0    0      0     0        0               0

[5 rows x 500 columns]
```

In [8]:
```
y_train.sum(axis=0).min()
```

Out[8]: 171

In [9]: y_test.sum(axis=0).min()

Out[9]: 69

4 Models

4.1 A) Logistic regression(OvR)

In [10]:
```
def get_best_hyperparam_OVR_LogisticRegression(param_dict, X, y, random_search=False):

    # set the scoring function
    final_scorer = 'f1-micro'

    # declare a scoring dictionary
    score_dict = {
        'f1-micro': make_scorer(score_func=f1_score, greater_is_better=True,
                                         needs_proba=False, needs_threshold=False, average=
    }


     #Declare the metric as  'minimization' or 'maximization'
    optimization_dict = {
        'f1-micro' : 'maximization'
    }

    # Set a data partitioning strategy
    cv_data = 3


    # declare model
    #log_reg = LogisticRegression()
    log_reg = SGDClassifier(loss='log', penalty='l1', max_iter=1e+03, tol=1e-03)
    model = OneVsRestClassifier(log_reg)

    if random_search:
        search_cv = RandomizedSearchCV(estimator=model, param_distributions=param_dict,
                                       cv=cv_data, scoring=score_dict, refit=False,
                                       return_train_score=True, n_iter=6, n_jobs=-1)

    else:
        # declare grid search CV object
        search_cv = GridSearchCV(estimator=model, param_grid=param_dict, cv=cv_data,
                                 scoring=score_dict, refit=False,
                                 return_train_score=True, n_jobs=-1)

    # fit to the data
```

```
search_cv.fit(X, y)


# get total number of param settings
param_list = list(param_dict.keys())
param_field_list = ['param_' + item for item in param_list]

# get list of train metric list
train_metric_list = ['mean_train_' + item for item in score_dict.keys()]
# get list of test metric list
test_metric_list = ['mean_test_' + item for item in score_dict.keys()]

# get number of rows in the search cv data frame
num_rows = len(search_cv.cv_results_['params'])

# create the grid search info df
grid_info_df = pd.DataFrame(search_cv.cv_results_, index=range(num_rows))

# prepare a list of reqired columns
required_columns = ['params'] + param_field_list + train_metric_list + \
                   test_metric_list

# slice the data frame to only required columns
grid_info_df = grid_info_df[required_columns]

# process individual metrics
for metric, optimization in optimization_dict.items():
    if optimization == 'minimization':
        grid_info_df['mean_train_' + metric] *= -1
        grid_info_df['mean_test_' + metric] *= -1


# Find the best hyperparam & its corresponding scores
if optimization_dict[final_scorer] == 'minimization':
    best_hyperparam_record = grid_info_df.loc[grid_info_df[
                              'mean_test_'+ final_scorer].idxmin(),:]
else:
    best_hyperparam_record = grid_info_df.loc[grid_info_df[
                              'mean_test_'+ final_scorer].idxmax(),:]

# best hyperparam & corresponding scores
best_hyperparam = best_hyperparam_record['params']
best_train_score = best_hyperparam_record['mean_train_'+ final_scorer]
best_validation_score = best_hyperparam_record['mean_test_'+ final_scorer]

# plot the hyper params
if len(param_list) == 1:
```

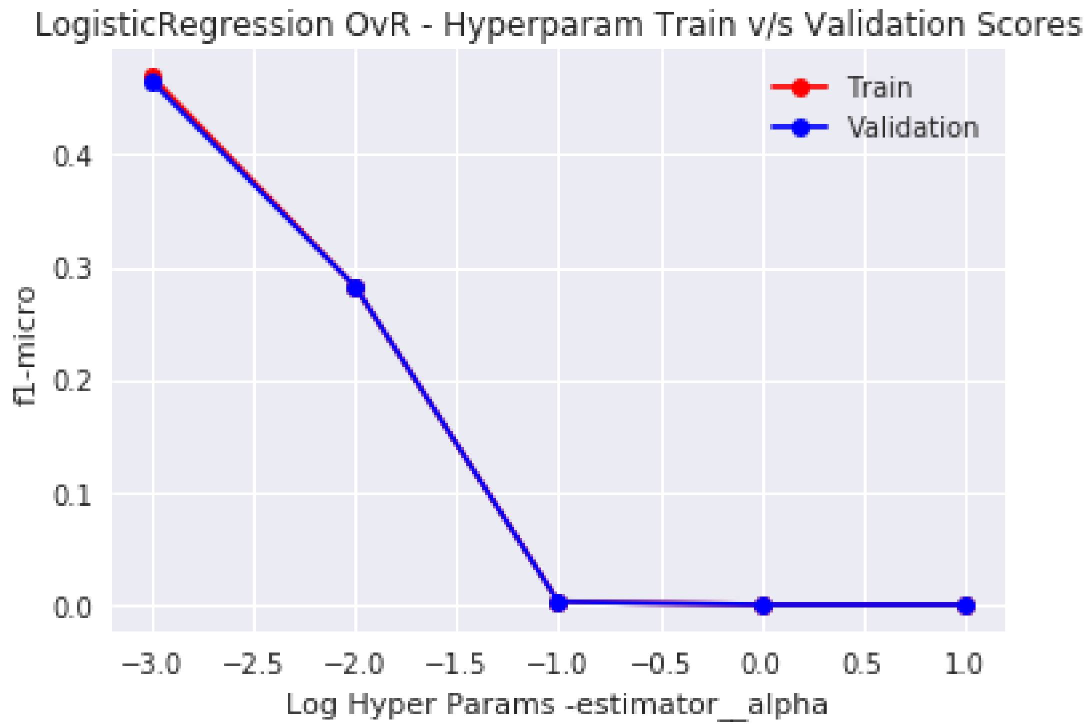
```
        # extract individual fiedls
        x_vals = np.log10(grid_info_df[param_field_list[0]].tolist())
        y_vals_tr = grid_info_df['mean_train_' + final_scorer].tolist()
        y_vals_val = grid_info_df['mean_test_' + final_scorer].tolist()

        # plot train, validation performances
        plt.plot(x_vals, y_vals_tr, label='Train', color='r', marker='o', linestyle='-'
        plt.plot(x_vals, y_vals_val, label='Validation', color='b', marker='o', linesty
        plt.xlabel('Log Hyper Params -' + param_list[0])
        plt.ylabel(final_scorer)
        plt.legend()
        plt.title('LogisticRegression OvR - Hyperparam Train v/s Validation Scores')
        plt.show()


    # Heatmap plot for pair of hyperparam values
    elif len(param_list) == 2:
        # get pivoted table
        train_hyp_df = pd.pivot_table(data=grid_info_df, index=param_field_list[0],
                                      columns=param_field_list[1],
                                      values='mean_train_' + final_scorer ,
                                      fill_value=np.inf)
        sns.heatmap(train_hyp_df, annot=True, cmap='YlGnBu', fmt='.4f',
                    cbar_kws={'label': final_scorer, 'format':'%.2f'})
        plt.xlabel(param_list[1])
        plt.ylabel(param_list[0])
        plt.title('LogisticRegression OvR - Hyperparams Scores - Train')
        plt.show()

        print('\n'*3)

        # Test hyperparam

        # get pivoted table
        train_hyp_df = pd.pivot_table(data=grid_info_df, index=param_field_list[0],
                                      columns=param_field_list[1],
                                      values='mean_test_' + final_scorer, fill_value=np
        sns.heatmap(train_hyp_df, annot=True, cmap='YlGnBu', fmt='.4f',
                    cbar_kws={'label': final_scorer, 'format':'%.2f'})
        plt.xlabel(param_list[1])
        plt.ylabel(param_list[0])
        plt.title('LogisticRegression OvR - Hyperparams Scores - Validation')
        plt.show()

    else:
        print(grid_info_df)

    print('Best hyperparam value: ', best_hyperparam, 'Best Train Score: ', best_train_
```

```
                'Best Validation Score: ', best_validation_score)


        #best_mse_train = best_hyperparam_record['mean_train_MSE']
        #best_mse_validation = best_hyperparam_record['mean_test_MSE']

        # return tuple
        ret_tuple = (best_hyperparam, best_train_score, best_validation_score,)


        return ret_tuple
```

4.1.1 1. Find the best Hyperparam

```
In [11]: param_dict_lr_ovr = {'estimator__alpha': [1e-03, 1e-02, 1e-01, 1e+00, 1e+01]}
         print(datetime.now() ,' Hyperparam Tuning of Logistic Regression OvR started')
         hyp_tuned_info_lgr = get_best_hyperparam_OVR_LogisticRegression(param_dict_lr_ovr,
                                                                          X_train, y_train)
         print(datetime.now() ,' Hyperparam Tuning of Logistic Regression OvR completed')
         best_hyp_lgr, best_tr_score_lgr, best_val_score_lgr = hyp_tuned_info_lgr
```

```
2019-06-27 00:47:18.744195  Hyperparam Tuning of Logistic Regression OvR started


/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```




```
Best hyperparam value:  {'estimator__alpha': 0.001} Best Train Score:  0.4689696589260479 Best V
2019-06-27 01:15:04.100310  Hyperparam Tuning of Logistic Regression OvR completed
```

4.1.2 2. Train the model with best hyperparam

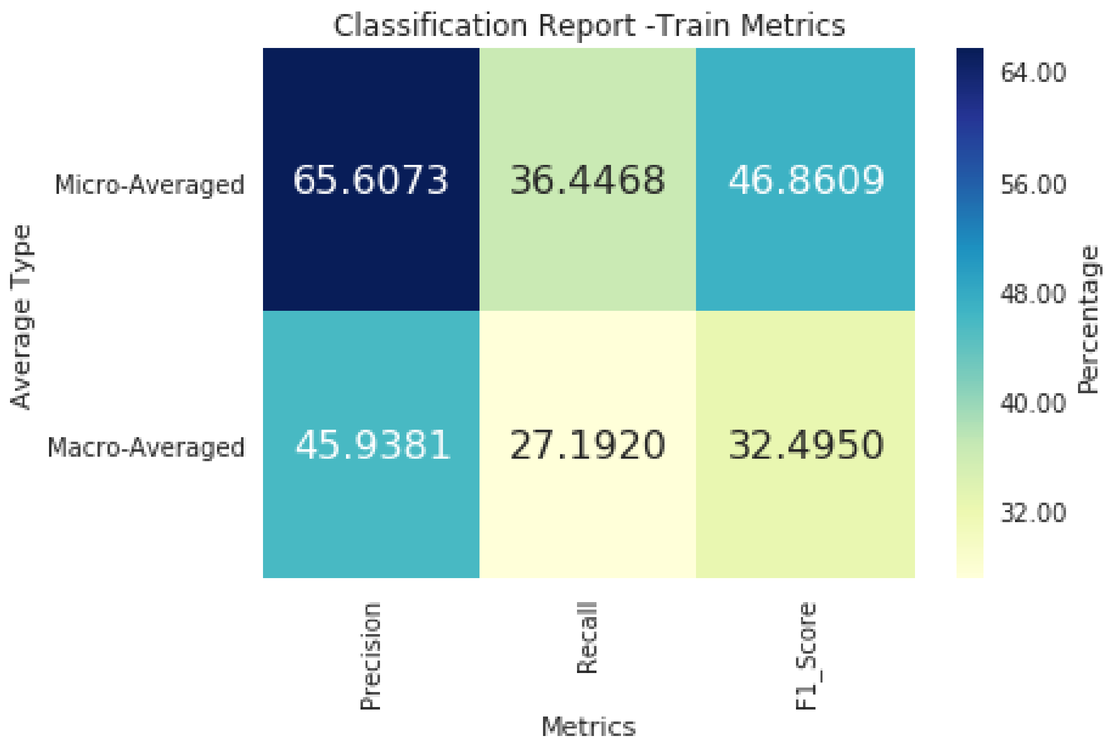
```
In [12]: log_reg = SGDClassifier(loss='log', alpha=best_hyp_lgr['estimator__alpha'], penalty='l1
                                 max_iter=1e+03, tol=1e-03)
         log_reg_ovr = OneVsRestClassifier(log_reg, n_jobs=-1)

         print(datetime.now() ,' Training of Logistic Regression OvR completed')
         log_reg_ovr.fit(X_train, y_train)
         print(datetime.now() ,' Training of Logistic Regression OvR completed')

         # save model to disk
         pickle_out = open("./model/logistic_regression_ovr.pkl","wb")
         pickle.dump(log_reg_ovr, pickle_out)
         pickle_out.close()
```

```
2019-06-27 01:15:04.107993  Training of Logistic Regression OvR completed
2019-06-27 01:20:09.674191  Training of Logistic Regression OvR completed
```

```
In [13]: #load model from disk
         pickle_in = open("./model/logistic_regression_ovr.pkl","rb")
```

```
log_reg_ovr = pickle.load(pickle_in)
pickle_in.close()

# evaluate the trained model on train data
table_entry_train_lgr = evaluate_model(log_reg_ovr, X_train, y_train, 'Train Metrics')
```

```
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```

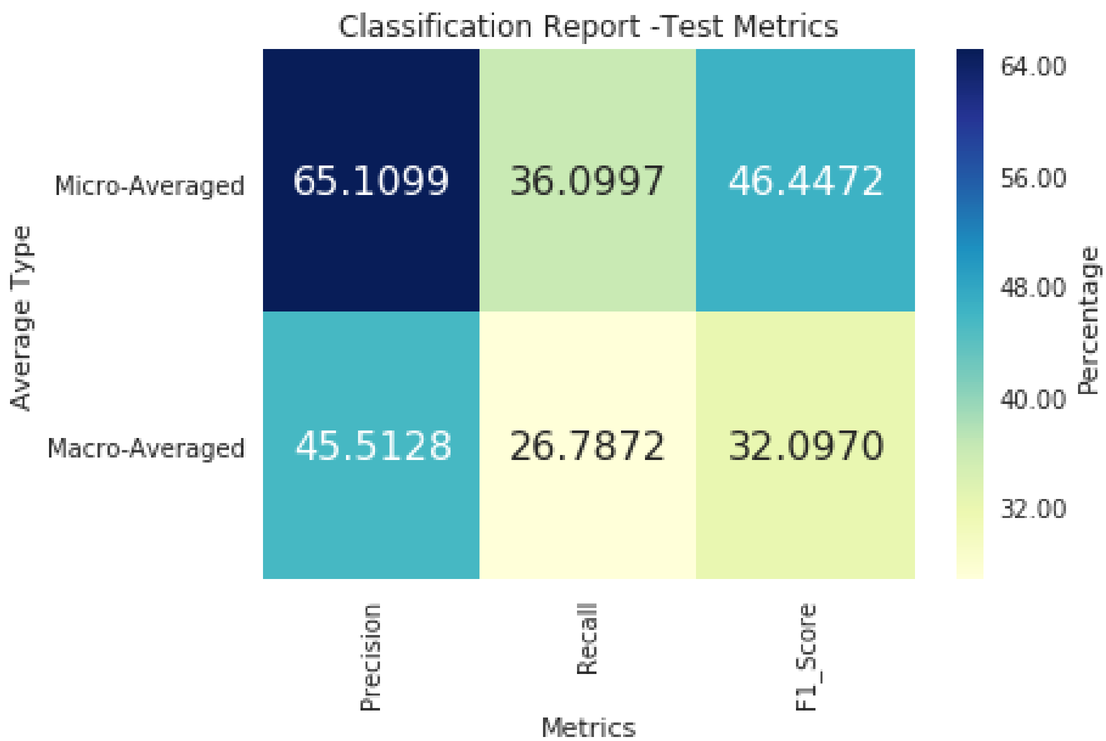



```
Accuracy : 0.157210          Hamming loss : 0.003309
```

4.1.3 3. Test the model

```
In [14]: # evaluate the trained model on test data
         table_entry_test_lgr = evaluate_model(log_reg_ovr, X_test, y_test, 'Test Metrics')
```

```
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```




```
Accuracy : 0.154867          Hamming loss : 0.003327
```

```
In [15]: table_entry_lgr = ('Logistic Regression (OvR)', best_hyp_lgr,) + \
                           (table_entry_train_lgr[1],) + (table_entry_test_lgr[1],)
```

4.2 B) Linear SVM (OvR)

```
In [16]: def get_best_hyperparam_OVR_SVC(param_dict, X, y, random_search=False):

             # set the scoring function
             final_scorer = 'f1-micro'

             # declare a scoring dictionary
             score_dict = {
                 'f1-micro': make_scorer(score_func=f1_score, greater_is_better=True,
                                         needs_proba=False, needs_threshold=False, average=
             }


              #Declare the metric as  'minimization' or 'maximization'
             optimization_dict = {
                 'f1-micro' : 'maximization'
```

```
}


# Set a data partitioning strategy
cv_data = 3


# declare model
svm = SGDClassifier(loss='hinge', penalty='l1', max_iter=1e+03, tol=1e-03)
model = OneVsRestClassifier(svm)

if random_search:
    search_cv = RandomizedSearchCV(estimator=model, param_distributions=param_dict,
                                   cv=cv_data, scoring=score_dict, refit=False,
                                   return_train_score=True, n_iter=6, n_jobs=-1)

else:
    # declare grid search CV object
    search_cv = GridSearchCV(estimator=model, param_grid=param_dict, cv=cv_data,
                             scoring=score_dict, refit=False,
                             return_train_score=True, n_jobs=-1)

# fit to the data
search_cv.fit(X, y)


# get total number of param settings
param_list = list(param_dict.keys())
param_field_list = ['param_' + item for item in param_list]

# get list of train metric list
train_metric_list = ['mean_train_' + item for item in score_dict.keys()]
# get list of test metric list
test_metric_list = ['mean_test_' + item for item in score_dict.keys()]

# get number of rows in the search cv data frame
num_rows = len(search_cv.cv_results_['params'])

# create the grid search info df
grid_info_df = pd.DataFrame(search_cv.cv_results_, index=range(num_rows))

# prepare a list of reqired columns
required_columns = ['params'] + param_field_list + train_metric_list + \
                   test_metric_list

# slice the data frame to only required columns
grid_info_df = grid_info_df[required_columns]
```

```
# process individual metrics
for metric, optimization in optimization_dict.items():
    if optimization == 'minimization':
        grid_info_df['mean_train_' + metric] *= -1
        grid_info_df['mean_test_' + metric] *= -1


# Find the best hyperparam & its corresponding scores
if optimization_dict[final_scorer] == 'minimization':
    best_hyperparam_record = grid_info_df.loc[grid_info_df[
                                'mean_test_'+ final_scorer].idxmin(),:]
else:
    best_hyperparam_record = grid_info_df.loc[grid_info_df[
                                'mean_test_'+ final_scorer].idxmax(),:]

# best hyperparam & corresponding scores
best_hyperparam = best_hyperparam_record['params']
best_train_score = best_hyperparam_record['mean_train_'+ final_scorer]
best_validation_score = best_hyperparam_record['mean_test_'+ final_scorer]

# plot the hyper params
if len(param_list) == 1:

    # extract individual fiedls
    x_vals = np.log10(grid_info_df[param_field_list[0]].tolist())
    y_vals_tr = grid_info_df['mean_train_' + final_scorer].tolist()
    y_vals_val = grid_info_df['mean_test_' + final_scorer].tolist()

    # plot train, validation performances
    plt.plot(x_vals, y_vals_tr, label='Train', color='r', marker='o', linestyle='-'
    plt.plot(x_vals, y_vals_val, label='Validation', color='b', marker='o', linesty
    plt.xlabel('Log Hyper Params -' + param_list[0])
    plt.ylabel(final_scorer)
    plt.legend()
    plt.title('SVC OvR - Hyperparam Train v/s Validation Scores')
    plt.show()


# Heatmap plot for pair of hyperparam values
elif len(param_list) == 2:
    # get pivoted table
    train_hyp_df = pd.pivot_table(data=grid_info_df, index=param_field_list[0],
                                  columns=param_field_list[1],
                                  values='mean_train_' + final_scorer ,
                                  fill_value=np.inf)
    sns.heatmap(train_hyp_df, annot=True, cmap='YlGnBu', fmt='.4f',
                cbar_kws={'label': final_scorer, 'format':'%.2f'})
    plt.xlabel(param_list[1])
```

```
            plt.ylabel(param_list[0])
            plt.title('SVC OvR - Hyperparams Scores - Train')
            plt.show()

            print('\n'*3)

            # Test hyperparam

            # get pivoted table
            train_hyp_df = pd.pivot_table(data=grid_info_df, index=param_field_list[0],
                                          columns=param_field_list[1],
                                          values='mean_test_' + final_scorer, fill_value=np
            sns.heatmap(train_hyp_df, annot=True, cmap='YlGnBu', fmt='.4f',
                        cbar_kws={'label': final_scorer, 'format':'%.2f'})
            plt.xlabel(param_list[1])
            plt.ylabel(param_list[0])
            plt.title('SVC OvR - Hyperparams Scores - Validation')
            plt.show()

        else:
            print(grid_info_df)

        print('Best hyperparam value: ', best_hyperparam, 'Best Train Score: ', best_train_
              'Best Validation Score: ', best_validation_score)


        #best_mse_train = best_hyperparam_record['mean_train_MSE']
        #best_mse_validation = best_hyperparam_record['mean_test_MSE']

        # return tuple
        ret_tuple = (best_hyperparam, best_train_score, best_validation_score,)


        return ret_tuple
```

4.2.1 1. Find the best Hyperparam

```
In [17]: param_dict_svm_ovr = {'estimator__alpha': [1e-03, 1e-02, 1e-01, 1e+00, 1e+01]}

         print(datetime.now() ,' Hyperparam Tuning of SVC OvR started')
         hyp_tuned_info = get_best_hyperparam_OVR_SVC(param_dict_svm_ovr, X_train, y_train)
         print(datetime.now() ,' Hyperparam Tuning of SVC OvR completed')


         best_hyp_svm, best_tr_score_svm, best_val_score_svm = hyp_tuned_info
```

```
2019-06-27 01:21:06.445062  Hyperparam Tuning of SVC OvR started
```

```
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
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  'precision', 'predicted', average, warn_for)
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```
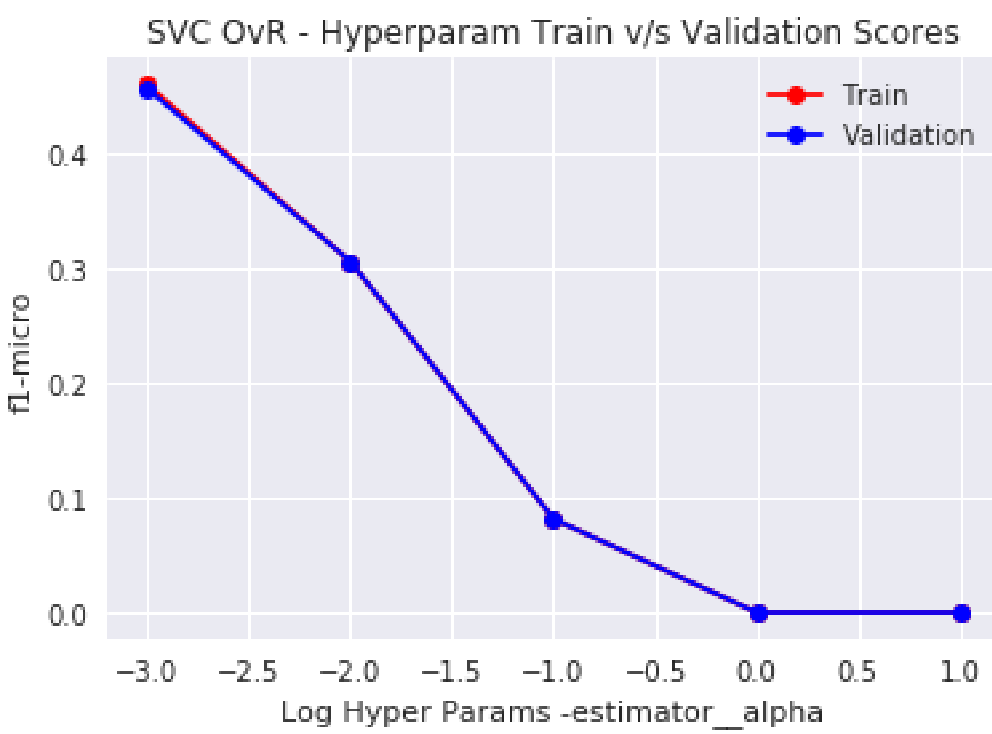



```
Best hyperparam value:  {'estimator__alpha': 0.001} Best Train Score:  0.4599030081943924 Best V
2019-06-27 02:00:50.698555  Hyperparam Tuning of SVC OvR completed
```

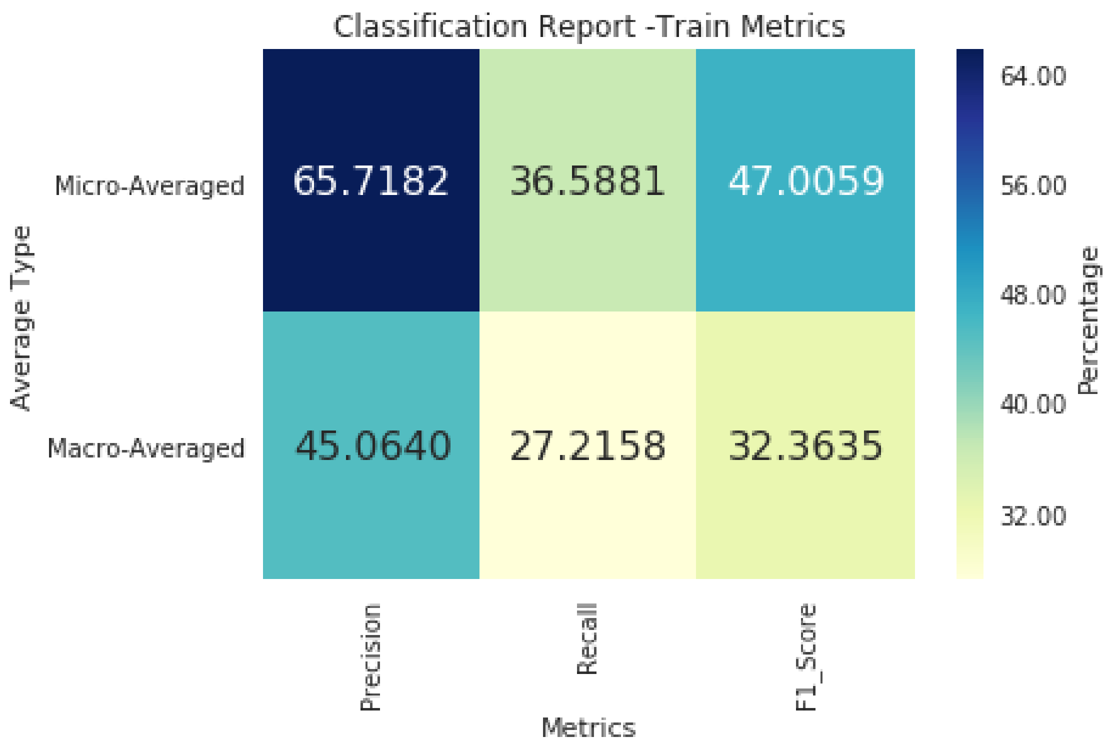
4.2.2 2. Train the model with best hyperparam

```
In [18]: svm = SGDClassifier(loss='log', alpha=best_hyp_svm['estimator__alpha'], penalty='l1',
                                 max_iter=1e+03, tol=1e-03)
         svm_ovr = OneVsRestClassifier(svm, n_jobs=-1)

         print(datetime.now() ,' Training of SVC OvR started')
         svm_ovr.fit(X_train, y_train)
         print(datetime.now() ,' Training of SVC OvR completed')

         # save model to disk
         pickle_out = open("./model/svc_ovr.pkl","wb")
         pickle.dump(svm_ovr, pickle_out)
         pickle_out.close()
```

```
2019-06-27 02:00:50.706338  Training of SVC OvR started
2019-06-27 02:05:53.997662  Training of SVC OvR completed
```

```
In [19]: #load model from disk
         pickle_in = open("./model/svc_ovr.pkl","rb")
         svm_ovr = pickle.load(pickle_in)
         pickle_in.close()

         # evaluate the trained model on train data
         table_entry_train_svm = evaluate_model(svm_ovr, X_train, y_train, 'Train Metrics')
```

```
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```

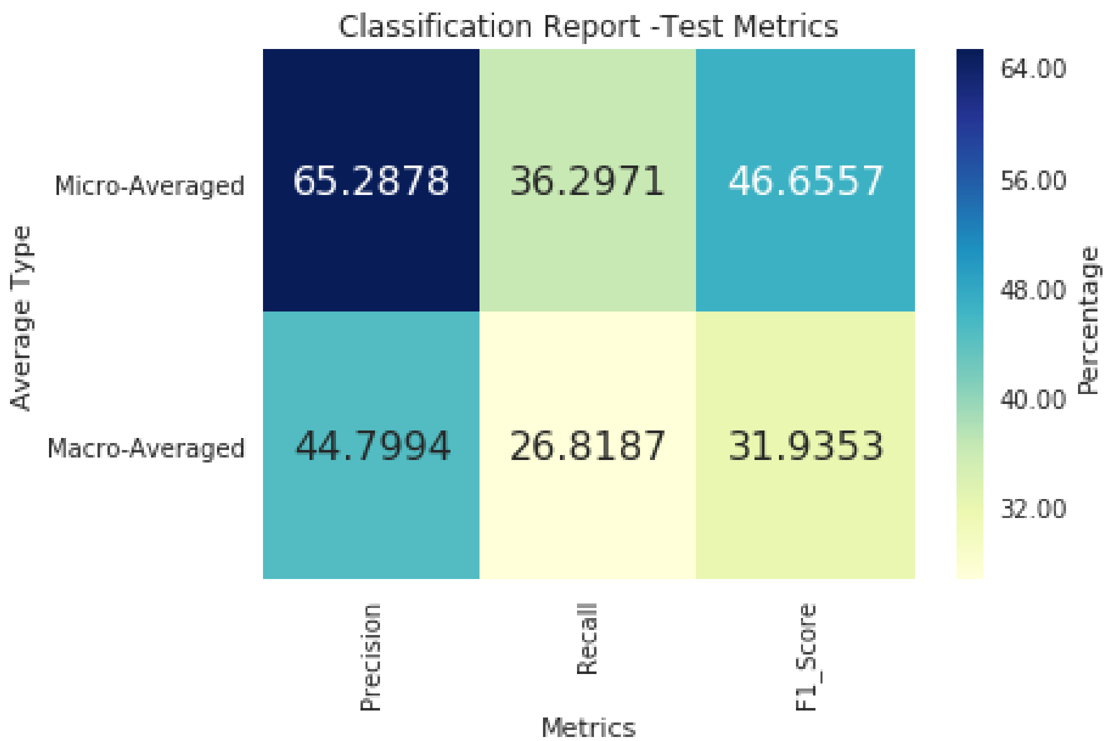



```
Accuracy : 0.158486          Hamming loss : 0.003303
```

4.2.3 3. Test the model

```
In [20]: # evaluate the trained model on test data
         table_entry_test_svm = evaluate_model(svm_ovr, X_test, y_test, 'Test Metrics')
```

```
/home/amd_3/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: Undefi
  'precision', 'predicted', average, warn_for)
```




```
Accuracy : 0.156033          Hamming loss : 0.003317
```

```
In [21]: table_entry_svm = ('SVM Classifier (OvR)', best_hyp_svm,) + \
                           (table_entry_train_svm[1],) + (table_entry_test_svm[1],)
```

5 Results

```
In [22]: Pret_table = PrettyTable()
         Pret_table.field_names = ['Model', 'Hyperparam',
                                   'Micro-Avg-F1(Train)',
                                   'Micro-Avg-F1(Test)']

         Pret_table.title = 'Multilabelled Classifier Results Summary'

         # add model results
         Pret_table.add_row(table_entry_lgr)
         Pret_table.add_row(table_entry_svm)
         print(Pret_table)
```

```
+------------------------------------------------------------------------------------------------
|                                Multilabelled Classifier Results Summary
+----------------------------+------------------------------+----------------------+--------------
```

Model	Hyperparam	Micro-Avg-F1(Train)	Micro-Avg-F1(T
Logistic Regression (OvR)	{'estimator__alpha': 0.001}	46.8609	46.4472
SVM Classifier (OvR)	{'estimator__alpha': 0.001}	47.0059	46.6557

6 Procedure Summary

Class label is enoded in a format suitable for One vs Rest classification

Hyperparameter is tuned for each of the One Vs Rest Classsifiers

Each classifier is trained with the best hyperpatam setting obtained

Two models are evaluated on a test dataset

7 Conclusion

The best model obtaind is the SVM OvR classifier with 46.6557 micro f1-score

The performace of the Logistic classifier (with 46.4472 micro f1-score) is also very close to SVM

The difference between the train, test f1-scores are very less for both the model, this is an indication that the model is generalizing well

More feature engineering methods can be tried to improve the score furhter