Assignment 7

October 24, 2018

0.1 Assignment 7: Apply SVM to Amazon reviews data set [M]

Given Dataset consists of reviews of fine foods from amazon. Reviews describe (1)product and user information, (2)ratings, and (3) a plain text review.Here, SVM algorithm is applied on amazon reviews datasets to predict whether a review is positive or negative.

Procedure to execute the above task is as follows:

- **Step1: Data Pre-processing is applied on given amazon reviews data-set.And Take sample of data from dataset because of computational limitations**
- **Step2: Time based splitting on train and test datasets.**
- **Step3: Apply Feature generation techniques(Bow,tfidf,avg w2v,tfidfw2v)**
- **Step4: Apply SVM algorithm using each technique.**
- **Step5: To find C(1/alpha) and gamma(=1/sigma) using gridsearch cross-validation and random cross-validation**

0.2 Objective:

- To classify given reviews (positive (Rating of 4 or 5) & negative (rating of 1 or 2)) using SVM algorithm.

```
In [1]: # All necessary module
        %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")
        #import  sys
        import re
        import math
        import sqlite3
        import pandas as pd
        import numpy as np
        import pickle
        # modules for text processing
        import nltk
        import string
        from nltk.corpus import stopwords
        from nltk.stem import PorterStemmer
        from nltk.stem.wordnet import WordNetLemmatizer
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        from sklearn.model_selection import train_test_split
        from sklearn.model_selection import TimeSeriesSplit
        from sklearn.model_selection import cross_val_score
        from sklearn.model_selection import GridSearchCV
        from sklearn.decomposition import TruncatedSVD

        import pytablewriter
        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import f1_score
        from sklearn.metrics import recall_score
        from sklearn.metrics import precision_score

        #import scikitplot.metrics as skplt
        from sklearn.metrics import classification_report,confusion_matrix,accuracy_score

        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer



        # train-split data,accuracy-score,cross-validation modules

        from sklearn.neighbors import KNeighborsClassifier



        from sklearn.preprocessing import StandardScaler
        from sklearn import preprocessing

        from sklearn.svm import SVC
        from sklearn import linear_model
        from scipy.stats import uniform
        from sklearn.model_selection import RandomizedSearchCV
        from tqdm import tqdm
        import os
```

In [2]:

```
import zipfile
archive = zipfile.ZipFile('/floyd/input/pri/Reviews.zip', 'r')
csvfile = archive.open('Reviews.csv')
```

In [3]:

```
# Reading CSV file and printing first five rows
```

```
        amz = pd.read_csv(csvfile ) # reviews.csv is  dataset file
        print(amz.head())
```

```
   Id   ProductId          UserId                      ProfileName  \
0   1  B001E4KFG0  A3SGXH7AUHU8GW                       delmartian   
1   2  B00813GRG4  A1D87F6ZCVE5NK                           dll pa   
2   3  B000LQOCH0   ABXLMWJIXXAIN  Natalia Corres "Natalia Corres"   
3   4  B000UA0QIQ  A395BORC6FGVXV                             Karl   
4   5  B006K2ZZ7K  A1UQRSCLF8GW1T    Michael D. Bigham "M. Wassir"   

   HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
0                     1                       1      5  1303862400   
1                     0                       0      1  1346976000   
2                     1                       1      4  1219017600   
3                     3                       3      2  1307923200   
4                     0                       0      5  1350777600   

                 Summary                                               Text  
0  Good Quality Dog Food  I have bought several of the Vitality canned d...  
1      Not as Advertised  Product arrived labeled as Jumbo Salted Peanut...  
2  "Delight" says it all  This is a confection that has been around a fe...  
3         Cough Medicine  If you are looking for the secret ingredient i...  
4            Great taffy  Great taffy at a great price.  There was a wid...  
```

```
In [4]: # dimensions of dataset and columns name
        print(amz.shape)
        #print(amz1.shape)
        print(amz.columns)
```

```
(568454, 10)
Index(['Id', 'ProductId', 'UserId', 'ProfileName', 'HelpfulnessNumerator',
       'HelpfulnessDenominator', 'Score', 'Time', 'Summary', 'Text'],
      dtype='object')
```

The amazon reviews datafile contains 568454 rows of entry and 10 columns.For given objective, processing of data is necessary."Score" and "text" columns is processed for required result.

Given reviews with Score>3 a positive rating, and reviews with a score<3 a negative rating. If score is equal to 3,it is considered as neutral score.

```
In [5]: # Processing
        #Give reviews with Score>3 a positive rating, and reviews with a score<3 a negative rati

        def score_part(x):
            if x < 3:
                return 'negative'
            return 'positive'
        actualScore = amz['Score']
        #print(actualScore)
        New_score = actualScore.map(score_part)
        #print(New_score)
        amz['Score']=New_score

        # If score is equal to 3,it is considered as neutral score.
```

```
In [6]: print(amz.shape)
        amz.head(5)
```

```
(568454, 10)
```

```
Out[6]:    Id   ProductId          UserId                      ProfileName  \
        0   1  B001E4KFG0  A3SGXH7AUHU8GW                       delmartian
        1   2  B00813GRG4  A1D87F6ZCVE5NK                           dll pa
        2   3  B000LQOCH0   ABXLMWJIXXAIN  Natalia Corres "Natalia Corres"
        3   4  B000UA0QIQ  A395BORC6FGVXV                             Karl
        4   5  B006K2ZZ7K  A1UQRSCLF8GW1T    Michael D. Bigham "M. Wassir"

           HelpfulnessNumerator  HelpfulnessDenominator     Score        Time  \
        0                     1                       1  positive  1303862400
        1                     0                       0  negative  1346976000
        2                     1                       1  positive  1219017600
        3                     3                       3  negative  1307923200
        4                     0                       0  positive  1350777600

                         Summary                                               Text
        0  Good Quality Dog Food  I have bought several of the Vitality canned d...
        1      Not as Advertised  Product arrived labeled as Jumbo Salted Peanut...
        2  "Delight" says it all  This is a confection that has been around a fe...
        3         Cough Medicine  If you are looking for the secret ingredient i...
        4            Great taffy  Great taffy at a great price.  There was a wid...
```

Data Pre-processing on raw data: Every datasets contains some unwanted data.Raw data is preprocessed by removing duplication.

```
In [7]: #Processing of ProductId
        #Sorting data according to ProductId in ascending order
        sorted_data=amz.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='qu
        #sorted_data.head() # printing sorted data
        # To check the duplications in raw data
        dupli=sorted_data[sorted_data.duplicated(["UserId","ProfileName","Time","Text"])]
        print(dupli.head(5))
        # Remove Deduplication of entries
        final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='f
        final.shape
        #Checking to see how much % of data still remains
        (final['Id'].size*1.0)/(amz['Id'].size*1.0)*100
        final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
        #Before starting the next phase of preprocessing lets see the number of entries left
        print(final.shape)

        #How many positive and negative reviews are present in our dataset?
        final['Score'].value_counts()
```

```
            Id   ProductId          UserId  \
171222  171223  7310172001   AJD41FBJD9010
171153  171154  7310172001   AJD41FBJD9010
171151  171152  7310172001   AJD41FBJD9010
217443  217444  7310172101  A22FICU3LCG2J1
217444  217445  7310172101  A1LQV0PSM04DWI

                                         ProfileName  HelpfulnessNumerator  \
171222  N. Ferguson "Two, Daisy, Hannah, and Kitten"                     1
171153  N. Ferguson "Two, Daisy, Hannah, and Kitten"                     0
171151  N. Ferguson "Two, Daisy, Hannah, and Kitten"                     0
217443                                      C. Knapp                     1
217444                                 B. Feuerstein                     1

        HelpfulnessDenominator     Score        Time  \
171222                       1  positive  1233360000
171153                       0  positive  1233360000
171151                       0  positive  1233360000
217443                       1  positive  1275523200
217444                       1  positive  1274313600

                                                  Summary  \
171222  best dog treat-- great for training---  all do...
171153  best dog treat-- great for training---  all do...
171151  dogs LOVE it--  best treat for rewards and tra...
217443                              Can't resist this !
217444                 Freeze dried liver as dog treats

                                                     Text
171222  Freeze dried liver has a hypnotic effect on do...
171153  Freeze dried liver has a hypnotic effect on do...
171151  Freeze dried liver has a hypnotic effect on do...
217443  My dog can't resist these treats - I can get h...
217444  My little pupster loves these things. She is n...
(393931, 10)
```

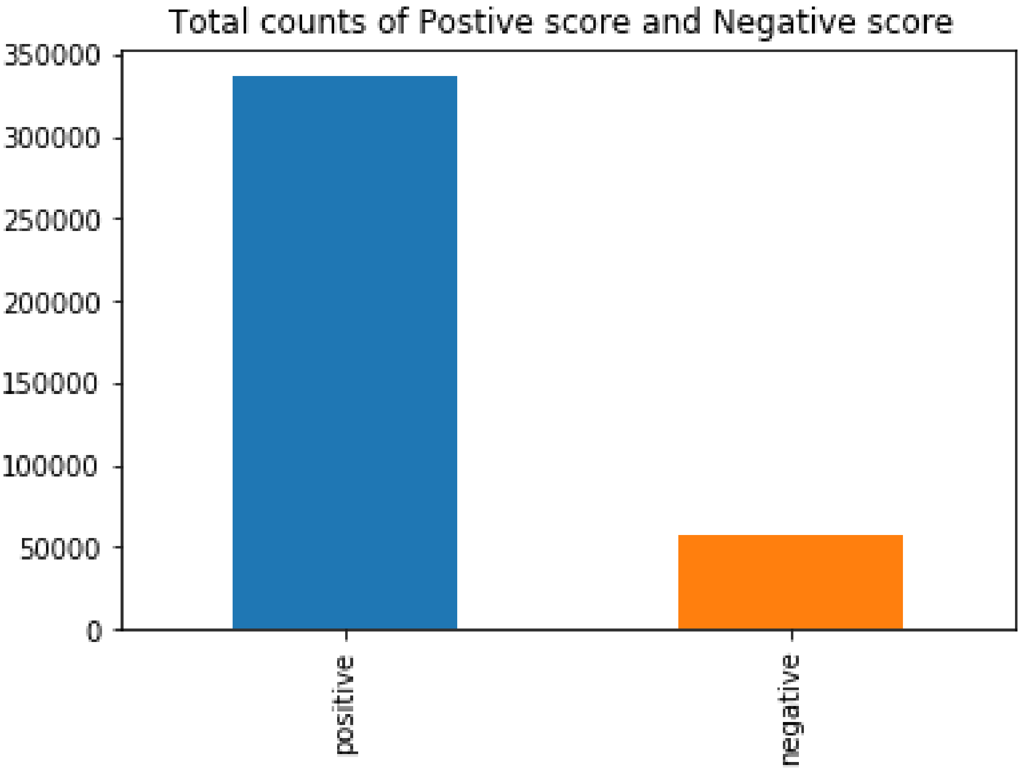
```
Out[7]: positive    336824
```

```
         negative     57107
         Name: Score, dtype: int64
```

```
In [8]: a=final['Score'].value_counts().tolist()
        print('List of total counts Postive score and Negative score ==>',a)
        final['Score'].value_counts().plot(kind='bar')
        plt.title('Total counts of Postive score and Negative score ')
```

```
List of total counts Postive score and Negative score ==> [336824, 57107]
```

```
Out[8]: Text(0.5,1,'Total counts of Postive score and Negative score ')
```



observations

- The positive reviews is greater than negative reviews.It makes data imbalanced.
- From the bar plot ,it is seen that sampled datasets of review is imbalnced.

1 Text Preprocessing:

```
In [9]: import nltk
        nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

```
Out[9]: True
```

```
In [10]:
         stop = set(stopwords.words('english')) #set of stopwords
         sno = nltk.stem.SnowballStemmer('english') #initialising the snowball stemmer

         def cleanhtml(sentence): #function to clean the word of any html-tags
             cleanr = re.compile('<.*?>$< /><')
             #cleanr = re.compile('<.*?>')
             cleantext = re.sub(cleanr, ' ', sentence)
             return cleantext
         def cleanpunc(sentence): #function to clean the word of any punctuation or special char
             cleaned = re.sub(r'[?|!|\'|"|#]',r'',sentence)
             cleaned = re.sub(r'[.|,|)|(|\|/]',r' ',cleaned)
             return  cleaned
```

cleaning html tags like" <.*?>" and punctuations like " r’[?|!|’|"|#]’,r”" from senetences

```
In [11]: #final = final.sample(frac=0.004,random_state=1)
         #print(final.shape)
```

```
In [12]: #Code for implementing step-by-step the checks mentioned in the pre-processing phase.

         '''Pre processing of text data:It is cleaning and flitering text'''
         i=0
         str1=' '
         global final_string
         final_string=[]
         all_positive_words=[]
         all_negative_words=[]
         s=''
         for sent in final['Text'].values:
             filtered_sentence=[]
             #print(sent);
             sent=cleanhtml(sent) # remove HTMl tags
             for w in sent.split():
                 for cleaned_words in cleanpunc(w).split():
                     if((cleaned_words.isalpha()) & (len(cleaned_words)>2)):
                         if(cleaned_words.lower() not in stop):
                             s=(sno.stem(cleaned_words.lower())).encode('utf8')
                             filtered_sentence.append(s)
                             if (final['Score'].values)[i] == 'positive':
                                 all_positive_words.append(s) #list of all words used to describ
                             if(final['Score'].values)[i] == 'negative':
                                 all_negative_words.append(s) #list of all words used to describ
```

```
                    else:
                        continue
                else:
                    continue
    #print(filtered_sentence)
    str1 = b" ".join(filtered_sentence) #final string of cleaned words
    #print("***********************************************************************")

    final_string.append(str1)
    i+=1
#print('all_positive_words =',len(all_positive_words))
#print('all_negative_words =',len(all_negative_words))

# Finding most frequently occuring Positive and Negative words

freq_positive=nltk.FreqDist(all_positive_words)

freq_negative=nltk.FreqDist(all_negative_words)

#print("\nMost Common Positive Words : ",freq_positive.most_common(20))

#print("\nMost Common Negative Words : ",freq_negative.most_common(20))
```

Dumping and loading Pre processing of text data in pickle file

```
In [13]: pickle_path_final_string='final_string.pkl'
         final_string_file=open(pickle_path_final_string,'wb')
         pickle.dump(final_string,final_string_file)
         final_string_file.close()
```

```
In [11]: pickle_path_final_string='final_string.pkl'
         final_string_unpkl=open(pickle_path_final_string,'rb')
         final_string=pickle.load(final_string_unpkl)
```

```
In [12]: final['CleanedText']=final_string
         #adding a column of CleanedText which displays the data after pre-processing of the rev
         Pre_Process_Data = final[['CleanedText','Score','Time']]

         X_Text=Pre_Process_Data ['CleanedText']

         Y_Score =Pre_Process_Data ['Score'] # positive or negative score
         print('\nPre_Process_Text_Data  X_Text=',X_Text.shape)
         print('\nPre_Process_Score_Data Y_Score=',Y_Score.shape)
```

```

Pre_Process_Text_Data  X_Text= (393931,)

Pre_Process_Score_Data Y_Score= (393931,)
```

```
In [13]: # postive and negtive reviews from original datasets of amazon
         pos_final = Pre_Process_Data[Pre_Process_Data .Score == 'positive']# postive reviews
         pos_final = pos_final.sample(frac=0.3)
         print(pos_final.Score.value_counts())

         neg_final = Pre_Process_Data [Pre_Process_Data .Score == 'negative'] # negative reviews
         print(neg_final.Score.value_counts())
```

```
positive    101047
Name: Score, dtype: int64
negative    57107
Name: Score, dtype: int64
```

```
In [14]: final_pos_neg = pd.concat([pos_final,neg_final],axis=0)
         print(len(final_pos_neg))
         print(type(final_pos_neg))
```

```
158154
<class 'pandas.core.frame.DataFrame'>
```

```
In [15]: print(final_pos_neg.columns)
```

```
Index(['CleanedText', 'Score', 'Time'], dtype='object')
```

1.0.1 Splitting Training and Testing dataset based on Time

```
In [16]: # splitting training and testing dataset (Time based splitting)

         X1 = final_pos_neg[['CleanedText','Time']].sort_values('Time',axis=0).drop('Time',axis=
         #40k data sample
         X=X1[:40000]

         print(X.shape)
         Y1 = final_pos_neg[['Score','Time']].sort_values('Time',axis=0).drop('Time',axis=1)
         #40k data sample
         Y=Y1[:40000]
         print(Y.shape)
         ## 70 % of data

         X_train_data ,X_test_data,Y_train_data,Y_test_data  = train_test_split(X,
                                                                 Y.values.ravel(),
                                                               test_size=0.3,
                                                               shuffle=False)
         print('X_train_data ',X_train_data.shape)

         print('X_test_data ',X_test_data.shape )

         print('Y_train_data ',Y_train_data .shape)

         print('Y_test_data ',Y_test_data .shape)
```

```
(40000, 1)
(40000, 1)
X_train_data  (28000, 1)
X_test_data  (12000, 1)
Y_train_data  (28000,)
Y_test_data  (12000,)
```

```
In [17]: Y_new = Y['Score'].map(lambda x: 1 if x == 'positive' else 0).values.ravel()
         # Y train and Test for sparse datasets

         y_train_new,y_test_new = train_test_split(Y_new,test_size=0.3,shuffle=False)
         print('y_train_new ',y_train_new.shape)

         print('y_test_new ',y_test_new .shape)
```

```
y_train_new  (28000,)
y_test_new  (12000,)
```

2 Optimal Lambda for SVM

```
In [18]: models_performence = {
             'Model':[],
             'Vectorizer': [],
             'SearchCV':[],
             'Scoring Metrics': [],
             'Train_model_score': [],
             'Test_model_score': [],
             'Best lambda':[],
         }

         columns = ["Model","Vectorizer","SearchCV", "Scoring Metrics","Train_model_score","Test
         pd.DataFrame(models_performence, columns=columns)
```

```
Out[18]: Empty DataFrame
         Columns: [Model, Vectorizer, SearchCV, Scoring Metrics, Train_model_score, Test_model_s
         Index: []
```

In [19]:

```
 # Time seris splitting Cross-Validation
tscv = TimeSeriesSplit(n_splits=3)
```

In [20]:

```
#  optimal_svm is function to calculate the hyperparametr c for SGD_clf

def optimal_svm(X_train,y_train,X_test, y_test,vectorization):
    C = [1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.0001]


    #  hyperparameter options
    hp1 =dict(alpha= C)

    # Scoring options
    d=[ 'f1','roc_auc']
    for i in tqdm(range(len(d))):
        models_performence['Model'].append('SGDClassifier')
        models_performence['Vectorizer'].append(vectorization)
        models_performence['SearchCV'].append('GridSearchCV')
        p = d[i]
        SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                             n_iter=100,
                                             learning_rate='optimal',
                                             class_weight='balanced',
                                             n_jobs= -1)
        models_performence['Scoring Metrics'].append(p)
        model1 = GridSearchCV(SGD_clf,
                              hp1,
                              scoring = p,
                              cv=tscv,n_jobs= -1)
        best_model1=model1.fit(X_train, y_train)
        Test_model_score=best_model1.score(X_test, y_test)
        Train_model_score=best_model1.score(X_train, y_train)

        models_performence['Train_model_score'].append(Train_model_score.mean())
        models_performence['Test_model_score'].append(Test_model_score.mean())

        optimal_l1=best_model1.best_estimator_.get_params()['alpha']
        models_performence['Best lambda'].append(optimal_l1)
```

In [21]:

```
#  error_plot is function to calculate performance of datasets with different value of
#  the hyperparametr c .

def error_plot(classifier,p,X_train,y_train,X_test, y_test):
    C = [1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.0001]
    train_error=[]
    test_error=[]
    for i in tqdm(range(len(C))):
        hp1 =dict(alpha=[C[i]])

        model1 = GridSearchCV(classifier, hp1,
                              scoring =p ,
                              cv=tscv,n_jobs= -1)
        best_model1=model1.fit(X_train, y_train)
        Test_score=model1.score(X_test, y_test)
        test_error.append(1-Test_score)

        Train_score=model1.score(X_train, y_train)
        train_error.append(1-Train_score)



    fig = plt.figure( facecolor='y', edgecolor='k')
    plt.semilogx(C,train_error,'m*',linestyle='dashed', label='Train')
    plt.semilogx(C,test_error,'r*', linestyle='dashed',label='Test')
    plt.legend(loc='lower left')
    plt.grid()

    plt.xlabel('Regularization parameter(C)')
    plt.ylabel('Performance')
    plt.show()
```

Pandas dataframe to markdown Table format

```
In [22]: # result_display  is function to convert dataframe into table format in Markdown
         def result_display(df):
             writer = pytablewriter.MarkdownTableWriter()
             writer.header_list = list(df.columns.values)
             writer.value_matrix = df.values.tolist()
             writer.write_table()
```

3 Methods to convert text into vector

Methods: * Bag of Words * Avg word2vec * Tf-idf * tf-idf weighted Word2Vec

Using above four method is used to convert text to numeric vector.

4 1. Bag of Words (BoW)

BOW for Training Data

```
In [23]: count_vect = CountVectorizer() #in scikit-learn
         vect_Data = count_vect.fit_transform(X_train_data.values.ravel())
         print(vect_Data .shape)
```

```
(28000, 20759)
```

```
In [24]: # truncated SVD for dimesionality reduction for 100 dimensions
         svd = TruncatedSVD(n_components=100,n_iter=7)

         Data=svd.fit_transform(vect_Data )
         print("TruncatedSVD :",Data.shape)
```

```
TruncatedSVD : (28000, 100)
```

```
In [25]: # StandardScaler
         final_data= StandardScaler(with_mean=False).fit_transform(Data )

         print(final_data.shape)
         #Normalize Data


         warnings.filterwarnings("ignore")
```

```
(28000, 100)
```

Dumping & Loading Pickle file for training data (BOW)

```
In [26]: #Pickle file for training data

         pickle_path_BOW_train='X_train_data_BOW.pkl'
         X_train_data_BOW=open(pickle_path_BOW_train,'wb')
         pickle.dump(final_data ,X_train_data_BOW)
         X_train_data_BOW.close()
```

```
In [27]: pickle_path_BOW_train='X_train_data_BOW.pkl'
         unpickle_path1=open(pickle_path_BOW_train,'rb')
         final_data=pickle.load(unpickle_path1)
```

```
In [28]: from sklearn.externals import joblib
         joblib.dump(final_data, 'final_data.joblib')
```

```
Out[28]: ['final_data.joblib']
```

```
In [29]: final_data = joblib.load('final_data.joblib')
```

BOW for Testing Data

```
In [30]: #vector of test data
         vect_Data1= count_vect.transform(X_test_data.values.ravel())
         print(vect_Data1.shape)



         final_data_test=svd.transform(vect_Data1)
         print("TruncatedSVD :",final_data_test.shape)
```

```
(12000, 20759)
TruncatedSVD : (12000, 100)
```

Dumping & Loading Pickle file for testing data (BOW)

```
In [31]: pickle_path_BOW_test='X_test_data_BOW.pkl'
         X_test_data_BOW=open(pickle_path_BOW_test,'wb')
         pickle.dump(final_data_test ,X_test_data_BOW)
         X_test_data_BOW.close()
```

```
In [32]: pickle_path_BOW_test='X_test_data_BOW.pkl'
         unpickle_path2=open(pickle_path_BOW_test,'rb')
         final_data_test=pickle.load(unpickle_path2)
```

Featured data of Bag of words is Standardization (mean=0 and std.dev=1).

```
In [33]: Train_data=y_train_new
```

```
In [34]: # To get optimal lambda using BOW


         #print(Y_test_data)

         #print(Train_data)
         vectorization='BOW'
         optimal_lambda = optimal_svm(final_data ,Train_data,
                                      final_data_test,y_test_new,
                                      vectorization)
```

```
100%|??????????| 2/2 [00:44<00:00, 22.01s/it]
```

```
In [35]: columns = ["Model","Vectorizer","SearchCV",
                    "Scoring Metrics","Train_model_score","Test_model_score","Best lambda"]
         df=pd.DataFrame(models_performence, columns=columns)
         result_display(df)
```

```
|    Model     |Vectorizer|  SearchCV   |Scoring Metrics|Train_model_score|Test_model_score|Best l
|-------------|----------|------------|---------------|----------------:|---------------:|------
|SGDClassifier|BOW       |GridSearchCV|f1             |         0.000201|           0.000|
|SGDClassifier|BOW       |GridSearchCV|roc_auc        |         0.837396|           0.820|
```

4.0.1 Observation:

Model	Vectorizer	SearchCV	Scoring Metrics	Train_model_score	Test_model_score	Best lambda
SGDClassifier	BOW	GridSearchCV	f1	0.000201	0.000	5.00
SGDClassifier	BOW	GridSearchCV	roc_auc	0.837396	0.820	0.05

```
In [36]: #### Observations:
         df=pd.DataFrame(models_performence, columns=columns)
         zx=df[df['Scoring Metrics'] == 'f1']['Best lambda'].ravel()
         lambdax=zx[0]
         print(lambdax)
         #Mscoring=
```

```
5.0
```

```
In [37]: #Best lambda
         hp1=dict(alpha=[lambdax])
         SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                              n_iter=100,
                                              learning_rate='optimal',
                                              class_weight='balanced',
                                              n_jobs= -1)


         svm =GridSearchCV(SGD_clf,
                           hp1,
                           scoring ='f1',
                           cv=tscv,
                           n_jobs= -1)
         svm.fit(final_data ,Train_data)

         prediction1 =svm.predict(final_data_test)
```

```
In [38]: #Training accuracy and training error
         training_score=svm.score(final_data,Train_data)
         print('training accuracy=',training_score)
         training_error=1-training_score
         print('training error is =',training_error)
```

```
training accuracy= 0.8330283719267251
training error is = 0.16697162807327492
```

```
In [39]: # Testing Accuracy and testing error for LogisticRegression model

         Testing_score=round(accuracy_score(y_test_new ,prediction1),5)
         print("Accuracy for SGD_clf model with Bag of words is = ",Testing_score)
         Testing_error=1-Testing_score
         print("Testing error for SGD_clf model with Bag of words is = ",Testing_error)
```

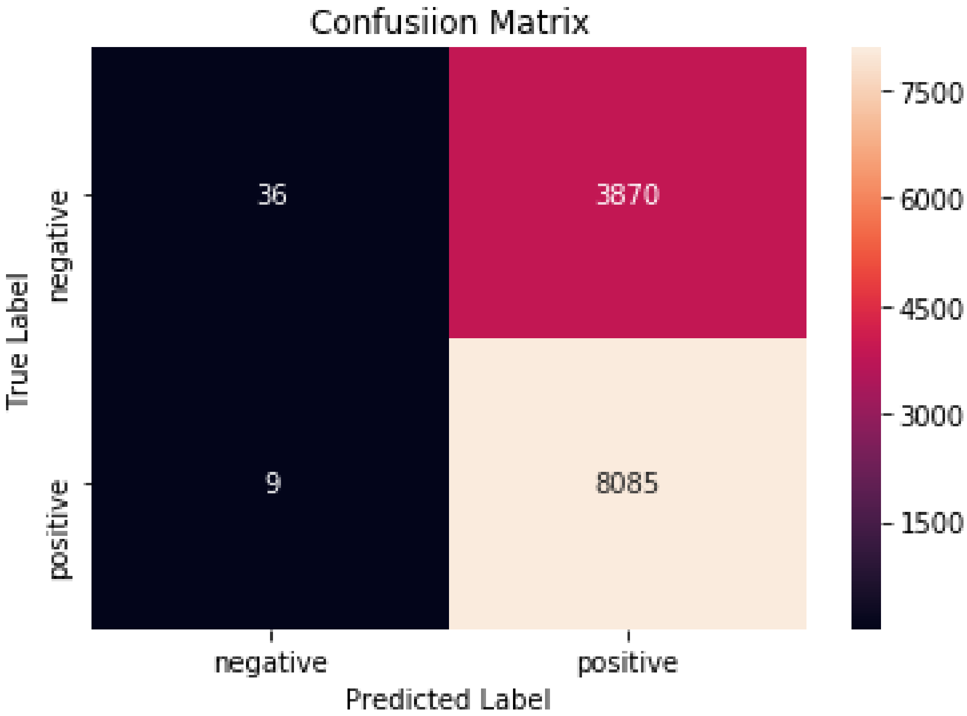
```
Accuracy for SGD_clf model with Bag of words is =  0.67675
Testing error for SGD_clf model with Bag of words is =  0.32325000000000004
```

```
In [40]: F1_score = round(f1_score(y_test_new ,prediction1,average='macro'),5)*100
         recall = round(recall_score(y_test_new,prediction1,average='macro'),5)*100
         precision = round(precision_score(y_test_new ,prediction1,average='macro'),5)*100
```

```
In [41]: print(classification_report(y_test_new,prediction1))
```

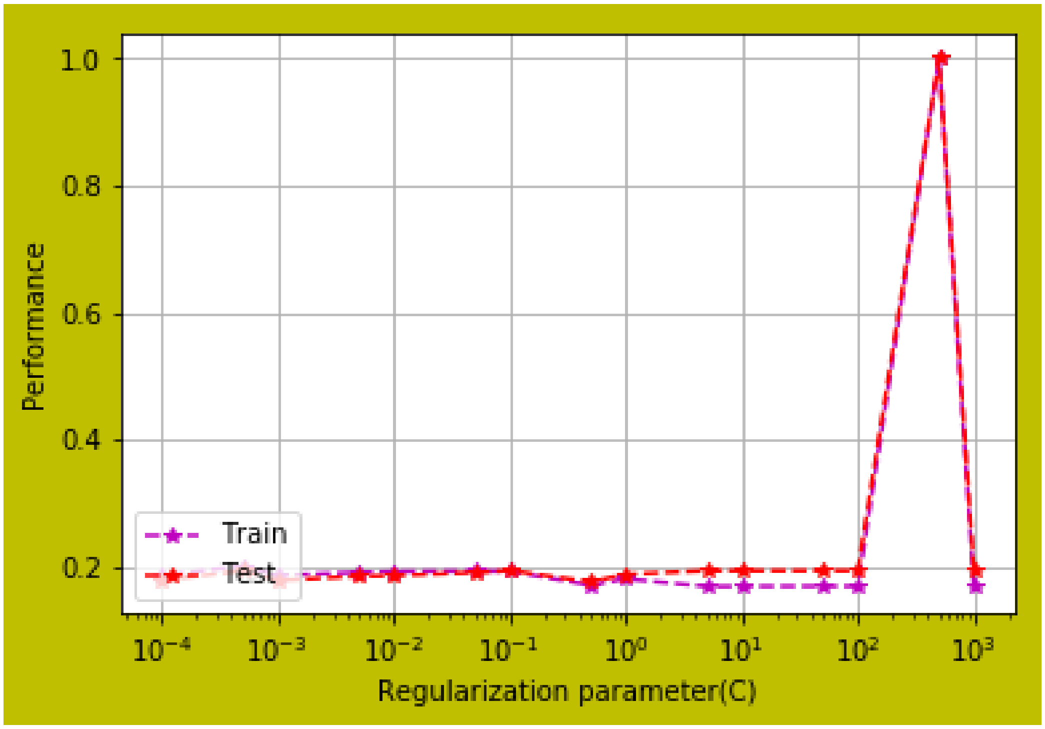
```
             precision    recall  f1-score   support

          0       0.80      0.01      0.02      3906
          1       0.68      1.00      0.81      8094

avg / total       0.72      0.68      0.55     12000
```

```
In [42]: cm = confusion_matrix(y_test_new ,prediction1)
         label = ['negative', 'positive']
         df_conf = pd.DataFrame(cm, index = label, columns = label)
         sns.heatmap(df_conf, annot = True, fmt = "d")
         plt.title("Confusiion Matrix")
         plt.xlabel("Predicted Label")
         plt.ylabel("True Label")
         plt.show()
```



In [43]:
```
classifier=SGD_clf
p='f1'
error_plot(classifier,p,final_data ,Train_data
            ,final_data_test,y_test_new)
```

```
100%|??????????| 15/15 [00:38<00:00,  2.59s/it]
```



```
In [44]: models_performence1 = {
             'Model':['SGD_clf'],
             'Vectorizer': [vectorization],

             'Optimal lambda': [lambdax],
             'Training error':[training_error],
             'Test error':[Testing_error],
             'Accuracy':[Testing_score],
             'F1':[F1_score],
             'recall':[recall],
             'precision':[precision]


         }

In [45]: columns = ["Model","Vectorizer","Optimal lambda",
                    "Training error",  "Test error",
                     "Accuracy","F1","recall","precision",
                   ]
         df1=pd.DataFrame(models_performence1, columns=columns)
         result_display(df1)
```

```
| Model |Vectorizer|Optimal lambda|Training error|Test error|Accuracy| F1  |recall|precision|
|-------|----------|-------------:|-------------:|---------:|-------:|----:|-----:|--------:|
|SGD_clf|BOW       |              5|        0.1670|     0.3233|   0.6767|41.24| 50.40|     73.81|
```

4.0.2 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5	0.1670	0.3233	0.6767	41.24	50.40	73.81

- Optimal lambda using SGD_clf for BOW is 5 using 'f1' scoring metrics
- from Performance graph of traing and testing data with different lambda value is almost overlapping each other.
- TPR & FPR is too high as seen in confusion matrix.

```
In [46]: zx=df[df['Scoring Metrics'] == 'roc_auc']['Best lambda'].ravel()
         lambdax=zx[0]
         print(lambdax)
```

```
0.05
```

```
In [47]: #Best lambda
         hp1=dict(alpha=[lambdax])
         SGD_clf = linear_model.SGDClassifier(loss='hinge',n_iter=1000,
                                              learning_rate='optimal',
                                              class_weight='balanced',
                                              n_jobs= -1)


         svm1 =GridSearchCV(SGD_clf, hp1,
                            scoring ='roc_auc',
                            cv=tscv,n_jobs= -1)
         svm1.fit(final_data ,Train_data)

         prediction2 =svm1.predict(final_data_test)
```

```
In [48]: #Training accuracy and training error
         training_score=svm1.score(final_data,Train_data)
         print('training accuracy=',training_score)
         training_error=1-training_score
         print('training error is =',training_error)
```

```
training accuracy= 0.8374079776093861
training error is = 0.16259202239061388
```

```
In [49]: # Testing Accuracy and testing error
         Testing_score=round(accuracy_score(y_test_new ,prediction2),5)
```

```
        print("Accuracy for SGD_clf model with Bag of words is = ",Testing_score)
        Testing_error=1-Testing_score
        print("Testing error for SGD_clf model with Bag of words is = ",Testing_error)
```

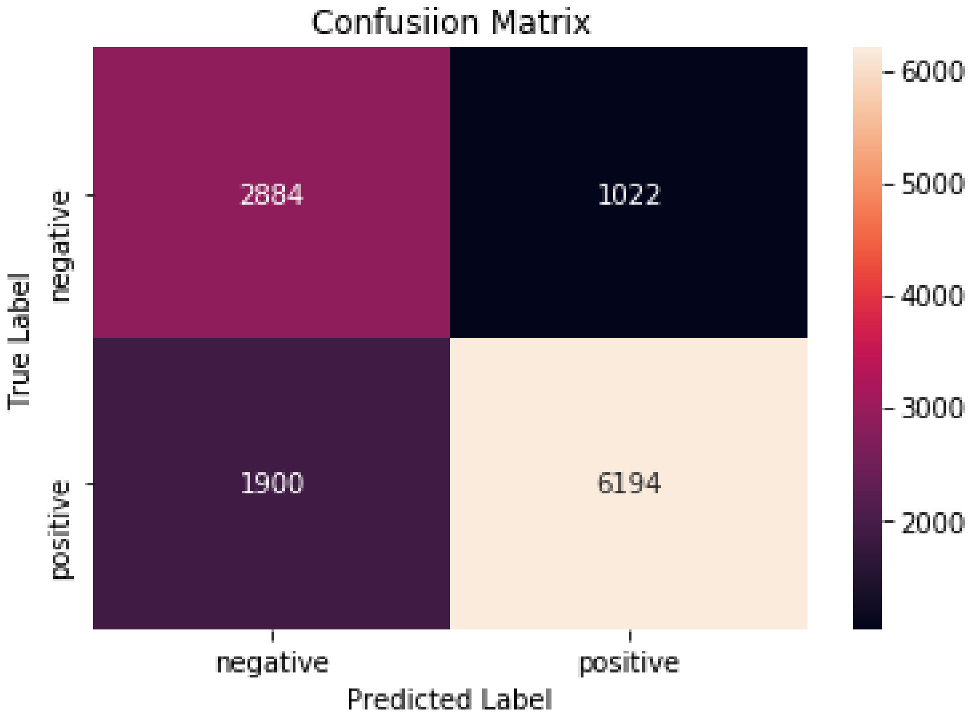
```
Accuracy for SGD_clf model with Bag of words is =  0.7565
Testing error for SGD_clf model with Bag of words is =  0.24350000000000005
```

```
In [50]: F1_score = round(f1_score(y_test_new ,prediction2,average='macro'),5)*100
         recall = round(recall_score(y_test_new,prediction2,average='macro'),5)*100
         precision = round(precision_score(y_test_new,prediction2,average='macro'),5)*100
```

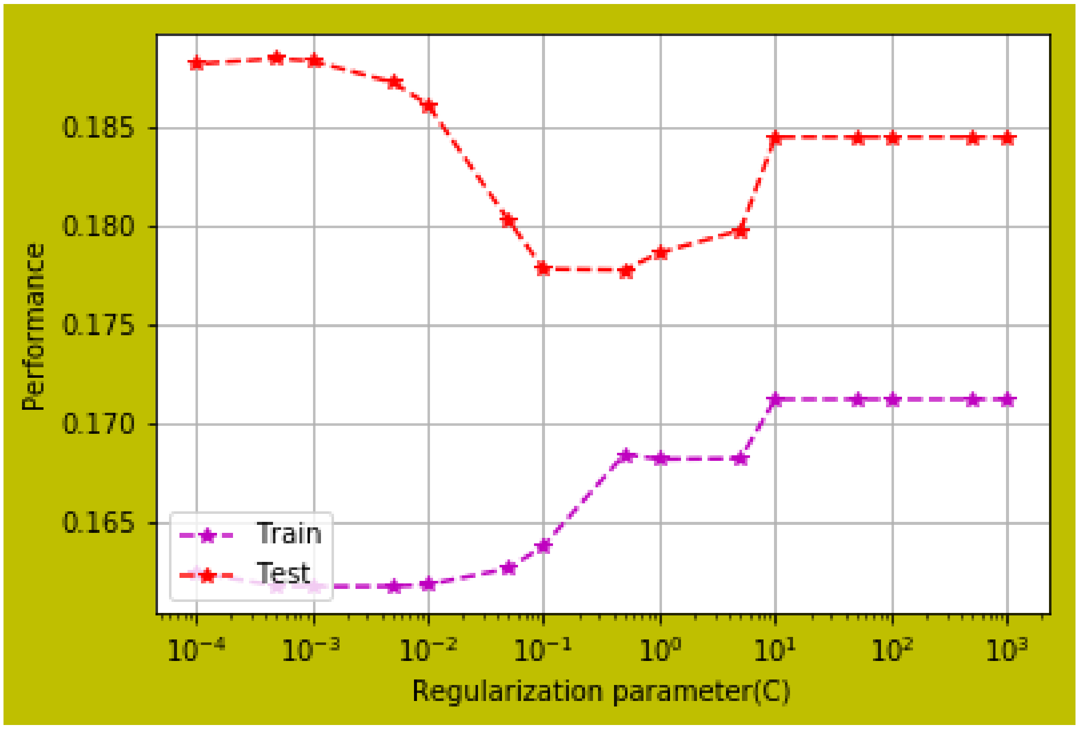
```
In [51]: print(classification_report( y_test_new,prediction2))
```

```
             precision    recall  f1-score   support

          0       0.60      0.74      0.66      3906
          1       0.86      0.77      0.81      8094

avg / total       0.78      0.76      0.76     12000
```

```
In [52]: cm = confusion_matrix(y_test_new,prediction2)
         label = ['negative', 'positive']
         df_conf = pd.DataFrame(cm, index = label, columns = label)
         sns.heatmap(df_conf, annot = True, fmt = "d")
         plt.title("Confusiion Matrix")
         plt.xlabel("Predicted Label")
         plt.ylabel("True Label")
         plt.show()
```



```
In [53]: classifier=SGD_clf
         p='roc_auc'
         error_plot(classifier,p,final_data ,Train_data,
                    final_data_test,y_test_new)

100%|??????????| 15/15 [05:24<00:00, 21.61s/it]
```



```
In [54]: models_performence1['Model'].append('SGDClassifier')
         models_performence1['Vectorizer'].append(vectorization)

         models_performence1[ 'Optimal lambda'].append(lambdax)
         models_performence1['Training error'].append(training_error)
         models_performence1[ 'Test error'].append(Testing_error)
         models_performence1[ 'Accuracy'].append(Testing_score)
         models_performence1[ 'F1'].append(F1_score)
         models_performence1['recall'].append(recall)
         models_performence1[ 'precision'].append(precision)
```

```
In [55]: columns = ["Model","Vectorizer","Optimal lambda",
                     "Training error",  "Test error",
                      "Accuracy","F1","recall","precision",
                    ]
         df2=pd.DataFrame(models_performence1, columns=columns)
         result_display(df2)
```

```
|    Model    |Vectorizer|Optimal lambda|Training error|Test error|Accuracy| F1  |recall|precisi
|-------------|----------|-------------:|-------------:|---------:|-------:|----:|-----:|-------
|SGD_clf      |BOW       |          5.00|        0.1670|    0.3233|  0.6767|41.24| 50.40|    73.
|SGDClassifier|BOW       |          0.05|        0.1626|    0.2435|  0.7565|73.65| 75.18|    73.
```

4.0.3 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.00	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.05	0.1626	0.2435	0.7565	73.65	75.18	73.06

- Optimal lambda using sgd_clf for BOW with scoring metrics "roc_auc" is 0.05. which is giving best result as compared sgd_clf for BOW with scoring metrics "f1".
- 'f1' score is 73.65%
- from Performance graph of traing and testing data with different lambda value is seen in graph. The training and testing performance differs at initial period and then it remains same.
- TPR & TNR is high as compared FPR & FNR. It means model performs very well ans model is sensible.
- From above observation it can be concluded that ##### SGD_clf for BOW using scoring metrics "roc_auc" works best as comapred to scoring metrics "f1".

5 2. Avg word2vec

Firstly, word2vec model is designed for amazon reviews using gensim module.

```
In [56]: import gensim
         list_sent=[]
         for text in tqdm(X_train_data.values.ravel()):
             filter_text=[]
             for i in text.split():
                 if(i.isalpha()):
                     filter_text.append(i.lower().decode("utf-8"))
                 else:
                     continue
             list_sent.append(filter_text)
         print(len(list_sent))
```

```
100%|??????????| 28000/28000 [00:00<00:00, 31150.03it/s]

28000
```

word2vec Model using Training Datasets

```
In [57]: w2v_model=gensim.models.Word2Vec(list_sent,min_count=5,size=100, workers=4)
         #this model is used in avg word2vec  .

In [58]: words = list(w2v_model.wv.vocab)
         print(len(words))

7245


In [59]: pickle_path_w2v_model='w2v_model.pkl'
         w2v_model_path=open(pickle_path_w2v_model,'wb')
         pickle.dump(w2v_model,w2v_model_path)
         w2v_model_path.close()

In [60]: pickle_path_w2v_model='w2v_model.pkl'
         unpickle_w2v_model=open(pickle_path_w2v_model,'rb')
         w2v_model=pickle.load(unpickle_w2v_model)
```

Avg Word2Vec

```
In [61]: #  For Training

         sent_vectors = []
         for sent in  tqdm(list_sent): # for each review/sentence
             sent_vec = np.zeros(100)
             cnt_words =0 # num of words with a valid vector in the sentence/review
             for word in sent:
                 try:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
                 except:
                     pass
             sent_vec /= cnt_words
             sent_vectors.append(sent_vec)


         print(len(sent_vectors))

         #print(sent_vectors[0:4])

100%|??????????| 28000/28000 [00:05<00:00, 5537.60it/s]

28000
```

```
In [62]: # Converting Nan value to zero in sent vectors.
         Sent_Nan = np.where(np.isnan(sent_vectors), 0, sent_vectors)
```

```
In [63]: # converting sent list to nd array
         Sent_final_vector = np.asarray(Sent_Nan )
         print(type(Sent_final_vector))
```

```
<class 'numpy.ndarray'>
```

```
In [64]: #  ForTesting
         # Words in test reviews
         list_sent_test=[]
         for text in tqdm(X_test_data.values.ravel()):
             filter_text=[]
             for i in text.split():
                 if(i.isalpha()):
                     filter_text.append(i.lower().decode("utf-8"))
                 else:
                     continue
             list_sent_test.append(filter_text)
         #print(len(list_sent_test))

         sent_vectors1 = []
         for sent in tqdm(list_sent_test): # for each review/sentence
             sent_vec = np.zeros(100)
             cnt_words =0 # num of words with a valid vector in the sentence/review
             for word in sent:
                 try:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
                 except:
                     pass
             sent_vec /= cnt_words
             sent_vectors1.append(sent_vec)


         print(len(sent_vectors1))

         #print(sent_vectors1)
         # Converting Nan value to zero in sent vectors.
         Sent_Nan1 = np.where(np.isnan(sent_vectors1), 0, sent_vectors1)

         # converting sent list to nd array
         Sent_final_vector1 = np.asarray(Sent_Nan1)
         print(type(Sent_final_vector1))
```

```
100%|??????????| 12000/12000 [00:00<00:00, 34037.08it/s]
100%|??????????| 12000/12000 [00:02<00:00, 5277.81it/s]
```

```
12000
<class 'numpy.ndarray'>
```

Dumping & Loading Pickle file for Avg word2vec

```
In [65]: pickle_path_AW2V_train='X_data_AW2V_train.pkl'
         X_data_AW2V_train=open(pickle_path_AW2V_train,'wb')
         pickle.dump(Sent_final_vector,X_data_AW2V_train)
         X_data_AW2V_train.close()

         pickle_path_AW2V_test='X_data_AW2V_test.pkl'
         X_data_AW2V_test=open(pickle_path_AW2V_test,'wb')
         pickle.dump(Sent_final_vector1,X_data_AW2V_test)
         X_data_AW2V_test.close()
```

```
In [66]: pickle_path_AW2V_train='X_data_AW2V_train.pkl'
         unpickle_path3_train=open(pickle_path_AW2V_train,'rb')
         Sent_final_vector=pickle.load(unpickle_path3_train)

         pickle_path_AW2V_test='X_data_AW2V_test.pkl'
         unpickle_path3_test=open(pickle_path_AW2V_test,'rb')
         Sent_final_vecto1=pickle.load(unpickle_path3_test)
```

Standardscaler training avg word2vec

```
In [67]: final_w2v_count_Train= StandardScaler(with_mean=False).fit_transform(Sent_final_vector)
         # For Train
         print(final_w2v_count_Train.shape)

(28000, 100)
```

```
In [68]: final_w2v_count_Test=Sent_final_vector1
```

```
In [69]: print(final_w2v_count_Test.shape)

(12000, 100)
```

for Training datasets ,avg word2vec

```
final_w2v_count_Train,
```

for testing datasets ,avg word2vec

```
final_w2v_count_Test,
```

```
In [70]: vectorization='Avg Word2Vec'
         optimal_lambda = optimal_svm(final_w2v_count_Train ,
                                      Train_data,
                                      final_w2v_count_Test,
                                      y_test_new,vectorization )
```

```
100%|??????????| 2/2 [00:42<00:00, 21.07s/it]
```

```
In [71]: columns = ["Model","Vectorizer","SearchCV",
                    "Scoring Metrics","Train_model_score",
                    "Test_model_score","Best lambda"]
         df3=pd.DataFrame(models_performence, columns=columns)
         result_display(df3)
```

```
|    Model     | Vectorizer |  SearchCV  |Scoring Metrics|Train_model_score|Test_model_score|Best
|-------------|------------|------------|---------------|----------------:|---------------:|----
|SGDClassifier|BOW         |GridSearchCV|f1             |         0.000201|           0.000|
|SGDClassifier|BOW         |GridSearchCV|roc_auc        |         0.837396|           0.820|
|SGDClassifier|Avg Word2Vec|GridSearchCV|f1             |         0.338159|           0.000|
|SGDClassifier|Avg Word2Vec|GridSearchCV|roc_auc        |         0.881242|           0.880|
```

Model	Vectorizer	SearchCV	Scoring Metrics	Train_model_score	Test_model_score	Best lambda
SGDClassifier	BOW	GridSearchCV	f1	0.000201	0.000	5.000
SGDClassifier	BOW	GridSearchCV	roc_auc	0.837396	0.820	0.050
SGDClassifier	Avg Word2Vec	GridSearchCV	f1	0.338159	0.000	10.000
SGDClassifier	Avg Word2Vec	GridSearchCV	roc_auc	0.881242	0.880	0.005

```
In [72]: df=pd.DataFrame(models_performence, columns=columns)
         df=df[df['Vectorizer'] == 'Avg Word2Vec']
         zx=df[df['Scoring Metrics'] == 'f1']['Best lambda'].ravel()
         lambdax=zx[0]
         print(lambdax)
```

```
10.0
```

```
In [73]: #Best lambda
         hp1=dict(alpha=[lambdax])
         SGD_clf = linear_model.SGDClassifier(loss='hinge',n_iter=1000,
                                              learning_rate='optimal',
                                              class_weight='balanced',
                                              n_jobs= -1)


         svm3 =GridSearchCV(SGD_clf,hp1, scoring ='f1', cv=tscv,n_jobs= -1)
         svm3.fit(final_w2v_count_Train ,Train_data)

         prediction3 =svm3.predict( final_w2v_count_Test)
```

```
In [74]: #Training accuracy and training error
         training_score=svm3.score(final_w2v_count_Train ,Train_data)
         print('training accuracy=',training_score)
         training_error=1-training_score
         print('training error is =',training_error)
```

```
training accuracy= 0.8605808546928666
training error is = 0.1394191453071334
```

```
In [75]: # Testing Accuracy and testing error for  model
         Testing_score=round(accuracy_score(y_test_new ,prediction3),5)
         print("Accuracy for  model with Avg word2vec is = ",Testing_score)
         Testing_error=1-Testing_score
         print("Testing error for  model with Avg word2ve is = ",Testing_error)
```

```
Accuracy for  model with Avg word2vec is =  0.67483
Testing error for  model with Avg word2ve is =  0.32516999999999996
```

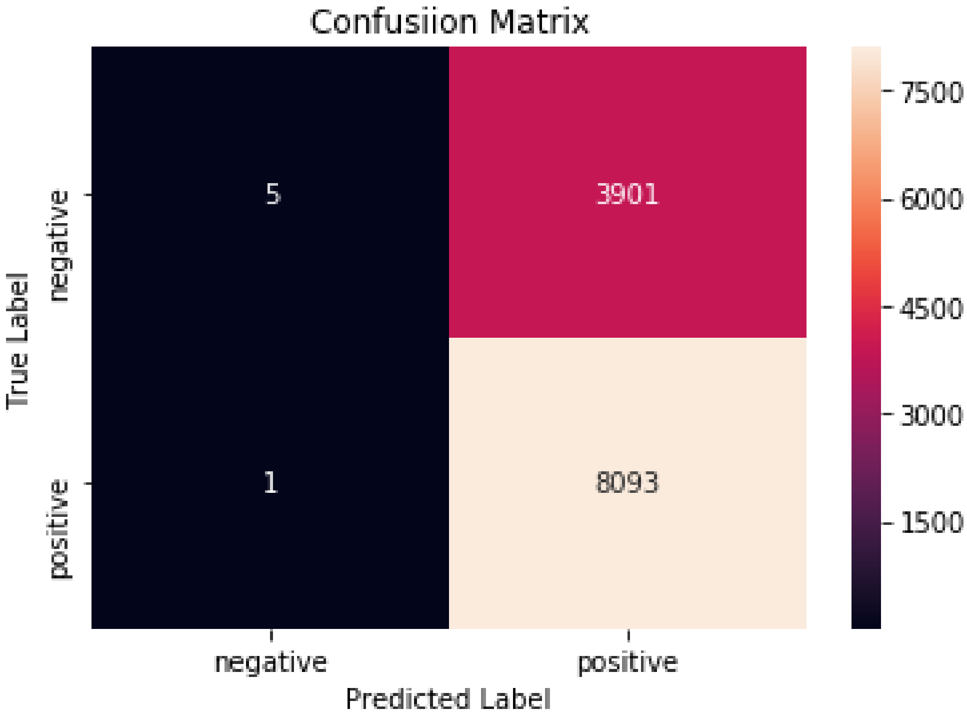
```
In [76]: F1_score = round(f1_score(y_test_new ,prediction3,average='macro'),5)*100
         recall = round(recall_score(y_test_new,prediction3,average='macro'),5)*100
         precision = round(precision_score(y_test_new ,prediction3,average='macro'),5)*100
```

```
In [77]: print(classification_report( y_test_new,prediction3))
```

```
             precision    recall  f1-score   support

          0       0.83      0.00      0.00      3906
          1       0.67      1.00      0.81      8094

avg / total       0.73      0.67      0.54     12000
```

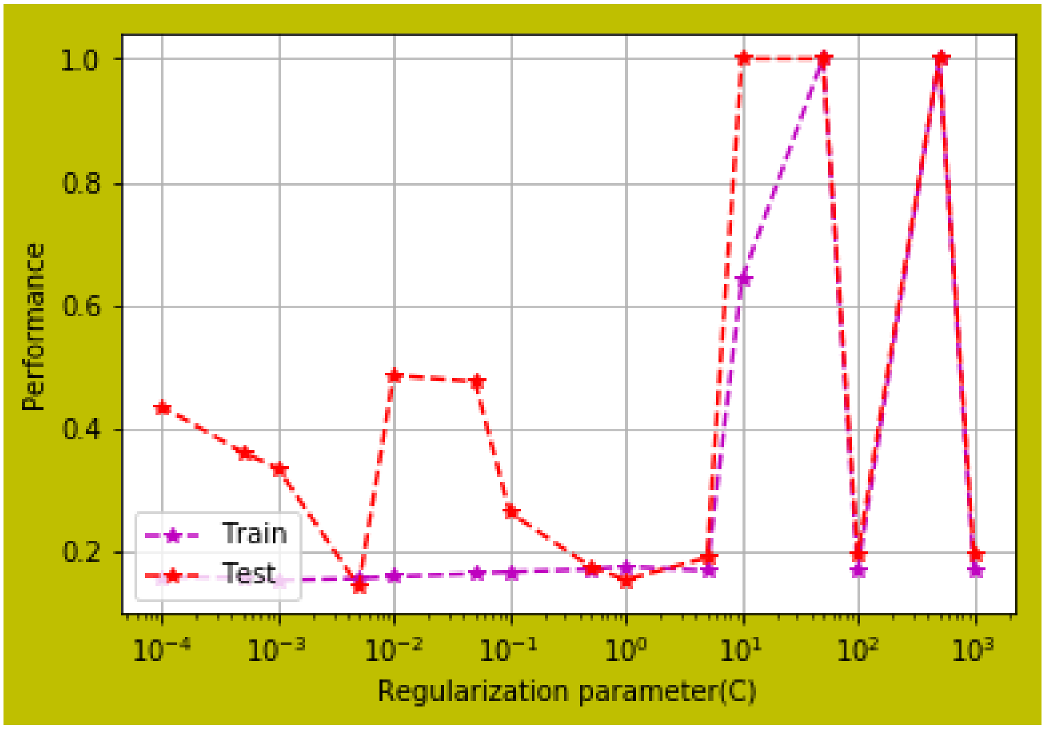
```
In [78]: cm = confusion_matrix(y_test_new,prediction3)
         label = ['negative', 'positive']
```

```
df_conf = pd.DataFrame(cm, index = label, columns = label)
sns.heatmap(df_conf, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



```
In [79]: classifier=SGD_clf
         p='f1'
         error_plot(classifier,p,
                    final_w2v_count_Train ,
                    Train_data,
                    final_w2v_count_Test,
                    y_test_new)
```

```
100%|??????????| 15/15 [05:09<00:00, 20.61s/it]
```



```
In [80]: models_performence1['Model'].append('SGD_clf')
         models_performence1['Vectorizer'].append(vectorization)

         models_performence1[ 'Optimal lambda'].append(lambdax)
         models_performence1['Training error'].append(training_error)
         models_performence1[ 'Test error'].append(Testing_error)
         models_performence1[ 'Accuracy'].append(Testing_score)
         models_performence1[ 'F1'].append(F1_score)
         models_performence1['recall'].append(recall)
         models_performence1[ 'precision'].append(precision)
```

```
In [81]: columns = ["Model","Vectorizer","Optimal lambda",
                     "Training error",  "Test error",
                      "Accuracy","F1","recall","precision",
                    ]
         df4=pd.DataFrame(models_performence1, columns=columns)
         result_display(df4)
```

```
|    Model     | Vectorizer |Optimal lambda|Training error|Test error|Accuracy| F1  |recall|preci
|-------------|------------|-------------:|-------------:|---------:|-------:|----:|-----:|-----
|SGD_clf      |BOW         |          5.00|        0.1670|    0.3233|  0.6767|41.24| 50.40|    7
|SGDClassifier|BOW         |          0.05|        0.1626|    0.2435|  0.7565|73.65| 75.18|    7
|SGD_clf      |Avg Word2Vec|         10.00|        0.1394|    0.3252|  0.6748|40.42| 50.06|    7
```

5.0.1 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.00	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.05	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.00	0.1394	0.3252	0.6748	40.42	50.06	75.40

- Using Avg Word2vec & scoring metrics f1, Optimal lambda for model is 10.
- TPR & FPR is too high and TNR & FNR is too low.
- Performance of traing and testing with different lamda values are shown in figure.
- Precision istoo high and F1 is too low.

```
In [82]: zx=df[df['Scoring Metrics'] == 'roc_auc']['Best lambda'].ravel()
         lambdax=zx[0]
         print(lambdax)

0.005


In [83]: #Best lambda
         hp1=dict(alpha=[lambdax])
         SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                              n_iter=1000,
                                              learning_rate='optimal',
                                              class_weight='balanced',
                                               n_jobs= -1)


         svm4 =GridSearchCV(SGD_clf, hp1,
                            scoring ='roc_auc',
                            cv=tscv,n_jobs= -1)
         svm4.fit(final_w2v_count_Train ,Train_data)

         prediction4 = svm4.predict(final_w2v_count_Test)

In [84]: #Training accuracy and training error
         training_score=svm4.score(final_w2v_count_Train ,Train_data)
         print('training accuracy=',training_score)
         training_error=1-training_score
         print('training error is =',training_error)

training accuracy= 0.8814606970701757
training error is = 0.11853930292982429


In [85]: # Testing Accuracy and testing error
```

```
         Testing_score=round(accuracy_score(y_test_new ,prediction4),5)
         print("Accuracy for SGD_clf model with Avg word2ve is = ",Testing_score)
         Testing_error=1-Testing_score
         print("Testing error for SGD_clf model with Avg word2ve is = ",Testing_error)
```

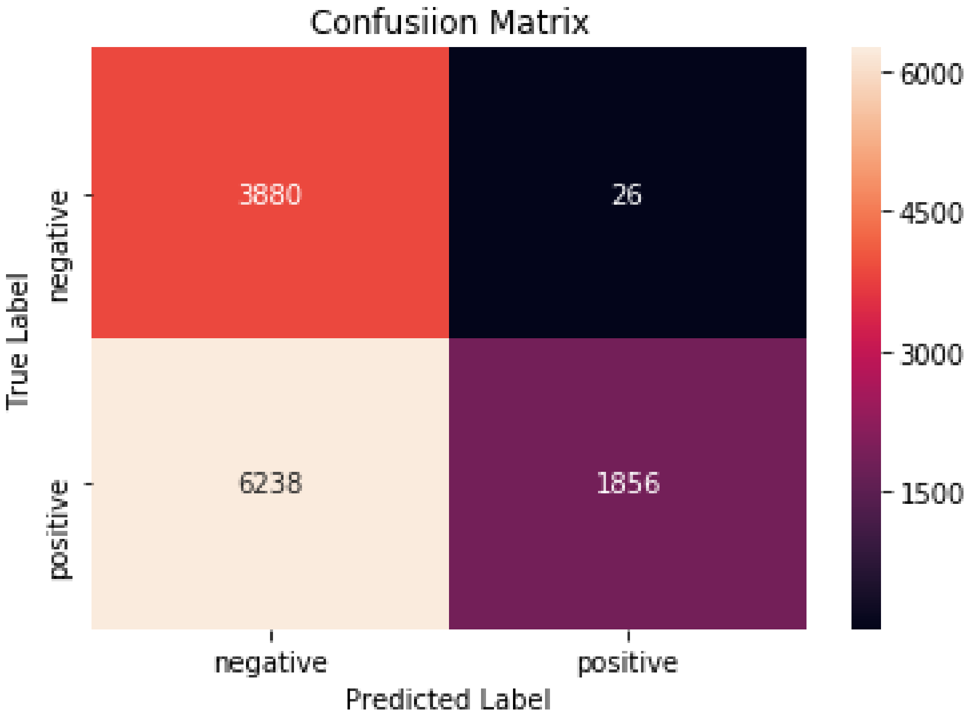
```
Accuracy for SGD_clf model with Avg word2ve is =  0.478
Testing error for SGD_clf model with Avg word2ve is =  0.522
```

```
In [86]: F1_score = round(f1_score(y_test_new ,prediction4,average='macro'),5)*100
         recall = round(recall_score(y_test_new,prediction4,average='macro'),5)*100
         precision = round(precision_score(y_test_new ,prediction4,average='macro'),5)*100
```

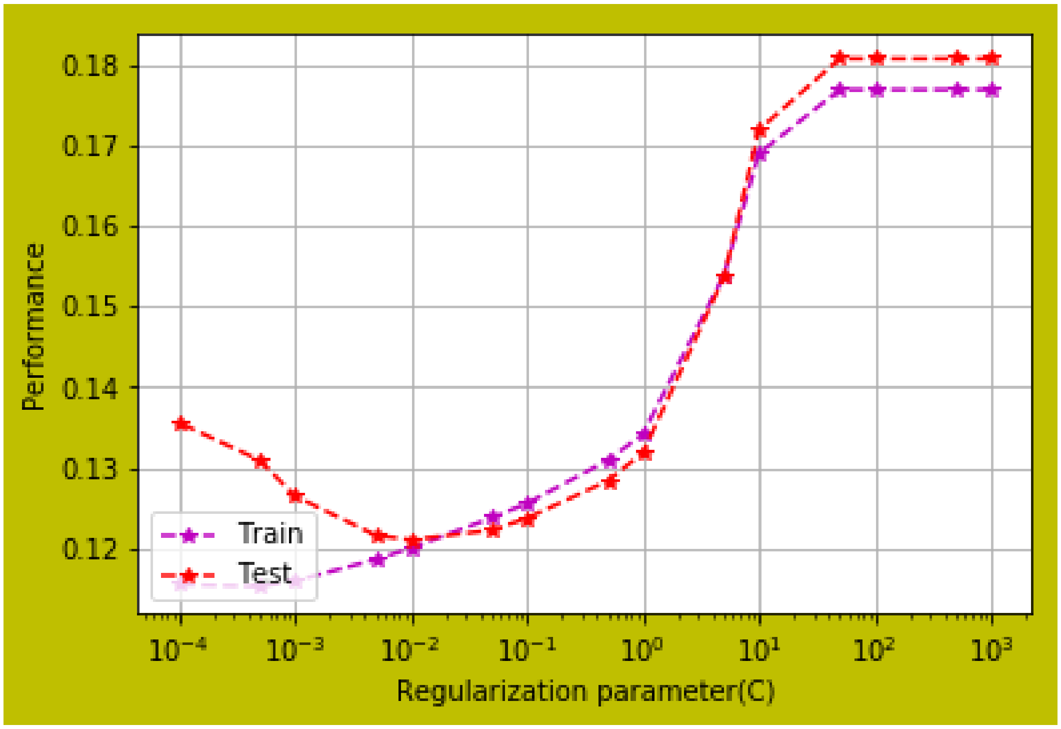
```
In [87]: print(classification_report( y_test_new,prediction4))
```

```
             precision    recall  f1-score   support

          0       0.38      0.99      0.55      3906
          1       0.99      0.23      0.37      8094

avg / total       0.79      0.48      0.43     12000
```

```
In [88]: cm = confusion_matrix(y_test_new,prediction4)
         label = ['negative', 'positive']
         df_conf = pd.DataFrame(cm, index = label, columns = label)
         sns.heatmap(df_conf, annot = True, fmt = "d")
         plt.title("Confusiion Matrix")
         plt.xlabel("Predicted Label")
         plt.ylabel("True Label")
         plt.show()
```



```
In [89]: classifier=SGD_clf
         p='roc_auc'
         error_plot(classifier,p,
                    final_w2v_count_Train ,Train_data,
                    final_w2v_count_Test,y_test_new)

100%|??????????| 15/15 [05:17<00:00, 21.20s/it]
```



```
In [90]: models_performence1['Model'].append('SGD_clf')
         models_performence1['Vectorizer'].append(vectorization)

         models_performence1[ 'Optimal lambda'].append(lambdax)
         models_performence1['Training error'].append(training_error)
         models_performence1[ 'Test error'].append(Testing_error)
         models_performence1[ 'Accuracy'].append(Testing_score)
         models_performence1[ 'F1'].append(F1_score)
         models_performence1['recall'].append(recall)
         models_performence1[ 'precision'].append(precision)
```

```
In [91]: columns = ["Model","Vectorizer","Optimal lambda", "Training error",  "Test error",
                     "Accuracy","F1","recall","precision",
                   ]
         df5=pd.DataFrame(models_performence1, columns=columns)
         result_display(df5)
```

```
|    Model    | Vectorizer |Optimal lambda|Training error|Test error|Accuracy| F1  |recall|preci
|-------------|------------|-------------:|-------------:|---------:|-------:|----:|-----:|-----
|SGD_clf      |BOW         |         5.000|        0.1670|    0.3233|  0.6767|41.24| 50.40|     7
|SGDClassifier|BOW         |         0.050|        0.1626|    0.2435|  0.7565|73.65| 75.18|     7
|SGD_clf      |Avg Word2Vec|        10.000|        0.1394|    0.3252|  0.6748|40.42| 50.06|     7
|SGD_clf      |Avg Word2Vec|         0.005|        0.1185|    0.5220|  0.4780|46.27| 61.13|     6
```

5.0.2 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.000	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.050	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.000	0.1394	0.3252	0.6748	40.42	50.06	75.40
SGD_clf	Avg Word2Vec	0.005	0.1185	0.5220	0.4780	46.27	61.13	68.48

- Optimal lambda using SGD_clf with scoring metrics "roc_auc" is 0.005.
- TNR & FNR is too high as compared to TPR & FPR.
- Error is high for highest value of lambda as seen in performance metrics.

TF-IDF for Training data

```
In [92]: tf_idf_vect = TfidfVectorizer(ngram_range=(1,2))
         final_tf_idf11 = tf_idf_vect.fit_transform(X_train_data.values.ravel())
         final_tf_idf11.get_shape()
         tfidf_feat = tf_idf_vect.get_feature_names()
```

```
In [93]: final_tf_idf=svd.fit_transform(final_tf_idf11 )
         print("TruncatedSVD :",final_tf_idf.shape)
```

```
TruncatedSVD : (28000, 100)
```

Dumping & Loading Pickle file for training data (TF-IDF)

```
In [94]: pickle_path_tfidf_train='X_train_data_tfidf.pkl'
         X_train_data_tfidf=open(pickle_path_tfidf_train,'wb')
         pickle.dump(final_tf_idf ,X_train_data_tfidf)
         X_train_data_tfidf.close()
```

```
In [95]: pickle_path_tfidf_train='X_train_data_tfidf.pkl'
         unpickle_path5=open(pickle_path_tfidf_train,'rb')
         final_tf_idf=pickle.load(unpickle_path5)
```

```
In [96]: #StandardScaleing and normalizing training Tf-IDF
         final_tfidf_np= StandardScaler(with_mean=False).fit_transform(final_tf_idf)

         print("Train Data: ",final_tfidf_np.shape)


         warnings.filterwarnings("ignore")
```

```
Train Data:  (28000, 100)
```

tf-idf For Testing datasets

```
In [97]: final_tf_idf_test1_svd = tf_idf_vect.transform(X_test_data.values.ravel())
         final_tf_idf_test1_svd.get_shape()

Out[97]: (12000, 493550)
```

```
In [98]: final_tf_idf_test1=svd.transform(final_tf_idf_test1_svd)
         print("TruncatedSVD :",final_tf_idf_test1.shape)
         #Normalize Data
         #X_sparse_tsvd = svd.fit(vect_Data1).transform(X_sparse)

TruncatedSVD : (12000, 100)
```

Dumping & Loading Pickle file for testing data(TF-IDF)

```
In [99]: pickle_path_tfidf_test='X_test_data_tfidf.pkl'
         X_test_data_tfidf=open(pickle_path_tfidf_test,'wb')
         pickle.dump(final_tf_idf_test1 ,X_test_data_tfidf)
         X_test_data_tfidf.close()
```

```
In [100]: pickle_path_tfidf_test='X_test_data_tfidf.pkl'
          unpickle_path6=open(pickle_path_tfidf_test,'rb')
          final_tfidf_np_test=pickle.load(unpickle_path6)
```

```
In [101]: vectorization='TF-IDF'
          optimal_lambda = optimal_svm(final_tfidf_np ,
                                       Train_data,final_tfidf_np_test,
                                       y_test_new,vectorization )

100%|??????????| 2/2 [00:42<00:00, 21.48s/it]
```

```
In [102]: columns = ["Model","Vectorizer","SearchCV",
                     "Scoring Metrics","Train_model_score",
                     "Test_model_score","Best lambda"]
          df6=pd.DataFrame(models_performence, columns=columns)
          result_display(df6)
```

```
|    Model    | Vectorizer |  SearchCV  |Scoring Metrics|Train_model_score|Test_model_score|Best
|-------------|------------|------------|---------------|----------------:|---------------:|----
|SGDClassifier|BOW         |GridSearchCV|f1             |         0.000201|           0.000|
|SGDClassifier|BOW         |GridSearchCV|roc_auc        |         0.837396|           0.820|
|SGDClassifier|Avg Word2Vec|GridSearchCV|f1             |         0.338159|           0.000|
|SGDClassifier|Avg Word2Vec|GridSearchCV|roc_auc        |         0.881242|           0.880|
|SGDClassifier|TF-IDF      |GridSearchCV|f1             |         0.767114|           0.000|
|SGDClassifier|TF-IDF      |GridSearchCV|roc_auc        |         0.892100|           0.886|
```

Model	Vectorizer	SearchCV	Scoring Metrics	Train_model_score	Test_model_score	Best lambda
SGDClassifier	BOW	GridSearchCV	f1	0.000201	0.000	5.000
SGDClassifier	BOW	GridSearchCV	roc_auc	0.837396	0.820	0.050
SGDClassifier	Avg Word2Vec	GridSearchCV	f1	0.338159	0.000	10.000
SGDClassifier	Avg Word2Vec	GridSearchCV	roc_auc	0.881242	0.880	0.005
SGDClassifier	TF-IDF	GridSearchCV	f1	0.767114	0.000	1.000
SGDClassifier	TF-IDF	GridSearchCV	roc_auc	0.892100	0.886	0.005

```
In [103]: df=pd.DataFrame(models_performence, columns=columns)
          df=df[df['Vectorizer'] == 'TF-IDF']
          zx=df[df['Scoring Metrics'] == 'f1']['Best lambda'].ravel()
          lambdax=zx[0]
          print(lambdax)
```

```
1.0
```

```
In [104]: #Best lambda
          hp1=dict(alpha=[lambdax])
          SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                               n_iter=1000,
                                               learning_rate='optimal',
                                               class_weight='balanced',

                                              n_jobs= -1)


          svm5 =GridSearchCV(SGD_clf,hp1,
                             scoring ='f1',
                             cv=tscv,n_jobs= -1)
          svm5.fit(final_tfidf_np ,Train_data)

          prediction5 =svm5.predict(final_tfidf_np_test)
```

```
In [105]: #Training accuracy and training error
          training_score=svm5.score(final_tfidf_np ,Train_data)
          print('training accuracy=',training_score)
          training_error=1-training_score
          print('training error is =',training_error)
```

```
training accuracy= 0.8710525643971305
training error is = 0.12894743560286948
```

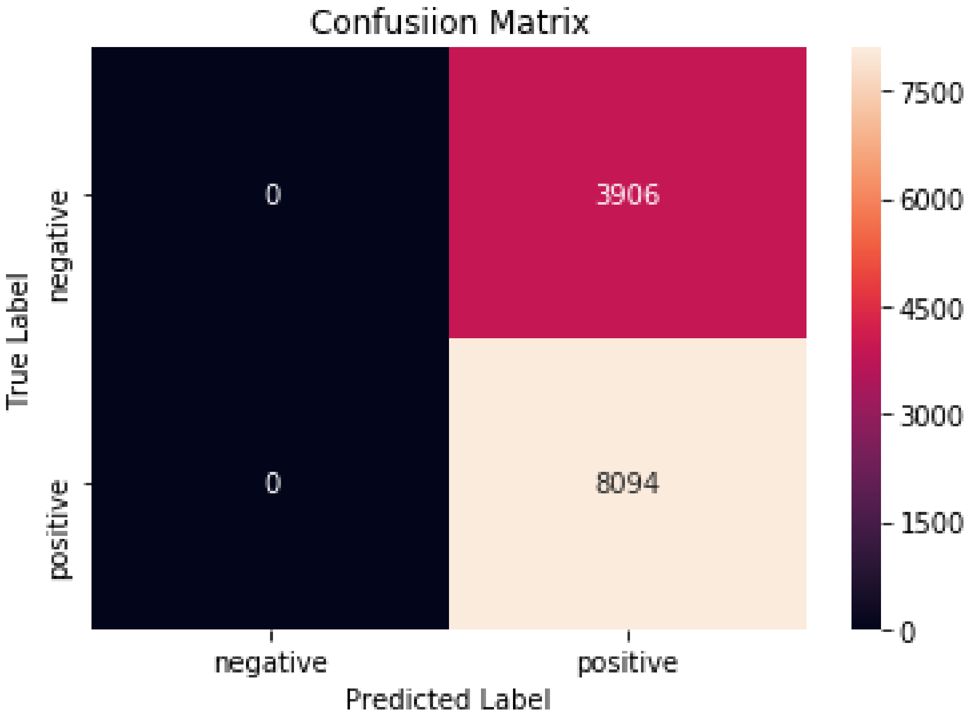
```
In [106]: # Testing Accuracy and testing error
```

```
          Testing_score=round(accuracy_score(y_test_new ,prediction5),5)
          print("Accuracy for SGD_clf model with TF-IDF is = ",Testing_score)
          Testing_error=1-Testing_score
          print("Testing error for SGD_clf model with TF-IDF is = ",Testing_error)

Accuracy for SGD_clf model with TF-IDF is =  0.6745
Testing error for SGD_clf model with TF-IDF is =  0.3255
```

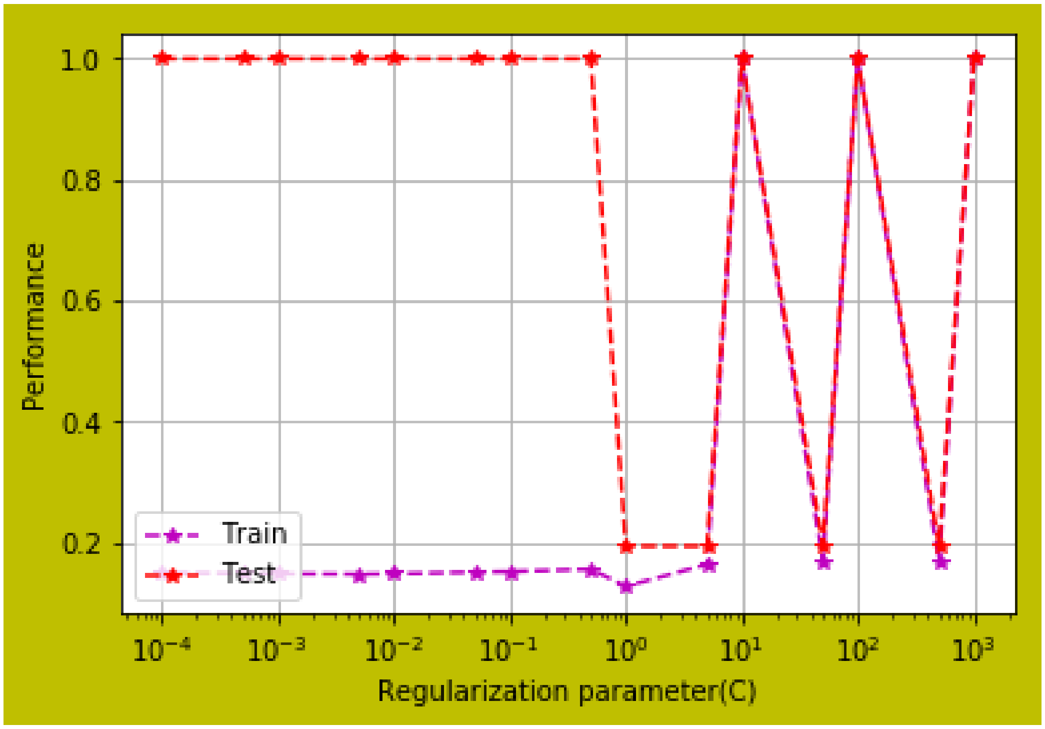
```
In [107]: F1_score = round(f1_score(y_test_new ,prediction5,average='macro'),5)*100
          recall = round(recall_score(y_test_new,prediction5,average='macro'),5)*100
          precision = round(precision_score(y_test_new ,prediction5,average='macro'),5)*100
```

```
In [108]: print(classification_report( y_test_new,prediction5))

             precision    recall  f1-score   support

          0       0.00      0.00      0.00      3906
          1       0.67      1.00      0.81      8094

avg / total       0.45      0.67      0.54     12000
```

```
In [109]: cm = confusion_matrix(y_test_new ,prediction5)
          label = ['negative', 'positive']
          df_conf = pd.DataFrame(cm, index = label, columns = label)
          sns.heatmap(df_conf, annot = True, fmt = "d")
          plt.title("Confusiion Matrix")
          plt.xlabel("Predicted Label")
          plt.ylabel("True Label")
          plt.show()
```



```
In [110]: classifier=SGD_clf
          p='f1'
          error_plot(classifier,p,final_tfidf_np ,
                     Train_data,
                     final_tfidf_np_test,y_test_new)

100%|??????????| 15/15 [05:19<00:00, 21.28s/it]
```



```
In [111]: models_performence1['Model'].append('SGD_clf')
          models_performence1['Vectorizer'].append(vectorization)

          models_performence1[ 'Optimal lambda'].append(lambdax)
          models_performence1['Training error'].append(training_error)
          models_performence1[ 'Test error'].append(Testing_error)
          models_performence1[ 'Accuracy'].append(Testing_score)
          models_performence1[ 'F1'].append(F1_score)
          models_performence1['recall'].append(recall)
          models_performence1[ 'precision'].append(precision)
```

```
In [112]: columns = ["Model","Vectorizer","Optimal lambda",
                      "Training error",  "Test error",
                       "Accuracy","F1","recall","precision",
                     ]
          df7=pd.DataFrame(models_performence1, columns=columns)
          result_display(df7)
```

```
|    Model    | Vectorizer |Optimal lambda|Training error|Test error|Accuracy| F1  |recall|preci
|-------------|------------|-------------:|-------------:|---------:|-------:|----:|-----:|-----
|SGD_clf      |BOW         |          5.00|        0.1670|    0.3233|  0.6767|41.24| 50.40|    7
|SGDClassifier|BOW         |          0.05|        0.1626|    0.2435|  0.7565|73.65| 75.18|    7
|SGD_clf      |Avg Word2Vec|         10.00|        0.1394|    0.3252|  0.6748|40.42| 50.06|    7
|SGD_clf      |Avg Word2Vec|          0.00|        0.1185|    0.5220|  0.4780|46.27| 61.13|    6
```

```
|SGD_clf       |TF-IDF       |           1.00|        0.1289|    0.3255|  0.6745|40.28| 50.00|     3
```

5.0.3 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.00	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.05	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.00	0.1394	0.3252	0.6748	40.42	50.06	75.40
SGD_clf	Avg Word2Vec	0.00	0.1185	0.5220	0.4780	46.27	61.13	68.48
SGD_clf	TF-IDF	1.00	0.1289	0.3255	0.6745	40.28	50.00	33.72

- Optimal lambda is 1 for TF_IDF with scoring metrics"f1".
- Performnce of datasets with different lambda value is shown in graph.Traing graph and testing graph for different lambda values are almost overlapping each other when lambda value is high

```
In [113]: zx=df[df['Scoring Metrics'] == 'roc_auc']['Best lambda'].ravel()
          lambdax=zx[0]
          print(lambdax)
```

```
0.005
```

```
In [114]: #Best lambda
          hp1=dict(alpha=[lambdax])
          SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                               n_iter=1000,
                                               learning_rate='optimal',
                                               class_weight='balanced',
                                               n_jobs= -1)


          svm6 =GridSearchCV(SGD_clf, hp1,
                             scoring ='roc_auc',
                             cv=tscv,n_jobs= -1)
          svm6.fit(final_tfidf_np ,Train_data)

          prediction6 = svm6.predict(final_tfidf_np_test)
```

```
In [115]: #Training accuracy and training error
          training_score=svm6.score(final_tfidf_np,Train_data)
          print('training accuracy=',training_score)
          training_error=1-training_score
          print('training error is =',training_error)
```

```
training accuracy= 0.89207620082491
training error is = 0.10792379917508998
```

```
In [116]: # Testing Accuracy and testing error

          Testing_score=round(accuracy_score(y_test_new ,prediction6),5)
          print("Accuracy for SGD_clf model with TF-IDF is = ",Testing_score)
          Testing_error=1-Testing_score
          print("Testing error for SGD_clf model with TF-IDF is = ",Testing_error)
```

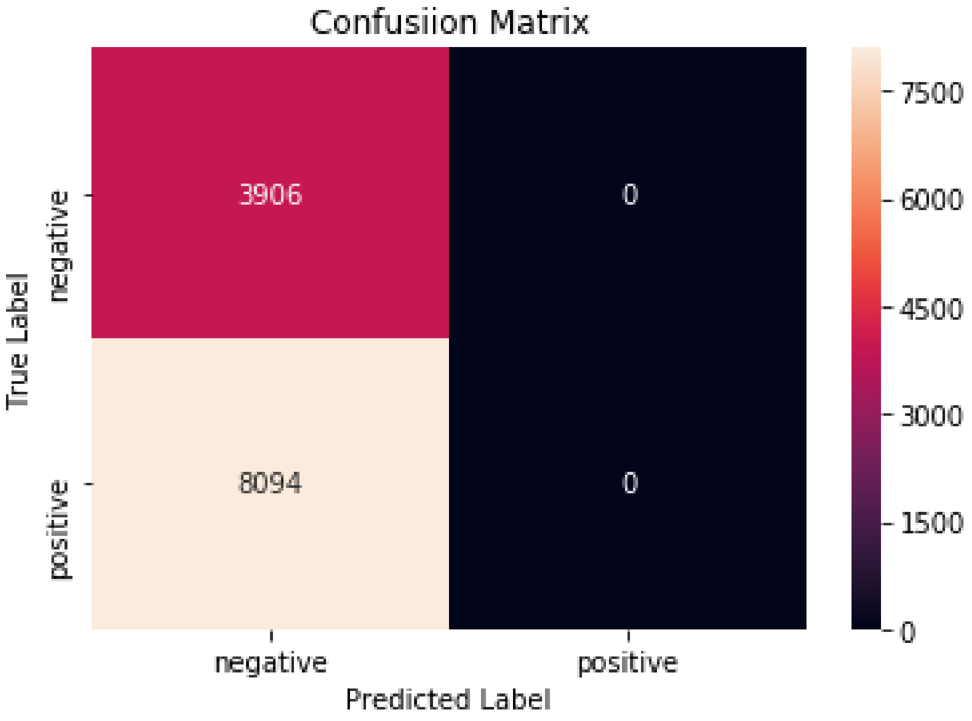
```
Accuracy for SGD_clf model with TF-IDF is =  0.3255
Testing error for SGD_clf model with TF-IDF is =  0.6745
```

```
In [117]: F1_score = round(f1_score(y_test_new ,prediction6,average='macro'),5)*100
          recall = round(recall_score(y_test_new,prediction6,average='macro'),5)*100
          precision = round(precision_score(y_test_new ,prediction6,average='macro'),5)*100
```

```
In [118]: print(classification_report(y_test_new,prediction6))
```

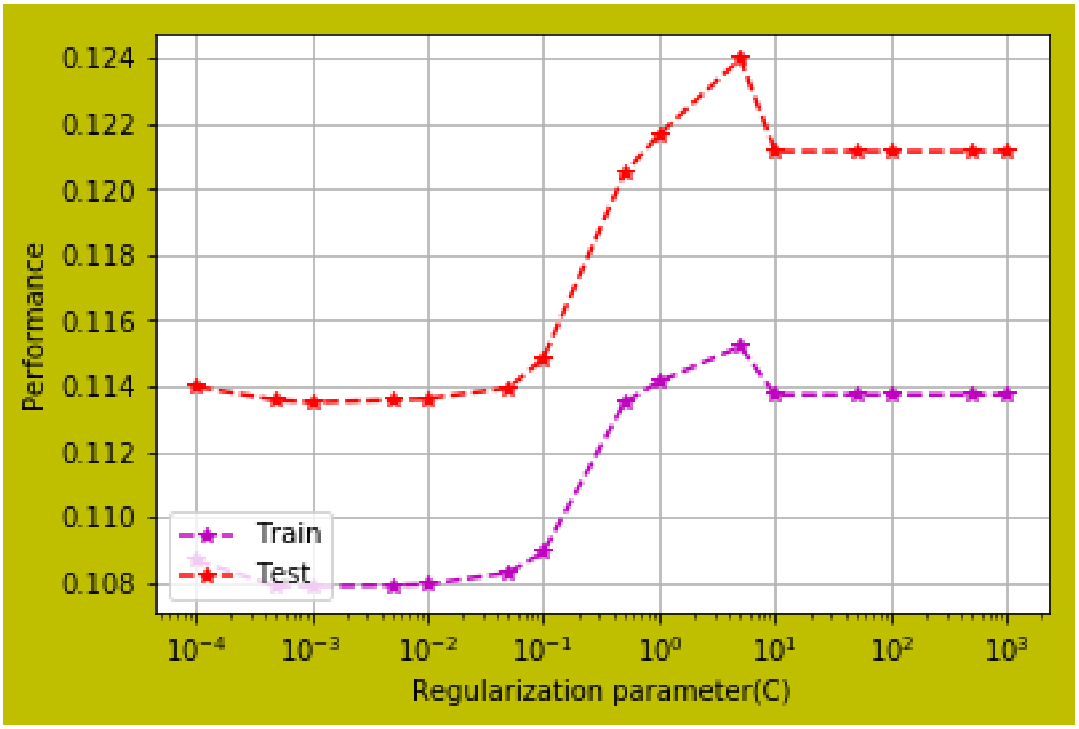
```
             precision    recall  f1-score   support

          0       0.33      1.00      0.49      3906
          1       0.00      0.00      0.00      8094

avg / total       0.11      0.33      0.16     12000
```

```
In [119]: cm = confusion_matrix(y_test_new ,prediction6)
          label = ['negative', 'positive']
          df_conf = pd.DataFrame(cm, index = label, columns = label)
          sns.heatmap(df_conf, annot = True, fmt = "d")
          plt.title("Confusiion Matrix")
          plt.xlabel("Predicted Label")
          plt.ylabel("True Label")
          plt.show()
```



```
In [120]: classifier=SGD_clf
          p='roc_auc'
          error_plot(classifier,p,
                     final_tfidf_np ,
                     Train_data,
                     final_tfidf_np_test,
                     y_test_new)
```

```
100%|??????????| 15/15 [05:13<00:00, 20.91s/it]
```



```
In [121]: models_performence1['Model'].append('SGD_clf')
          models_performence1['Vectorizer'].append(vectorization)

          models_performence1[ 'Optimal lambda'].append(lambdax)
          models_performence1['Training error'].append(training_error)
          models_performence1[ 'Test error'].append(Testing_error)
          models_performence1[ 'Accuracy'].append(Testing_score)
          models_performence1[ 'F1'].append(F1_score)
          models_performence1['recall'].append(recall)
          models_performence1[ 'precision'].append(precision)
```

```
In [122]: columns = ["Model","Vectorizer","Optimal lambda",
                     "Training error",  "Test error",
                      "Accuracy","F1","recall","precision",
                    ]
          df8=pd.DataFrame(models_performence1, columns=columns)
          result_display(df8)
```

```
|    Model     | Vectorizer  |Optimal lambda|Training error|Test error|Accuracy| F1  |recall|preci
|-------------|------------|-------------:|-------------:|---------:|-------:|----:|-----:|-----
|SGD_clf      |BOW         |         5.000|        0.1670|    0.3233|  0.6767|41.24| 50.40|    7
|SGDClassifier|BOW         |         0.050|        0.1626|    0.2435|  0.7565|73.65| 75.18|    7
|SGD_clf      |Avg Word2Vec|        10.000|        0.1394|    0.3252|  0.6748|40.42| 50.06|    7
|SGD_clf      |Avg Word2Vec|         0.005|        0.1185|    0.5220|  0.4780|46.27| 61.13|    6
```

```
|SGD_clf       |TF-IDF      |          1.000|         0.1289|     0.3255|   0.6745|40.28| 50.00|     3
|SGD_clf       |TF-IDF      |          0.005|         0.1079|     0.6745|   0.3255|24.56| 50.00|     1
```

5.0.4 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.000	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifie	BOW	0.050	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.000	0.1394	0.3252	0.6748	40.42	50.06	75.40
SGD_clf	Avg Word2Vec	0.005	0.1185	0.5220	0.4780	46.27	61.13	68.48
SGD_clf	TF-IDF	1.000	0.1289	0.3255	0.6745	40.28	50.00	33.72
SGD_clf	TF-IDF	0.005	0.1079	0.6745	0.3255	24.56	50.00	16.28

- SGD_clf using TF-IDF for scoring metrics "roc_auc" is 0.005.
- Performance graph is as shown above.
- TNR & FNR is high in case of SGD_clf using TF-IDF for scoring metrics "roc_auc" whereas TPR & FPR is high in case of SGD_clf using TF-IDF for scoring metrics "f1".

6 4.TF-IDF weighted Word2Vec

```
In [123]: w2v_words = list(w2v_model.wv.vocab)
```

```
In [124]: tfidf_feat = tf_idf_vect.get_feature_names()
          dictionary = dict(zip(tf_idf_vect.get_feature_names(), list(tf_idf_vect.idf_)))
```

```
In [125]: # TF-IDF weighted Word2Vec
          tfidf_feat =tf_idf_vect.get_feature_names() # tfidf words/col-names

          tfidf_sent_vectors = [];
          row=0;
          for sent in tqdm(X_train_data.values.ravel()):
              sent_vec = np.zeros(100)
              weight_sum =0;
              for word in sent:
                  if word in w2v_words:
                      vec = w2v_model.wv[word]
          #
                      tf_idf = dictionary[word]*sent.count(word)
                      sent_vec += (vec * tf_idf)
                      weight_sum += tf_idf
              if weight_sum != 0:
                  sent_vec /= weight_sum
              tfidf_sent_vectors .append(sent_vec)
              row += 1
```

```
100%|??????????| 28000/28000 [15:02<00:00, 31.01it/s]
```

```
In [126]: print(len(tfidf_sent_vectors))
```

```
28000
```

```
In [127]: print(tfidf_sent_vectors[2])
          tfidf_sent_vectors_train  = np.where(np.isnan(tfidf_sent_vectors ), 0, tfidf_sent_vect
          print(tfidf_sent_vectors_train[2])
```

```
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
```

```
In [128]: tfidf_sent_vectors_train  = np.asarray(tfidf_sent_vectors_train )
          print(type(tfidf_sent_vectors))
```

```
<class 'list'>
```

Dumping & Loading Pickle file for trainText data (TF-IDF weighted word2vec)

```
In [129]: pickle_path_tfidf_weighted='X_data_tfidf_weighted.pkl'
          X_data_tfidf_weighted=open(pickle_path_tfidf_weighted,'wb')
          pickle.dump(tfidf_sent_vectors_train  ,X_data_tfidf_weighted)
          X_data_tfidf_weighted.close()
```

```
In [130]: pickle_path_tfidf_weighted='X_data_tfidf_weighted.pkl'
          unpickle_path7=open(pickle_path_tfidf_weighted,'rb')
          tfidf_sent_vectors_train =pickle.load(unpickle_path7)
```

```
In [131]: final_tfidf_w2v_np_train= StandardScaler(with_mean=False).fit_transform(tfidf_sent_vec
```

For test Tf-idf weighted word2vec

```
In [132]: # TF-IDF weighted Word2Vec
          tfidf_feat =tf_idf_vect.get_feature_names() # tfidf words/col-names

          tfidf_sent_vectors1 = [];
          row=0;
          for sent in tqdm(X_test_data.values.ravel()):
              sent_vec = np.zeros(100)
              weight_sum =0;
              for word in sent:
                  if word in w2v_words:
                      vec = w2v_model.wv[word]
          #
                      tf_idf = dictionary[word]*sent.count(word)
                      sent_vec += (vec * tf_idf)
                      weight_sum += tf_idf
              if weight_sum != 0:
                  sent_vec /= weight_sum
              tfidf_sent_vectors1 .append(sent_vec)
              row += 1
```

```
100%|??????????| 12000/12000 [06:40<00:00, 29.96it/s]
```

```
In [133]: print(len(tfidf_sent_vectors1))
          print(tfidf_sent_vectors1[2])
          tfidf_sent_vectors_test  = np.where(np.isnan(tfidf_sent_vectors1 ),
                                               0, tfidf_sent_vectors1 )
          print(tfidf_sent_vectors_test[2])
          final_tfidf_w2v_np_test = np.asarray(tfidf_sent_vectors_test )
          print(type(tfidf_sent_vectors1))
```

```
12000
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
<class 'list'>
```

Dumping & Loading Pickle file for test Text data (TF-IDF weighted word2vec)

```
In [134]: pickle_path_tfidf_weighted1='X_data_tfidf_weighted_test.pkl'
          X_data_tfidf_weighted1=open(pickle_path_tfidf_weighted1,'wb')
          pickle.dump(final_tfidf_w2v_np_test  ,X_data_tfidf_weighted1)
          X_data_tfidf_weighted1.close()
```

```
In [135]: pickle_path_tfidf_weighted1='X_data_tfidf_weighted_test.pkl'
          unpickle_path71=open(pickle_path_tfidf_weighted1,'rb')
          final_tfidf_w2v_np_test =pickle.load(unpickle_path71)
```

for Training Data:

```
final_tfidf_w2v_np_train
```

For testing data:

```
final_tfidf_w2v_np_test
```

6.0.1 Optimal SVM for TF-IDF weighted Word2Vec

```
In [136]: vectorization='TF-IDF weighted Word2Vec'
          optimal_lambda = optimal_svm(final_tfidf_w2v_np_train,
                                        Train_data,
                                        final_tfidf_w2v_np_test,
                                        y_test_new,vectorization )
```

```
100%|??????????| 2/2 [00:50<00:00, 25.10s/it]
```

```
In [137]: columns = ["Model","Vectorizer","SearchCV",
                      "Scoring Metrics","Train_model_score",
                      "Test_model_score","Best lambda"]
          df9=pd.DataFrame(models_performence, columns=columns)
          result_display(df9)
```

```
|    Model    |       Vectorizer       |  SearchCV  |Scoring Metrics|Train_model_score|Test_mode
|-------------|------------------------|------------|---------------|----------------:|---------
|SGDClassifier|BOW                     |GridSearchCV|f1             |          0.00020|
|SGDClassifier|BOW                     |GridSearchCV|roc_auc        |          0.83740|
|SGDClassifier|Avg Word2Vec            |GridSearchCV|f1             |          0.33816|
|SGDClassifier|Avg Word2Vec            |GridSearchCV|roc_auc        |          0.88124|
|SGDClassifier|TF-IDF                  |GridSearchCV|f1             |          0.76711|
|SGDClassifier|TF-IDF                  |GridSearchCV|roc_auc        |          0.89210|
|SGDClassifier|TF-IDF weighted Word2Vec|GridSearchCV|f1             |          0.83014|
|SGDClassifier|TF-IDF weighted Word2Vec|GridSearchCV|roc_auc        |          0.50000|
```

Model	Vectorizer	SearchCV	Scoring Metrics	Train_model_score	Test_model_score	Best lambda
SGDClassifier	BOW	GridSearchCV	f1	0.00020	0.0000	5.00
SGDClassifier	BOW	GridSearchCV	roc_auc	0.83740	0.8197	0.05
SGDClassifier	Avg Word2Vec	GridSearchCV	f1	0.33816	0.0000	10.00
SGDClassifier	Avg Word2Vec	GridSearchCV	roc_auc	0.88124	0.8796	0.00
SGDClassifier	TF-IDF	GridSearchCV	f1	0.76711	0.0000	1.00
SGDClassifier	TF-IDF	GridSearchCV	roc_auc	0.89210	0.8864	0.00
SGDClassifier	TF-IDF weighted Word2Vec	GridSearchCV	f1	0.83014	0.8056	1000.00
SGDClassifier	TF-IDF weighted Word2Vec	GridSearchCV	roc_auc	0.50000	0.5000	1000.00

```
In [138]: df=pd.DataFrame(models_performence, columns=columns)
          df=df[df['Vectorizer'] == 'TF-IDF weighted Word2Vec']
          zx=df[df['Scoring Metrics'] == 'f1']['Best lambda'].ravel()
          lambdax=zx[0]
          print(lambdax)
```

```
1000.0
```

```
In [139]: #Best lambda
          hp1=dict(alpha=[lambdax])
          SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                               n_iter=1000,
                                               learning_rate='optimal',
                                               class_weight='balanced',
                                              n_jobs= -1)


          svm7 =GridSearchCV(SGD_clf,hp1,
                             scoring ='f1',
                             cv=tscv,n_jobs= -1)
          svm7.fit(final_tfidf_w2v_np_train,Train_data)

          prediction7 =svm7.predict(final_tfidf_w2v_np_test)
```

```
In [140]: #Training accuracy and training error
          training_score=svm7.score(final_tfidf_w2v_np_train,Train_data)
          print('training accuracy=',training_score)
          training_error=1-training_score
          print('training error is =',training_error)
```

```
training accuracy= 0.8301405920324219
training error is = 0.16985940796757815
```

```
In [141]: # Testing Accuracy and testing error
```

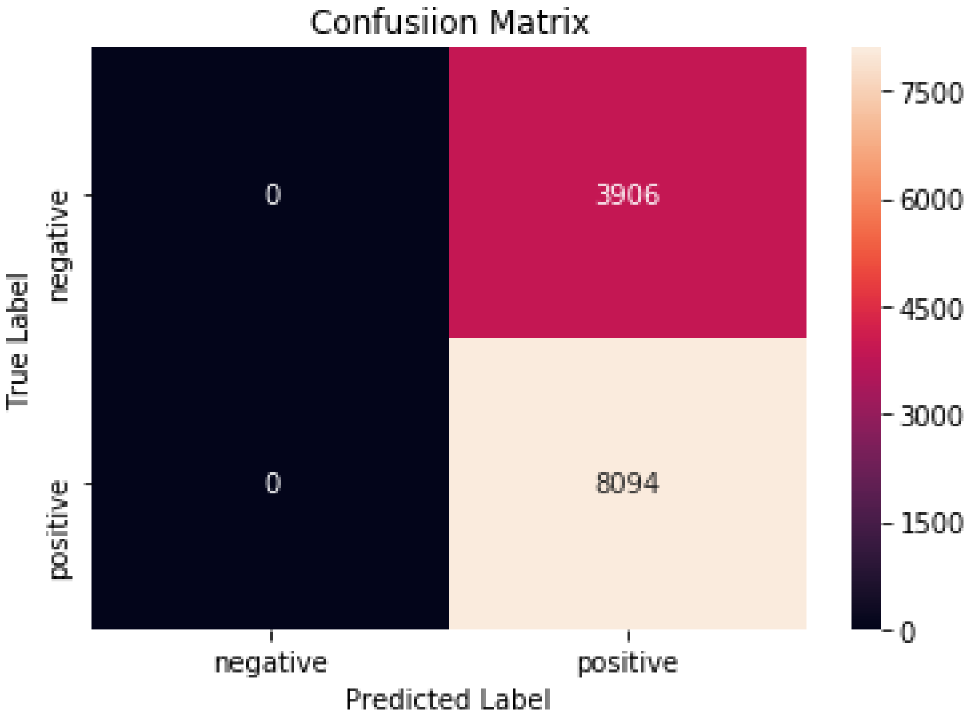
```
          Testing_score=round(accuracy_score(y_test_new ,prediction7),5)
          print("Accuracy for SGD_clf model with TF-IDF weighted Word2Vec is = ",Testing_score)
          Testing_error=1-Testing_score
          print("Testing error for SGD_clfmodel with TF-IDF weighted Word2Vec is = ",Testing_err
```

```
Accuracy for SGD_clf model with TF-IDF weighted Word2Vec is =  0.6745
Testing error for SGD_clfmodel with TF-IDF weighted Word2Vec is =  0.3255
```

```
In [142]: F1_score = round(f1_score(y_test_new ,prediction7,average='macro'),5)*100
          recall = round(recall_score(y_test_new,prediction7,average='macro'),5)*100
          precision = round(precision_score(y_test_new ,prediction7,average='macro'),5)*100

In [143]: print(classification_report( y_test_new,prediction7))
```

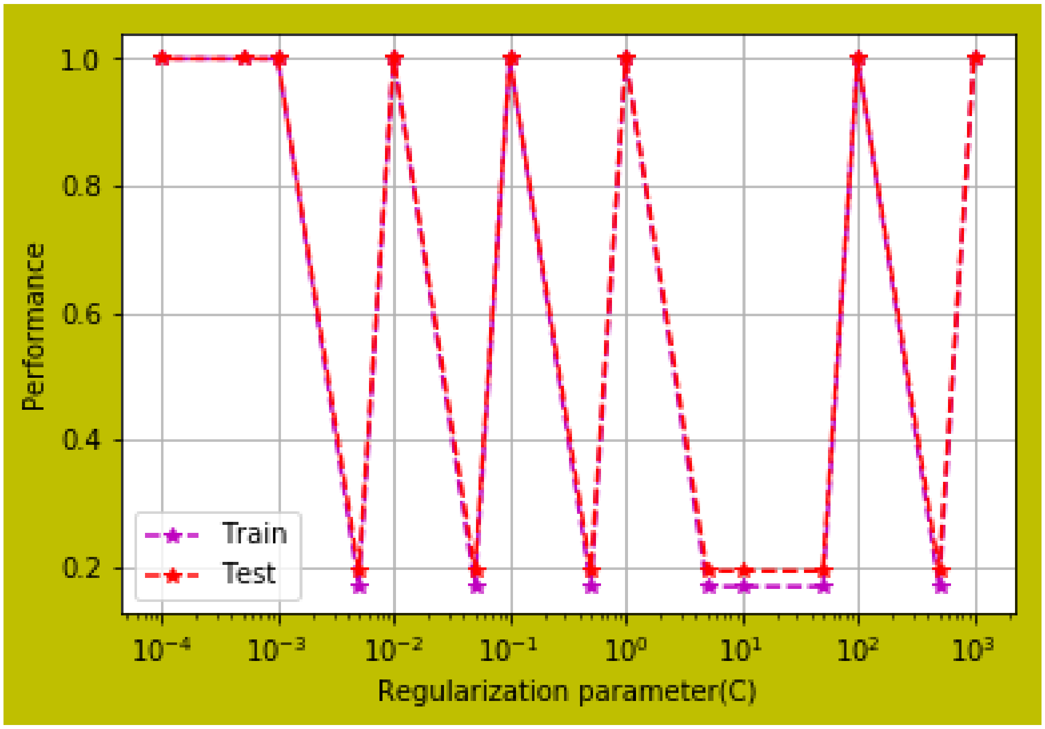
```
             precision    recall  f1-score   support

          0       0.00      0.00      0.00      3906
          1       0.67      1.00      0.81      8094

avg / total       0.45      0.67      0.54     12000
```

```
In [144]: cm = confusion_matrix(y_test_new ,prediction7)
          label = ['negative', 'positive']
          df_conf = pd.DataFrame(cm, index = label, columns = label)
          sns.heatmap(df_conf, annot = True, fmt = "d")
          plt.title("Confusiion Matrix")
          plt.xlabel("Predicted Label")
          plt.ylabel("True Label")
          plt.show()
```



```
In [145]: classifier=SGD_clf
          p='f1'
          error_plot(classifier,p,
                     final_tfidf_w2v_np_train,
                     Train_data,
                     final_tfidf_w2v_np_test,y_test_new)
```

```
100%|??????????| 15/15 [05:58<00:00, 23.88s/it]
```



```
In [146]: models_performence1['Model'].append('SGD_clf')
          models_performence1['Vectorizer'].append(vectorization)

          models_performence1[ 'Optimal lambda'].append(lambdax)
          models_performence1['Training error'].append(training_error)
          models_performence1[ 'Test error'].append(Testing_error)
          models_performence1[ 'Accuracy'].append(Testing_score)
          models_performence1[ 'F1'].append(F1_score)
          models_performence1['recall'].append(recall)
          models_performence1[ 'precision'].append(precision)
```

```
In [147]: columns = ["Model","Vectorizer","Optimal lambda",
                      "Training error",  "Test error",
                       "Accuracy","F1","recall","precision",
                     ]
          df10=pd.DataFrame(models_performence1, columns=columns)
          result_display(df10)
```

```
|    Model    |       Vectorizer        |Optimal lambda|Training error|Test error|Accuracy| F1  |
|-------------|-------------------------|-------------:|-------------:|---------:|-------:|----:|
|SGD_clf      |BOW                      |         5.000|        0.1670|    0.3233|  0.6767|41.24|
|SGDClassifier|BOW                      |         0.050|        0.1626|    0.2435|  0.7565|73.65|
|SGD_clf      |Avg Word2Vec             |        10.000|        0.1394|    0.3252|  0.6748|40.42|
|SGD_clf      |Avg Word2Vec             |         0.005|        0.1185|    0.5220|  0.4780|46.27|
|SGD_clf       |TF-IDF                  |         1.000|          0.1289|     0.3255|   0.6745|40.28|
|SGD_clf       |TF-IDF                  |         0.005|          0.1079|     0.6745|   0.3255|24.56|
|SGD_clf       |TF-IDF weighted Word2Vec|      1000.000|          0.1699|     0.3255|   0.6745|40.28|
```

6.0.2 Observations:

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.000	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.050	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.000	0.1394	0.3252	0.6748	40.42	50.06	75.40
SGD_clf	Avg Word2Vec	0.005	0.1185	0.5220	0.4780	46.27	61.13	68.48
SGD_clf	TF-IDF	1.000	0.1289	0.3255	0.6745	40.28	50.00	33.72
SGD_clf	TF-IDF	0.005	0.1079	0.6745	0.3255	24.56	50.00	16.28
SGD_clf	TF-IDF weighted Word2Vec	1000.000	0.1699	0.3255	0.6745	40.28	50.00	33.72

- lambda value for TF-IDF weighted Word2Vec usingscoring metrics "f1"is high (1000).
- TPR & FPR is high and performance graph looks like peak tooth wave.

```
In [148]: zx=df[df['Scoring Metrics'] == 'roc_auc']['Best lambda'].ravel()
          lambdax=zx[0]
          print(lambdax)
```

```
1000.0
```

```
In [149]: #Best lambda
          hp1=dict(alpha=[lambdax])
          SGD_clf = linear_model.SGDClassifier(loss='hinge',
                                               n_iter=1000,
                                               learning_rate='optimal',
                                               class_weight='balanced',
                                               n_jobs= -1)


          svm8 =GridSearchCV(SGD_clf, hp1,
                             scoring ='roc_auc',
                             cv=tscv,n_jobs= -1)
          svm8.fit(final_tfidf_w2v_np_train,Train_data)

          prediction8 = svm8.predict(final_tfidf_w2v_np_test)
```

```
In [150]: #Training accuracy and training error
          training_score=svm8.score(final_tfidf_w2v_np_train,Train_data)
          print('training accuracy=',training_score)
          training_error=1-training_score
          print('training error is =',training_error)
```

```
training accuracy= 0.5
training error is = 0.5
```

```
In [151]: # Testing Accuracy and testing error

          Testing_score=round(accuracy_score(y_test_new ,prediction8),5)
          print("Accuracy for SGD_clf model with TF-IDF weighted Word2Vec is = ",Testing_score)
          Testing_error=1-Testing_score
          print("Testing error for SGD_clf model with TF-IDF weighted Word2Vec is = ",Testing_er
```

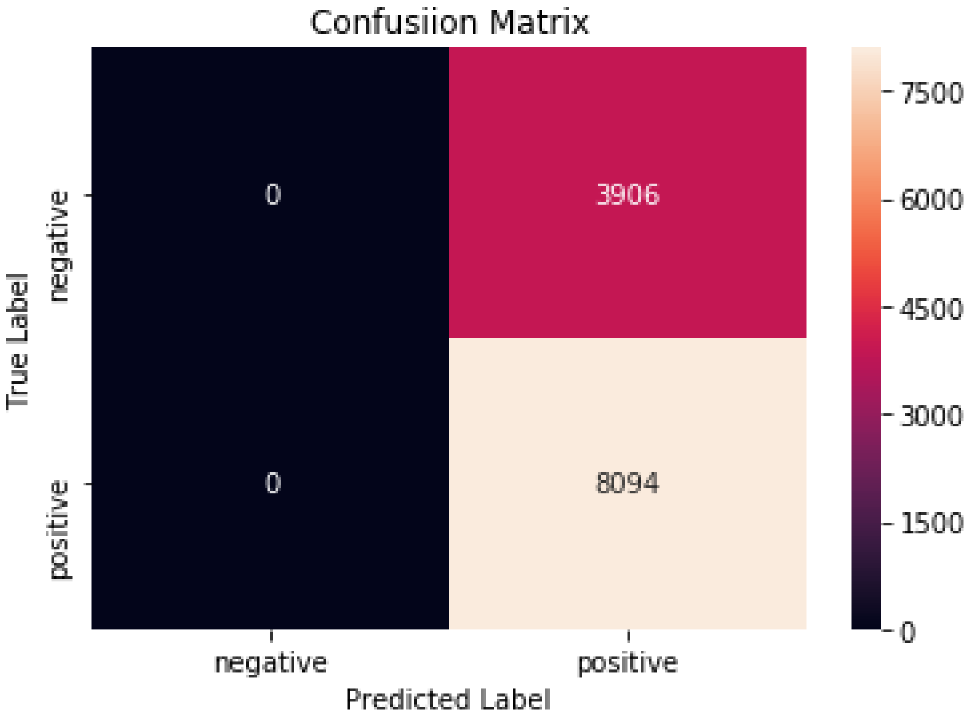
```
Accuracy for SGD_clf model with TF-IDF weighted Word2Vec is =  0.6745
Testing error for SGD_clf model with TF-IDF weighted Word2Vec is =  0.3255
```

```
In [152]: F1_score = round(f1_score(y_test_new,prediction8,average='macro'),5)*100
          recall = round(recall_score(y_test_new,prediction8,average='macro'),5)*100
          precision = round(precision_score(y_test_new ,prediction8,average='macro'),5)*100
```

```
In [153]: print(classification_report( y_test_new,prediction8))
```

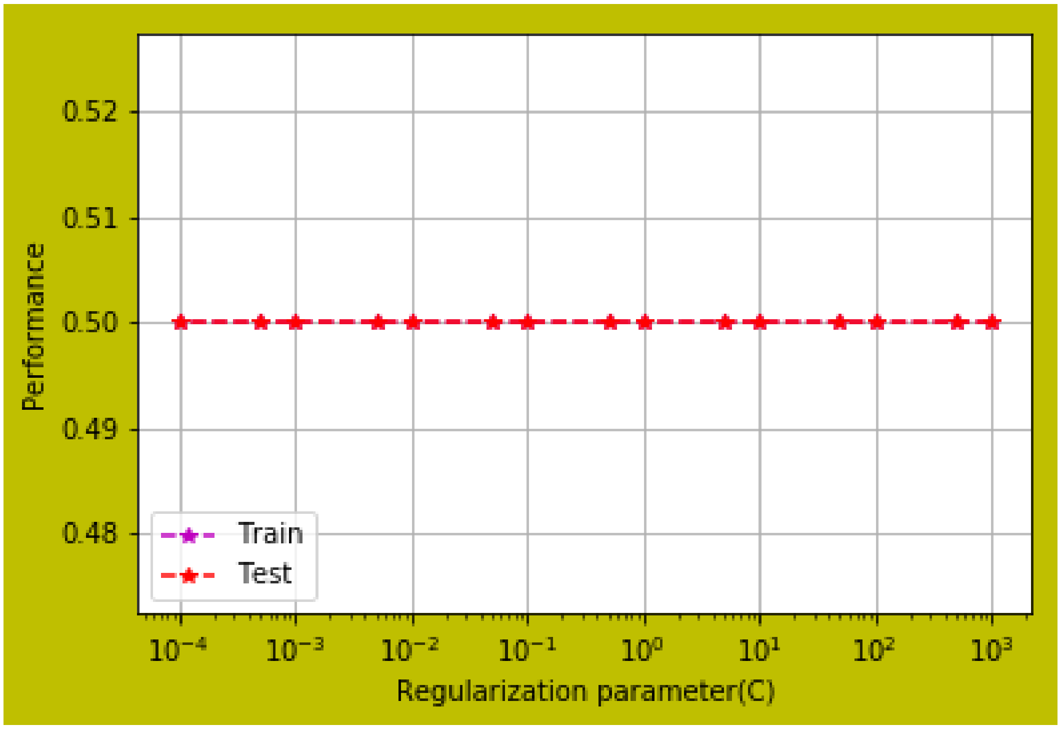
```
             precision    recall  f1-score   support

          0       0.00      0.00      0.00      3906
          1       0.67      1.00      0.81      8094

avg / total       0.45      0.67      0.54     12000
```

```
In [154]: cm = confusion_matrix(y_test_new ,prediction8)
          label = ['negative', 'positive']
          df_conf = pd.DataFrame(cm, index = label, columns = label)
          sns.heatmap(df_conf, annot = True, fmt = "d")
          plt.title("Confusiion Matrix")
          plt.xlabel("Predicted Label")
          plt.ylabel("True Label")
          plt.show()
```



```
In [155]: classifier=SGD_clf
          p='roc_auc'
          error_plot(classifier,p,
                     final_tfidf_w2v_np_train,
                     Train_data,final_tfidf_w2v_np_test,
                     y_test_new)
```

```
100%|??????????| 15/15 [05:59<00:00, 23.97s/it]
```



```
In [156]: models_performence1['Model'].append('SGD_clf')
          models_performence1['Vectorizer'].append(vectorization)

          models_performence1[ 'Optimal lambda'].append(lambdax)
          models_performence1['Training error'].append(training_error)
          models_performence1[ 'Test error'].append(Testing_error)
          models_performence1[ 'Accuracy'].append(Testing_score)
          models_performence1[ 'F1'].append(F1_score)
          models_performence1['recall'].append(recall)
          models_performence1[ 'precision'].append(precision)
```

```
In [157]: columns = ["Model","Vectorizer","Optimal lambda", "Training error",  "Test error",
                      "Accuracy","F1","recall","precision",
                    ]
          df11=pd.DataFrame(models_performence1, columns=columns)
          result_display(df11)
```

```
|    Model     |        Vectorizer        |Optimal lambda|Training error|Test error|Accuracy| F1  |
|-------------|-------------------------|-------------:|-------------:|---------:|-------:|----:|
|SGD_clf      |BOW                      |          5.00|        0.1670|    0.3233|  0.6767|41.24|
|SGDClassifier|BOW                      |          0.05|        0.1626|    0.2435|  0.7565|73.65|
|SGD_clf      |Avg Word2Vec             |         10.00|        0.1394|    0.3252|  0.6748|40.42|
|SGD_clf      |Avg Word2Vec             |          0.00|        0.1185|    0.5220|  0.4780|46.27|
|SGD_clf      |TF-IDF                   |          1.00|        0.1289|    0.3255|  0.6745|40.28|
|SGD_clf      |TF-IDF                   |         0.00|         0.1079|     0.6745|   0.3255|24.56|
|SGD_clf      |TF-IDF weighted Word2Vec|      1000.00|         0.1699|     0.3255|   0.6745|40.28|
|SGD_clf      |TF-IDF weighted Word2Vec|      1000.00|         0.5000|     0.3255|   0.6745|40.28|
```

6.0.3 Observation

Model	Vectorizer	Optimal lambda	Training error	Test error	Accuracy	F1	recall	precision
SGD_clf	BOW	5.00	0.1670	0.3233	0.6767	41.24	50.40	73.81
SGDClassifier	BOW	0.05	0.1626	0.2435	0.7565	73.65	75.18	73.06
SGD_clf	Avg Word2Vec	10.00	0.1394	0.3252	0.6748	40.42	50.06	75.40
SGD_clf	Avg Word2Vec	0.00	0.1185	0.5220	0.4780	46.27	61.13	68.48
SGD_clf	TF-IDF	1.00	0.1289	0.3255	0.6745	40.28	50.00	33.72
SGD_clf	TF-IDF	0.00	0.1079	0.6745	0.3255	24.56	50.00	16.28
SGD_clf	TF-IDF weighted Word2Vec	1000.00	0.1699	0.3255	0.6745	40.28	50.00	33.72
SGD_clf	TF-IDF weighted Word2Vec	1000.00	0.5000	0.3255	0.6745	40.28	50.00	33.72

- lambda value is same in both scoring techniques.
- Performance graph with different lambda value is straight line.

7 Best Model for SVC

```
In [158]: pickle_path112='df11.pkl'
          df121=open(pickle_path112,'wb')
          pickle.dump(df11,df121)
          df121.close()
```

```
In [34]: pickle_path112='df11.pkl'

         unpickle_path61=open(pickle_path112,'rb')
         dff=pickle.load(unpickle_path61)
```

```
In [35]: dff=dff.ix[dff['Training error'].idxmin() & dff['Test error'].idxmin()]
         print(dff)
         vect=dff['Vectorizer']
```

```
Model              SGDClassifier
Vectorizer                   BOW
Optimal lambda              0.05
Training error          0.162592
```

```
Test error                  0.2435
Accuracy                    0.7565
F1                          73.645
recall                       75.18
precision                   73.061
Name: 1, dtype: object
```

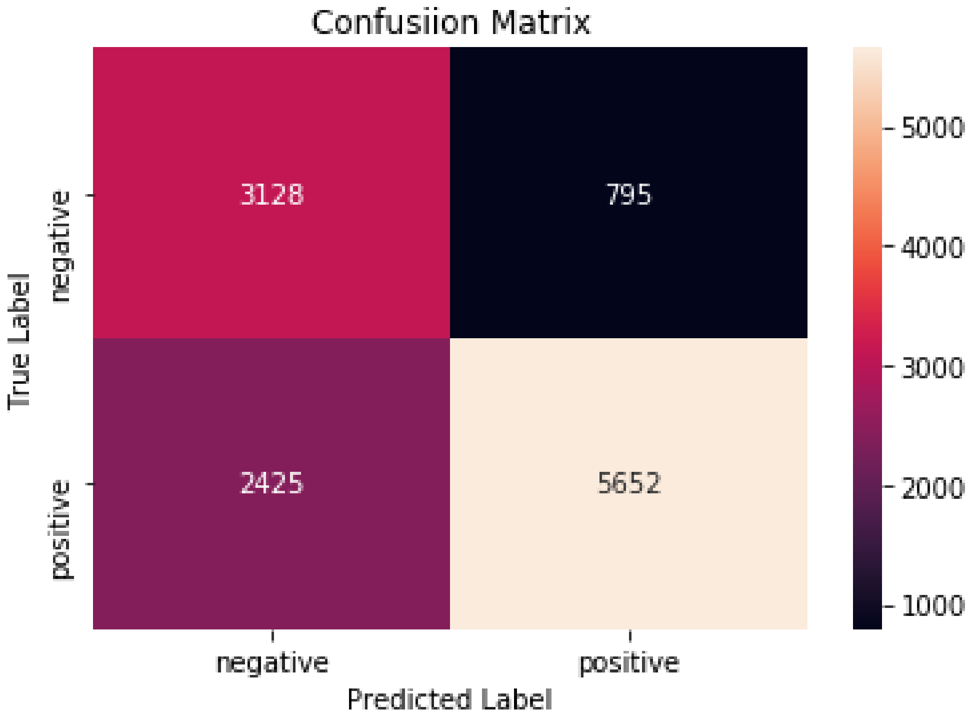
#### SGD Classifier for BOW with scoring metrics "roc_auc" performs well amongs other techquies .

Now , Apply this best results on SVC using rbf kernel to classify given reviews (positive (Rating of 4 or 5) & negative (rating of 1 or 2)) using SVM algorithm .

```
In [36]: from time import sleep
         from tqdm import tqdm
         import multiprocessing as mp


         def main122():
             print("started")

             values = range(1)
             with tqdm(total=len(values)) as pbar:
                 for i in values:
                     pbar.write('processed: %d' %i)
                     hyperparam_range=[5,0.1,0.05]

                     kernel= ['rbf']
                     hp1=dict(kernel=kernel,C=hyperparam_range, gamma=hyperparam_range)
                     clf=SVC(class_weight='balanced')
                     svm_final =  GridSearchCV(clf,
                                               hp1,
                                             scoring ='roc_auc',
                                             cv=tscv,
                                             n_jobs= -1)
                     svm_final.fit(final_data ,Train_data)

                     Reg143=svm_final.best_estimator_.get_params()['gamma']
                     print('Optimal gamma for SVC',Reg143)
                     optimal_l143=svm_final.best_estimator_.get_params()['C']
                     print('Optimal lambada for SVC',(1/optimal_l143))
                     prediction_final =svm_final.predict(final_data_test)
                     #Training accuracy and training error
                     training_score=svm_final.score(final_data,Train_data)
                     print('training accuracy=',training_score)
                     training_error=1-training_score
                     print('training error is =',training_error)
                     # Testing Accuracy and testing error
```

```
            Testing_score=round(accuracy_score(y_test_new,prediction_final),5)
            print("Accuracy for SVM model  is = ",Testing_score)
            Testing_error=1-Testing_score
            print("Testing error for SVM model is = ",Testing_error)
            F1_score = round(f1_score(y_test_new ,prediction_final,average='macro'),5)*
            recall = round(recall_score(y_test_new,prediction_final,average='macro'),5)
            precision = round(precision_score(y_test_new,prediction_final,average='macr
            print(classification_report(y_test_new,prediction_final))
            cm = confusion_matrix(y_test_new ,prediction_final)
            label = ['negative', 'positive']
            df_conf = pd.DataFrame(cm, index = label, columns = label)
            sns.heatmap(df_conf, annot = True, fmt = "d")
            plt.title("Confusiion Matrix")
            plt.xlabel("Predicted Label")
            plt.ylabel("True Label")
            plt.show()
            pbar.update(1)
            sleep(1)

if __name__=='__main__':
    mp.freeze_support()
    main122()
```

```
  0%|          | 0/1 [00:00<?, ?it/s]

started
processed: 0
Optimal gamma for SVC 0.05
Optimal lambada for SVC 10.0
training accuracy= 0.8971495409649287
training error is = 0.10285045903507128
Accuracy for SVM model  is =  0.73167
Testing error for SVM model is =  0.26832999999999996
             precision    recall  f1-score   support

          0       0.56      0.80      0.66      3923
          1       0.88      0.70      0.78      8077

avg / total       0.77      0.73      0.74     12000
```



```
100%|??????????| 1/1 [45:33<00:00, 2733.32s/it]
```

8 Observations

- Optimal gamma for SVC = 0.05
- Optimal lambada for SVC = 10.0
- training accuracy= 0.8971495409649287
- training error is = 0.10285045903507128
- Accuracy for SVM model is = 0.73167
- Testing error for SVM model is = 0.26832999999999996
- From confusion metrics, TPR & TNR is high and FPR & FNR is low. It means model performs is sensible and model works well.
- SVC using BOW with scoring metrics "roc_auc" performs well to classify postive and negative reviews .

```
In [ ]:
```