AFR-SVC

September 19, 2018

```
In [1]: #main libraries
        import sqlite3
        import pandas as pd
        import numpy as np
        import seaborn as sns
        import matplotlib.pyplot as plt
        import warnings
        warnings.filterwarnings("ignore")
```

```
In [2]: #vectorizors
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        from sklearn.feature_extraction.text import CountVectorizer
        import gensim
        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle
```

```
In [3]: #store values in pickles
        from sklearn.externals import joblib
```

```
In [4]: #performence metrics
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import accuracy_score
        from sklearn.metrics import f1_score
        from sklearn.metrics import precision_score
        from sklearn.metrics import recall_score
```

```
In [5]: #modules for building ML model
        from sklearn import preprocessing
        from sklearn.model_selection import train_test_split
        from sklearn.linear_model import SGDClassifier
        from sklearn.svm import SVC
        from sklearn.model_selection import GridSearchCV
        from sklearn.model_selection import RandomizedSearchCV
        from sklearn.model_selection import TimeSeriesSplit
```

0.1 Objective

1. Train, CV, Test split.
2. find right 'c' (1/Lambda), gamma(1/sigma) using gridsearchcv(), randomsearchcv().
3. Build SVC with featurisation techniques like BOW, TFIDF AVGW2V2 TFIDFW2V and use l1 or l2 regularizor.
4. get accuracy, precision scores, confusion matrrix, recall score, f1 score.

```
In [8]: #connect sql database
        con = sqlite3.connect('final.sqlite')
```

```
In [9]: #read sql data using pandas
        data = pd.read_sql("SELECT * FROM REVIEWS", con)
```

```
In [10]: def partition(x) :
             if x == 'positive' :
                 return 1
             return 0

         actualscore = data['Score']
         positivenegative = actualscore.map(partition)
         data['Score'] = positivenegative
```

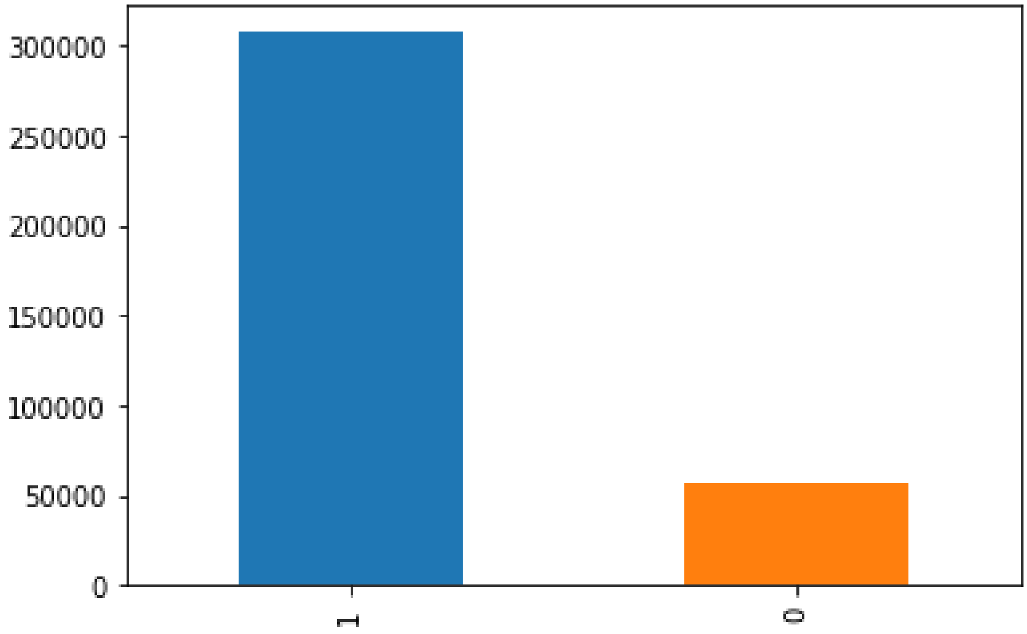
```
In [11]: data.head()
```

```
Out[11]:     index      Id   ProductId          UserId                  ProfileName  \
         0  138706  150524  0006641040   ACITT7DI6IDDL              shari zychinski
         1  138688  150506  0006641040  A2IW4PEEKO2R0U                        Tracy
         2  138689  150507  0006641040   A1S4A3IQ2MU7V4       sally sue "sally sue"
         3  138690  150508  0006641040      AZGXZ2UUK6X  Catherine Hallberg "(Kate)"
         4  138691  150509  0006641040  A3CMRKGE0P909G                       Teresa

            HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
         0                     0                       0      1   939340800
         1                     1                       1      1  1194739200
         2                     1                       1      1  1191456000
         3                     1                       1      1  1076025600
         4                     3                       4      1  1018396800

                                               Summary  \
         0                   EVERY book is educational
         1  Love the book, miss the hard cover version
         2                 chicken soup with rice months
         3       a good swingy rhythm for reading aloud
         4               A great way to learn the months

                                                      Text  \
0  this witty little book makes my son laugh at l...
1  I grew up reading these Sendak books, and watc...
2  This is a fun way for children to learn their ...
3  This is a great little book to read aloud- it ...
4  This is a book of poetry about the months of t...

                                        CleanedText
0  witti littl book make son laugh loud recit car...
1  grew read sendak book watch realli rosi movi i...
2  fun way children learn month year learn poem t...
3  great littl book read nice rhythm well good re...
4  book poetri month year goe month cute littl po...
```

```
In [12]: print ('Number of positive & negative data points are \n',data['Score'].value_counts()
         data['Score'].value_counts().plot(kind='bar')
```

```
Number of positive & negative data points are
 1    307061
0     57110
Name: Score, dtype: int64
```

```
Out[12]: <matplotlib.axes._subplots.AxesSubplot at 0x27f30075588>
```



```
In [13]: #sort data based on time
         df_time_sorted = data.sort_values('Time', kind ='quicksort')
```

```
In [14]: df_time_sorted.head()
```

```
Out[14]:       index      Id   ProductId          UserId             ProfileName  \
         0    138706  150524  0006641040   ACITT7DI6IDDL         shari zychinski
         30   138683  150501  0006641040   AJ46FKXOVC7NR      Nicholas A Mesiano
         424  417839  451856  B00004CXX9   AIUWLEQ1ADEG5        Elizabeth Medina
         330  346055  374359  B00004CI84  A344SMIA5JECGM         Vincent P. Ross
         423  417838  451855  B00004CXX9   AJH6LUC1UT1ON  The Phantom of the Opera

              HelpfulnessNumerator  HelpfulnessDenominator  Score       Time  \
         0                       0                       0      1  939340800
         30                      2                       2      1  940809600
         424                     0                       0      1  944092800
         330                     1                       2      1  944438400
         423                     0                       0      1  946857600

                                                        Summary  \
         0                               EVERY book is educational
         30   This whole series is great way to spend time w...
         424                                 Entertainingl Funny!
         330                              A modern day fairy tale
         423                                           FANTASTIC!

                                                           Text  \
         0    this witty little book makes my son laugh at l...
         30   I can remember seeing the show when it aired o...
         424  Beetlejuice is a well written movie ... ever...
         330  A twist of rumplestiskin captured on film, sta...
         423  Beetlejuice is an excellent and funny movie. K...

                                                    CleanedText
         0    witti littl book make son laugh loud recit car...
         30   rememb see show air televis year ago child sis...
         424  beetlejuic well written movi everyth excel act...
         330  twist rumplestiskin captur film star michael k...
         423  beetlejuic excel funni movi keaton hilari wack...
```

The important piece of information from dataset for building ML models are text reviews and their Scores if they are positive or negative so lets seperate only those two columns into a seperate dataframe using pandas

```
In [15]: df = pd.DataFrame(data, columns=['CleanedText', 'Score'])
         df.head()
```

```
Out[15]:                                          CleanedText  Score
         0  witti littl book make son laugh loud recit car...      1
         1  grew read sendak book watch realli rosi movi i...      1
         2  fun way children learn month year learn poem t...      1
         3   great littl book read nice rhythm well good re...      1
         4   book poetri month year goe month cute littl po...      1
```

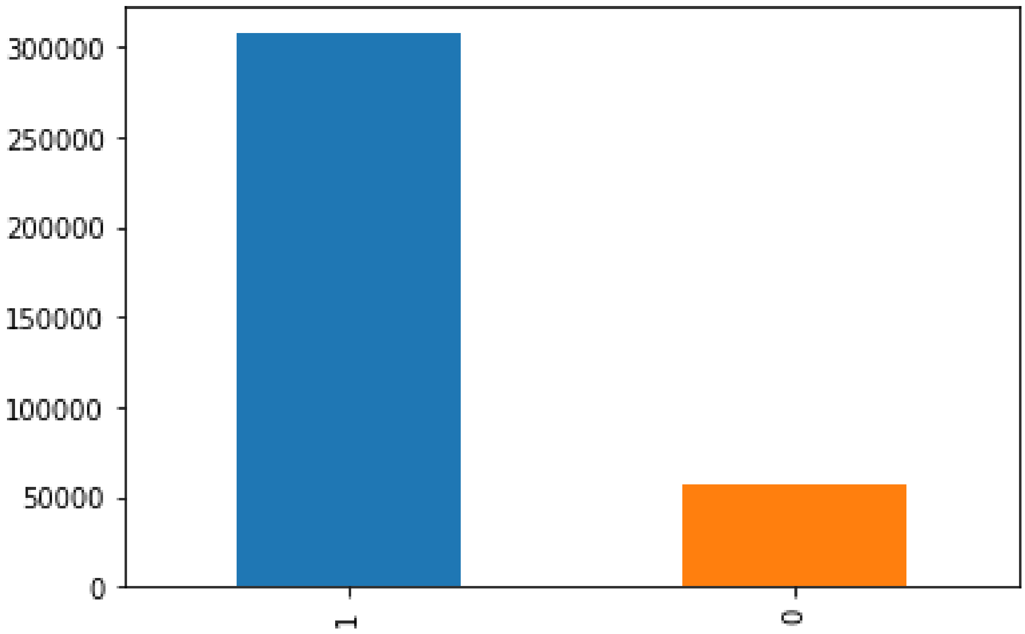
```
In [16]: #lets check the total dataset values
         df.shape
```

```
Out[16]: (364171, 2)
```

```
In [15]: df_sample = df
         print ('Number of +ve & -ve datapoints \n' ,df_sample['Score'].value_counts())
         df_sample['Score'].value_counts().plot(kind='bar')
```

```
Number of +ve & -ve datapoints
 1    307061
0     57110
Name: Score, dtype: int64
```

```
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x2665f1c3e10>
```



```
In [16]: X = df_sample['CleanedText']
         y = df_sample['Score']
         print (X.shape)
         print (y.shape)
```

```
(364171,)
(364171,)
```

```
In [17]: #test-train-split
         X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,shuffle=False
         print('X_train shape :' ,X_train.shape)
         print('y_train shape :' ,y_train.shape)
         print('X_test shape :' ,X_test.shape)
         print('y_test shape :' ,y_test.shape)
```

```
X_train shape : (254919,)
y_train shape : (254919,)
X_test shape : (109252,)
y_test shape : (109252,)
```

```
In [18]: joblib.dump(X_train, 'X_train.pkl')
         joblib.dump(X_test, 'X_test.pkl')
         joblib.dump(X_train, 'y_train.pkl')
         joblib.dump(X_test, 'y_test.pkl')
```

```
Out[18]: ['y_test.pkl']
```

```
In [19]: X_train = joblib.load('X_train.pkl')
         X_test = joblib.load('X_test.pkl')
         y_train = joblib.load('y_train.pkl')
         y_test = joblib.load('y_test.pkl')
```

0.1.1 check if rows are not shuffled since its time series data

```
In [18]: X_train.head()
```

```
Out[18]: 0    witti littl book make son laugh loud recit car...
         1    grew read sendak book watch realli rosi movi i...
         2    fun way children learn month year learn poem t...
         3    great littl book read nice rhythm well good re...
         4    book poetri month year goe month cute littl po...
         Name: CleanedText, dtype: object
```

```
In [19]: X_test.head()
```

```
Out[19]: 254919    word want reduc caffienn brand best choic use ...
         254920    louisiana nativ like peopl louisiana drink com...
         254921    drink number brand coffe definit dont enjoy fi...
         254922    purchas great price amazon pleas flavor buddi ...
         254923    love coffe still block form fresh communiti co...
         Name: CleanedText, dtype: object
```

```
In [20]: X_train.tail()
```

```
Out[20]: 254914       havent found decaff serv challah one give rebb
         254915    purchas coffe base posit feedback either got b...
```

```
254916    drank communiti coffe mani year recent becam c...
254917    bought pack give other kept one tri glad great...
254918    love communiti coffe yummi strong without grea...
Name: CleanedText, dtype: object
```

```
In [21]: X_test.tail()
```

```
Out[21]: 364166    love love sweeten use bake unsweeten flavor co...
         364167    tri sauc believ start littl sweet honey tast b...
         364168    bought hazelnut past nocciola spread local sho...
         364169    purchas product local store kid love quick eas...
         364170    purchas send son whos away colleg deliv right ...
         Name: CleanedText, dtype: object
```

Since SVM is Computationally expensive and very time consuming. and specifically GridSearch takes a lot of time for SVC(). so, we use - SGDClassifier with hinge loss along with GridSearchCV & RandomizedSearchCV

1 Functions to find Hyperparameter & Use Logistic Regression

```
In [22]: def SGD_best_params (X_train, y_train) :
             #c=1/lambda, lambda = 0.001,0.002,0.01,0.02,0.1,0.2,1,2,10,20,100,200,1000,2000,1
             #gamma = 1/sigma, sigma = 0.001,0.002,0.01,0.02,0.1,0.2,1,2,10,20,100,200,1000,20
             clf = SGDClassifier(loss='hinge')
             cv= TimeSeriesSplit(n_splits=10)
             param_grid = {'alpha':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005
                           'penalty':['l1','l2', 'elasticnet']}
             grid_cv = GridSearchCV(clf, param_grid, cv=cv, verbose=1, n_jobs=-1)
             grid_cv.fit(X_train,y_train)
             print("Best HyperParameter: ",grid_cv.best_params_)
             print("Best Accuracy: ", (grid_cv.best_score_*100))
             #accessing cv_results
             cv_results = pd.DataFrame(grid_cv.cv_results_)
             alpha_cv = cv_results[['param_alpha', 'mean_test_score']]
             plot_data = alpha_cv.loc[::3, :]
             #Function for cv_error vs alpha plot
             plt.figure(figsize=(10,6))
             plt.xlabel('Alpha')
             plt.ylabel('Best Score')
             plt.plot(plot_data['param_alpha'], plot_data['mean_test_score'], marker='o', marke
```

```
In [23]: def SGD(alpha, penalty, X_train, y_train, X_test, y_test) :
             clf = SGDClassifier(alpha=alpha, penalty=penalty, loss='hinge')
             clf.fit(X_train, y_train)
             y_pred=clf.predict(X_test)
             print('accuracy_score =', accuracy_score(y_test, y_pred))
             print('precision_score =', precision_score(y_test, y_pred))
             print('recall_score =', recall_score(y_test, y_pred))
```

```
        cm = confusion_matrix(y_test, y_pred)
        sns.heatmap(cm, annot=True, fmt="d")
        return y_pred
```

```
In [49]: #c=1/lambda, lambda = 0.001,0.002,0.01,0.02,0.1,0.2,1,2,10,20,100,200,1000,2000,10000
         def SGD_best_params_rand (X_train, y_train) :
             clf = SGDClassifier(loss='hinge')
             cv= TimeSeriesSplit(n_splits=10)
             #param_grid = {'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0
             param_grid = {'alpha':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005
                         'penalty':['l1','l2', 'elasticnet']}
             rand_cv = RandomizedSearchCV(clf, param_grid, cv=cv, verbose=1, n_jobs=-1, random_
             rand_cv.fit(X_train,y_train)
             print("Best HyperParameter: ",rand_cv.best_params_)
             print("Best Accuracy: ", (rand_cv.best_score_*100))
             #accessing cv_results
             cv_results = pd.DataFrame(rand_cv.cv_results_)
             alpha_cv = cv_results[['param_alpha', 'mean_test_score']]
             plot_data = alpha_cv.sort_values('param_alpha')
             #Function for cv_error vs alpha plot
             plt.figure(figsize=(10,6))
             plt.xlabel('Alpha')
             plt.ylabel('Best Score')
             plt.plot(plot_data['param_alpha'], plot_data['mean_test_score'], marker='o', marke
```

```
In [25]: def SGD_rand(alpha, penalty, X_train, y_train, X_test, y_test) :
             #clf = SVC(C=C , gamma=gamma )
             clf = SGDClassifier(alpha=alpha, penalty=penalty, loss='hinge')
             clf.fit(X_train, y_train)
             y_pred = clf.predict(X_test)
             print('accuracy_score =', accuracy_score(y_test, y_pred))
             print('precision_score =', precision_score(y_test, y_pred))
             print('recall_score =', recall_score(y_test, y_pred))
             cm = confusion_matrix(y_test, y_pred)
             sns.heatmap(cm, annot=True, fmt="d")
             return y_pred
```

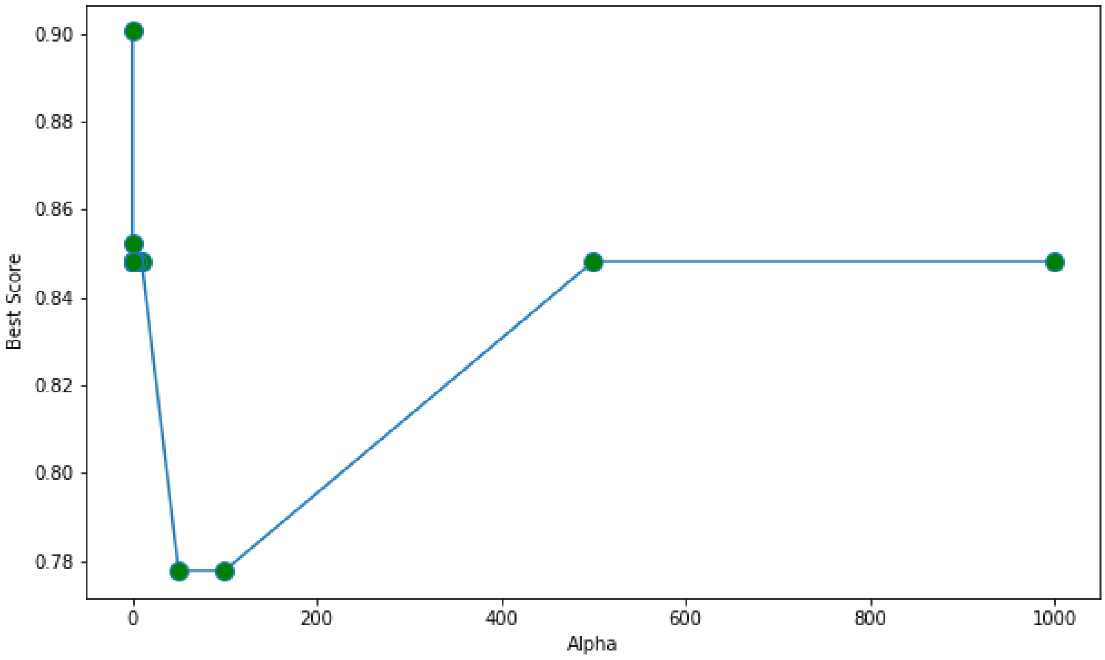
2 BAG of WORDS

```
In [54]: vect = CountVectorizer()
```

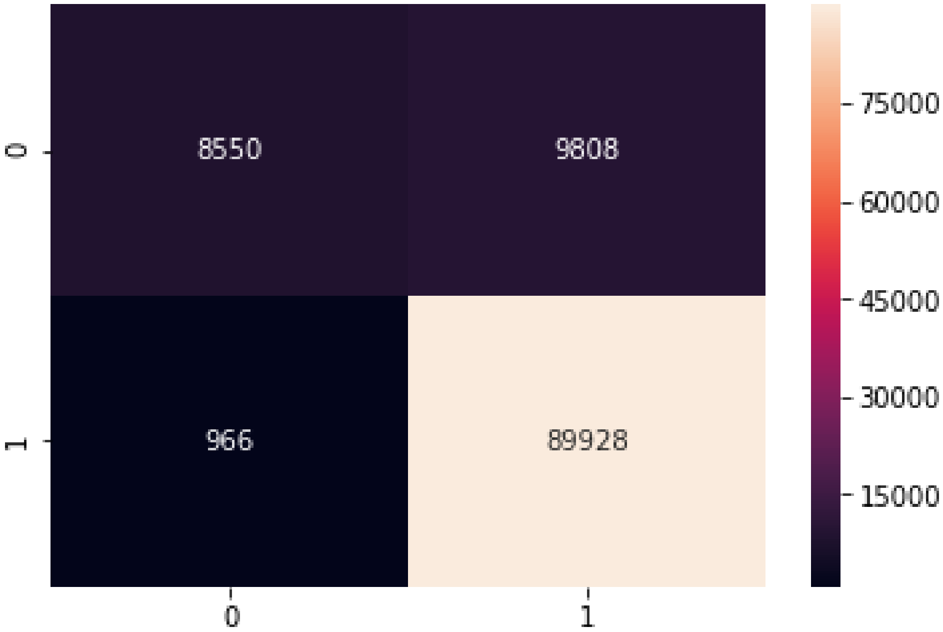
```
In [55]: bow_X_train = vect.fit_transform(X_train)
         bow_X_train = preprocessing.normalize(bow_X_train)
         bow_X_train
```

```
Out[55]: <254919x59601 sparse matrix of type '<class 'numpy.float64'>'
                 with 7863068 stored elements in Compressed Sparse Row format>
```

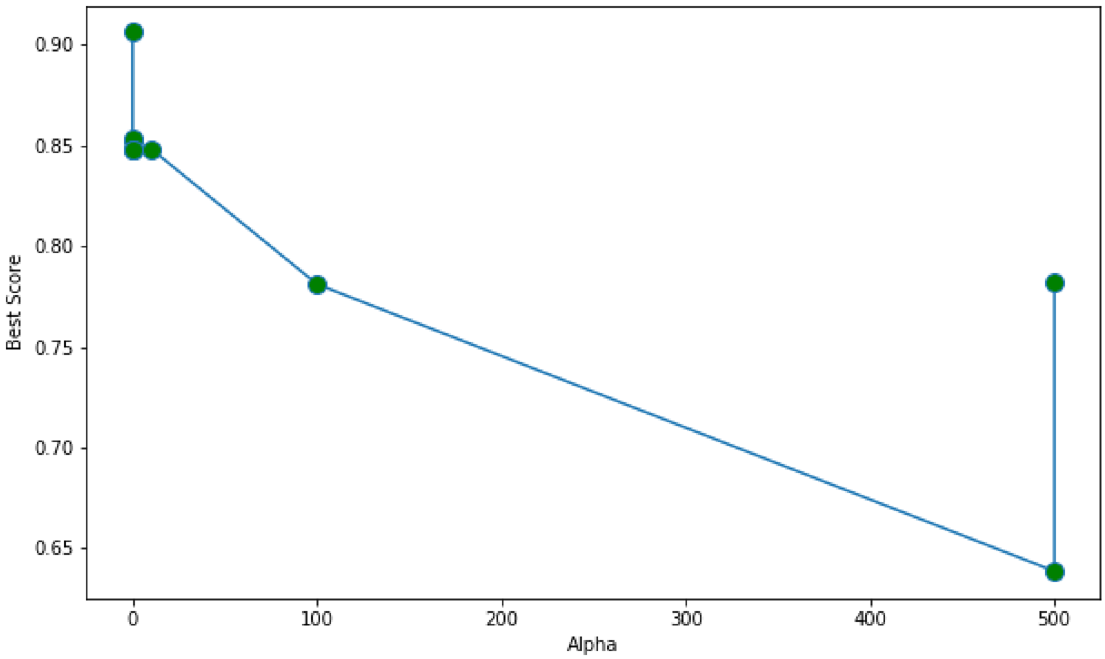
```
In [56]: bow_X_test = vect.transform(X_test)
         bow_X_test = preprocessing.normalize(bow_X_test)
         bow_X_test

Out[56]: <109252x59601 sparse matrix of type '<class 'numpy.float64'>'
                 with 3581565 stored elements in Compressed Sparse Row format>

In [57]: joblib.dump(bow_X_train, 'bow_X_train.pkl')
         joblib.dump(bow_X_test, 'bow_X_test.pkl')

Out[57]: ['bow_X_test.pkl']

In [58]: bow_X_train = joblib.load('bow_X_train.pkl')
         bow_X_test = joblib.load('bow_X_test.pkl')

In [29]: SGD_best_params(bow_X_train, y_train)

Fitting 10 folds for each of 45 candidates, totalling 450 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    8.9s
[Parallel(n_jobs=-1)]: Done 176 tasks      | elapsed:   35.4s
[Parallel(n_jobs=-1)]: Done 426 tasks      | elapsed:  1.4min
[Parallel(n_jobs=-1)]: Done 450 out of 450 | elapsed:  1.5min finished


Best HyperParameter:  {'alpha': 0.0001, 'penalty': 'l2'}
Best Accuracy:  90.57305601104686
```



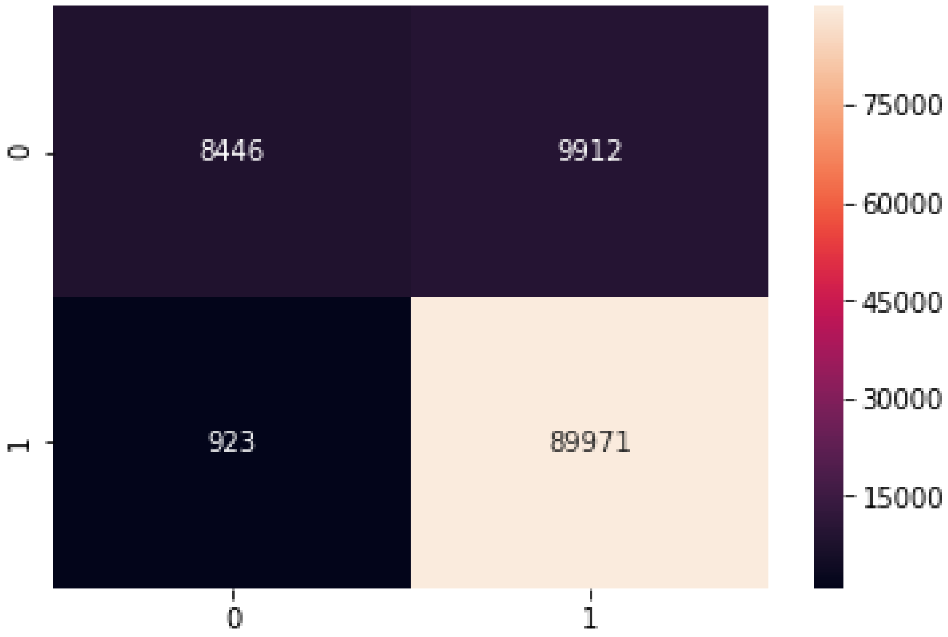
```
In [30]: %time SGD(0.0001, 'l2', bow_X_train, y_train, bow_X_test, y_test)

accuracy_score = 0.9013839563577783
precision_score = 0.9016603834122082
recall_score = 0.9893722357911413
Wall time: 528 ms


Out[30]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```



```
In [59]: SGD_best_params_rand(bow_X_train, y_train)

Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    9.3s
[Parallel(n_jobs=-1)]: Done 100 out of 100 | elapsed:   23.2s finished


Best HyperParameter:  {'penalty': 'l2', 'alpha': 0.0001}
Best Accuracy:  90.59894709588332
```



```
In [32]: SGD_rand(0.0001,'l2', bow_X_train, y_train, bow_X_test, y_test)

accuracy_score = 0.9008256141763995
precision_score = 0.9007638937556942
recall_score = 0.9898453143221775


Out[32]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```



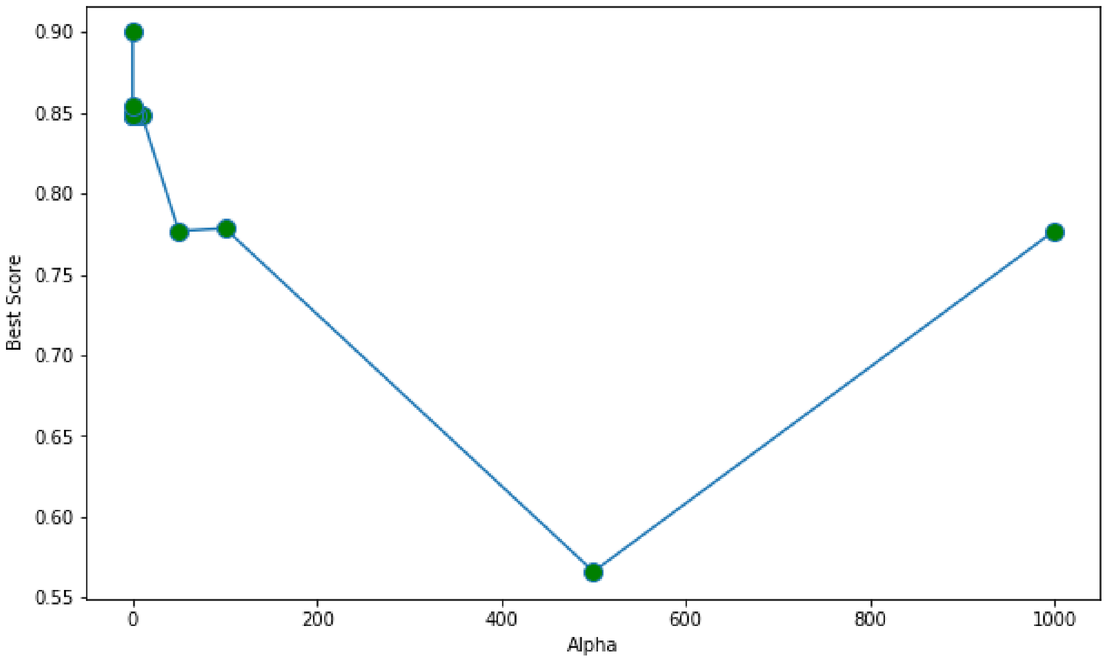
3 TFIDF

```
In [33]: vect = TfidfVectorizer()

In [34]: from sklearn import preprocessing
         tfidf_X_train = vect.fit_transform(X_train)
         tfidf_X_train = preprocessing.normalize(tfidf_X_train)
         tfidf_X_train

Out[34]: <254919x59601 sparse matrix of type '<class 'numpy.float64'>'
                 with 7863068 stored elements in Compressed Sparse Row format>

In [35]: tfidf_X_test = vect.transform(X_test)
         tfidf_X_test = preprocessing.normalize(tfidf_X_test)
         tfidf_X_test

Out[35]: <109252x59601 sparse matrix of type '<class 'numpy.float64'>'
                 with 3581565 stored elements in Compressed Sparse Row format>

In [ ]: joblib.dump(tfidf_X_train, 'tfidf_X_train.pkl')
        joblib.dump(tfidf_X_test, 'tfidf_X_test.pkl')

In [ ]: tfidf_X_train = joblib.load(tfidf_X_train, 'tfidf_X_train.pkl')
        tfidf_X_test = joblib.load(tfidf_X_test, 'tfidf_X_test.pkl')

In [36]: SGD_best_params(tfidf_X_train, y_train)
```

```
Fitting 10 folds for each of 45 candidates, totalling 450 fits
```

```
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    8.5s
[Parallel(n_jobs=-1)]: Done 176 tasks      | elapsed:   34.4s
[Parallel(n_jobs=-1)]: Done 426 tasks      | elapsed:  1.4min
[Parallel(n_jobs=-1)]: Done 450 out of 450 | elapsed:  1.4min finished
```

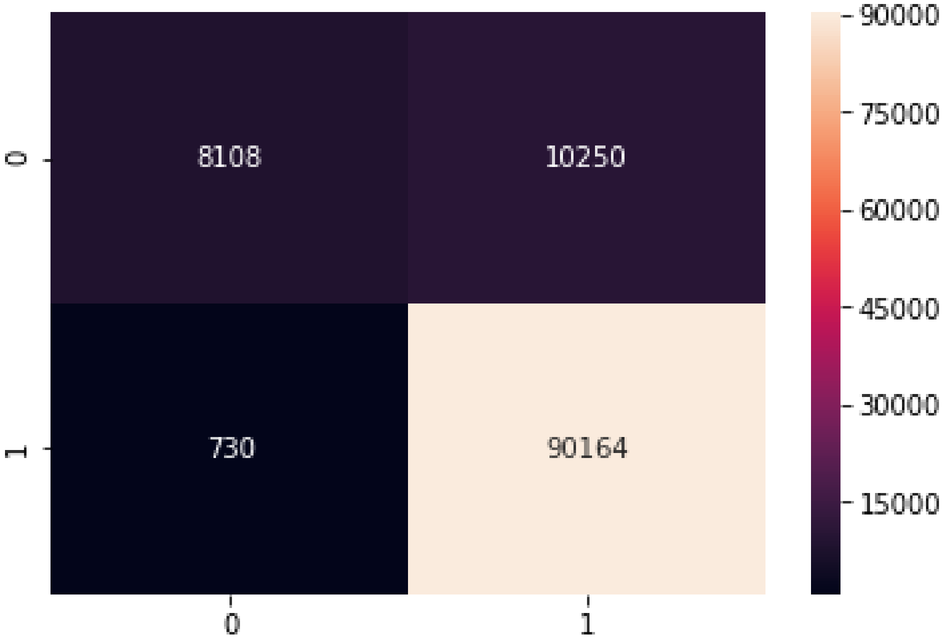
```
Best HyperParameter:  {'alpha': 0.0001, 'penalty': 'l2'}
Best Accuracy:  90.53378786571157
```



```
In [37]: SGD(0.0001, 'l2', tfidf_X_train, y_train, tfidf_X_test, y_test)
```

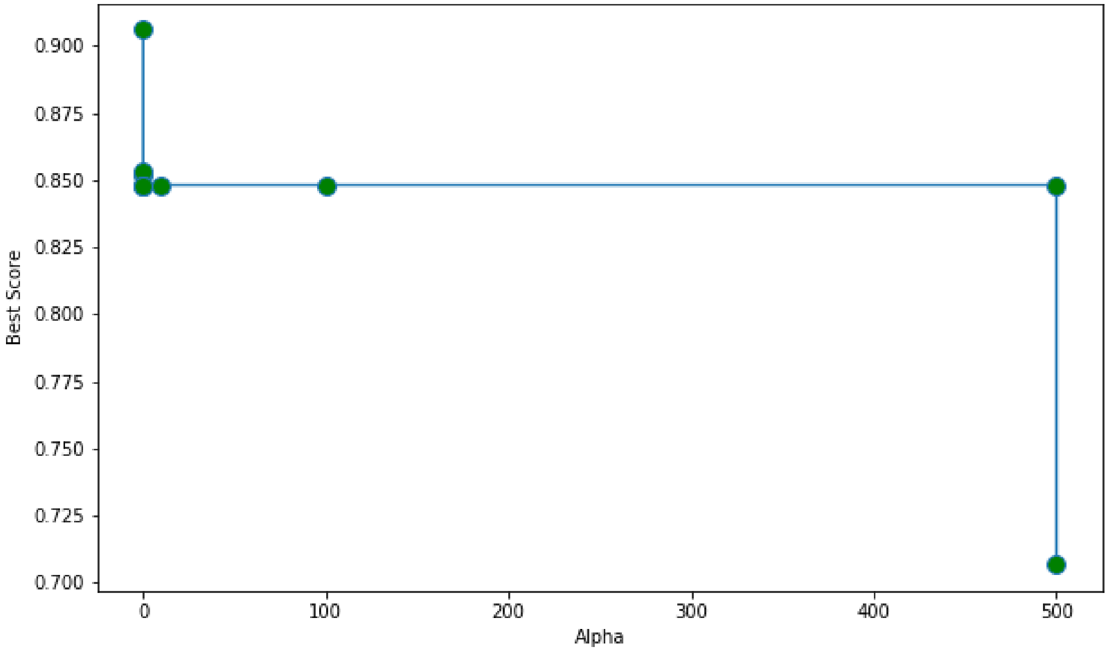
```
accuracy_score = 0.8994984073518105
precision_score = 0.8979226004342024
recall_score = 0.9919686667986886
```

```
Out[37]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```

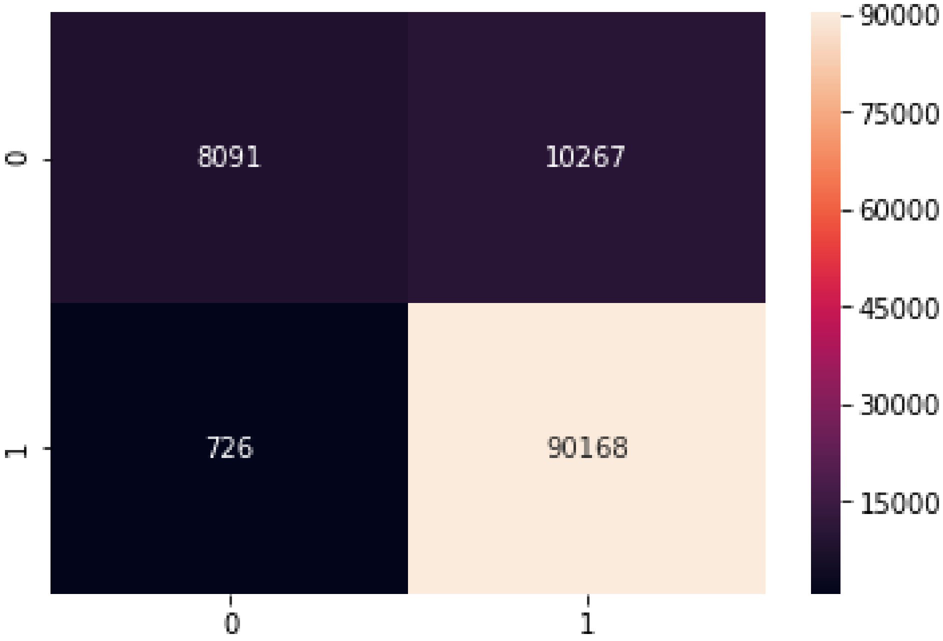


In [38]: SGD_best_params_rand(tfidf_X_train, y_train)

```
Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    8.6s
[Parallel(n_jobs=-1)]: Done 100 out of 100 | elapsed:   20.5s finished


Best HyperParameter:  {'penalty': 'l2', 'alpha': 0.0001}
Best Accuracy:  90.59074825235177
```



```
In [39]: SGD_rand(0.0001,'l2', tfidf_X_train, y_train, tfidf_X_test, y_test)

accuracy_score = 0.8993794163951232
precision_score = 0.897774680141385
recall_score = 0.9920126741039013

Out[39]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```



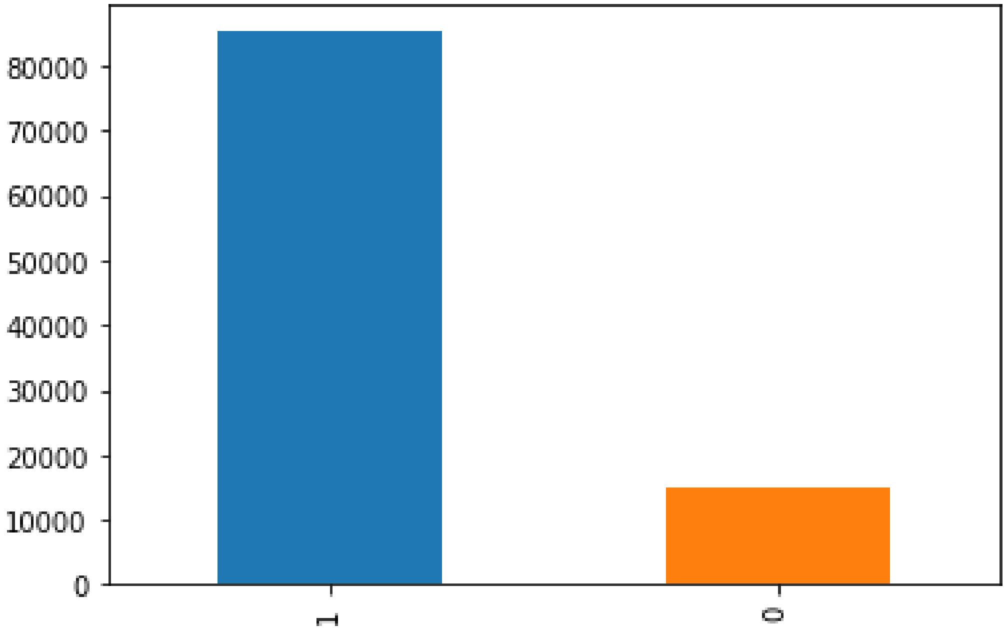
4 WORD2VECTOR Model

AVGW2V & TFIDFW2V takes lot of time to train so we use only first 100k data

```
In [26]: w2v_data = df.head(100000)
         print ('Number of +ve & -ve datapoints \n' ,df_sample['Score'].value_counts())
         w2v_data['Score'].value_counts().plot(kind='bar')
```

```
Number of +ve & -ve datapoints
 1    307061
0     57110
Name: Score, dtype: int64
```

```
Out[26]: <matplotlib.axes._subplots.AxesSubplot at 0x266672328d0>
```



```
In [27]: w2v_X = w2v_data['CleanedText']
         w2v_y = w2v_data['Score']
         print (w2v_X.shape)
         print (w2v_y.shape)
```

```
(100000,)
(100000,)
```

```
In [28]: #test-train-split
         w2v_X_train, w2v_X_test, w2v_y_train, w2v_y_test = train_test_split(w2v_X, w2v_y, tes
         print('X_train shape :' ,w2v_X_train.shape)
         print('y_train shape :' ,w2v_y_train.shape)
         print('X_test shape :' ,w2v_X_test.shape)
         print('y_test shape :' ,w2v_y_test.shape)
```

```
X_train shape : (70000,)
y_train shape : (70000,)
X_test shape : (30000,)
y_test shape : (30000,)
```

```
In [29]: # Train your own Word2Vec model using your own text corpus
         i=0
         list_of_sent=[]
         for sent in w2v_X_train.values:
             list_of_sent.append(sent.split())
```

```
In [30]: print(w2v_X_train.values[0])
         print("******************************************************************")
         print(list_of_sent[0])
```

```
witti littl book make son laugh loud recit car drive along alway sing refrain hes learn whale i
******************************************************************
['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'recit', 'car', 'drive', 'along', 'a
```

```
In [31]: # min_count = 5 considers only words that occured atleast 5 times
         w2v_model=Word2Vec(list_of_sent,min_count=5,size=50, workers=4)
```

```
In [ ]: joblib.dump(w2v, 'w2v.pkl')
```

```
In [ ]: w2v_model = joblib.load(w2v, 'w2v.pkl')
```

```
In [32]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  10848
sample words  ['littl', 'book', 'make', 'son', 'laugh', 'loud', 'recit', 'car', 'drive', 'alon
```

5 AVGW2V

5.0.1 AVGW2V on train data

```
In [44]: # average Word2Vec
         # compute average word2vec for each review.
```

```
        %time train_vectors = []; # the avg-w2v for each sentence/review is stored in this li
        for sent in list_of_sent: # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length
            cnt_words =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                if word in w2v_words:
                    vec = w2v_model.wv[word]
                    sent_vec += vec
                    cnt_words += 1
            if cnt_words != 0:
                sent_vec /= cnt_words
            train_vectors.append(sent_vec)
        print(len(train_vectors))
        print(len(train_vectors[0]))
```

```
Wall time: 0 ns
254919
50
```

```
In [45]: avgw2v_train = preprocessing.normalize(train_vectors)
```

5.0.2 AVGW2V on test data

```
In [39]: # Train your own Word2Vec model using your own text corpus
         i=0
         list_of_sent_in_test=[]
         for sent in w2v_X_test.values:
             list_of_sent_in_test.append(sent.split())
```

```
In [40]: print(w2v_X_test.values[0])
         print("*****************************************************************")
         print(list_of_sent_in_test[0])
```

```
introduc madhava agav sister back jan diabet run famili decid use tea coffe cereal cold hot pa
*****************************************************************
['introduc', 'madhava', 'agav', 'sister', 'back', 'jan', 'diabet', 'run', 'famili', 'decid', '
```

```
In [48]: # average Word2Vec
         # compute average word2vec for each review.
         test_vectors = []; # the avg-w2v for each sentence/review is stored in this list

         for sent in list_of_sent_in_test : # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
```

```
                sent_vec += vec
                cnt_words += 1
        if cnt_words != 0:
            sent_vec /= cnt_words
        test_vectors.append(sent_vec)
print(len(test_vectors))
print(len(test_vectors[0]))
```

```
109252
50
```

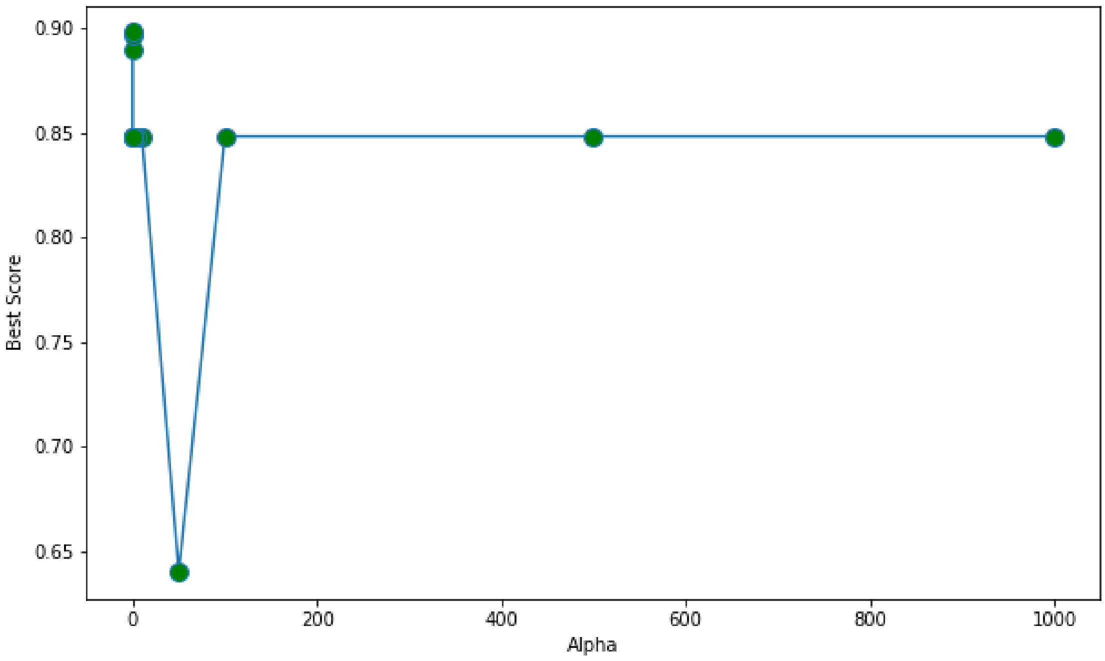
```
In [49]: avgw2v_test = preprocessing.normalize(test_vectors)
```

```
In [ ]: joblib.dump(avgw2v_train, 'avgw2v_train.pkl')
        joblib.dump(avgw2v_test, 'avgw2v_test.pkl')
```

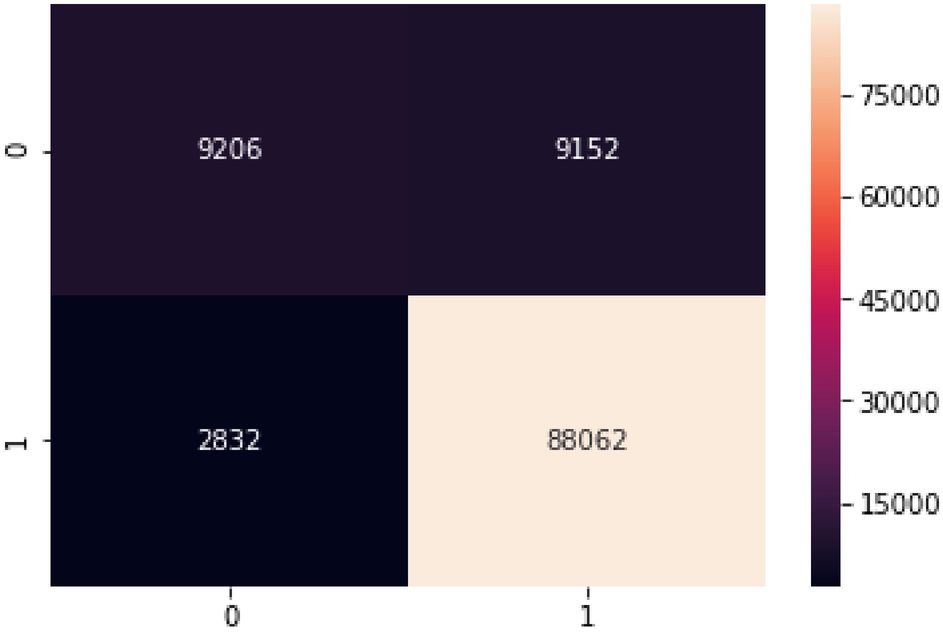
```
In [ ]: avgw2v_train = joblib.load('avgw2v_train.pkl')
        avgw2v_test = joblib.load('avgw2v_test.pkl')
```

```
In [50]: SGD_best_params(avgw2v_train, y_train)
```

```
Fitting 10 folds for each of 45 candidates, totalling 450 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    9.3s
[Parallel(n_jobs=-1)]: Done 176 tasks      | elapsed:   35.8s
[Parallel(n_jobs=-1)]: Done 426 tasks      | elapsed:  1.4min
[Parallel(n_jobs=-1)]: Done 450 out of 450 | elapsed:  1.5min finished


Best HyperParameter:  {'alpha': 0.0001, 'penalty': 'l2'}
Best Accuracy:  89.81703633382239
```

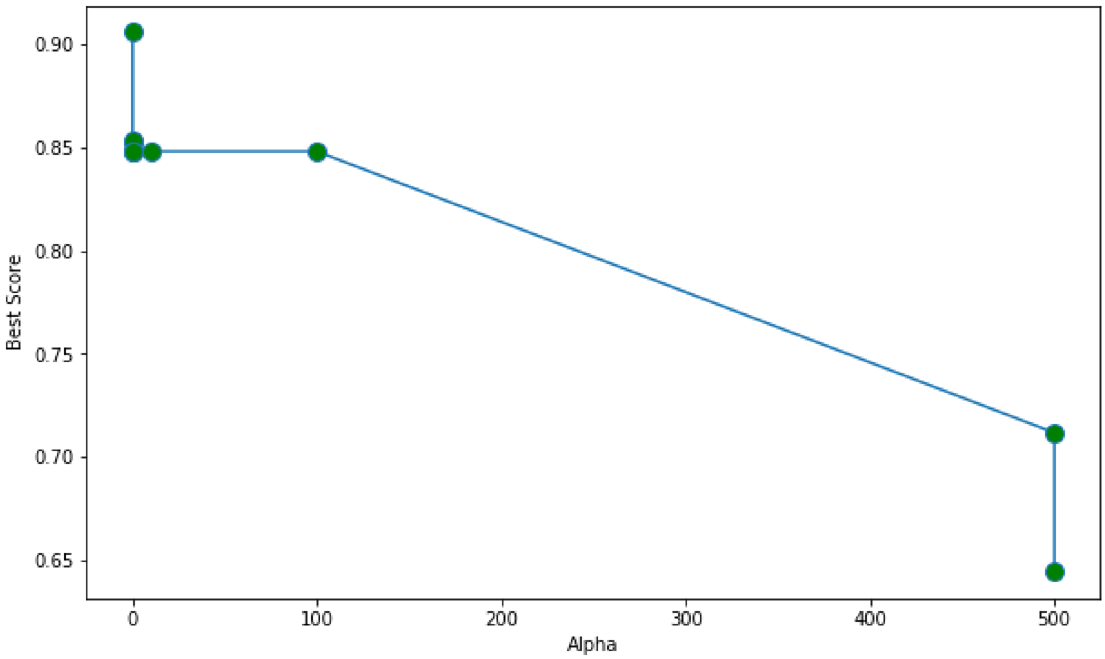


```
In [51]: SGD(0.0001, 'l2', avgw2v_train, y_train, avgw2v_test, y_test)

accuracy_score = 0.8903086442353458
precision_score = 0.9058571810644558
recall_score = 0.968842827909433


Out[51]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```

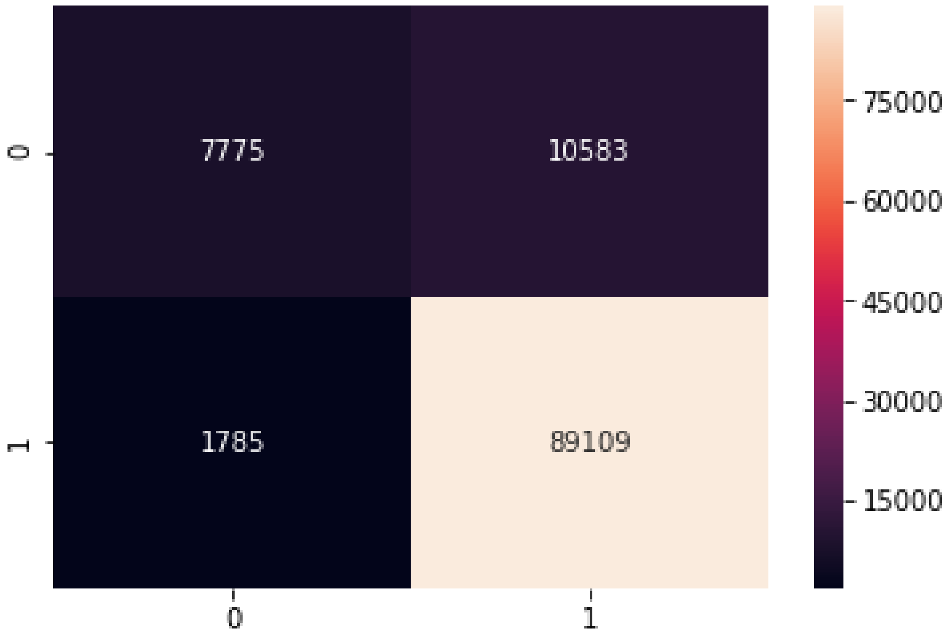


```
In [52]: SGD_best_params_rand(avgw2v_train, y_train)
```

```
Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    8.8s
[Parallel(n_jobs=-1)]: Done 100 out of 100 | elapsed:   20.7s finished


Best HyperParameter:  {'penalty': 'l2', 'alpha': 0.0001}
Best Accuracy:  90.59506343315785
```



```
In [53]: SGD_rand(0.0001,'l2', avgw2v_train, y_train, avgw2v_test, y_test)

accuracy_score = 0.8867938344378135
precision_score = 0.8938430365525819
recall_score = 0.9803617400488481


Out[53]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```



6 TFIDFW2V

6.0.1 TFIDFW2V on Train data

```
In [33]: #calculate TFIDF
         tf_idf_vect = TfidfVectorizer()
         final_tf_idf_train = tf_idf_vect.fit_transform(w2v_X_train.values)
         final_tf_idf_test = tf_idf_vect.transform(w2v_X_test.values)
```

```
In [34]: # TF-IDF weighted Word2Vec
         tfidf_feat = tf_idf_vect.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
         np.seterr(divide='ignore', invalid='ignore')
         tfidf_train_vectors = []; # the tfidf-w2v for each sentence/review is stored in this
         row=0;
         for sent in list_of_sent: # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 try:
                     vec = w2v_model.wv[word]
                     # obtain the tf_idfidf of a word in a sentence/review
                     tf_idf = final_tf_idf_train[row, tfidf_feat.index(word)]
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
```

```
                except:
                    pass
            sent_vec /= weight_sum
            tfidf_train_vectors.append(sent_vec)
            row += 1
        print(len(tfidf_train_vectors))
        print(len(tfidf_train_vectors[0]))
```

```
70000
50
```

```
In [44]: tfidfw2v_train = preprocessing.normalize(tfidf_train_vectors)
         #tfidfw2v_train = tfidf_train_vectors
```

6.0.2 TFIDFW2V on Test Data

```
In [41]: # TF-IDF weighted Word2Vec
         tfidf_feat = tf_idf_vect.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
         np.seterr(divide='ignore', invalid='ignore')
         tfidf_test_vectors = []; # the tfidf-w2v for each sentence/review is stored in this l
         row=0;
         for sent in list_of_sent_in_test: # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 try:
                     vec = w2v_model.wv[word]
                     # obtain the tf_idfidf of a word in a sentence/review
                     tf_idf = final_tf_idf_test[row, tfidf_feat.index(word)]
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
                 except:
                     pass
             sent_vec /= weight_sum
             tfidf_test_vectors.append(sent_vec)
             row += 1
         print(len(tfidf_test_vectors))
         print(len(tfidf_test_vectors[0]))
```

```
30000
50
```

```
In [43]: tfidfw2v_test = preprocessing.normalize(tfidf_test_vectors)
         tfidfw2v_test.shape
```

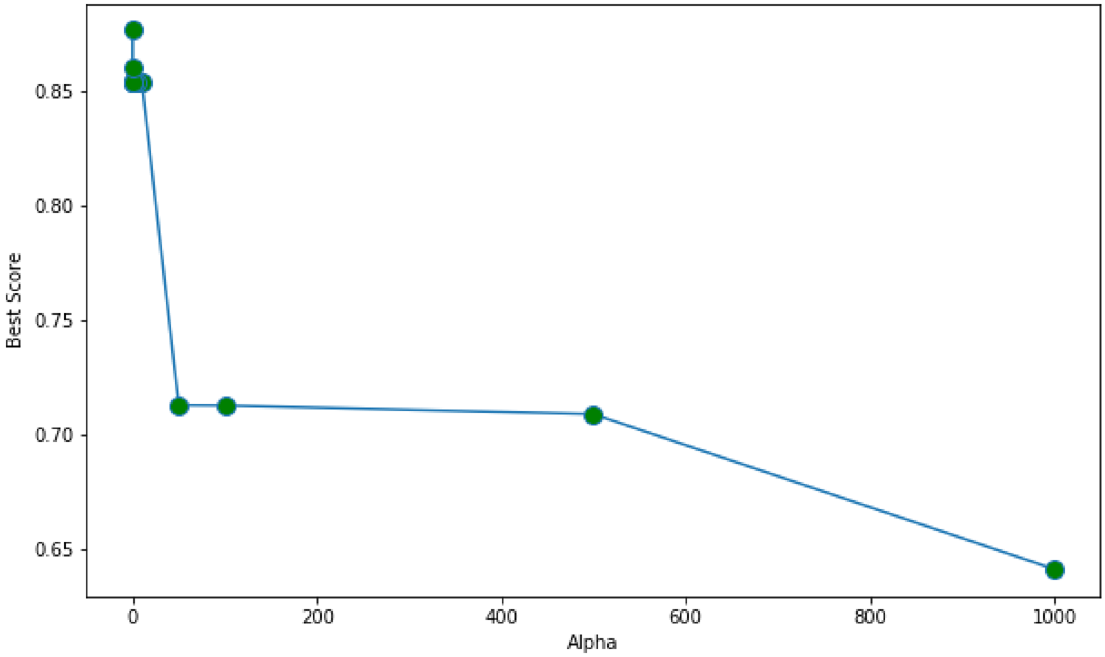
```
Out[43]: (30000, 50)
```

```
In [ ]: joblib.dump(tfidfw2v_train, 'tfidfw2v_train.pkl')
        joblib.dump(tfidfw2v_test, 'tfidfw2v_test.pkl')
```

```
In [ ]: tfidfw2v_train = joblib.load('tfidfw2v_train.pkl')
        tfidfw2v_test = joblib.load('tfidfw2v_test.pkl')
```

```
In [46]: SGD_best_params(tfidfw2v_train, w2v_y_train)
```

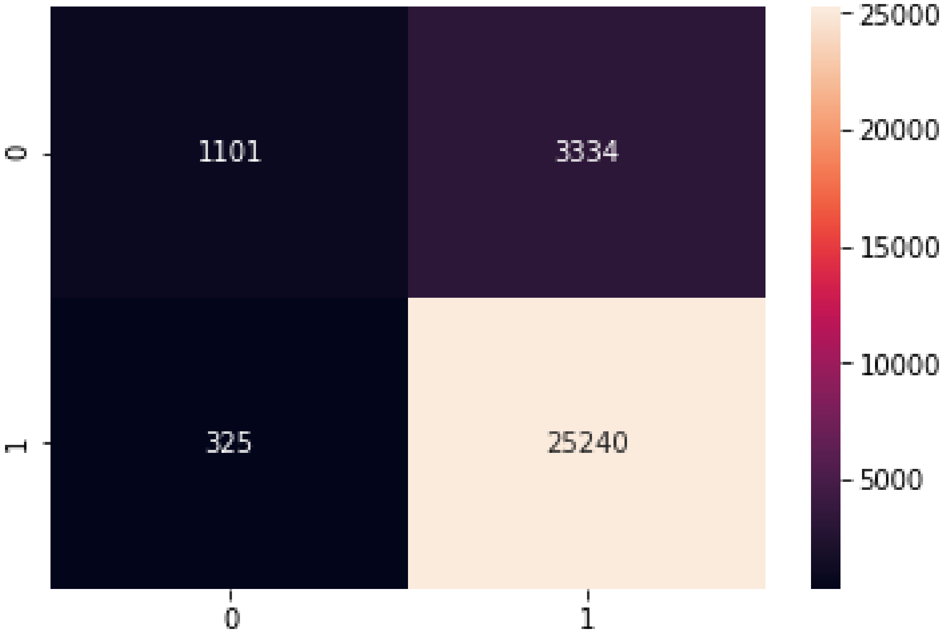
```
Fitting 10 folds for each of 45 candidates, totalling 450 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    6.8s
[Parallel(n_jobs=-1)]: Done 176 tasks      | elapsed:   16.3s
[Parallel(n_jobs=-1)]: Done 426 tasks      | elapsed:   31.4s
[Parallel(n_jobs=-1)]: Done 450 out of 450 | elapsed:   32.4s finished


Best HyperParameter:  {'alpha': 0.0001, 'penalty': 'l2'}
Best Accuracy:  87.82806852113782
```



```
In [47]: SGD(0.0001, 'l2', tfidfw2v_train, w2v_y_train, tfidfw2v_test, w2v_y_test)
```

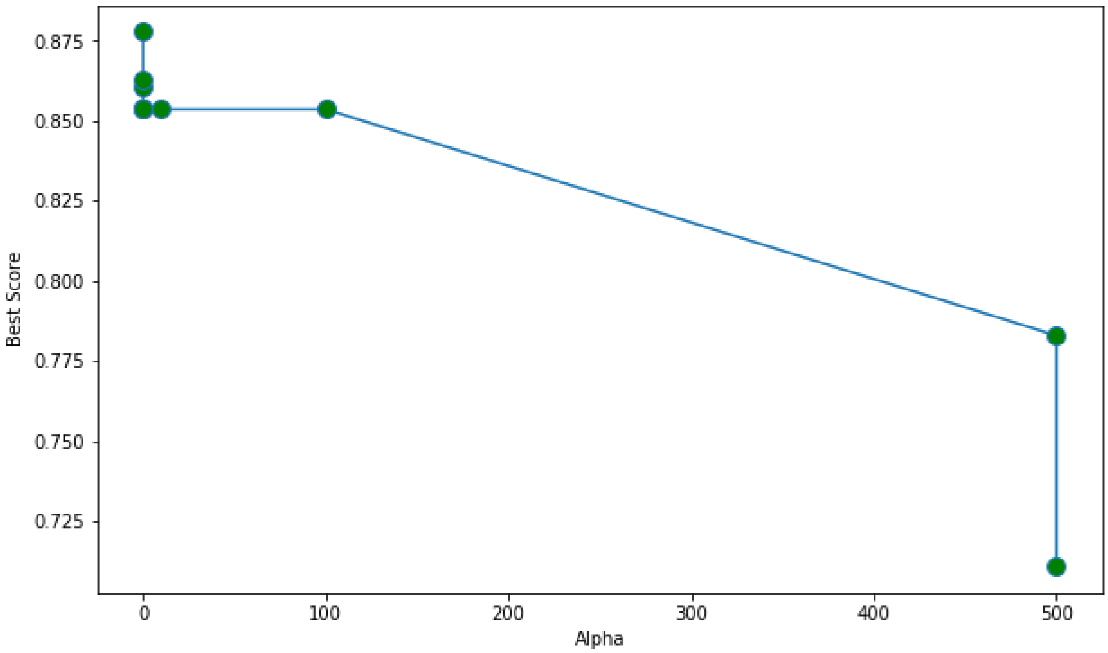
```
accuracy_score = 0.8780333333333333
precision_score = 0.883320501154896
recall_score = 0.9872873068648543
```

```
Out[47]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```



```
In [50]: SGD_best_params_rand(tfidfw2v_train, w2v_y_train)
```

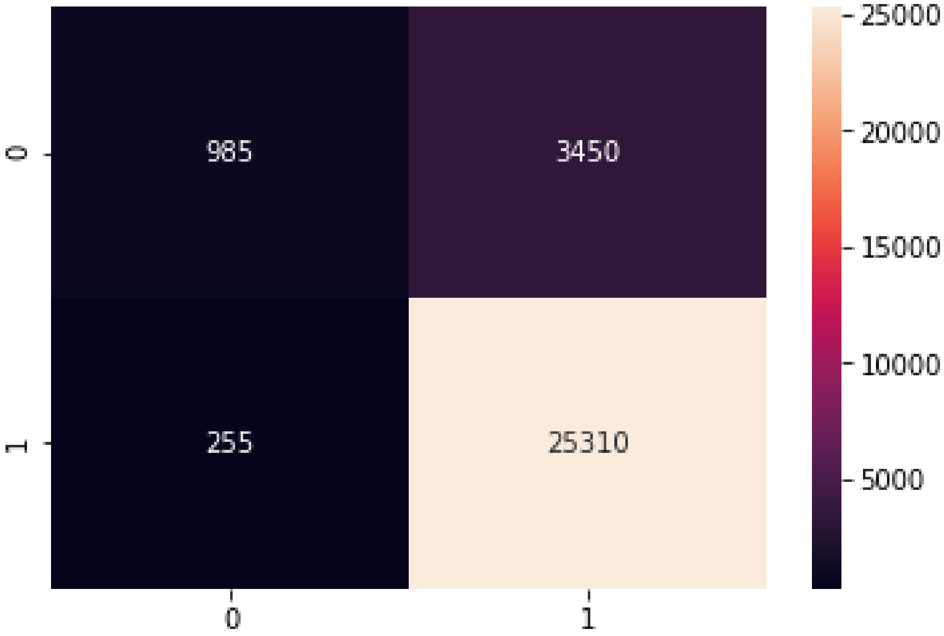
```
Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:    6.6s
[Parallel(n_jobs=-1)]: Done 100 out of 100 | elapsed:   11.2s finished


Best HyperParameter:  {'penalty': 'l2', 'alpha': 0.0001}
Best Accuracy:  87.78249253496779
```



```
In [51]: SGD_rand(0.0001,'l2', tfidfw2v_train, w2v_y_train, tfidfw2v_test, w2v_y_test)
```

```
accuracy_score = 0.8765
precision_score = 0.8800417246175244
recall_score = 0.9900254253862703
```

```
Out[51]: array([1, 1, 1, ..., 1, 1, 1], dtype=int64)
```

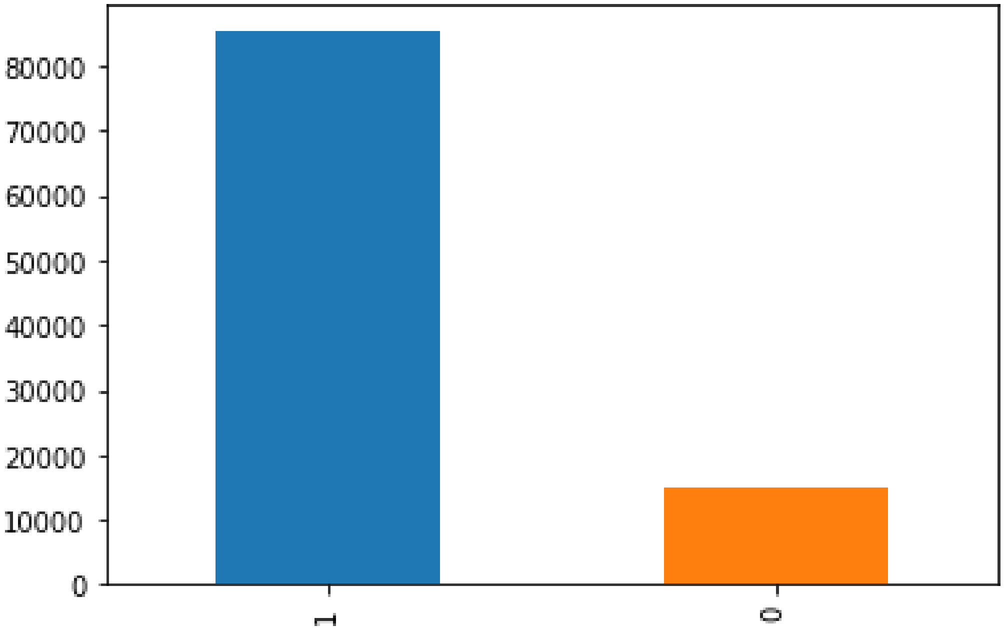


7 SVM WITH SKLEARN CLASSIFIER ON OUR BEST MODEL BOW

```
In [79]: SVM_df_sample = df.head(100000)
         print ('Number of +ve & -ve datapoints \n' ,SVM_df_sample['Score'].value_counts())
         SVM_df_sample['Score'].value_counts().plot(kind='bar')
```

```
Number of +ve & -ve datapoints
 1    85197
0    14803
Name: Score, dtype: int64
```

```
Out[79]: <matplotlib.axes._subplots.AxesSubplot at 0x27f3ca809e8>
```



```
In [80]: SVM_X = SVM_df_sample['CleanedText']
         SVM_y = SVM_df_sample['Score']
         print (SVM_X.shape)
         print (SVM_y.shape)
```

```
(100000,)
(100000,)
```

```
In [81]: #test-train-split
         SVM_X_train, SVM_X_test, SVM_y_train, SVM_y_test = train_test_split(SVM_X, SVM_y, tes
         print('X_train shape :' ,SVM_X_train.shape)
         print('y_train shape :' ,SVM_y_train.shape)
         print('X_test shape :' ,SVM_X_test.shape)
         print('y_test shape :' ,SVM_y_test.shape)
```

```
X_train shape : (70000,)
y_train shape : (70000,)
X_test shape : (30000,)
y_test shape : (30000,)
```

```
In [82]: vect = CountVectorizer()
```

```
In [83]: bow_X_train = vect.fit_transform(SVM_X_train)
         bow_X_train = preprocessing.normalize(bow_X_train)
         bow_X_train
```

```
Out[83]: <70000x32149 sparse matrix of type '<class 'numpy.float64'>'
                 with 2162199 stored elements in Compressed Sparse Row format>
```

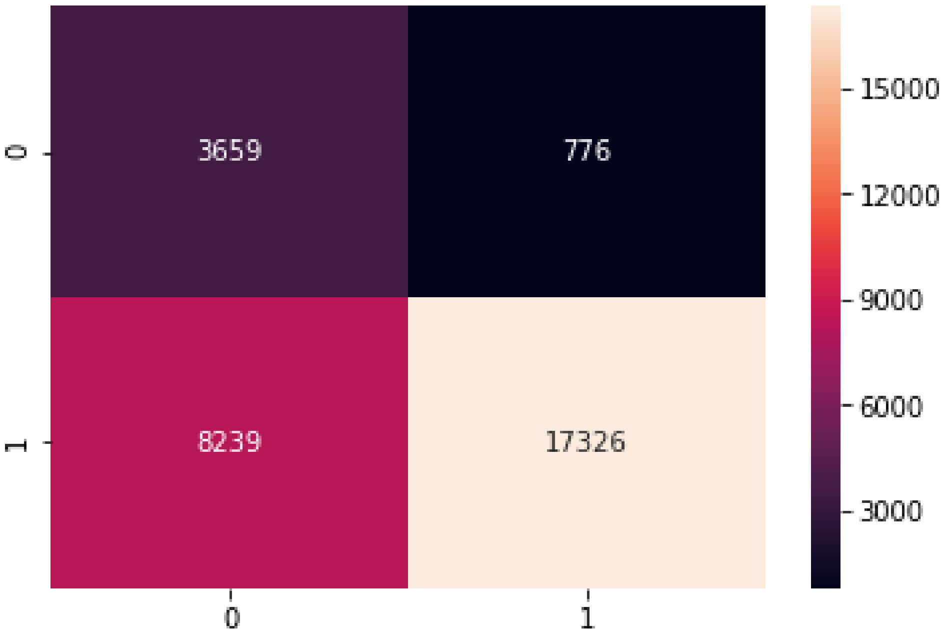
```
In [84]: bow_X_test = vect.transform(SVM_X_test)
         bow_X_test = preprocessing.normalize(bow_X_test)
         bow_X_test
```

```
Out[84]: <30000x32149 sparse matrix of type '<class 'numpy.float64'>'
                 with 880827 stored elements in Compressed Sparse Row format>
```

```
In [86]: from sklearn.svm import SVC
         clf = SVC(max_iter = 800)
         clf.fit(bow_X_train, SVM_y_train)
         SVM_y_pred=clf.predict(bow_X_test)
         print('accuracy_score =', accuracy_score(SVM_y_test, SVM_y_pred))
         print('precision_score =', precision_score(SVM_y_test, SVM_y_pred))
         print('recall_score =', recall_score(SVM_y_test, SVM_y_pred))
         cm = confusion_matrix(SVM_y_test, SVM_y_pred)
         sns.heatmap(cm, annot=True, fmt="d")
```

```
accuracy_score = 0.6995
precision_score = 0.9571318086399293
recall_score = 0.677723450029337
```

```
Out[86]: <matplotlib.axes._subplots.AxesSubplot at 0x27f42f5b128>
```



8 RESULTS

```
In [88]: from prettytable import PrettyTable
         x = PrettyTable()
         x.field_names = ["MODEL", "Alpha & PENALTY", "ACCURACY", "PRECISION", "RECALL" ]
         #BOW
         x.add_row(['BOW with SVM GridSearch', '5 & L2', 0.90, 0.90, 0.99])
         x.add_row(["BOW with SVM Random", '1 & L1', 0.90, 0.90, 0.99])
         x.add_row(['--'*5,'-'*5,'-'*8,'-'*5, '--'*5])
         #TFIDF
         x.add_row(['TFIDF with SVM GridSearch', '5 & L2', 0.89, 0.89, 0.99])
         x.add_row(["TFIDF with SVM Random", '10 & L1' ,0.89, 0.89, 0.99])
         x.add_row(['--'*5,'-'*8,'-'*8,'-'*5, '--'*5])
         #AVGW2V
         x.add_row(['AVGW2V with SVM GridSearch', '100 & L2', 0.89, 0.89, 0.98])
         x.add_row(["AVGW2V with SVM Random", '10 & L1', 0.88, 0.88, 0.97])
         x.add_row(['--'*5,'-'*8,'-'*8,'-'*5, '--'*5])
         #TFIDFW2V
         x.add_row(['TFIDFW2V with SVM GridSearch', '0.000 & L2', 0.87, 0.88, 0.98])
         x.add_row(["TFIDFW2V with SVM Random", '0.0001 & L2', 0.87, 0.88, 0.99])
         x.add_row(['--'*5,'-'*8,'-'*8,'-'*5, '--'*5])
         #SVC
         x.add_row(['BOW with SVC', 'Default', 0.69, 0.95, 0.67])
         print(x)
```

```
+------------------------------+-----------------+----------+-----------+------------+
|            MODEL             | Alpha & PENALTY | ACCURACY | PRECISION |   RECALL   |
+------------------------------+-----------------+----------+-----------+------------+
|   BOW with SVM GridSearch    |      5 & L2     |   0.9    |    0.9    |    0.99    |
|     BOW with SVM Random      |      1 & L1     |   0.9    |    0.9    |    0.99    |
|          ----------          |      -----      | -------- |   -----   | ---------- |
|  TFIDF with SVM GridSearch   |      5 & L2     |   0.89   |    0.89   |    0.99    |
|    TFIDF with SVM Random     |     10 & L1     |   0.89   |    0.89   |    0.99    |
|          ----------          |     --------    | -------- |   -----   | ---------- |
|  AVGW2V with SVM GridSearch  |     100 & L2    |   0.89   |    0.89   |    0.98    |
|    AVGW2V with SVM Random    |     10 & L1     |   0.88   |    0.88   |    0.97    |
|          ----------          |     --------    | -------- |   -----   | ---------- |
| TFIDFW2V with SVM GridSearch |    0.000 & L2   |   0.87   |    0.88   |    0.98    |
|   TFIDFW2V with SVM Random   |   0.0001 & L2   |   0.87   |    0.88   |    0.99    |
|          ----------          |     --------    | -------- |   -----   | ---------- |
|         BOW with SVC         |     Default     |   0.69   |    0.95   |    0.67    |
+------------------------------+-----------------+----------+-----------+------------+
```

```
In [60]: #number of positive and negative values in test data
         y_test.value_counts()
```

```
Out[60]: 1    90894
         0    18358
         Name: Score, dtype: int64
```

OBSERVATIONS

since AVGW2v and TFIDFW2V took too much time for converting to a vector. the total number of datapoints used are limited to 100K. also, the BOW & TFIDF were trained on all data and the confusion matrix and accuracy score were same in percentages.

1. The best results were obtained from BOW with closely 10.7k mis-classifications out of 100k datapoints.
2. SVM lags behind Logistic Regression Model. the maximum misclassification in logistic regression was 2.5k. but this exceeds to atleast 3k misclassification in all models.
3. The original SVM classifer in SKlearn is trained on our best model with default values and the best values we get is less than what we achieved in SGDClassifier with hinge loss.
4. SVM gave 10k misclassification out of 100k points than SGD which showed 3k misclassification. so it is good to use SGD with Hingeloss which is fast and also can operate on whole data.
5. the precision and recall were high on almost all the models.
6. Till now the best model on amazon fine food reviews is Logistic Regression it has accuracy of 92 and misclassification of 2.3K reviews.
7. since this data is imbalanced, there are large amount of data for positive reviews. so, the False positive rate is very high on almost all the vectorizers. W2V perfom very bad on this.