Amazon Food Review-Logistic Regression

December 1, 2018

In [1]:
```
%matplotlib inline

        #import all the modules
        import sqlite3
        import numpy as np
        import pandas as pd
        import nltk
        import seaborn as sns

        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix,accuracy_score,precision_score,recall_sco
        from sklearn import metrics
        from sklearn.manifold import TSNE
        from nltk.corpus import stopwords
        from nltk.stem.porter import PorterStemmer
        from nltk.stem import SnowballStemmer
        from nltk.stem.wordnet import WordNetLemmatizer
        from sklearn.linear_model import LogisticRegression
        from sklearn.model_selection import train_test_split,GridSearchCV,RandomizedSearchCV
        from sklearn.cross_validation import cross_val_score
        from collections import Counter
        from sklearn import cross_validation
        from sklearn.preprocessing import StandardScaler
```

```
D:\Anaconda\lib\site-packages\sklearn\cross_validation.py:41: DeprecationWarning: This module w
  "This module will be removed in 0.20.", DeprecationWarning)
```

In [2]:
```
conn2=sqlite3.connect('D:/Applied AI Course/final.sqlite')
```

In [3]:
```
label_df=pd.read_sql_query("""SELECT * FROM REVIEWS""",conn2)
```

In [4]:
```
label_df.head(4)
```

Out[4]:

	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)"

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

                                    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

                                                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 ...

                                           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...
```

In [5]:
```
label_df=label_df.sort_values('Time',axis=0,inplace=False,kind='quicksort')
```

In [6]:
```
d_pos=label_df[label_df["Score"] == 'Positive'].sample(n=50000)
d_neg=label_df[label_df["Score"] == 'Negative'].sample(n=50000)
finald=pd.concat([d_pos,d_neg])
finald.shape
```

Out[6]:
```
(100000, 12)
```

In [7]:
```
finald.head(2)
final_d=finald.sort_values(by='Time')
final_d.head(3)
```

Out[7]:
```
      index      Id   ProductId          UserId       ProfileName  \
0    138706  150524  0006641040   ACITT7DI6IDDL   shari zychinski
308  346041  374343  B00004CI84   A1B2IZU1JLZA6               Wes
868  138017  149789  B00004S1C6  A1KXONFPU2XQ5K  Stephanie Manley

     HelpfulnessNumerator  HelpfulnessDenominator     Score       Time  \
0                       0                       0  Positive  939340800
308                    19                      23  Negative  948240000
```

```
868                    26                         28  Positive  965779200

                                                 Summary  \
0                             EVERY book is educational
308  WARNING: CLAMSHELL EDITION IS EDITED TV VERSION
868                                       A must have!

                                                    Text  \
0    this witty little book makes my son laugh at l...
308  I, myself always enjoyed this movie, it's very...
868  These are easy to use, they do not make a mess...

                                           CleanedText
0    witti littl book make son laugh loud recit car...
308  alway enjoy movi funni entertain didnt hesit p...
868  easi use make mess offer vibrant color taint d...
```

1 BagOfWords

In [8]:
```
X=final_d["CleanedText"]
X.shape
```

Out[8]: (100000,)

In [9]:
```
y=final_d["Score"]
y.shape
```

Out[9]: (100000,)

In [10]:
```
#split the data into train and test fo bag of words

X_train,X_test,Y_train,Y_test=train_test_split(X,y,test_size=0.3,random_state=None,shu
#split train into cross val train and cross val test
X_t,X_cv,Y_t,Y_cv=train_test_split(X_train,Y_train,test_size=0.3,shuffle=False)
```

In [11]:
```
print(X_train.shape,X_test.shape,Y_train.shape,Y_test.shape)
```

```
(70000,) (30000,) (70000,) (30000,)
```

In [12]:
```
#Bag of Words
BoW=CountVectorizer()
X_train=BoW.fit_transform(X_train)
#X_train=StandardScaler(with_mean=False).fit_transform(X_train)
x_test=BoW.transform(X_test)
```

In [13]:
```
from sklearn import preprocessing
X_train=preprocessing.normalize(X_train)
X_test=preprocessing.normalize(x_test)

print(X_train.shape, X_test.shape)
```

```
(70000, 44575) (30000, 44575)
```

```
In [14]: #X_train=StandardScaler(with_mean=False).fit_transform(X_train)
         #X_test=StandardScaler(with_mean=False).fit(X_train).transform(x_test)
```

```
In [15]: print(X_train.shape,X_test.shape)
```

```
(70000, 44575) (30000, 44575)
```

Using time series splitting

```
In [16]: from sklearn.model_selection import TimeSeriesSplit

         tcv=TimeSeriesSplit(n_splits=10)
         for train,cv in tcv.split(X_train):
             print(X_train[train].shape,X_train[cv].shape)
```

```
(6370, 44575) (6363, 44575)
(12733, 44575) (6363, 44575)
(19096, 44575) (6363, 44575)
(25459, 44575) (6363, 44575)
(31822, 44575) (6363, 44575)
(38185, 44575) (6363, 44575)
(44548, 44575) (6363, 44575)
(50911, 44575) (6363, 44575)
(57274, 44575) (6363, 44575)
(63637, 44575) (6363, 44575)
```

1.1 Find the best hyperparameter C or 1/Lambda and regulariser[L1,L2] using cross validation

```
In [17]: import pickle
         def savetofile(obj,filename):
             pickle.dump(obj,open(filename+".p","wb"))
```

```
In [18]: def openfromfile(filename):
             temp = pickle.load(open(filename+".p","rb"))
             return temp
```

2 GridSearch Cross validation

```
In [19]: cls=LogisticRegression()
         param_grid={'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.00001]
                     'penalty':['l1','l2']}
         tcv=TimeSeriesSplit(n_splits=10)
         gcv=GridSearchCV(cls,param_grid,cv=tcv,verbose=1)
```

```
        gcv.fit(X_train,Y_train)
        savetofile(gcv,"D:/Applied AI Course/gcv_uni")
        print("Best HyperParameter: ",gcv.best_params_)
        print("Best Accuracy: %.2f%%"%(gcv.best_score_*100))
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits


[Parallel(n_jobs=1)]: Done 300 out of 300 | elapsed: 10.4min finished


Best HyperParameter:  {'C': 5, 'penalty': 'l2'}
Best Accuracy: 86.88%
```

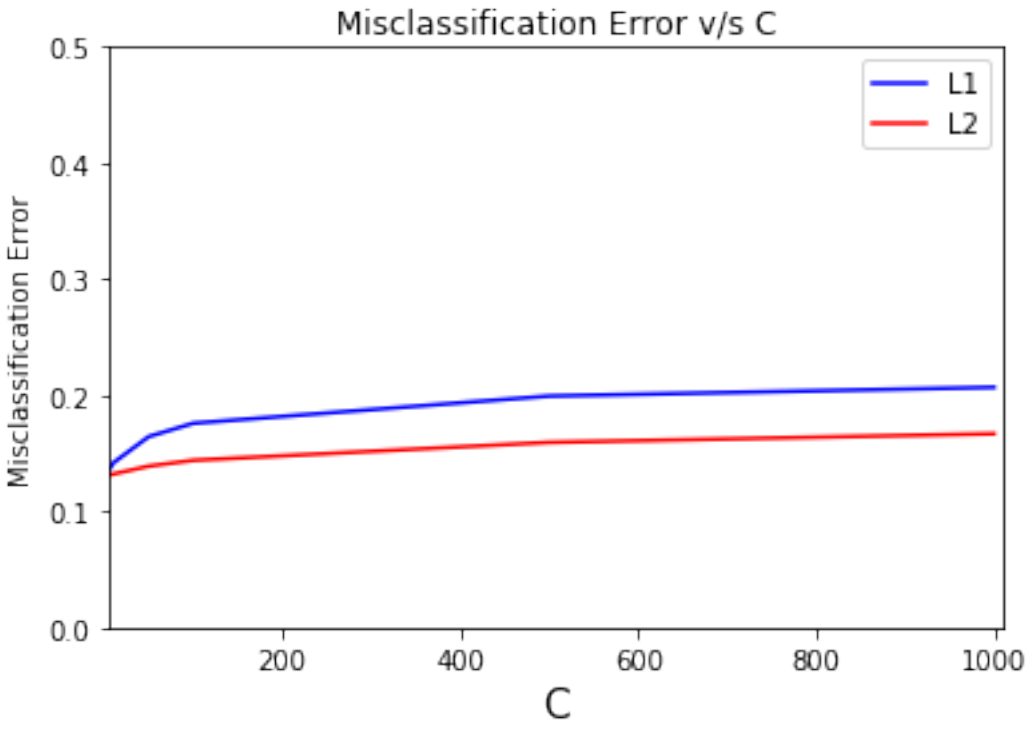
In [20]:
```
savetofile(gcv,"D:/Applied AI Course/gcv_uni")
```

In [21]:
```
import matplotlib.pyplot as plt
```

In [22]:
```
 def plot_error_vs_c(gcv):
    x1=[]
    y1=[]
    x2=[]
    y2=[]
    for a in gcv.grid_scores_:
        if (a[0]['penalty']) =='l1':
            y1.append(1-a[1])
            x1.append(a[0]['C'])
        else:
            y2.append(1-a[1])
            x2.append(a[0]['C'])
    plt.xlim(5,1010)
    plt.ylim(0,0.5)
    plt.xlabel("C",fontsize=15)
    plt.ylabel("Misclassification Error")
    plt.title('Misclassification Error v/s C')
    plt.plot(x1,y1,'b',label="L1")
    plt.plot(x2,y2,'r',label="L2")
    plt.legend()
    plt.show()
```

In [23]:
```
gcv = openfromfile("D:/Applied AI Course/gcv_uni")
plot_error_vs_c(gcv)
```

```
D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```




```
In [25]: clf=LogisticRegression(C=5,penalty='l2')
         clf.fit(X_train,Y_train)
         y_pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, y_pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, y_pred)
         test_error = 1 - test_accuracy

Accuracy on test set: 87.837%
Non Zero weights: 44575
```

3 sparsity increase with change in C and lambda hyperparameters

```
In [26]: from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression(C= 1000, penalty= 'l1')
```

```
        clf.fit(X_train,Y_train)
        prediction = clf.predict(X_test)
        precision_scorer = make_scorer(precision_score, pos_label='Positive')
        recall_scorer=make_scorer(recall_score, pos_label='Positive')
        precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
        recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
        precision=np.mean(precision)
        recall=np.mean(recall)
        f1_score= 2 * (precision * recall) / (precision + recall)
        print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
        print("F1-Score on test set: %0.3f%%"%(f1_score * 100))
        print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 81.333%
F1-Score on test set: 80.036%
Non Zero weights: 22543
```

In [27]:
```
from sklearn.linear_model import LogisticRegression

        clf = LogisticRegression(C= 1000, penalty= 'l1')
        clf.fit(X_train,Y_train)
        prediction = clf.predict(X_test)
        precision_scorer = make_scorer(precision_score, pos_label='Negative')
        recall_scorer=make_scorer(recall_score, pos_label='Negative')
        precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
        recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
        precision=np.mean(precision)
        recall=np.mean(recall)
        f1_score= 2 * (precision * recall) / (precision + recall)
        print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
        print("F1-Score on test set: %0.3f%%"%(f1_score * 100))
        print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 81.327%
F1-Score on test set: 78.768%
Non Zero weights: 22541
```

In [28]:
```
from sklearn.linear_model import LogisticRegression

        clf = LogisticRegression(C= 100, penalty= 'l1')
        clf.fit(X_train,Y_train)
        prediction = clf.predict(X_test)
        precision_scorer = make_scorer(precision_score, pos_label='Positive')
        recall_scorer=make_scorer(recall_score, pos_label='Positive')
        precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
        recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
        precision=np.mean(precision)
```

```
        recall=np.mean(recall)
        f1_score= 2 * (precision * recall) / (precision + recall)
        print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
        print("F1-Score on test set: %0.3f"%(f1_score * 100))
        print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 84.067%
F1-Score on test set: 83.877
Non Zero weights: 16687
```

```
In [29]: from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression(C= 100, penalty= 'l1')
         clf.fit(X_train,Y_train)
         prediction = clf.predict(X_test)
         precision_scorer = make_scorer(precision_score, pos_label='Negative')
         recall_scorer=make_scorer(recall_score, pos_label='Negative')
         precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
         recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
         precision=np.mean(precision)
         recall=np.mean(recall)
         f1_score= 2 * (precision * recall) / (precision + recall)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
         print("F1-Score on test set: %0.3f"%(f1_score * 100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 84.073%
F1-Score on test set: 82.826
Non Zero weights: 16691
```

```
In [30]: from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression(C= 10, penalty= 'l1')
         clf.fit(X_train,Y_train)
         prediction = clf.predict(X_test)
         precision_scorer = make_scorer(precision_score, pos_label='Positive')
         recall_scorer=make_scorer(recall_score, pos_label='Positive')
         precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
         recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
         precision=np.mean(precision)
         recall=np.mean(recall)
         f1_score= 2 * (precision * recall) / (precision + recall)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
         print("F1-Score on test set: %0.3f%%"%(f1_score * 100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.070%
F1-Score on test set: 87.000%
```

```
Non Zero weights: 7331
```

```
In [31]: from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression(C= 1, penalty= 'l1')
         clf.fit(X_train,Y_train)
         prediction = clf.predict(X_test)
         precision_scorer = make_scorer(precision_score, pos_label='Positive')
         recall_scorer=make_scorer(recall_score, pos_label='Positive')
         precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
         recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
         precision=np.mean(precision)
         recall=np.mean(recall)
         f1_score= 2 * (precision * recall) / (precision + recall)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
         print("F1-Score on test set: %0.3f"%(f1_score * 100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.780%
F1-Score on test set: 87.374
Non Zero weights: 1454
```

```
In [32]: from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression(C= 0.1, penalty= 'l1')
         clf.fit(X_train,Y_train)
         prediction = clf.predict(X_test)
         precision_scorer = make_scorer(precision_score, pos_label='Positive')
         recall_scorer=make_scorer(recall_score, pos_label='Positive')
         precision = cross_val_score(clf, X_train, Y_train, cv=3, scoring=precision_scorer)
         recall=cross_val_score(clf, X_train, Y_train, cv=3, scoring=recall_scorer)
         precision=np.mean(precision)
         recall=np.mean(recall)
         f1_score= 2 * (precision * recall) / (precision + recall)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, prediction)*100))
         print("F1-Score on test set: %0.3f"%(f1_score * 100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 84.700%
F1-Score on test set: 83.391
Non Zero weights: 318
```

Conclusion

From running the above with L1 regularisation and decreasing value of C from 1000 to 0.1 the non zero weights has reduced from 44000 to around 313, this shows that there's an increase in zero weights which means sparsity has increased

4 Perturbation test

In [33]:
```
clf=LogisticRegression(C=5, penalty='l2')
clf.fit(X_train, Y_train)
pred=clf.predict(X_test)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.837%
Non Zero weights: 44575
```

In [34]:
```
#weights before adding noise
from scipy.sparse import find
#Weights before adding random noise
weights1 = find(clf.coef_[0])[2]
print(weights1[:50])
```

```
[-6.45134706e-02  5.41449874e-01  7.92125145e-02 -6.74464807e-03
  2.26538933e-01 -2.87203210e-01  1.30338176e-01  8.33743297e-03
  1.43322083e-02  3.33979744e-01 -1.28928985e-02  6.01199201e-02
  2.09165043e-02  2.00723540e-01  1.39294079e-01 -2.79966942e-01
  1.86290352e-02 -5.90652520e-01 -2.85773858e-01 -2.97632086e-01
  3.74291742e-03 -2.03945244e-03  1.73001721e-01  1.22455967e-01
 -1.22042079e-02 -7.72171333e-02  5.76853300e-03  5.14688348e-02
 -8.39001656e-02 -4.62725193e-01  4.66164023e-01 -9.46611332e-02
 -6.42889196e-01  4.05163037e-01  1.46881796e-01  5.57823369e-04
 -2.67005543e-01  1.55694898e-01 -1.03155438e-02  1.31771031e-01
 -1.48400892e-02  7.82446682e-01 -3.85145201e-01  2.63810996e-02
 -1.07144829e-01  1.21641314e+00 -1.44685637e-01  5.90991235e-02
 -6.51015987e-01  2.96784413e-02]
```

In [35]:
```
#insert random noise
X_train_t = X_train
#Random noise
z = np.random.uniform(low=-0.0001, high=0.0001, size=(find(X_train_t)[0].size,))
#Getting the postions(row and column) and value of non-zero datapoints
r,c,v = find(X_train_t)

#Introducing random noise to non-zero datapoints
X_train_t[r,c] = z + X_train_t[r,c]

print(X_train_t.shape)
```

```
(70000, 44575)
```

In [36]:
```
clf=LogisticRegression(C=5, penalty='l2')
clf.fit(X_train_t, Y_train)
```

```
        pred=clf.predict(X_test)
        print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
        print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.837%
Non Zero weights: 44575
```

```
In [37]: #weight after adding random noise
         from scipy.sparse import find
         #Weights before adding random noise
         weights2 = find(clf.coef_[0])[2]
         print(weights2[:50])
```

```
[-6.45135869e-02  5.41533417e-01  7.91978611e-02 -6.73679994e-03
  2.26489427e-01 -2.87243712e-01  1.30217008e-01  8.34298729e-03
  1.43372995e-02  3.34238789e-01 -1.28726377e-02  6.02034836e-02
  2.09045258e-02  2.00679004e-01  1.39548079e-01 -2.79572079e-01
  1.86314924e-02 -5.90440933e-01 -2.85789881e-01 -2.98027709e-01
  3.73849136e-03 -2.03668014e-03  1.72889422e-01  1.22465876e-01
 -1.22187053e-02 -7.70944987e-02  5.76291595e-03  5.14344490e-02
 -8.41266117e-02 -4.63111234e-01  4.66194547e-01 -9.48871992e-02
 -6.43517889e-01  4.05417256e-01  1.46793884e-01  5.50855639e-04
 -2.66850778e-01  1.55800648e-01 -1.03093333e-02  1.31840151e-01
 -1.48147619e-02  7.82278457e-01 -3.85190629e-01  2.63933841e-02
 -1.07234933e-01  1.21662519e+00 -1.44625595e-01  5.91943213e-02
 -6.51039594e-01  2.96462795e-02]
```

```
In [38]: print(weights2.size)
```

```
44575
```

```
In [39]: w_diff=(abs(weights1-weights2) / weights1) * 100
```

```
In [40]: print(w_diff[np.where(w_diff > 30)].size)
```

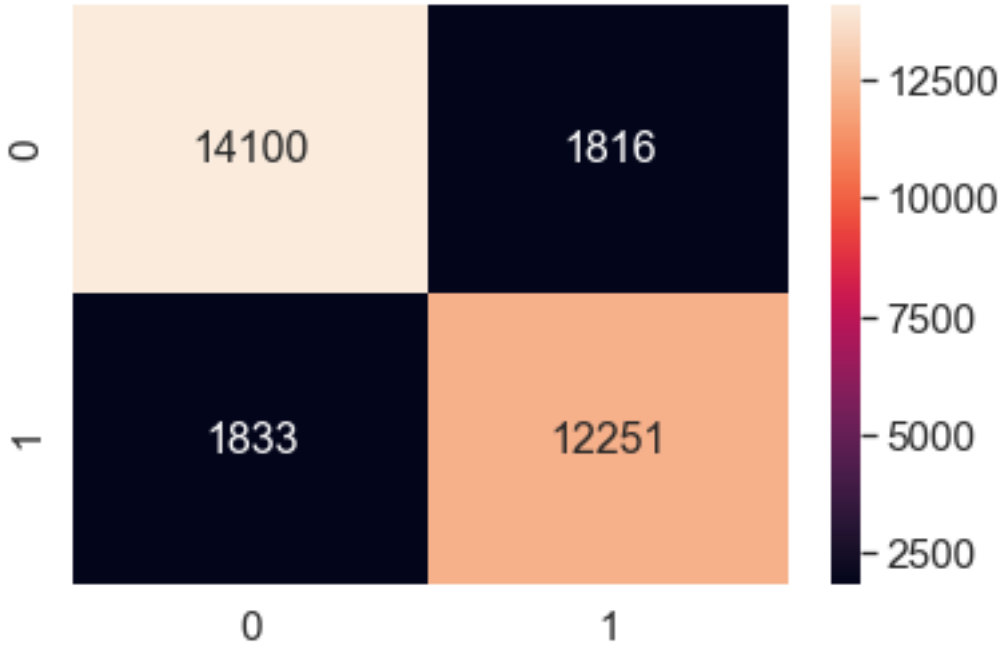
```
24
```

Conclusion
19 features have their weight changes greater than 30, Hence these features are multicollinear

5 Confusion matrix

```
In [41]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, pred), range(2),range(2))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[41]: <matplotlib.axes._subplots.AxesSubplot at 0x24a88a58>



In [42]:
```
from sklearn.metrics import classification_report,precision_score,recall_score

        print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   Negative       0.88      0.89      0.89     15916
   Positive       0.87      0.87      0.87     14084

avg / total       0.88      0.88      0.88     30000
```

6 Feature importance for BoW

In [43]:
```
def show_most_informative_features(vectorizer, clf, n=25):
    feature_names = vectorizer.get_feature_names()
    coefs_with_fns = sorted(zip(clf.coef_[0], feature_names))
    top = zip(coefs_with_fns[:n], coefs_with_fns[:-(n + 1):-1])
    print("\t\t\tPositive\t\t\t\t\t\tNegative")
    print("_____________________________________________________________________________
    for (coef_1, fn_1), (coef_2, fn_2) in top:
        print("\t%.4f\t%-15s\t\t\t\t%.4f\t%-15s" % (coef_1, fn_1, coef_2, fn_2))
```

In [44]: show_most_informative_features(BoW, clf)

Positive		Negative	
-13.1158	worst	9.3084	perfect
-10.7616	aw	9.1442	delici
-10.2469	horribl	8.8488	hook
-9.6490	terribl	8.4955	excel
-9.3599	unfortun	8.4485	amaz
-9.2762	tasteless	8.3076	skeptic
-8.4395	sad	7.7945	addict
-8.3974	disappoint	7.4624	beat
-8.3745	cancel	7.3647	best
-8.3489	return	7.2386	awesom
-8.3343	wors	7.0659	great
-8.2261	yuck	7.0623	fantast
-8.0214	threw	6.8488	satisfi
-7.9818	stale	6.8295	yum
-7.9153	gross	6.6189	worri
-7.6038	unpleas	6.5349	yummi
-7.5881	ruin	6.5163	smooth
-7.5422	disgust	6.3118	heaven
-7.3679	bland	6.2346	refresh
-7.1857	refund	6.1038	uniqu
-7.0302	weak	6.0718	glad
-7.0301	shame	5.8604	favorit
-6.9840	rip	5.8501	complaint
-6.8226	poor	5.8255	nice
-6.7697	mediocr	5.7704	hesit

7 RandomizedCVto find best C

```
In [45]: cls=LogisticRegression()
         param_grid={'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.00001]
                     'penalty':['l1','l2']}
         tcv=TimeSeriesSplit(n_splits=10)
         rcv=RandomizedSearchCV(cls,param_grid,cv=tcv,verbose=1,n_jobs=4)
         rcv.fit(X_train,Y_train)
         savetofile(rcv,"D:/Applied AI Course/rcv_r")
         print("Best HyperParameter: ",rcv.best_params_)
         print("Best Accuracy: %.2f%%"%(rcv.best_score_*100))
```

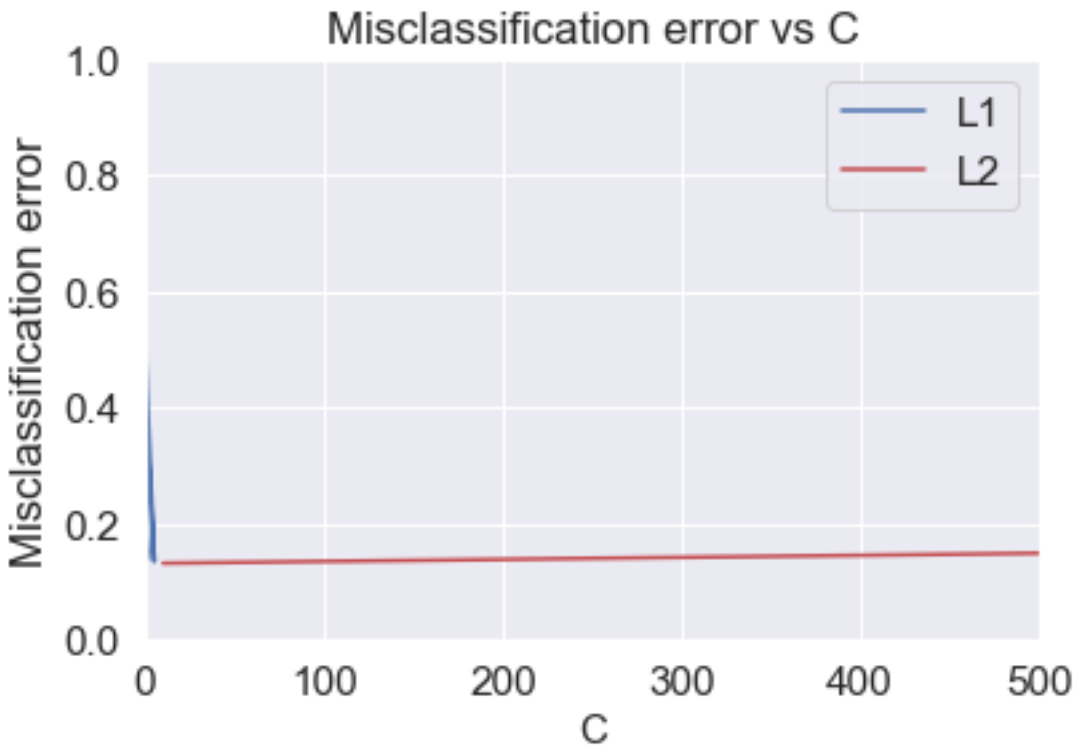
```
Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:   14.8s
[Parallel(n_jobs=4)]: Done 100 out of 100 | elapsed:  1.9min finished
```

```
Best HyperParameter:  {'penalty': 'l2', 'C': 10}
Best Accuracy: 86.79%
```

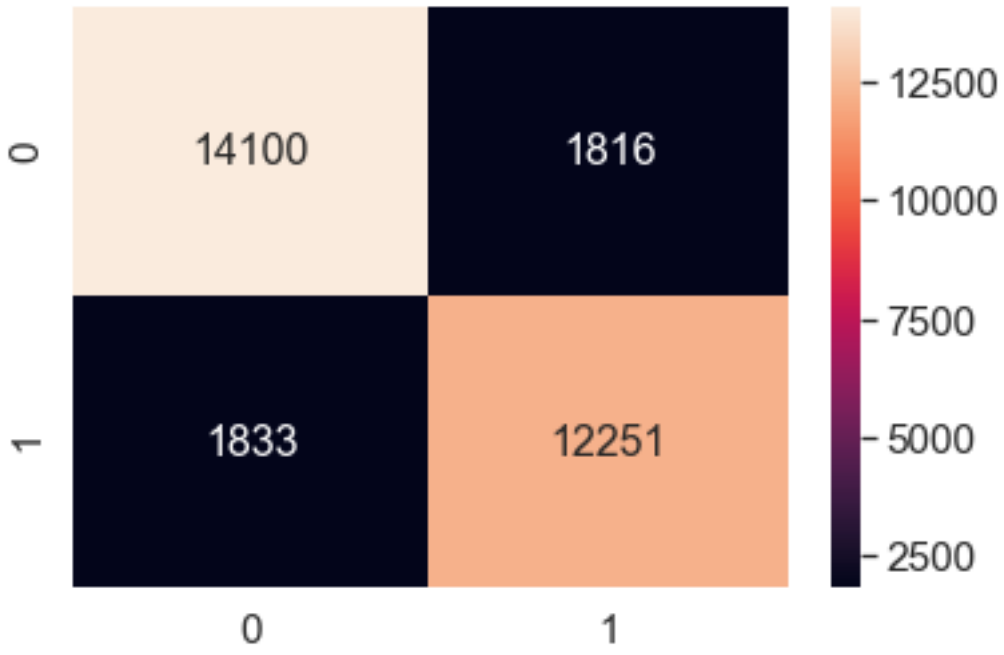
```
In [46]: def plot_error(rcv):
             x1=[]
             y1=[]
             x2=[]
             y2=[]

             for x in rcv.grid_scores_:
                 if (x[0]['penalty'])=='l1':
                     y1.append(1-x[1])
                     x1.append(x[0]['C'])
                 else:
                     y2.append(1-x[1])
                     x2.append(x[0]['C'])

             plt.xlim(1e-4,500)
             plt.ylim(0,1.0)
             plt.xlabel("C",fontsize=15)
             plt.ylabel("Misclassification error")
             plt.title("Misclassification error vs C")
             plt.plot(x1,y1,'b',label="L1")
             plt.plot(x2,y2,'r',label="L2")
             plt.legend()
             plt.show()
```

```
In [47]: plot_error(rcv)
```

```
D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```




```
In [48]: clf=LogisticRegression(C=5, penalty='l2')
         clf.fit(X_train,Y_train)
         y_pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, y_pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error_rcv = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, y_pred)
         test_error_rcv = 1 - test_accuracy

Accuracy on test set: 87.837%
Non Zero weights: 44575


In [49]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, y_pred), range(2),range(2))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')

Out[49]: <matplotlib.axes._subplots.AxesSubplot at 0x20355c88>
```




```
In [50]: from sklearn.metrics import classification_report,precision_score,recall_score

         print(classification_report(Y_test,y_pred))
```

```
             precision    recall  f1-score   support

   Negative       0.88      0.89      0.89     15916
   Positive       0.87      0.87      0.87     14084

avg / total       0.88      0.88      0.88     30000
```

8 Tf-Idf

```
In [51]: X=final_d["CleanedText"]
         X.shape
```

```
Out[51]: (100000,)
```

```
In [52]: y=final_d["Score"]
         y.shape
```

```
Out[52]: (100000,)
```

```
In [53]: #split the data into train and test fo bag of words

         X_train,X_test,Y_train,Y_test=train_test_split(X,y,test_size=0.3,random_state=None,shu
         #split train into cross val train and cross val test
         X_t,X_cv,Y_t,Y_cv=train_test_split(X_train,Y_train,test_size=0.3,shuffle=False)

In [54]: tfidf=TfidfVectorizer()
         X_train=tfidf.fit_transform(X_train)
         #X_train=StandardScaler(with_mean=False).fit_transform(X_train)
         x_test=tfidf.transform(X_test)

In [55]: from sklearn import preprocessing
         X_train=preprocessing.normalize(X_train)
         X_test=preprocessing.normalize(x_test)

         print(X_train.shape, X_test.shape)

(70000, 44575) (30000, 44575)


In [56]: from sklearn.model_selection import TimeSeriesSplit

         tcv=TimeSeriesSplit(n_splits=10)
         for train,cv in tcv.split(X_train):
             print(X_train[train].shape,X_train[cv].shape)

(6370, 44575) (6363, 44575)
(12733, 44575) (6363, 44575)
(19096, 44575) (6363, 44575)
(25459, 44575) (6363, 44575)
(31822, 44575) (6363, 44575)
(38185, 44575) (6363, 44575)
(44548, 44575) (6363, 44575)
(50911, 44575) (6363, 44575)
(57274, 44575) (6363, 44575)
(63637, 44575) (6363, 44575)
```

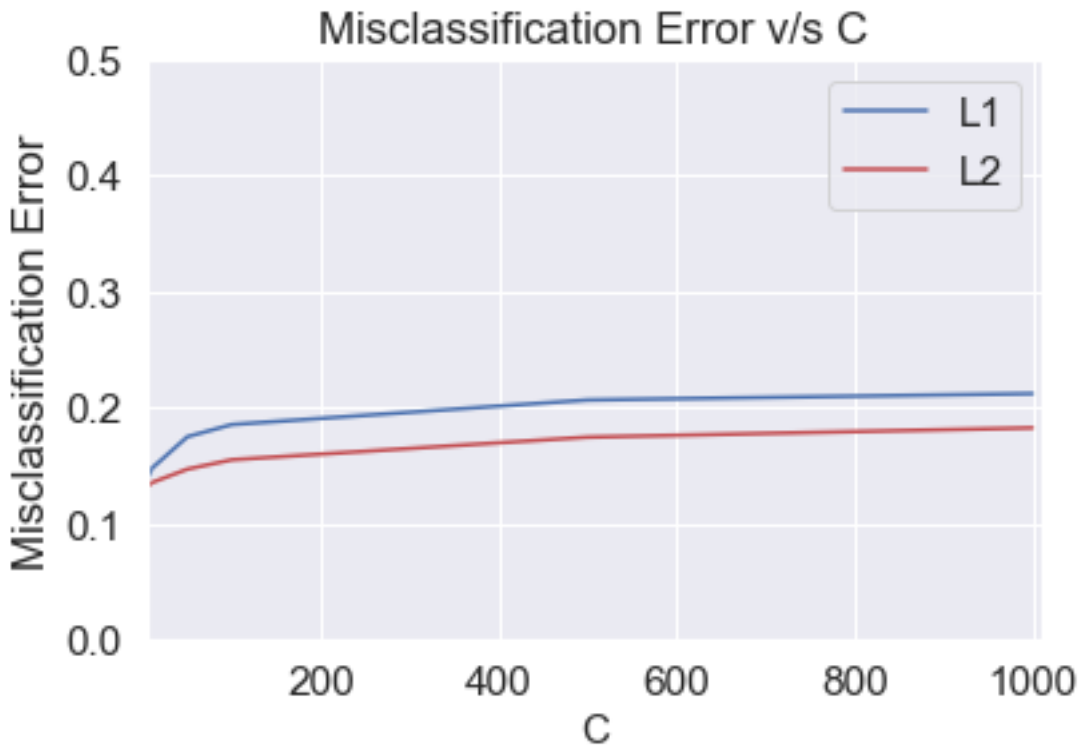
9 Choose best hyperparameter using GridSearchCV

```
In [57]: %time
         from sklearn.model_selection import GridSearchCV
         from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression()

         #params we need to try on classifier
         param_grid = {'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.0001
```

```
                    'penalty':['l1','l2']}
        tscv = TimeSeriesSplit(n_splits=10) #For time based splitting
        gsv_tfidf = GridSearchCV(clf,param_grid,cv=tscv,verbose=1)
        gsv_tfidf.fit(X_train,Y_train)
        savetofile(gsv_tfidf,"D:/Applied AI Course/gsv_tfidf")
        print("Best HyperParameter: ",gsv_tfidf.best_params_)
        print("Best Accuracy: %.2f%%"%(gsv_tfidf.best_score_*100))
```

```
Wall time: 0 ns
Fitting 10 folds for each of 30 candidates, totalling 300 fits


[Parallel(n_jobs=1)]: Done 300 out of 300 | elapsed:  8.6min finished


Best HyperParameter:  {'C': 5, 'penalty': 'l2'}
Best Accuracy: 86.83%
```

```
In [58]: def plot_error_vs_c(gsv):
             x1=[]
             y1=[]
             x2=[]
             y2=[]
             for a in gsv.grid_scores_:
                 if (a[0]['penalty']) =='l1':
                     y1.append(1-a[1])
                     x1.append(a[0]['C'])
                 else:
                     y2.append(1-a[1])
                     x2.append(a[0]['C'])
             plt.xlim(5,1010)
             plt.ylim(0,0.5)
             plt.xlabel("C",fontsize=15)
             plt.ylabel("Misclassification Error")
             plt.title('Misclassification Error v/s C')
             plt.plot(x1,y1,'b',label="L1")
             plt.plot(x2,y2,'r',label="L2")
             plt.legend()
             plt.show()

In [59]: plot_error_vs_c(gsv_tfidf)

D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```



10 Perturbation Test

```
In [60]: clf=LogisticRegression(C=1, penalty='l2')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.820%
Non Zero weights: 44575
```

```
In [61]: #weight before adding random noise
         from scipy.sparse import find
         #Weights before adding random noise
         weights1 = find(clf.coef_[0])[2]
         print(weights1[:50])
```

```
[-0.04053489  0.2185708   0.08413608 -0.00737421  0.11936881 -0.16148735
  0.05783046  0.009498    0.02452192  0.15993298 -0.01273076  0.05084801
  0.03859645  0.11856259  0.07135083 -0.11376825  0.02614606 -0.22853564
 -0.16347983 -0.27108698  0.00448616 -0.002792    0.08604424  0.13908059
```

```
 -0.01683189 -0.0409205   0.00366113  0.00597774 -0.03524158 -0.26363743
  0.21006693 -0.07940451 -0.34030893  0.13208726  0.07137482  0.00188177
 -0.12317676  0.07579839 -0.01335047  0.07735175 -0.01547063  0.41274839
 -0.13207432  0.03724167 -0.06100474  1.18437589 -0.06346688  0.03658489
 -0.29789426  0.03045555]
```

In [62]:
```
#insert random noise
X_train_t = X_train
#Random noise
z = np.random.uniform(low=-0.0001, high=0.0001, size=(find(X_train_t)[0].size,))
#Getting the postions(row and column) and value of non-zero datapoints
r,c,v = find(X_train_t)

#Introducing random noise to non-zero datapoints
X_train_t[r,c] = z + X_train_t[r,c]

print(X_train_t.shape)
```

```
(70000, 44575)
```

In [63]:
```
clf=LogisticRegression(C=1, penalty='l2')
clf.fit(X_train_t, Y_train)
pred=clf.predict(X_test)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 87.820%
Non Zero weights: 44575
```

In [64]:
```
#weight after adding random noise
from scipy.sparse import find
#Weights before adding random noise
weights2 = find(clf.coef_[0])[2]
print(weights2[:50])
```

```
[-0.04054298  0.2184667   0.08406127 -0.00736103  0.11933605 -0.16151016
  0.05780618  0.00947112  0.02449069  0.15992433 -0.01270971  0.05085112
  0.0386192   0.11862801  0.07135979 -0.11380638  0.02610672 -0.22840384
 -0.16346064 -0.27122137  0.00447613 -0.00278868  0.08608755  0.1390681
 -0.01684412 -0.04075514  0.00366312  0.00594582 -0.03520337 -0.26350191
  0.2100048  -0.07931782 -0.34035664  0.13207126  0.07142421  0.00188123
 -0.12322678  0.07583229 -0.01336515  0.07740348 -0.01544947  0.4128175
 -0.13206487  0.0372324  -0.06094933  1.18423037 -0.06344667  0.03656178
 -0.297914    0.03046092]
```

In [65]:
```
print(weights2.size)
```

```
44575
```

```
In [66]: w_diff=(abs(weights1-weights2) / weights1) * 100
```

```
In [67]: print(w_diff[np.where(w_diff > 30)].size)
```

```
8
```

Conclusion: 6 features have their weights greater than 30

```
In [68]: clf=LogisticRegression(C=1, penalty='l2')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error_tfidf = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, pred)
         test_error_tfidf = 1 - test_accuracy
```

```
Accuracy on test set: 87.820%
Non Zero weights: 44575
```

11 Hyperparameter using randomised CV

```
In [69]: cls=LogisticRegression()
         param_grid={'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.00001]
                     'penalty':['l1','l2']}
         tcv=TimeSeriesSplit(n_splits=10)
         rcv_tfidf=RandomizedSearchCV(cls,param_grid,cv=tcv,verbose=1,n_jobs=4)
         rcv_tfidf.fit(X_train,Y_train)
         savetofile(rcv_tfidf,"D:/Applied AI Course/rcv_r")
         print("Best HyperParameter: ",rcv_tfidf.best_params_)
         print("Best Accuracy: %.2f%%"%(rcv_tfidf.best_score_*100))
```

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

```
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:   19.2s
[Parallel(n_jobs=4)]: Done 100 out of 100 | elapsed:   46.6s finished
```

```
Best HyperParameter:  {'penalty': 'l2', 'C': 5}
Best Accuracy: 86.84%
```

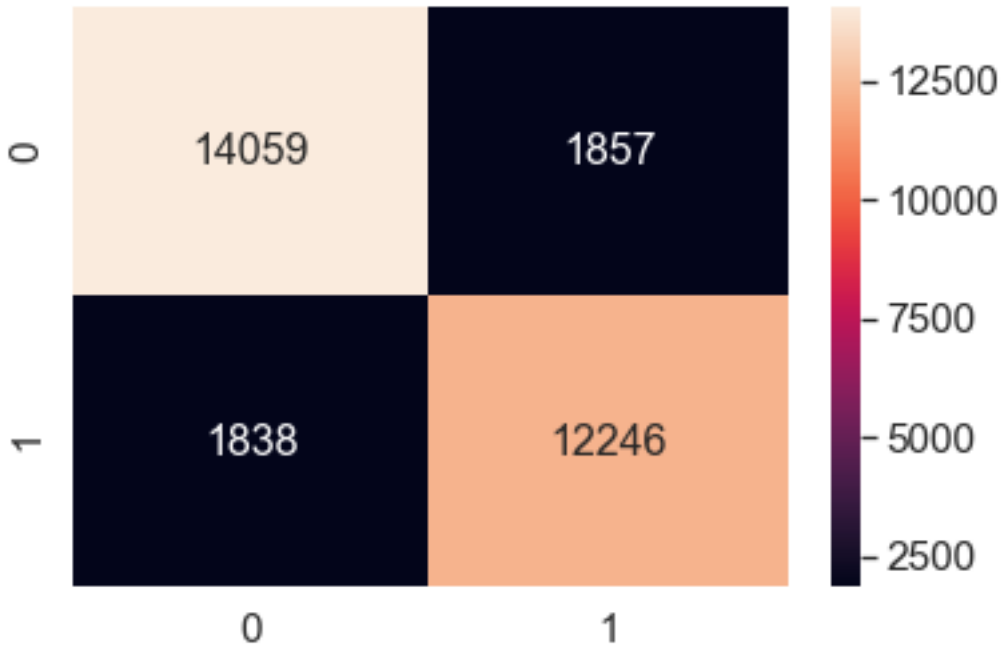
```
In [70]: clf=LogisticRegression(C=5, penalty='l2')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error_tfidf_rcv = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, pred)
         test_error_tfidf_rcv = 1 - test_accuracy
```

```
Accuracy on test set: 87.683%
Non Zero weights: 44575
```

12 Confusion matrix

```
In [71]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, pred), range(2),range(2))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[71]: <matplotlib.axes._subplots.AxesSubplot at 0x1958d828>
```




```
In [72]: from sklearn.metrics import classification_report,precision_score,recall_score

         print(classification_report(Y_test,pred))
```

```
              precision    recall  f1-score   support

   Negative       0.88      0.88      0.88     15916
   Positive       0.87      0.87      0.87     14084

avg / total       0.88      0.88      0.88     30000
```

13 Top important features

```
In [73]: def show_most_informative_features(vectorizer, clf, n=25):
             feature_names = vectorizer.get_feature_names()
             coefs_with_fns = sorted(zip(clf.coef_[0], feature_names))
             top = zip(coefs_with_fns[:n], coefs_with_fns[:-(n + 1):-1])
             print("\t\t\tPositive\t\t\t\t\t\tNegative")
             print("_____________________________________________________________________________
             for (coef_1, fn_1), (coef_2, fn_2) in top:
                 print("\t%.4f\t%-15s\t\t\t\t%.4f\t%-15s" % (coef_1, fn_1, coef_2, fn_2))

In [74]: show_most_informative_features(tfidf, clf)
```

Positive		Negative	
-12.9842	worst	12.4592	great
-11.0487	disappoint	11.2878	delici
-10.4858	aw	11.2324	perfect
-10.0916	horribl	10.6257	best
-9.7820	unfortun	9.4445	love
-9.6655	terribl	9.4390	excel
-9.1788	return	8.3835	amaz
-8.3176	tasteless	8.2369	hook
-7.7926	sad	7.7550	skeptic
-7.7521	stale	7.4376	addict
-7.7138	wors	7.3323	favorit
-7.6806	threw	7.3092	nice
-7.5973	yuck	6.9073	good
-7.4674	cancel	6.8757	awesom
-7.1924	gross	6.8705	beat
-6.9582	bland	6.7612	satisfi
-6.8500	ruin	6.6060	fantast
-6.7225	weak	6.3806	yum
-6.6254	refund	6.3703	smooth
-6.5854	unpleas	6.3186	yummi
-6.5209	disgust	6.2045	tasti
-6.5082	mediocr	6.0654	glad
-6.4332	poor	6.0511	happi
-6.2296	wast	5.9793	wonder

```
        -6.1536        rip                                          5.9426        worri
```

14 Word2Vec

```
In [75]: import gensim
         from gensim.models import word2vec,KeyedVectors
```

```
D:\Anaconda\lib\site-packages\gensim\utils.py:1209: UserWarning: detected Windows; aliasing chu
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

```
In [76]: X=final_d["Text"]
         X.shape
```

```
Out[76]: (100000,)
```

```
In [77]: y=final_d["Score"]
         y.shape
```

```
Out[77]: (100000,)
```

```
In [78]: X_train,X_test,Y_train,Y_test=train_test_split(X,y,test_size=0.30,random_state=None, s
         #split train into cross val train and cross val test
         X_t,X_cv,Y_t,Y_cv=train_test_split(X_train,Y_train,test_size=0.3, shuffle=False)
```

```
In [79]: print(X_train.shape,X_test.shape,Y_train.shape,Y_test.shape)
```

```
(70000,) (30000,) (70000,) (30000,)
```

```
In [80]: W2V_Tr=openfromfile("D:/Applied AI Course/W2V_Tr")
         words=list(W2V_Tr.wv.vocab)
         print(len(words))
```

```
35046
```

```
In [81]: i=0
         list_of_sentence=[]
         for sent in X_train.values:
             filtered_sentence=[]
             list_of_sentence.append(sent.split())
             #sent=cleanhtml(sent)
             #for w in sent.split():
               #   for cleaned in cleanpunc(w).split():
               #       if(cleaned.isalpha()):
                #          filtered_sentence.append(cleaned.lower())
                 #     else:
```

```
                #       continue
        #list_of_sentence.append(filtered_sentence)
        #print(X["CleanedText"].values[0])
        #print('############')
        #print(list_of_sentence[0])
        W2V_Tr=gensim.models.Word2Vec(list_of_sentence,min_count=5,size=50,workers=4)
        savetofile(W2V_Tr,"D:/Applied AI Course/W2V_Tr")
        words=list(W2V_Tr.wv.vocab)
        print(len(words))
```

```
35096
```

```
In [82]: W2V_Tr.wv.most_similar('like')
```

```
D:\Anaconda\lib\site-packages\gensim\matutils.py:737: FutureWarning: Conversion of the second a
  if np.issubdtype(vec.dtype, np.int):
```

```
Out[82]: [('like,', 0.6809192895889282),
          ('like.', 0.6442536115646362),
          ('resemble', 0.5514405369758606),
          ('prefer', 0.5499492883682251),
          ('enjoy', 0.5351779460906982),
          ('okay', 0.5345637798309326),
          ('dislike', 0.5334469079971313),
          ('know,', 0.5277306437492371),
          ('want', 0.526965856552124),
          ('liked', 0.5147050619125366)]
```

```
In [83]: #word2vec for test
        i=0
        list_of_sentences=[]
        for sent in X_test.values:
            filtered_sentences=[]
            list_of_sentences.append(sent.split())
            #sent=cleanhtml(sent)
            #for w in sent.split():
             #   for cleaned in cleanpunc(w).split():
              #      if(cleaned.isalpha()):
               #         filtered_sentence.append(cleaned.lower())
                #    else:
                 #       continue
        #list_of_sentences.append(filtered_sentence)
        #print(X_train.values[0])
        #print('############')
        print(list_of_sentences[0])
        W2V_test=gensim.models.Word2Vec(list_of_sentences,min_count=5,size=50,workers=4)
        savetofile(W2V_test,"D:/Applied AI Course/W2V_test")
```

```
words_test=list(W2V_test.wv.vocab)
print(len(words_test))
```

```
['Starbucks', 'Caffe', 'Verona', 'is', 'one', 'of', 'the', 'most', 'full-bodied,', 'aromatic',
20734
```

15 Avg W2Vec

```
In [84]: from tqdm import tqdm

sent_vectors = []
for sent in tqdm(list_of_sentence): # 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
        try:
            vec = W2V_Tr.wv[word]
            sent_vec += vec
            cnt_words += 1
        except:
            pass

    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors.append(sent_vec)
print(len(sent_vectors))
print(len(sent_vectors[0]))


train_vectors=np.nan_to_num(sent_vectors)

test_vectors = []
for sent in tqdm(list_of_sentences):
    sent_vec = np.zeros(50)
    cnt_words = 0
    for word in sent:
        try:
            vec = W2V_Tr.wv[word]
            sent_vec += vec
            cnt_words += 1
        except:
            pass
    sent_vec /= cnt_words
    test_vectors.append(sent_vec)
test_vectors = np.nan_to_num(test_vectors)
```

```
100%|| 70000/70000 [00:21<00:00, 3276.62it/s]
```

```
70000
50


 92%|  | 27731/30000 [00:08<00:00, 3345.24it/s]D:\Anaconda\lib\site-packages\ipykernel_launcher
100%|| 30000/30000 [00:09<00:00, 3192.49it/s]
```

```
In [85]: X_train=np.array(train_vectors)
         X_test=np.array(test_vectors)

In [86]: X_train.shape

Out[86]: (70000, 50)

In [87]: Y_train.shape

Out[87]: (70000,)

In [88]: tcv=TimeSeriesSplit(n_splits=10)
         for train,cv in tcv.split(X_train):
             print(X_train[train].shape,X_train[cv].shape)
```

```
(6370, 50) (6363, 50)
(12733, 50) (6363, 50)
(19096, 50) (6363, 50)
(25459, 50) (6363, 50)
(31822, 50) (6363, 50)
(38185, 50) (6363, 50)
(44548, 50) (6363, 50)
(50911, 50) (6363, 50)
(57274, 50) (6363, 50)
(63637, 50) (6363, 50)
```

16 Best hyperparameter using GridSearchCV

```
In [89]: %time
         from sklearn.model_selection import GridSearchCV
         from sklearn.linear_model import LogisticRegression

         clf = LogisticRegression()

         #params we need to try on classifier
         param_grid = {'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.0001
                       'penalty':['l1','l2']}
         tscv = TimeSeriesSplit(n_splits=10) #For time based splitting
```

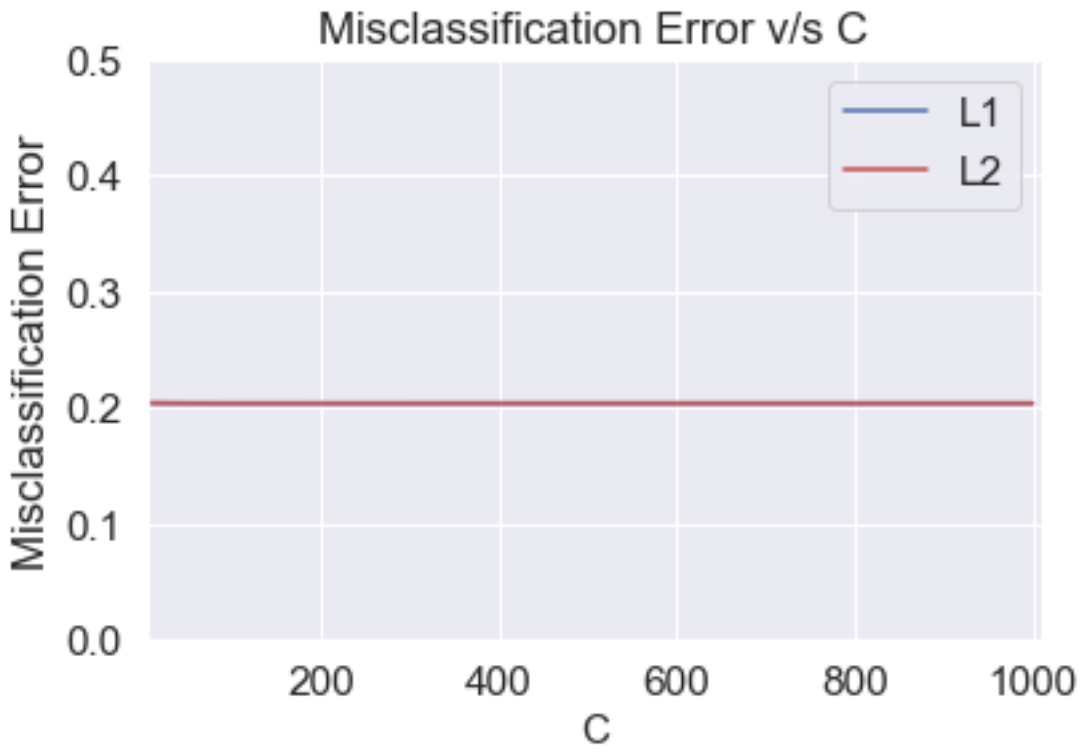
```
        gsv_avgw2v = GridSearchCV(clf,param_grid,cv=tscv,verbose=1)
        gsv_avgw2v.fit(X_train,Y_train)
        savetofile(gsv_avgw2v,"D:/Applied AI Course/gsv_avgw2v")
        print("Best HyperParameter: ",gsv_avgw2v.best_params_)
        print("Best Accuracy: %.2f%%"%(gsv_avgw2v.best_score_*100))
```

```
Wall time: 0 ns
Fitting 10 folds for each of 30 candidates, totalling 300 fits


[Parallel(n_jobs=1)]: Done 300 out of 300 | elapsed: 32.4min finished


Best HyperParameter:  {'C': 100, 'penalty': 'l2'}
Best Accuracy: 79.62%
```

```
In [90]: def plot_error_vs_c(gsv):
             x1=[]
             y1=[]
             x2=[]
             y2=[]
             for a in gsv.grid_scores_:
                 if (a[0]['penalty']) =='l1':
                     y1.append(1-a[1])
                     x1.append(a[0]['C'])
                 else:
                     y2.append(1-a[1])
                     x2.append(a[0]['C'])
             plt.xlim(5,1010)
             plt.ylim(0,0.5)
             plt.xlabel("C",fontsize=15)
             plt.ylabel("Misclassification Error")
             plt.title('Misclassification Error v/s C')
             plt.plot(x1,y1,'b',label="L1")
             plt.plot(x2,y2,'r',label="L2")
             plt.legend()
             plt.show()
```

```
In [91]: plot_error_vs_c(gsv_avgw2v)
```

```
D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```




```
In [92]: clf=LogisticRegression(C=50, penalty='l1')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error_avgw2v_gcv = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, prediction)
         test_error_avgw2v_gcv = 1 - test_accuracy

Accuracy on test set: 80.123%
Non Zero weights: 50
```

17 Hyperparameter using RandomizedCV

```
In [93]: cls=LogisticRegression()
         param_grid={'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.00001]
                     'penalty':['l1','l2']}
         tcv=TimeSeriesSplit(n_splits=10)
         rcv_avgw2v=RandomizedSearchCV(cls,param_grid,cv=tcv,verbose=1,n_jobs=4)
         rcv_avgw2v.fit(X_train,Y_train)
```

```
        savetofile(rcv_avgw2v,"D:/Applied AI Course/rcv_r")
        print("Best HyperParameter: ",rcv_avgw2v.best_params_)
        print("Best Accuracy: %.2f%%"%(rcv_avgw2v.best_score_*100))
```

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


[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  3.1min
[Parallel(n_jobs=4)]: Done 100 out of 100 | elapsed: 11.6min finished


Best HyperParameter:  {'penalty': 'l2', 'C': 500}
Best Accuracy: 79.62%
```

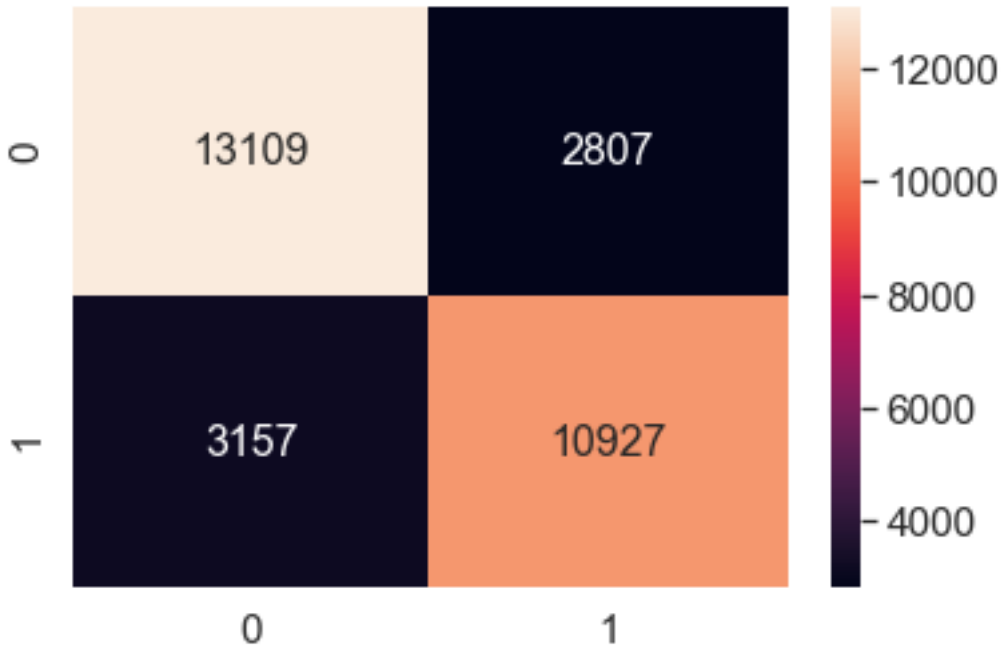
```
In [94]: clf=LogisticRegression(C=50, penalty='l1')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
         training_accuracy = clf.score(X_train, Y_train)
         training_error_avgw2v_rcv = 1 - training_accuracy
         test_accuracy = accuracy_score(Y_test, pred)
         test_error_avgw2v_rcv = 1 - test_accuracy
```

```
Accuracy on test set: 80.120%
Non Zero weights: 50
```

18 Confusion matrix

```
In [95]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, pred), range(2),range(2))
         sns.set(font_scale=1.4)#for label size
         sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[95]: <matplotlib.axes._subplots.AxesSubplot at 0x62d86208>
```




```
In [96]: from sklearn.metrics import classification_report,precision_score,recall_score

         print(classification_report(Y_test,y_pred))
```

```
             precision    recall  f1-score   support

   Negative       0.88      0.89      0.89     15916
   Positive       0.87      0.87      0.87     14084

avg / total       0.88      0.88      0.88     30000
```

19 Perturbation test

```
In [97]: clf=LogisticRegression(C=1, penalty='l1')
         clf.fit(X_train, Y_train)
         pred=clf.predict(X_test)
         print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
         print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 80.093%
Non Zero weights: 50
```

```
In [98]: #weight before adding random noise
         from scipy.sparse import find
         #Weights before adding random noise
         weights1 = find(clf.coef_[0])[2]
         print(weights1[:50])
```

```
[ 9.82373167e-01  6.43962983e-01 -1.26942449e-01 -9.21938453e-01
 -2.26221577e+00 -1.32507173e+00  6.76852950e-01 -7.48149239e-01
  7.81987045e-02 -9.06542083e-01 -1.75450614e+00  8.75719895e-02
  1.39020583e-01  4.00644046e-01  2.21260375e+00  1.59206568e+00
  2.31603299e-01 -4.60930123e-01 -1.26046266e+00 -7.81269835e-01
 -4.56897484e-01 -1.15332885e+00  6.84127019e-01 -1.19756987e-01
  7.08440722e-01  3.24579814e+00 -1.71425935e-03 -2.24966718e-01
  9.88270214e-01 -7.37326447e-01 -3.44741991e-01 -1.16730813e+00
  2.70815076e-01  1.27817198e+00 -9.97468943e-01  4.77464681e-01
  8.30178635e-01  8.80155629e-02 -8.77464769e-01 -1.03799156e+00
  1.10995641e+00  9.67191431e-01 -7.60279505e-01 -8.70654208e-01
 -8.96236943e-01  1.60561948e-01  5.98219914e-01 -1.94074678e+00
 -8.26192570e-01 -3.35685280e+00]
```

```
In [99]: #insert random noise
         X_train_t = X_train
         #Random noise
         z = np.random.uniform(low=-0.0001, high=0.0001, size=(find(X_train_t)[0].size,))
         #Getting the postions(row and column) and value of non-zero datapoints
         r,c,v = find(X_train_t)

         #Introducing random noise to non-zero datapoints
         X_train_t[r,c] = z + X_train_t[r,c]

         print(X_train_t.shape)
```

```
(70000, 50)
```

```
In [100]: clf=LogisticRegression(C=1, penalty='l1')
          clf.fit(X_train_t, Y_train)
          pred=clf.predict(X_test)
          print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
          print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 80.090%
Non Zero weights: 50
```

```
In [101]: #weight after adding random noise
          from scipy.sparse import find
          #Weights before adding random noise
```

```
        weights2 = find(clf.coef_[0])[2]
        print(weights2[:50])
```

```
[ 9.81623273e-01  6.43842492e-01 -1.27104135e-01 -9.21182547e-01
 -2.26111782e+00 -1.32487356e+00  6.76752464e-01 -7.47723822e-01
  7.80887342e-02 -9.05746596e-01 -1.75431608e+00  8.74792689e-02
  1.38916536e-01  4.00300118e-01  2.21148655e+00  1.59191481e+00
  2.31061453e-01 -4.60862630e-01 -1.25932429e+00 -7.80854180e-01
 -4.57642131e-01 -1.15277060e+00  6.84037856e-01 -1.19906802e-01
  7.08747755e-01  3.24392174e+00 -1.78637896e-03 -2.25066153e-01
  9.88184847e-01 -7.36971882e-01 -3.44169328e-01 -1.16723087e+00
  2.71264586e-01  1.27827923e+00 -9.97012534e-01  4.77803351e-01
  8.30443335e-01  8.80926059e-02 -8.76747351e-01 -1.03832525e+00
  1.10979316e+00  9.67084711e-01 -7.60567509e-01 -8.70574083e-01
 -8.95985285e-01  1.60280261e-01  5.98190856e-01 -1.93946364e+00
 -8.26070114e-01 -3.35600493e+00]
```

```
In [102]: print(weights2.size)

          w_diff=(abs(weights1-weights2) / weights1) * 100

          print(w_diff[np.where(w_diff > 30)].size)
```

```
50
0
```

Observations: For AvgW2V there are 0 features whose weight is greater than 30 hence there is no multicollinearity

20 Weighted TfIdf W2Vec

```
In [103]: model = TfidfVectorizer()
          tf_idf_matrix = model.fit_transform(final_d['CleanedText'].values)
          # we are converting a dictionary with word as a key, and the idf as a value
          dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))

In [104]: X=final_d["CleanedText"]
          X.shape

Out[104]: (100000,)

In [105]: y=final_d["Score"]
          y.shape

Out[105]: (100000,)
```

```
In [106]: X_train,X_test,Y_train,Y_test=train_test_split(X,y,test_size=0.30,random_state=None,
          #split train into cross val train and cross val test
          X_t,X_cv,Y_t,Y_cv=train_test_split(X_train,Y_train,test_size=0.3,random_state=None, s

In [107]: X_train = model.fit_transform(X_train)
          X_test = model.transform(X_test)

In [108]: X_train=preprocessing.normalize(X_train)
          X_test=preprocessing.normalize(X_test)

In [109]: savetofile(model,"D:/Applied AI Course/model")

In [110]: tfidf_feat = model.get_feature_names() # tfidf words/col-names
          # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfid

          tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this
          row=0;
          for sent in tqdm(list_of_sentence): # 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_Tr.wv[word]
          #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                      # to reduce the computation we are
                      # dictionary[word] = idf value of word in whole courpus
                      # sent.count(word) = tf valeus of word in this review
                      tf_idf = dictionary[word]*sent.count(word)
                      sent_vec += (vec * tf_idf)
                      weight_sum += tf_idf
                  except:
                      pass

              if weight_sum != 0:
                  sent_vec /= weight_sum
              tfidf_sent_vectors.append(sent_vec)
              row += 1
```

```
100%|| 70000/70000 [00:28<00:00, 2469.24it/s]
```

```
In [111]: tfidf_feat = model.get_feature_names() # tfidf words/col-names
          # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfid

          tfidf_sent_vectors_test = []; # the tfidf-w2v for each sentence/review is stored in
          row=0;
          for sent in tqdm(list_of_sentences): # 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_Tr.wv[word]
                    tf_idf = dictionary[word]*sent.count(word)
                    sent_vec += (vec * tf_idf)
                    weight_sum += tf_idf
                except:
                    pass

        #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                    # to reduce the computation we are
                    # dictionary[word] = idf value of word in whole courpus
                    # sent.count(word) = tf valeus of word in this review

            if weight_sum != 0:
                sent_vec /= weight_sum
            tfidf_sent_vectors_test.append(sent_vec)
            row += 1
```

```
100%|| 30000/30000 [00:12<00:00, 2408.51it/s]
```

```
In [112]: X_train=np.array(tfidf_sent_vectors)
          X_test=np.array(tfidf_sent_vectors_test)
```

```
In [113]: tcv=TimeSeriesSplit(n_splits=10)
          for train,cv in tcv.split(X_train):
              print(X_train[train].shape,X_train[cv].shape)
```

```
(6370, 50) (6363, 50)
(12733, 50) (6363, 50)
(19096, 50) (6363, 50)
(25459, 50) (6363, 50)
(31822, 50) (6363, 50)
(38185, 50) (6363, 50)
(44548, 50) (6363, 50)
(50911, 50) (6363, 50)
(57274, 50) (6363, 50)
(63637, 50) (6363, 50)
```

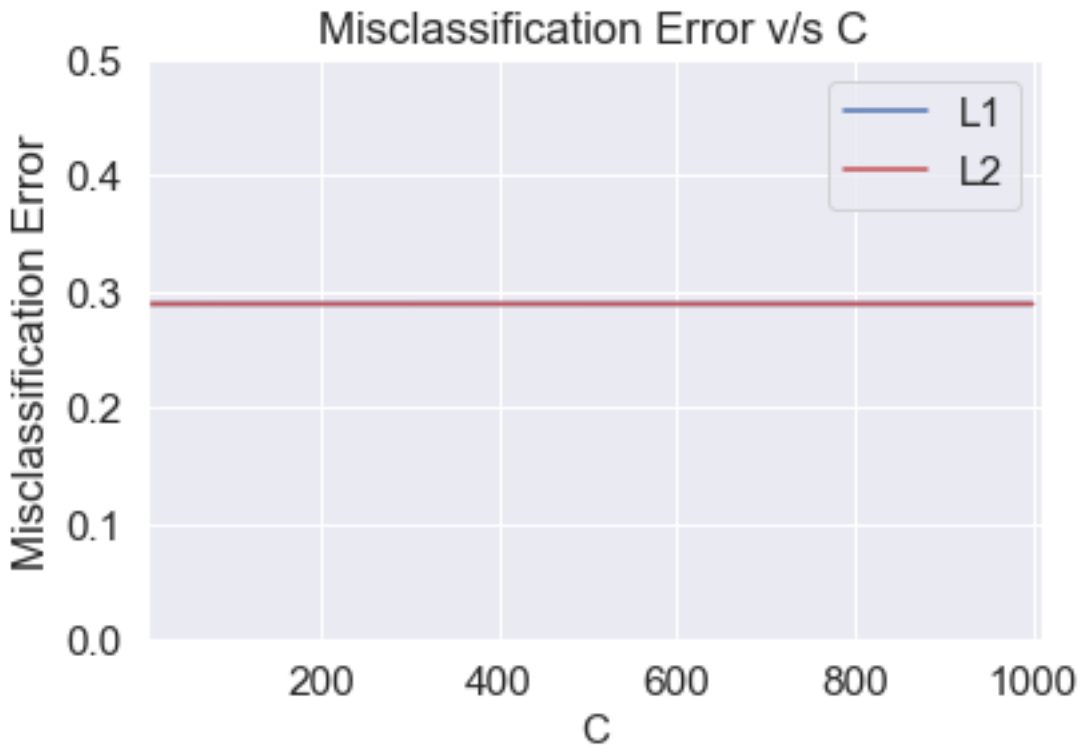
21 Hyperparameter selection using GridSearchCV

```
In [114]: %time
          from sklearn.model_selection import GridSearchCV
          from sklearn.linear_model import LogisticRegression

          clf = LogisticRegression()
```

```
        #params we need to try on classifier
        param_grid = {'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.000
                      'penalty':['l1','l2']}
        tscv = TimeSeriesSplit(n_splits=10) #For time based splitting
        gsv_tfidfw2v = GridSearchCV(clf,param_grid,cv=tscv,verbose=1)
        gsv_tfidfw2v.fit(X_train,Y_train)
        savetofile(gsv_tfidfw2v,"D:/Applied AI Course/gsv_tfidfw2v")
        print("Best HyperParameter: ",gsv_tfidfw2v.best_params_)
        print("Best Accuracy: %.2f%%"%(gsv_tfidfw2v.best_score_*100))
```

```
Wall time: 0 ns
Fitting 10 folds for each of 30 candidates, totalling 300 fits


[Parallel(n_jobs=1)]: Done 300 out of 300 | elapsed: 12.7min finished


Best HyperParameter:  {'C': 0.5, 'penalty': 'l2'}
Best Accuracy: 71.08%
```

```
In [115]: def plot_error_vs_c(gsv):
              x1=[]
              y1=[]
              x2=[]
              y2=[]
              for a in gsv.grid_scores_:
                  if (a[0]['penalty']) =='l1':
                      y1.append(1-a[1])
                      x1.append(a[0]['C'])
                  else:
                      y2.append(1-a[1])
                      x2.append(a[0]['C'])
              plt.xlim(5,1010)
              plt.ylim(0,0.5)
              plt.xlabel("C",fontsize=15)
              plt.ylabel("Misclassification Error")
              plt.title('Misclassification Error v/s C')
              plt.plot(x1,y1,'b',label="L1")
              plt.plot(x2,y2,'r',label="L2")
              plt.legend()
              plt.show()

In [116]: plot_error_vs_c(gsv_tfidfw2v)

D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```



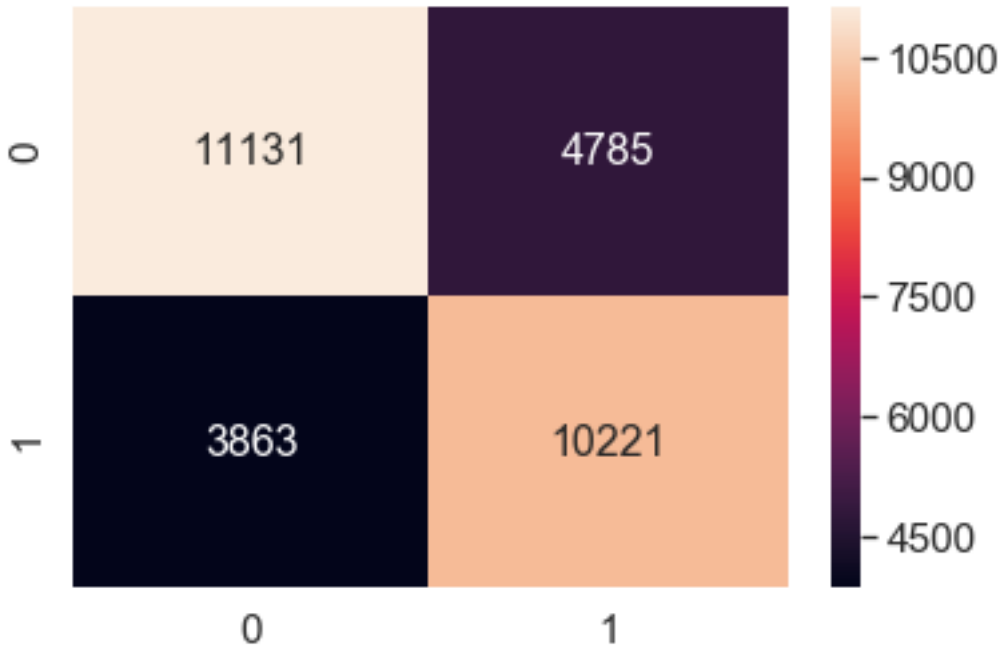

```
In [117]: clf=LogisticRegression(C=50, penalty='l1')
          clf.fit(X_train, Y_train)
          pred=clf.predict(X_test)
          print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
          print("Non Zero weights:",np.count_nonzero(clf.coef_))
          training_accuracy = clf.score(X_train, Y_train)
          training_error_tfidfw2v_gcv = 1 - training_accuracy
          test_accuracy = accuracy_score(Y_test, pred)
          test_error_tfidfw2v_gcv = 1 - test_accuracy
```

```
Accuracy on test set: 71.173%
Non Zero weights: 50
```

22 ConfusionMatrix

```
In [118]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, pred), range(2),range(2))
          sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[118]: <matplotlib.axes._subplots.AxesSubplot at 0x3a82d518>
```




```
In [119]: from sklearn.metrics import classification_report,precision_score,recall_score

          print(classification_report(Y_test,y_pred))
```

```
             precision    recall  f1-score   support

   Negative       0.88      0.89      0.89     15916
   Positive       0.87      0.87      0.87     14084

avg / total       0.88      0.88      0.88     30000
```

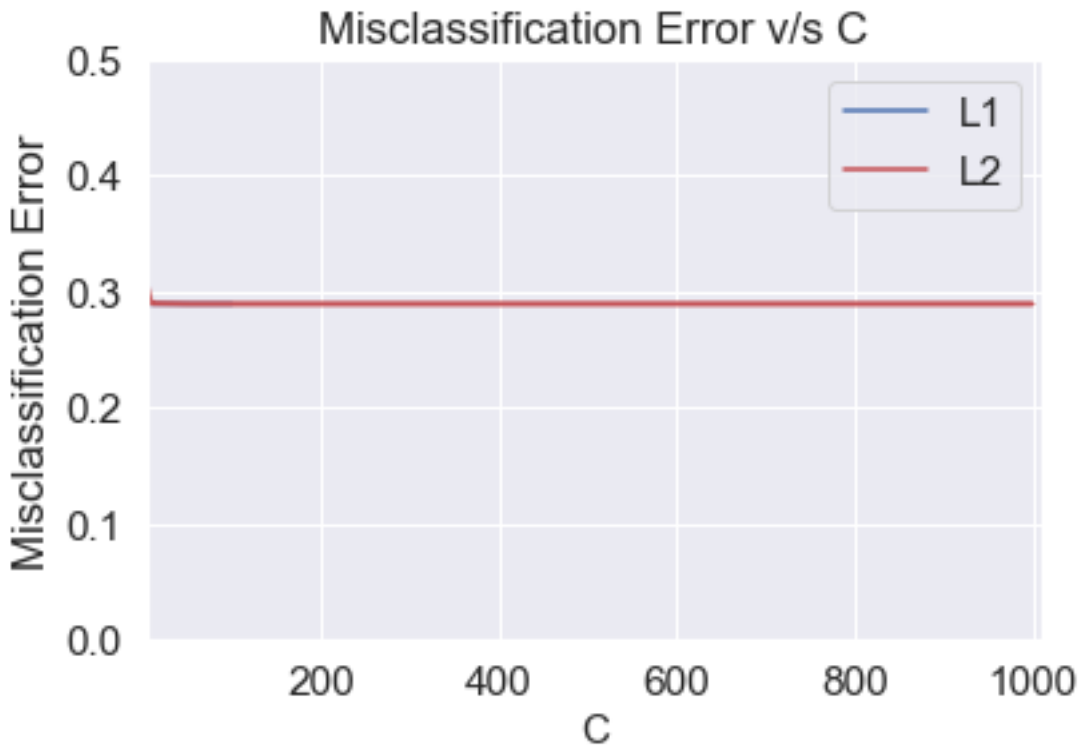
23 RandomizedCV

```
In [120]: %time
          from sklearn.model_selection import RandomizedSearchCV
          from sklearn.linear_model import LogisticRegression

          clf = LogisticRegression()

          #params we need to try on classifier
          param_grid = {'C':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.000
                        'penalty':['l1','l2']}
```

```
        tscv = TimeSeriesSplit(n_splits=10) #For time based splitting
        rcv_tfidfw2v = RandomizedSearchCV(clf,param_grid,cv=tscv,verbose=1)
        rcv_tfidfw2v.fit(X_train,Y_train)
        savetofile(rcv_tfidfw2v,"D:/Applied AI Course/rcv_tfidfw2v")
        print("Best HyperParameter: ",rcv_tfidfw2v.best_params_)
        print("Best Accuracy: %.2f%%"%(rcv_tfidfw2v.best_score_*100))
```

```
Wall time: 0 ns
Fitting 10 folds for each of 10 candidates, totalling 100 fits


[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:  3.5min finished


Best HyperParameter:  {'penalty': 'l2', 'C': 1}
Best Accuracy: 71.07%
```

```
In [121]: def plot_error_vs_c(gsv):
              x1=[]
              y1=[]
              x2=[]
              y2=[]
              for a in gsv.grid_scores_:
                  if (a[0]['penalty']) =='l1':
                      y1.append(1-a[1])
                      x1.append(a[0]['C'])
                  else:
                      y2.append(1-a[1])
                      x2.append(a[0]['C'])
              plt.xlim(5,1010)
              plt.ylim(0,0.5)
              plt.xlabel("C",fontsize=15)
              plt.ylabel("Misclassification Error")
              plt.title('Misclassification Error v/s C')
              plt.plot(x1,y1,'b',label="L1")
              plt.plot(x2,y2,'r',label="L2")
              plt.legend()
              plt.show()

In [122]: plot_error_vs_c(rcv_tfidfw2v)

D:\Anaconda\lib\site-packages\sklearn\model_selection\_search.py:762: DeprecationWarning: The g
  DeprecationWarning)
```



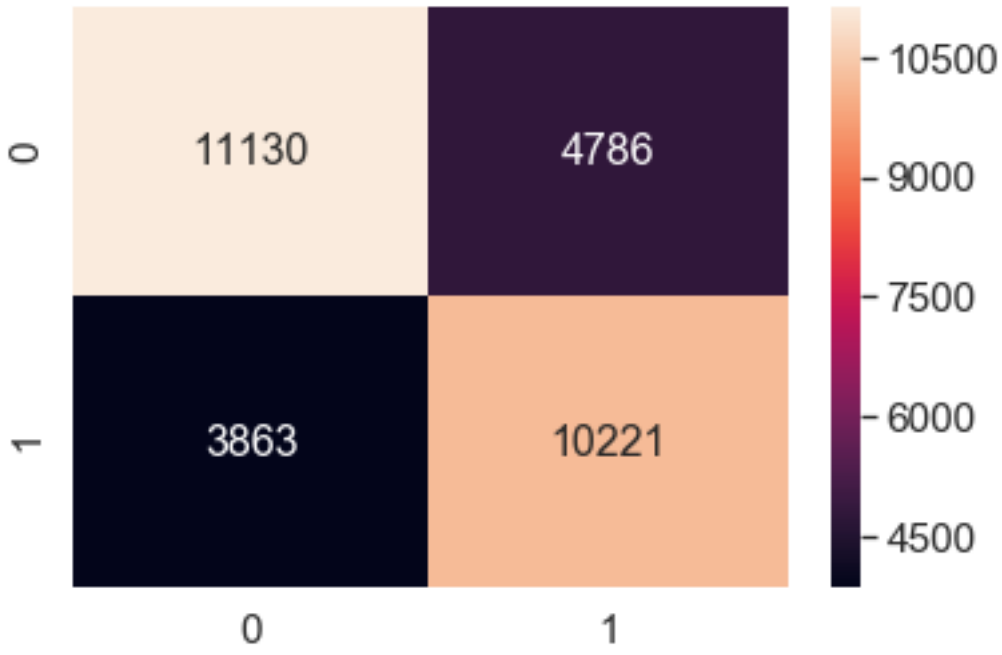

```
In [123]: clf=LogisticRegression(C=1000, penalty='l1')
          clf.fit(X_train, Y_train)
          pred=clf.predict(X_test)
          print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
          print("Non Zero weights:",np.count_nonzero(clf.coef_))
          training_accuracy = clf.score(X_train, Y_train)
          training_error_tfidfw2v_rcv = 1 - training_accuracy
          test_accuracy = accuracy_score(Y_test, pred)
          test_error_tfidfw2v_rcv = 1 - test_accuracy
```

```
Accuracy on test set: 71.170%
Non Zero weights: 50
```

24 Confusion matrix

```
In [124]: conf_matr_df = pd.DataFrame(confusion_matrix(Y_test, pred), range(2),range(2))
          sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[124]: <matplotlib.axes._subplots.AxesSubplot at 0x3a60d160>
```




```
In [125]: from sklearn.metrics import classification_report,precision_score,recall_score

          print(classification_report(Y_test,pred))
```

```
             precision    recall  f1-score   support

   Negative       0.74      0.70      0.72     15916
   Positive       0.68      0.73      0.70     14084

avg / total       0.71      0.71      0.71     30000
```

25 Perturbation test

```
In [126]: clf=LogisticRegression(C=50, penalty='l1')
          clf.fit(X_train, Y_train)
          pred=clf.predict(X_test)
          print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
          print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 71.173%
Non Zero weights: 50
```

In [127]:
```
#weight before adding random noise
from scipy.sparse import find
#Weights before adding random noise
weights1 = find(clf.coef_[0])[2]
print(weights1[:50])
```

```
[ 0.3922859   0.17647665 -0.31962992 -0.15680467 -0.29118056 -0.75469056
 -0.63037629  0.17852943 -0.07449325  0.52505246 -0.66808791  0.19181855
  0.22607817  0.01190473 -0.17406158  0.90362106 -0.91852076  0.1789419
  0.49139432  0.02384252 -1.02480475  0.1281986   0.27301226 -0.72921535
  0.51335895 -0.81936962 -0.15461104 -0.2241672   0.06173484  0.75018639
  0.58986491 -0.42933448 -0.03441005  0.43158596  0.38491749  0.31304216
  0.29512033  0.07290084  0.00707572 -1.01992877  0.23388793  0.48337678
 -0.59036309 -0.65015303 -0.40407653 -0.34095102  0.11902002 -0.14396864
 -0.52592214 -0.20862359]
```

In [128]:
```
#insert random noise
X_train_t = X_train
#Random noise
z = np.random.uniform(low=-0.0001, high=0.0001, size=(find(X_train_t)[0].size,))
#Getting the postions(row and column) and value of non-zero datapoints
r,c,v = find(X_train_t)

#Introducing random noise to non-zero datapoints
X_train_t[r,c] = z + X_train_t[r,c]

print(X_train_t.shape)
```

```
(70000, 50)
```

In [129]:
```
clf=LogisticRegression(C=50, penalty='l1')
clf.fit(X_train_t, Y_train)
pred=clf.predict(X_test)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(Y_test, pred)*100))
print("Non Zero weights:",np.count_nonzero(clf.coef_))
```

```
Accuracy on test set: 71.173%
Non Zero weights: 50
```

In [130]:
```
#weight after adding random noise
from scipy.sparse import find
#Weights before adding random noise
weights2 = find(clf.coef_[0])[2]
print(weights2[:50])
```

```
[ 0.39224849  0.17647089 -0.31969236 -0.15671782 -0.29107267 -0.75474185
 -0.63044625  0.17852163 -0.07452251  0.52519906 -0.66806719  0.19180711
```

```
  0.22603546  0.0118319  -0.17418277  0.90360444 -0.91862865  0.178994
  0.49146357  0.02391817 -1.0248276   0.1282408   0.27299366 -0.72933172
  0.51345062 -0.81952417 -0.15461125 -0.2240491   0.06180344  0.75018581
  0.58988674 -0.4293049  -0.03430604  0.43156047  0.38495254  0.31308421
  0.29517333  0.07295862  0.00710917 -1.01998219  0.23385943  0.48340951
 -0.59040188 -0.65014085 -0.40404553 -0.34097297  0.11897915 -0.14387591
 -0.52595078 -0.20852026]
```

In [131]:
```
print(weights2.size)

w_diff=(abs(weights1-weights2) / weights1) * 100

print(w_diff[np.where(w_diff > 30)].size)
```

```
50
0
```

Conclusion: 0 features have their weights less thank 30

26 Summary

In [134]:
```
from prettytable import PrettyTable

pr=PrettyTable()
tr=np.round(training_error,3)
te=np.round(test_error,3)
tr1=np.round(training_error_rcv,3)
te1=np.round(test_error_rcv,3)
tr2=np.round(training_error_tfidf, 3)
te2=np.round(test_error_tfidf, 3)
tr3=np.round(training_error_tfidf_rcv, 3)
te3=np.round(test_error_tfidf_rcv, 3)
tr4=np.round(training_error_avgw2v_gcv, 3)
te4=np.round(test_error_avgw2v_gcv, 3)
tr5=np.round(training_error_avgw2v_rcv, 3)
te5=np.round(test_error_avgw2v_rcv, 3)
tr6=np.round(training_error_tfidfw2v_gcv, 3)
te6=np.round(test_error_tfidfw2v_gcv, 3)
tr7=np.round(training_error_tfidfw2v_rcv, 3)
te7=np.round(test_error_tfidfw2v_rcv, 3)
#tr1=np.round(training_error_tf,2)
#te1=np.round(test_error_tf,2)
pr.field_names=["Model", "Hyperparameter(Alpha)", "Train error"," Test Error"]
pr.add_row(["BoW",gcv.best_params_,tr,te])
pr.add_row(["BoW",rcv.best_params_,tr1,te1])
pr.add_row(["Tfidf",gsv_tfidf.best_params_,tr2,te2])
```

```
pr.add_row(["Tfidf",rcv_tfidf.best_params_,tr3,te3])
pr.add_row(["AvgW2Vec",gsv_avgw2v.best_params_,tr4,te4])
pr.add_row(["AvgW2Vec",rcv_avgw2v.best_params_,tr5,te5])
pr.add_row(["TfidfW2Vec",gsv_tfidfw2v.best_params_,tr6,te6])
pr.add_row(["TfidfW2Vec",rcv_tfidfw2v.best_params_,tr7,te7])


#pr.add_row(["TFIDF",hyp2,tr1,te1])
#pr.add_row(["(Bernoulli Tfidf)",btf_optimal_alpha,np.round(training_error_tfidf,3),
#pr.add_row(["AvgWord2Vec",aw2v_optimal_alpha,np.round(training_error_aw2v,3),np.rou
#pr.add_row(["Weighted TFIDF Word2Vec",tfw2v_optimal_alpha,np.round(training_error_t
print(pr)
```

```
+------------+------------------------------+-------------+-------------+
|   Model    |    Hyperparameter(Alpha)     | Train error |  Test Error |
+------------+------------------------------+-------------+-------------+
|    BoW     |  {'C': 5, 'penalty': 'l2'}   |    0.094    |    0.122    |
|    BoW     |  {'penalty': 'l2', 'C': 10}  |    0.094    |    0.122    |
|   Tfidf    |  {'C': 5, 'penalty': 'l2'}   |    0.098    |    0.122    |
|   Tfidf    |  {'penalty': 'l2', 'C': 5}   |    0.077    |    0.123    |
|  AvgW2Vec  | {'C': 100, 'penalty': 'l2'}  |    0.202    |    0.153    |
|  AvgW2Vec  | {'penalty': 'l2', 'C': 500}  |    0.202    |    0.199    |
| TfidfW2Vec | {'C': 0.5, 'penalty': 'l2'}  |    0.282    |    0.288    |
| TfidfW2Vec |  {'penalty': 'l2', 'C': 1}   |    0.282    |    0.288    |
+------------+------------------------------+-------------+-------------+
```