RANDOM FOREST GBDT ALGORITHM on Amazon Fine Food Reviews

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

Given a review, determine whether the review is positive (Rating of 4 or 5) or negative (rating of 1 or 2).

Loading,Cleaning & Preprocessing the data

The dataset is available in two forms

1. .csv file
2. SQLite Database

   In order to load the data, We have used the SQLITE dataset as it easier to query the data and visualise the data efficiently.

   Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignc equal to 3. If the score id above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

```
%matplotlib inline
import warnings
import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
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.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

```

```
import re
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os

warnings.filterwarnings("ignore")
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is c
  import pandas.util.testing as tm
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pf

Enter your authorization code:
··········
Mounted at /content/drive
```

```
con = sqlite3.connect("/content/drive/My Drive/Colab Notebooks/database.sqlite")

filtered_data=pd.read_sql_query("""SELECT * FROM Reviews WHERE Score != 3""",con);
filtered_data.head(3)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1

```
filtered_data.shape

def partition(x):
  if x < 3 :
    return 'negative'
  return 'positive'

actualScore=filtered_data['Score']
positive_negative=actualScore.map(partition)
filtered_data['Score']=positive_negative
print("Number of datapoints",filtered_data.shape)
filtered_data.head(3)
```

```
Number of datapoints (525814, 10)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1

```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

```
print(display.shape)
display.head(3)
```

```
(80668, 7)
```

	UserId	ProductId	ProfileName	Time	Score	
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering t
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle sp
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortuna

```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND UserId="AR5J8UI46CURR"
ORDER BY ProductID
""", con)
display.head()
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2	5	119
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2	5	119
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2	5	119
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	2	5	119
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	2	5	119

```
sorted_data=filtered_data.sort_values('ProductId',axis=0,ascending=True,inplace=False,kind='quicksort',na_positior

final_data=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"},keep='first',inplace=False)
final_data.shape
```

```
(364173, 10)
```

```
(final_data['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

```
69.25890143662969
```

```python
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND Id=44737 OR Id=64422
ORDER BY ProductID
""", con)

display.head()
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Scor
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	1	5
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	2	4

```python
final_data=final_data[final_data.HelpfulnessNumerator<=final_data.HelpfulnessDenominator]
```

```python
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
True
```

```python
stopping_words = set(stopwords.words('english'))
print(stopping_words)
```

```
{'y', "mustn't", 'you', 'other', 'ours', 'hadn', "wouldn't", 'during', 'through', "you've", "hadn't", 'she', 'ar
```

```python
def clean_html(text):
    clean_r = re.compile('<,*?>')
    clean_text = re.sub(clean_r,'',text)
    return clean_text

def Clean_punc(text):
    clean_sentence = re.sub(r'[?|!|\'|"|#]',r' ',text)
    clean_data = re.sub(r'[.|,|)|(|\|/)]',r' ',clean_sentence)
    return clean_data
```

```python
from tqdm import tqdm
import os
import pdb
import pickle

from tqdm import tqdm
import os
import pdb
import pickle

stem_no = nltk.stem.SnowballStemmer('english')

if not os.path.isfile('final_data.sqlite'):
    final_string=[]
    all_positive_words=[]
    all_negative_words=[]
    for i,sentence in enumerate(tqdm(final_data['Text'].values)):
        filtered_sentence=[]
        sent_without_html_tags=clean_html(sentence)
        #pdb.set_trace()
        for w in sent_without_html_tags.split():
            for cleaned_words in Clean_punc(w).split():
                if ((cleaned_words.isalpha()) & (len(cleaned_words) > 2)):
                    if(cleaned_words.lower() not in stopping_words) :
                        stemming=(stem_no.stem(cleaned_words.lower())).encode('utf8')
                        filtered_sentence.append(stemming)
                        if(final_data['Score'].values)[i]=='positive':
                            all_positive_words.append(stemming)
                        if(final_data['Score'].values)[i]=='negative':
                            all_negative_words.append(stemming)
        str1 = b" ".join(filtered_sentence)
        final_string.append(str1)

    final_data['Cleaned_text']=final_string
    final_data['Cleaned_text']=final_data['Cleaned_text'].str.decode("utf-8")

    conn = sqlite3.connect('final_data.sqlite')
    cursor=conn.cursor
    conn.text_factory = str
    final_data.to_sql('Reviews',conn,schema=None,if_exists='replace',index=True,index_label=None,chunksize=None,dt
    conn.close()


    with open('positive_words.pkl','wb') as f :
        pickle.dump(all_positive_words,f)
    with open('negative_words.pkl','wb') as f :
        pickle.dump(all_negative_words,f)
```

```
100%|██████████| 364171/364171 [05:47<00:00, 1048.66it/s]
```

```
final_data['total_words'] = [len(x.split()) for x in final_data['Cleaned_text'].tolist()]
```

```
final_data.sort_values(by=['Time'], inplace=True, ascending=True)
```

```
final_data['Score'].value_counts()
```

```
positive    307061
negative     57110
Name: Score, dtype: int64
```

```
count_positive,count_negative=final_data['Score'].value_counts()
```

```
final_data_positive_class=final_data[final_data['Score']=='positive']
final_data_negative_class=final_data[final_data['Score']=='negative']
```

RANDOM UP SAMPLING

Note : In Up Sampling , there will be duplicate random records from the minority class which can caus

```
#final_data_negative=final_data_negative_class.sample(count_positive,replace=True)
#final_data_after_Sampling=pd.concat([final_data_positive_class,final_data_negative], axis=0 )
final_data_positive=final_data_positive_class.sample(count_negative)

fina_data_after_Sampling=pd.concat([final_data_positive,final_data_negative_class], axis=0)
```

```
fina_data_after_Sampling['Score'].value_counts()
```

```
negative    57110
positive    57110
Name: Score, dtype: int64
```

```
fina_data_after_Sampling.shape
```

```
(114220, 12)
```

```
final_data_100K=fina_data_after_Sampling[0:100000]
amazon_polarity_labels=final_data_100K['Score'].values
final_data_100K.head(2)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Sc
134333	145807	B003D4F1QS	A1XU4U4159OFXD	Liz	2	2	pos
455421	492385	B000F9ZDKI	AYCLRXW5VOIOQ	penny pincher "two cents"	13	13	pos

```
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from collections import Counter
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report

X_1,X_Test,Y_1,Y_Test = train_test_split(final_data_100K,amazon_polarity_labels,test_size=0.2,random_state=0)
X_Train,X_CV,Y_Train,Y_CV = train_test_split(X_1,Y_1,test_size=0.2)
```

RANDOM FOREST ALGORITHM

APPLY BAG OF WORDS VECTORIZATION TECHNIQUE USING RANDOM FOREST TO FIND HYPERPARAMETER

```
print(X_Train.shape, Y_Train.shape)
print(X_CV.shape, Y_CV.shape)
print(X_Test.shape, Y_Test.shape)

print("="*100)


count_vector=CountVectorizer(min_df=1)
X_Train_data_bow=(count_vector.fit_transform(X_Train['Cleaned_text'].values))
X_Test_data_bow=(count_vector.transform(X_Test['Cleaned_text'].values))
X_CV_data_bow=(count_vector.transform(X_CV['Cleaned_text'].values))

print("After vectorizations")
print(X_Train_data_bow.shape, Y_Train.shape)
print(X_CV_data_bow.shape, Y_CV.shape)
print(X_Test_data_bow.shape, Y_Test.shape)
print("="*100)
```

```
(64000, 12) (64000,)
(16000, 12) (16000,)
(20000, 12) (20000,)
====================================================================================================
After vectorizations
(64000, 30318) (64000,)
(16000, 30318) (16000,)
(20000, 30318) (20000,)
====================================================================================================
```

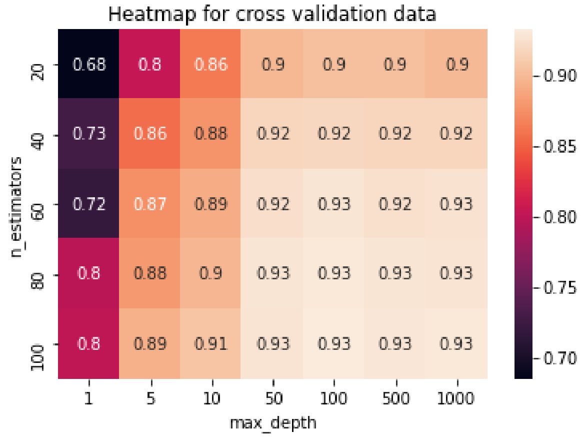
```
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import RandomForestClassifier

max_depth = [1,5,10,50,100,500,1000]
n_estimators =  [20,40,60,80,100]
def Random_Forest_Classifier(x_training_data,y_training_data,x_cv_training,y_cv_training):
  grid_params = { 'max_depth' : max_depth,
                 'n_estimators' : n_estimators
               }
  Classifier_RFT = RandomForestClassifier(random_state=None, class_weight ='balanced',oob_score=True)
  clf=GridSearchCV(Classifier_RFT,grid_params,scoring='roc_auc',return_train_score=True,cv=3,n_jobs=-1)
  clf.fit(x_training_data,y_training_data)
  results = pd.DataFrame.from_dict(clf.cv_results_)
  results = results.sort_values(['param_max_depth'])
  results = results.sort_values(['param_n_estimators'])
  train_auc= results['mean_train_score']
  train_auc_std= results['std_train_score']
  cv_auc = results['mean_test_score']
  cv_auc_std= results['std_test_score']
  best_depth =  results['param_max_depth']
  best_estimators =  results['param_n_estimators']
  #log_alpha=np.log10(list(results["param_alpha"]))
  print(clf.best_score_)
  print(clf.best_params_)
  Build_HeatMap(max_depth,n_estimators,x_training_data,y_training_data,x_cv_training,y_cv_training)
  return results,clf,Classifier_RFT
```

```
import seaborn as sns
from sklearn.metrics import roc_auc_score

def Build_HeatMap(max_depth,n_estimators,X_Train,Y_Train,X_CV,Y_CV) :
  base_learner= []
  depths =[]
  auc_score_cv =[]
  for i in n_estimators :
    for j in max_depth :
      RFClassifier=RandomForestClassifier(random_state=None, class_weight ='balanced',max_depth = j,n_estimators =
      RFClassifier.fit(X_Train,Y_Train)
      predict_cv=RFClassifier.predict_proba(X_CV)[:,1]
      predict_train=RFClassifier.predict_proba(X_Train)[:,1]
      base_learner.append(i)
      depths.append(j)
      auc_score_cv.append(roc_auc_score(Y_CV,predict_cv))
  data_frame = pd.DataFrame({'n_estimators': base_learner, 'max_depth': depths, 'AUC': auc_score_cv})
  data_pivoted = data_frame.pivot("n_estimators", "max_depth", "AUC")
  heat_map = sns.heatmap(data_pivoted,annot=True)
  plt.title('Heatmap for cross validation data')
  plt.show()
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,RF_Classiier=Random_Forest_Classifier(X_Train_data_bow,Y_Train,X_CV_data_bow,Y_CV)
```

```
result,best_depth,rf_classifier=Random_Forest_Classifier(X_Train_data_bow,Y_Train,X_cv_data_bow,Y_cv)
```

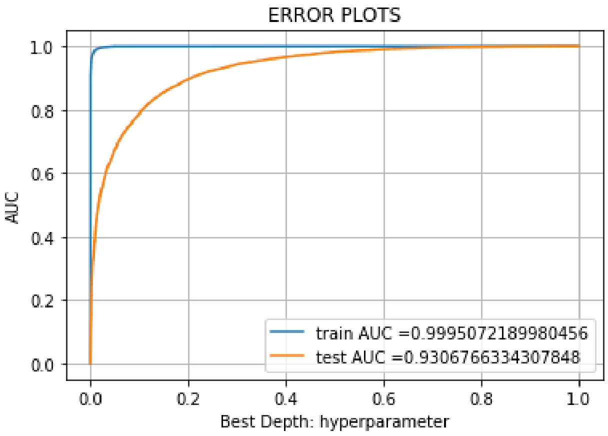
```
-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
0.9299056267764548
{'max_depth': 100, 'n_estimators': 100}
```



n_estimators \ max_depth	1	5	10	50	100	500	1000
20	0.68	0.8	0.86	0.9	0.9	0.9	0.9
40	0.73	0.86	0.88	0.92	0.92	0.92	0.92
60	0.72	0.87	0.89	0.92	0.93	0.92	0.93
80	0.8	0.88	0.9	0.93	0.93	0.93	0.93
100	0.8	0.89	0.91	0.93	0.93	0.93	0.93

```python
def Find_best_Depth_estimator(best_depth,best_estimators) :
  best_depth = best_depth.best_params_
  best_estimators = best_estimators.best_params_
  best_depth=best_depth.get("max_depth")
  best_estimators = best_estimators.get("n_estimators")
  print(best_depth)
  print(best_estimators)
  return best_depth,best_estimators
```

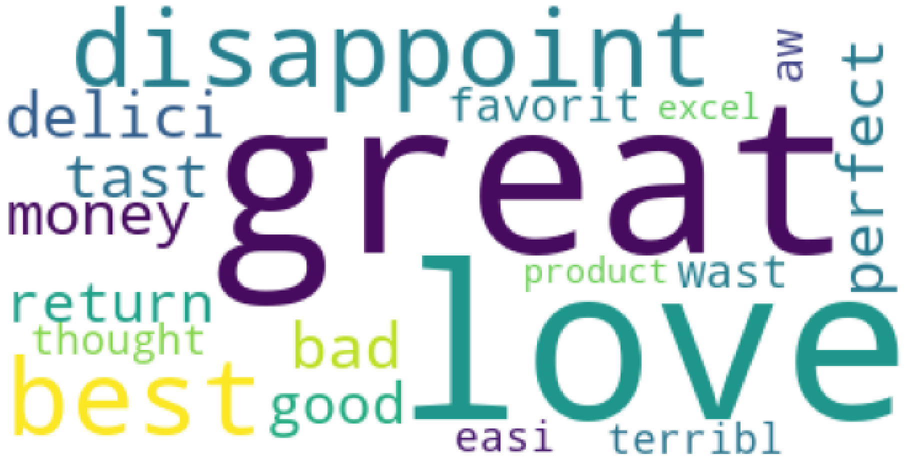
```python
from sklearn.metrics import roc_curve, auc

RFClassifier= RandomForestClassifier(random_state=None, class_weight ='balanced',max_depth = 100,n_estimators = 10
clf=RFClassifier.fit(X_Train_data_bow,Y_Train)
pred_test_data=RFClassifier.predict(X_Test_data_bow)
y_train_predicted_prob = RFClassifier.predict_proba(X_Train_data_bow)[:,1]
y_test_predicted_prob=RFClassifier.predict_proba(X_Test_data_bow)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



```
pip install WordCloud
```

```
Requirement already satisfied: WordCloud in /usr/local/lib/python3.6/dist-packages (1.5.0)
Requirement already satisfied: numpy>=1.6.1 in /usr/local/lib/python3.6/dist-packages (from WordCloud) (1.18.3)
Requirement already satisfied: pillow in /usr/local/lib/python3.6/dist-packages (from WordCloud) (7.0.0)
```

```python
feature_names = count_vector.get_feature_names()
display_data=''
coef=RFClassifier.feature_importances_
features=np.argsort(coef)[::-1]

for i in features[0:20]:
  display_data+=feature_names[i]
  display_data+=' '

from wordcloud import WordCloud
wordcloud = WordCloud(background_color='white').generate(display_data)
plt.figure(figsize=(8,8),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



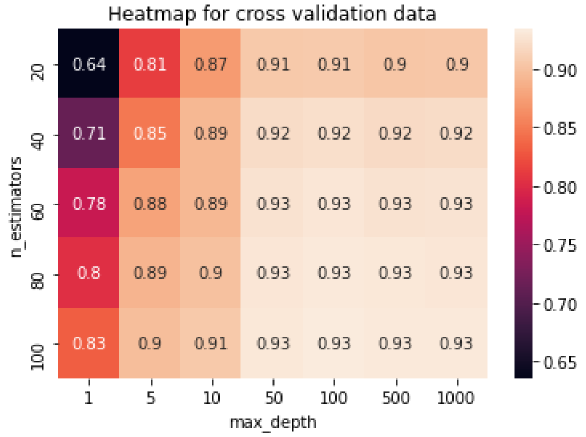
TF-IDF VECTORIZATION TECHNIQUE USING RANDOM FOREST TO FIND THE BEST HYPERPARAMETER

```python
from sklearn.feature_extraction.text import TfidfVectorizer

print(X_Train.shape, Y_Train.shape)
print(X_CV.shape, Y_CV.shape)
print(X_Test.shape, Y_Test.shape)

print("="*100)


tfidf_vector=TfidfVectorizer(min_df=10)
X_Train_data_tfidf=(tfidf_vector.fit_transform(X_Train['Cleaned_text'].values))
X_Test_data_tfidf=(tfidf_vector.transform(X_Test['Cleaned_text'].values))
X_CV_data_tfidf=(tfidf_vector.transform(X_CV['Cleaned_text'].values))

print("After vectorizations")
print(X_Train_data_tfidf.shape, Y_Train.shape)
print(X_CV_data_tfidf.shape, Y_CV.shape)
print(X_Test_data_tfidf.shape, Y_Test.shape)
print("="*100)
```

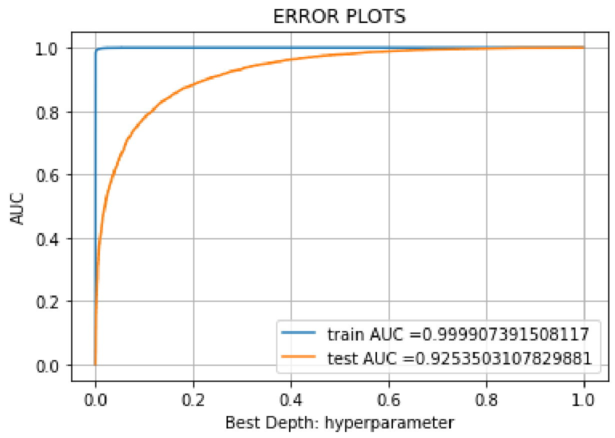
```
(64000, 12) (64000,)
(16000, 12) (16000,)
(20000, 12) (20000,)
====================================================================================================
After vectorizations
(64000, 6990) (64000,)
(16000, 6990) (16000,)
(20000, 6990) (20000,)
====================================================================================================
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,RF_Classiier=Random_Forest_Classifier(X_Train_data_tfidf,Y_Train,X_CV_data_tfidf,Y_CV)
```

```
-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
0.9265478624970153
{'max_depth': 100, 'n_estimators': 100}
```



```
RFClassifier= RandomForestClassifier(random_state=None, class_weight ='balanced',max_depth = 100,n_estimators = 1
clf=RFClassifier.fit(X_Train_data_tfidf,Y_Train)
pred_test_data=RFClassifier.predict(X_Test_data_tfidf)
y_train_predicted_prob = RFClassifier.predict_proba(X_Train_data_tfidf)[:,1]
y_test_predicted_prob=RFClassifier.predict_proba(X_Test_data_tfidf)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



```
feature_names = tfidf_vector.get_feature_names()
display_data=''
coef=RFClassifier.feature_importances_
features=np.argsort(coef)[::-1]

for i in features[0:20]:
  display_data+=feature_names[i]
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from wordcloud import WordCloud
wordcloud = WordCloud(background_color='white').generate(display_data)
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plt.axis("off")
plt.tight_layout(pad = 0)
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```
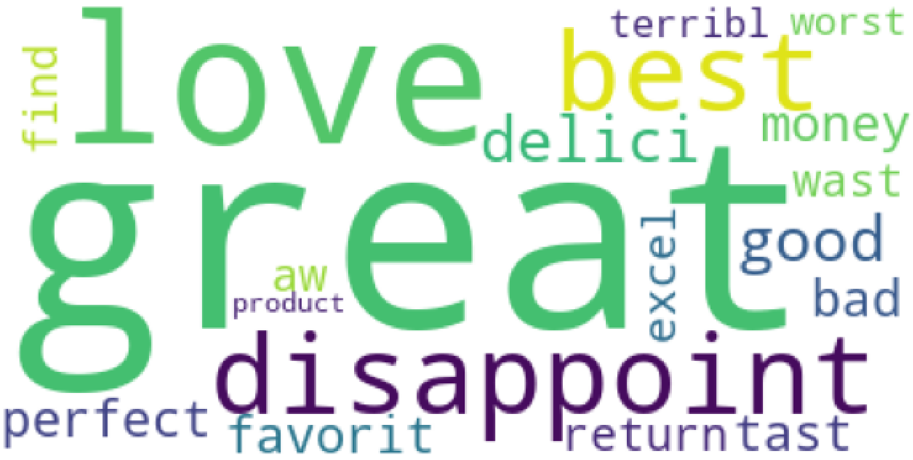



Avg Word2Vec Vectorization Technique using Random Forest

```
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

list_of_sent_train_avgw2v=[]
list_of_sent_test_avgw2v=[]
list_of_sent_cv_avgw2v=[]
for sent_train_avgw2v in tqdm(X_Train['Cleaned_text'].values):
    list_of_sent_train_avgw2v.append(sent_train_avgw2v.split())
```

```
100%|██████████| 64000/64000 [00:01<00:00, 36198.00it/s]
```

```
for sent_test_avgw2v in tqdm(X_Test['Cleaned_text'].values):
    list_of_sent_test_avgw2v.append(sent_test_avgw2v.split())

for sent_cv_avgw2v in tqdm(X_CV['Cleaned_text'].values):
    list_of_sent_cv_avgw2v.append(sent_cv_avgw2v.split())
```

```
100%|██████████| 20000/20000 [00:00<00:00, 137861.46it/s]
100%|██████████| 16000/16000 [00:00<00:00, 139946.29it/s]
```

```
w2v_model_train = Word2Vec(list_of_sent_train_avgw2v,min_count=5,size=50,workers=4)
w2v_words_svm_train=list(w2v_model_train.wv.vocab)
```

```
w2v_model_test = Word2Vec(list_of_sent_test_avgw2v,min_count=5,size=50,workers=4)
```

```
w2v_words_svm_test=list(w2v_model_test.wv.vocab)
```

```
w2v_model_cv = Word2Vec(list_of_sent_cv_avgw2v,min_count=5,size=50,workers=4)
w2v_words_svm_cv=list(w2v_model_cv.wv.vocab)
```

```
train_vectors=[];
for sent in list_of_sent_train_avgw2v:
    sent_vec=np.zeros(50)
    cnt_words=0;
    for word in sent:
        if word in w2v_words_svm_train:
            vec=w2v_model_train.wv[word]
            sent_vec+=vec
            cnt_words+=1
    if cnt_words !=0:
        sent_vec/=cnt_words
    train_vectors.append(sent_vec)
print(len(train_vectors))
print(len(train_vectors[0]))
```

```
64000
50
```

```
test_vectors=[];
for sent in tqdm(list_of_sent_test_avgw2v):
    sent_vec=np.zeros(50)
    cnt_words=0;
    for word in sent:
        if word in w2v_words_svm_test:
            vec=w2v_model_test.wv[word]
            sent_vec+=vec
            cnt_words+=1
    if cnt_words !=0:
        sent_vec/=cnt_words
    test_vectors.append(sent_vec)
print(len(test_vectors))
print(len(test_vectors[0]))
```

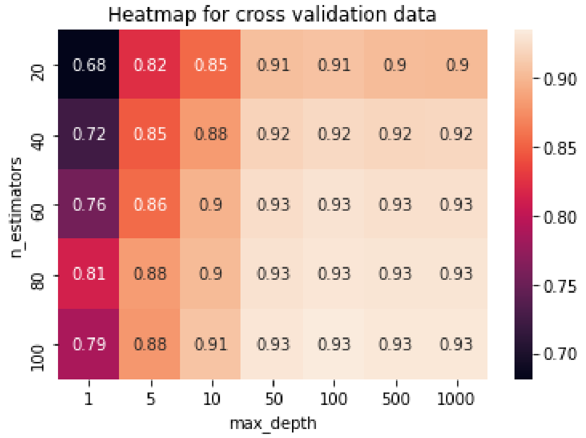
```
100%|██████████| 20000/20000 [00:16<00:00, 1210.51it/s]20000
50
```

```
cv_vectors=[];
for sent in tqdm(list_of_sent_cv_avgw2v):
    sent_vec=np.zeros(50)
    cnt_words=0;
    for word in sent:
        if word in w2v_words_svm_cv:
            vec=w2v_model_cv.wv[word]
            sent_vec+=vec
            cnt_words+=1
    if cnt_words !=0:
        sent_vec/=cnt_words
    cv_vectors.append(sent_vec)
print(len(cv_vectors))
print(len(cv_vectors[0]))
```

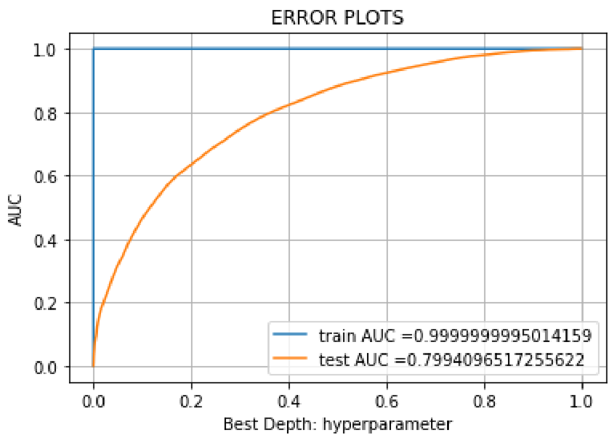
```
100%|██████████| 16000/16000 [00:12<00:00, 1241.77it/s]16000
50
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,RF_Classiier=Random_Forest_Classifier(train_vectors,Y_Train,cv_vectors,Y_CV)
```

```
-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
0.9072753950284099
{'max_depth': 50, 'n_estimators': 100}
```



```
RFClassifier= RandomForestClassifier(random_state=None, class_weight ='balanced',max_depth = 50,n_estimators = 10
clf=RFClassifier.fit(train_vectors,Y_Train)
pred_test_data=RFClassifier.predict(test_vectors)
y_train_predicted_prob = RFClassifier.predict_proba(train_vectors)[:,1]
y_test_predicted_prob=RFClassifier.predict_proba(test_vectors)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



TF-IDF Word2Vec Vectorization Technique using Random Forest

```
model_Avgw2v = TfidfVectorizer()
X_Train_Avgw2v=model_Avgw2v.fit_transform(X_Train['Cleaned_text'].values)
```

```
X_Test_Avgw2v=model_Avgw2v.transform(X_Test['Cleaned_text'].values)
X_CV_Avgw2v=model_Avgw2v.transform(X_CV['Cleaned_text'].values)
```

```
dictionary = dict(zip(model_Avgw2v.get_feature_names(), list(model_Avgw2v.idf_)))
```

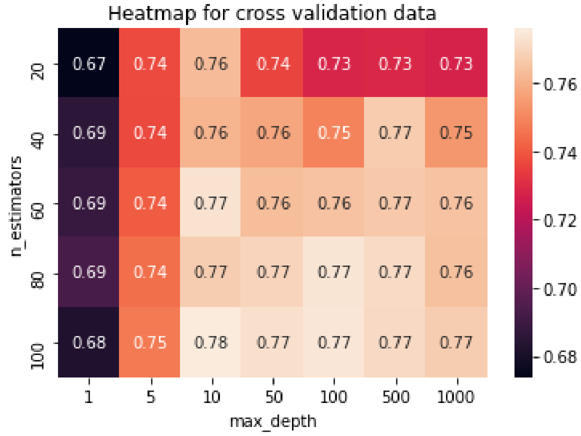
```
tfidf_feature=model_Avgw2v.get_feature_names()

tfidf_sent_vectors_train=[];
#final_tf_idf = [];
row=0;

for sent in tqdm(list_of_sent_train_avgw2v):
    sent_vec=np.zeros(50)
    weight_sum=0;
    for word in sent :
        if word in w2v_words_svm_train and word in tfidf_feature :
            vec=w2v_model_train.wv[word]
            #tf_idf=final_tf_idf[row,tfidf_feature.index(word)]
            tf_idf=dictionary[word]*(sent.count(word)/len(sent))
            sent_vec+=(vec*tf_idf)
            weight_sum+=tf_idf

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

```
100%|██████████| 64000/64000 [13:27<00:00, 79.30it/s]
```

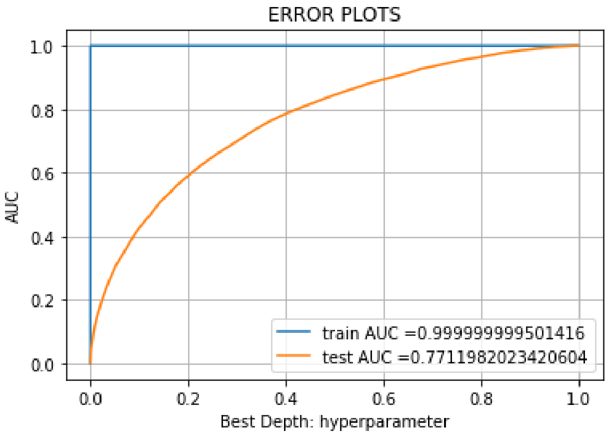
```
tfidf_sent_vectors_test=[];
#final_tf_idf = [];
row=0;

for sent in tqdm(list_of_sent_test_avgw2v):
    sent_vec=np.zeros(50)
    weight_sum=0;
    for word in sent :
        if word in w2v_words_svm_test and word in tfidf_feature :
            vec=w2v_model_test.wv[word]
            #tf_idf=final_tf_idf[row,tfidf_feature.index(word)]
            tf_idf=dictionary[word]*(sent.count(word)/len(sent))
            sent_vec+=(vec*tf_idf)
            weight_sum+=tf_idf

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

```
100%|██████████| 20000/20000 [04:08<00:00, 80.46it/s]
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,RF_Classiier=Random_Forest_Classifier(tfidf_sent_vectors_train,Y_Train,tfidf_sent_vectors_test,Y
  -------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
  0.8817480033471647
  {'max_depth': 100, 'n_estimators': 100}
```



```
RFClassifier= RandomForestClassifier(random_state=None, class_weight ='balanced',max_depth = 100,n_estimators = 10
clf=RFClassifier.fit(tfidf_sent_vectors_train,Y_Train)
pred_test_data=RFClassifier.predict(tfidf_sent_vectors_test)
y_train_predicted_prob = RFClassifier.predict_proba(tfidf_sent_vectors_train)[:,1]
y_test_predicted_prob=RFClassifier.predict_proba(tfidf_sent_vectors_test)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



PRETTY TABLE FOR RANDOM FOREST

```
pip install -U PTable
```

```
Collecting PTable
  Downloading https://files.pythonhosted.org/packages/ab/b3/b54301811173ca94119eb474634f120a49cd370f257d1aae5a4a
Building wheels for collected packages: PTable
  Building wheel for PTable (setup.py) ... done
  Created wheel for PTable: filename=PTable-0.9.2-cp36-none-any.whl size=22908 sha256=92b2471788d31ed83df5850fc3
  Stored in directory: /root/.cache/pip/wheels/22/cc/2e/55980bfe86393df3e9896146a01f6802978d09d7ebcba5ea56
Successfully built PTable
Installing collected packages: PTable
Successfully installed PTable-0.9.2
```

```
from prettytable import PrettyTable

x= PrettyTable()
x.field_names = ["Vectorizer" , "Hyperparameter(Best Depth)", "n-estimators","AUC"]
x.add_row(["Bag Of Words",100,100,0.9299])
x.add_row(["Tf-Idf",100,100,0.9265])
x.add_row(["Avg Word2Vec",50,100,0.9072])
x.add_row(["Tf-Idf Word2Vec",100,100,0.8817])
print(x)
```

```
+-----------------+----------------------------+--------------+--------+
|    Vectorizer   | Hyperparameter(Best Depth) | n-estimators |  AUC   |
+-----------------+----------------------------+--------------+--------+
|   Bag Of Words  |            100             |     100      | 0.9299 |
|      Tf-Idf     |            100             |     100      | 0.9265 |
|   Avg Word2Vec  |             50             |     100      | 0.9072 |
| Tf-Idf Word2Vec |            100             |     100      | 0.8817 |
+-----------------+----------------------------+--------------+--------+
```

GRADIENT BOOSTING ALGORITHM - XGBOOST

```
pip install xgboost
```

```
Requirement already satisfied: xgboost in /usr/local/lib/python3.6/dist-packages (0.90)
Requirement already satisfied: numpy in /usr/local/lib/python3.6/dist-packages (from xgboost) (1.18.3)
Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages (from xgboost) (1.4.1)
```

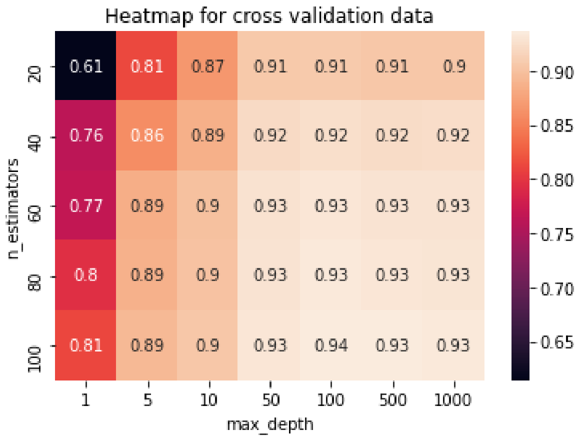
APPLY BAG OF WORDS VECTORIZATION TECHNIQUE USING GBDT TO FIND THE BEST DEPTH(HYPERPARAMETER)

```
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import cross_val_score
import xgboost as xgb


max_depth = [1,5,10,50,100,500,1000]
n_estimators =  [20,40,60,80,100]
def XGBoost_Classifier(x_training_data,y_training_data,x_cv_training,y_cv_training):
  grid_params = { 'max_depth' : max_depth,
                  'n_estimators' :n_estimators
                 }
  Classifier_XGBoost = xgb.XGBClassifier(random_state=0, booster='gbtree')
  clf=GridSearchCV(Classifier_XGBoost,grid_params,scoring='roc_auc',return_train_score=True,cv=3,n_jobs=-1)
  clf.fit(x_training_data,y_training_data)
  results = pd.DataFrame.from_dict(clf.cv_results_)
  results = results.sort_values(['param_max_depth'])
  results = results.sort_values(['param_n_estimators'])
  train_auc= results['mean_train_score']
```

```
    train_auc_std= results['std_train_score']
    cv_auc = results['mean_test_score']
    cv_auc_std= results['std_test_score']
    best_depth =  results['param_max_depth']
    best_estimators =  results['param_n_estimators']
    print(clf.best_score_)
    print(clf.best_params_)
    Build_HeatMap(max_depth,n_estimators,x_training_data,y_training_data,x_cv_training,y_cv_training)
    return results,clf,Classifier_XGBoost
```

```
print ('-------------BEST DEPTH---------------')
result,best_depth,XGBoostClassiier=XGBoost_Classifier(X_Train_data_bow,Y_Train,X_CV_data_bow,Y_CV)
```

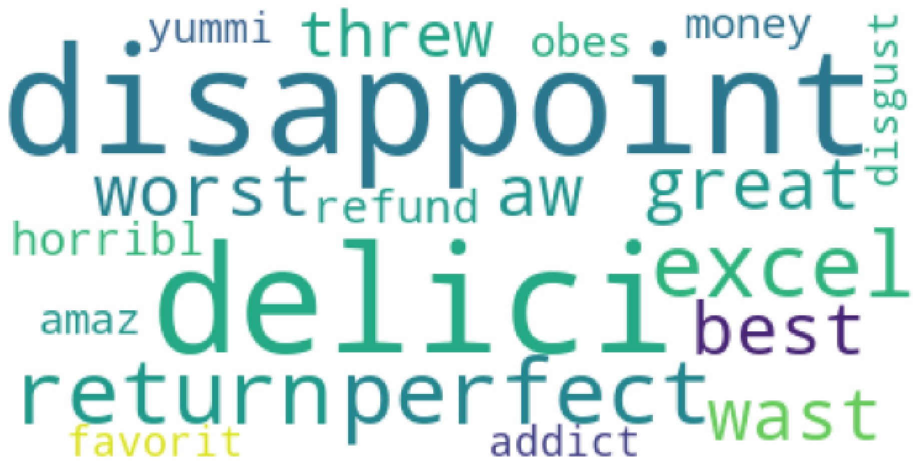
```
-------------BEST DEPTH---------------
0.928610806402034
{'max_depth': 100, 'n_estimators': 100}
```



```
from sklearn.metrics import roc_curve, auc

GBDTClassifier= xgb.XGBClassifier(random_state=0,max_depth = 100,n_estimators = 100,booster='gbtree')
clf=GBDTClassifier.fit(X_Train_data_bow,Y_Train)
pred_test_data=GBDTClassifier.predict(X_Test_data_bow)
y_train_predicted_prob = GBDTClassifier.predict_proba(X_Train_data_bow)[:,1]
y_test_predicted_prob=GBDTClassifier.predict_proba(X_Test_data_bow)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

ERROR PLOTS

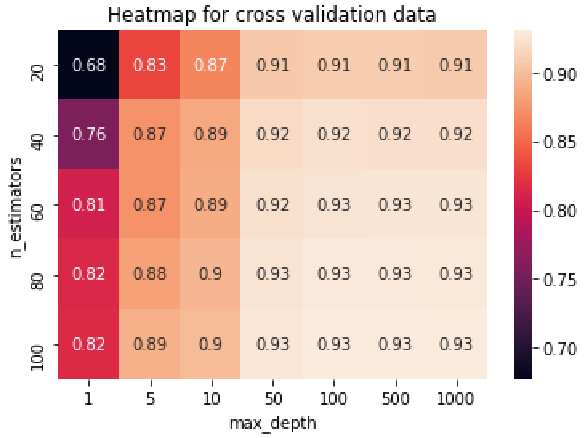
```
feature_names = count_vector.get_feature_names()
display_data=''
coef=GBDTClassifier.feature_importances_
features=np.argsort(coef)[::-1]

for i in features[0:20]:
  display_data+=feature_names[i]
  display_data+=' '

from wordcloud import WordCloud
wordcloud = WordCloud(background_color='white').generate(display_data)
plt.figure(figsize=(8,8),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



APPLY TF-IDF VECTORIZATION TECHNIQUE USING XGBOOST TO FIND BEST HYPERPAR

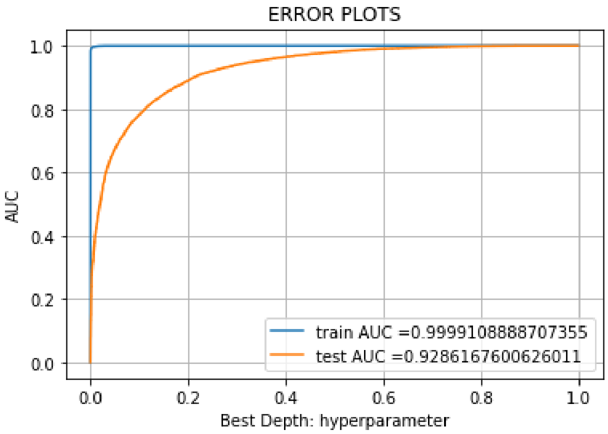
```
print ('-------------BEST DEPTH--------------')
result,best_depth,XGBoostClassiier=XGBoost_Classifier(X_Train_data_tfidf,Y_Train,X_CV_data_tfidf,Y_CV)
```

```
-------------BEST DEPTH---------------
0.9247632454806857
{'max_depth': 50, 'n_estimators': 100}
```



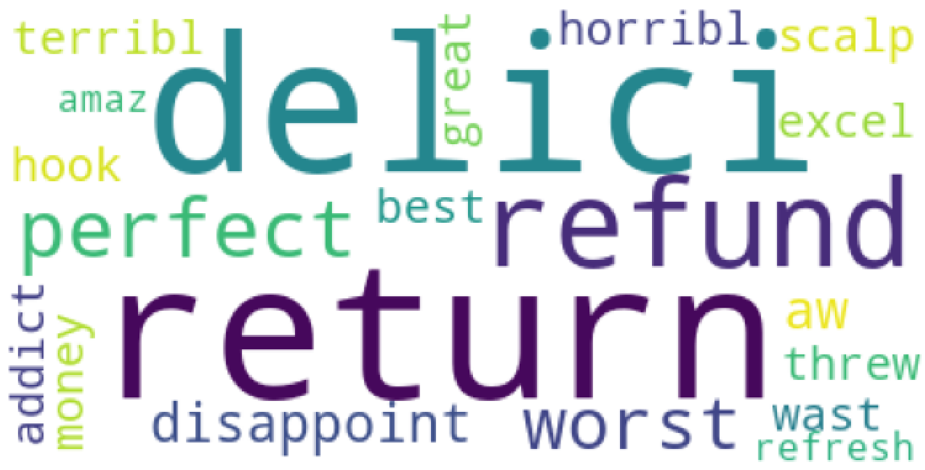
```
from sklearn.metrics import roc_curve, auc

GBDTClassifier= xgb.XGBClassifier(random_state=0,max_depth = 50,n_estimators = 100,booster='gbtree')
```

```
clf=GBDTClassifier.fit(X_Train_data_tfidf,Y_Train)
pred_test_data=GBDTClassifier.predict(X_Test_data_tfidf)
y_train_predicted_prob = GBDTClassifier.predict_proba(X_Train_data_tfidf)[:,1]
y_test_predicted_prob=GBDTClassifier.predict_proba(X_Test_data_tfidf)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



FIND THE IMPORTANT FEATURES AND PRINT THEM USING WORD CLOUD

```
feature_names = tfidf_vector.get_feature_names()
display_data=''
coef=GBDTClassifier.feature_importances_
features=np.argsort(coef)[::-1]

for i in features[0:20]:
  display_data+=feature_names[i]
  display_data+=' '

from wordcloud import WordCloud
wordcloud = WordCloud(background_color='white').generate(display_data)
plt.figure(figsize=(8,8),facecolor=None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

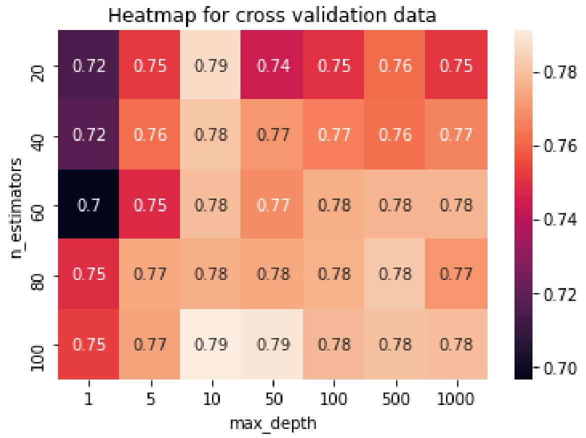


Avg Word2Vec Vectorization Technique using XGBoost Algorithm

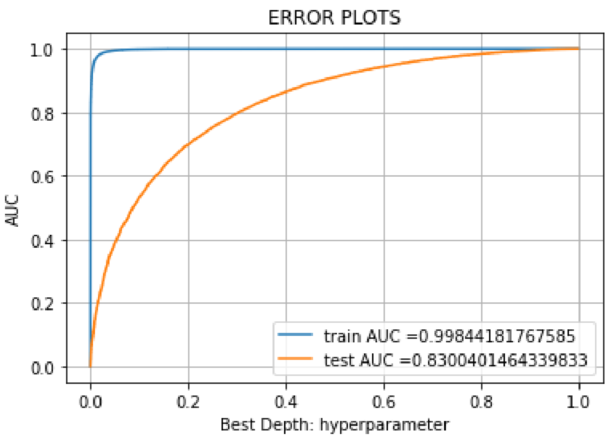
```
XGBoost_Train_AvgWord2Vec=np.array(train_vectors)
XGBoost_Test_AvgWord2Vec = np.array(test_vectors)
XGBoost_CV_AvgWord2Vec = np.array(cv_vectors)
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,XGBoostClassiier=XGBoost_Classifier(XGBoost_Train_AvgWord2Vec,Y_Train,XGBoost_CV_AvgWord2Vec,Y_C
```

```
-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
0.9186298659126494
{'max_depth': 10, 'n_estimators': 100}
```



```
from sklearn.metrics import roc_curve, auc

GBDTClassifier= xgb.XGBClassifier(random_state=0,max_depth = 10,n_estimators = 100,booster='gbtree')
clf=GBDTClassifier.fit(XGBoost_Train_AvgWord2Vec,Y_Train)
pred_test_data=GBDTClassifier.predict(XGBoost_Test_AvgWord2Vec)
y_train_predicted_prob = GBDTClassifier.predict_proba(XGBoost_Train_AvgWord2Vec)[:,1]
y_test_predicted_prob=GBDTClassifier.predict_proba(XGBoost_Test_AvgWord2Vec)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

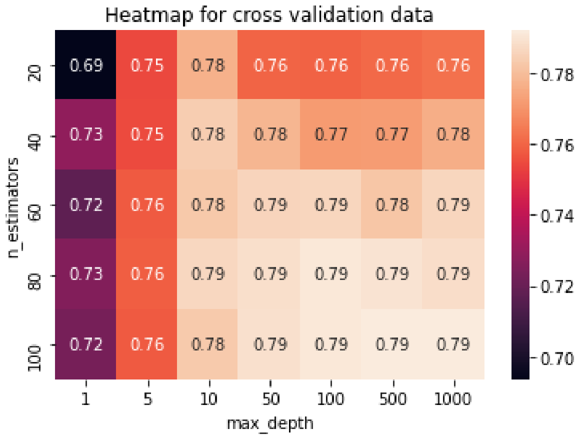


TF-IDF Word2Vec Vectorization Technique using XGBoost Algorithm

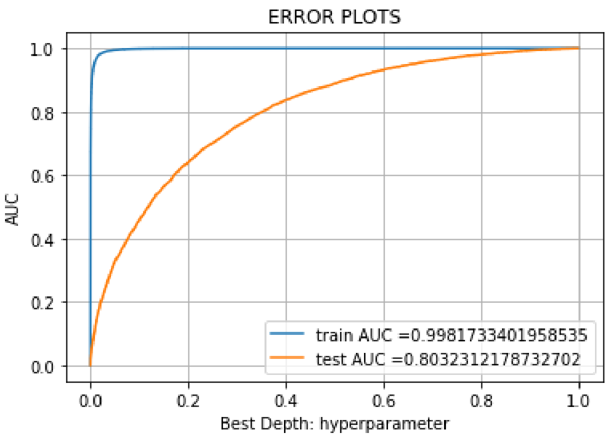
```
XGBoost_Train_TfidfWord2Vec=np.array(tfidf_sent_vectors_train)
XGBoost_Test_TfidfWord2Vec = np.array(tfidf_sent_vectors_test)
```

```
print ('-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS')
result,best_depth,XGBoostClassiier=XGBoost_Classifier(XGBoost_Train_TfidfWord2Vec,Y_Train,XGBoost_Test_TfidfWord2
```

```
-------------BEST DEPTH USING DIFFERENT RANGE OF ESTIMATORS
0.8986430183498193
{'max_depth': 10, 'n_estimators': 100}
```



```
from sklearn.metrics import roc_curve, auc

GBDTClassifier= xgb.XGBClassifier(random_state=0,max_depth = 10,n_estimators = 100,booster='gbtree')
clf=GBDTClassifier.fit(XGBoost_Train_TfidfWord2Vec,Y_Train)
pred_test_data=GBDTClassifier.predict(XGBoost_Test_TfidfWord2Vec)
y_train_predicted_prob = GBDTClassifier.predict_proba(XGBoost_Train_TfidfWord2Vec)[:,1]
y_test_predicted_prob=GBDTClassifier.predict_proba(XGBoost_Test_TfidfWord2Vec)[:,1]
train_fpr, train_tpr, train_thresholds=roc_curve(Y_Train,y_train_predicted_prob,pos_label='positive')
test_fpr, test_tpr, test_thresholds = roc_curve(Y_Test, y_test_predicted_prob,pos_label='positive')
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Best Depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



PRETTY TABLE FOR XGBOOST

```
from prettytable import PrettyTable

x= PrettyTable()
x.field_names = ["Vectorizer" , "Hyperparameter(Best Depth)", "n-estimators","AUC"]
x.add_row(["Bag Of Words",100,100,0.9286])
x.add_row(["Tf-Idf",50,100,0.9247])
x.add_row(["Avg Word2Vec",10,100,0.9186])
x.add_row(["Tf-Idf Word2Vec",10,100,0.8986])
print(x)
```

```
+-----------------+----------------------------+--------------+--------+
|    Vectorizer   | Hyperparameter(Best Depth) | n-estimators |  AUC   |
+-----------------+----------------------------+--------------+--------+
|   Bag Of Words  |            100             |     100      | 0.9286 |
|      Tf-Idf     |             50             |     100      | 0.9247 |
|   Avg Word2Vec  |             10             |     100      | 0.9186 |
| Tf-Idf Word2Vec |             10             |     100      | 0.8986 |
+-----------------+----------------------------+--------------+--------+
```

CONCLUSION

BY LOOKING AT THE TABLE FOR RANDOM FOREST AND XGBOOST , TF-IDF VECTORIZATION PERFOF WITH AUC OF 0.9247 HAVING BEST DEPTH AS 50

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