Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews

EDA: https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/

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).

[Q] How to determine if a review is positive or negative?

[Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and polarity (positivity/negativity) of a review.

[1]. Reading Data

[1.1] Loading 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 is easier to query the data and visualise the data eff

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

```
import warnings
warnings.filterwarnings("ignore")
```

```
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
# Tutorial about Python regular expressions: https://pymotw.com/2/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
```

```
# Run this cell to mount your Google Drive.
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=9473189

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

```
!ls /content/drive/My\ Drive/Colab\ Notebooks
```

```
 database.sqlite  'Logistic Regression.ipynb'   RF.ipynb
 DT.ipynb          NB.ipynb                     SVM.ipynb
 KNN.ipynb         Reviews.csv                  Untitled2.ipynb
```

```
data=pd.read_csv('/content/drive/My Drive/Colab Notebooks/Reviews.csv')
```

```
data.head()
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessD
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	

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

```
filter_data=pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 100000""",conn)
```

```
def partition (x):
  if x<3:
    return 0
  return 1
```

```
actualscore = filter_data['Score']
positivenegative = actualscore.map(partition)
filter_data['Score']= positivenegative
print('Nomber of data points in our data',filter_data.shape)
filter_data.head(5)
```

```
Nomber of data points in our data (100000, 10)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessD
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	

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

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

```
(80668, 7)
```

	UserId	ProductId	ProfileName	Time	Score	
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has rec
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is hor

```
display[display['UserId']=='AZY10LLTJ71NX']
```

	UserId	ProductId	ProfileName	Time	Score	
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	5	I was recc

```
display['COUNT(*)'].sum()
```

```
393063
```

[2] Exploratory Data Analysis

[2.1] Data Cleaning: Deduplication

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

```
(5, 10)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfulness
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	
				Geetha		

```
#Sorting data according to ProductId in ascending order
sorted_data=filter_data.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='quicks
```

```
#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='first', inpla
final.shape
```

```
(87775, 10)
```

```
#Checking to see how much % of data still remains
(final['Id'].size*1.0)/(filter_data['Id'].size*1.0)*100
```

```
87.775
```

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

display.head()
```

```
         Id      ProductId            UserId  ProfileName  HelpfulnessNumerator  Helpfulness
```

```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

```
      0   64422   B000MIDROQ   A161DK06JJMCYF      Stephens                    3
```

```
#Before starting the next phase of preprocessing lets see the number of entries left
print(final.shape)

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

```
(87773, 10)
1    73592
0    14181
Name: Score, dtype: int64
```

[3] Preprocessing

[3.1]. Preprocessing Review Text

```
# printing some random reviews
sent_0 = final['Text'].values[0]
print(sent_0)
print("="*50)

sent_1000 = final['Text'].values[1000]
print(sent_1000)
print("="*50)

sent_1500 = final['Text'].values[1500]
print(sent_1500)
print("="*50)

sent_4900 = final['Text'].values[4900]
print(sent_4900)
print("="*50)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are
==================================================
```

```
# remove urls from text python: https://stackoverflow.com/a/40823105/4084039
sent_0 = re.sub(r"http\S+", "", sent_0)
sent_1000 = re.sub(r"http\S+", "", sent_1000)
sent_150 = re.sub(r"http\S+", "", sent_1500)
sent_4900 = re.sub(r"http\S+", "", sent_4900)

print(sent_0)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore
```

```
# https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-tags-from-an-e
from bs4 import BeautifulSoup

soup = BeautifulSoup(sent_0, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1000, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1500, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_4900, 'lxml')
text = soup.get_text()
print(text)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are
```

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase


sent_1500 = decontracted(sent_1500)
print(sent_1500)
print("="*50)
```

```
was way to hot for my blood, took a bite and did a jig  lol
```

```
#remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
print(sent_0)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore
```

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
# <br /><br /> ==> after the above steps, we are getting "br br"
# we are including them into stop words list
# instead of <br /> if we have <br/> these tags would have revmoved in the 1st step

stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "yo
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himse
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'thes
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'w
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', '
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under',
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "do
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn'
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't
            'won', "won't", 'wouldn', "wouldn't"])
```

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentance in tqdm(final['Text'].values):
    sentance = re.sub(r"http\S+", "", sentance)
    sentance = BeautifulSoup(sentance, 'lxml').get_text()
    sentance = decontracted(sentance)
    sentance = re.sub("\S*\d\S*", "", sentance).strip()
    sentance = re.sub('[^A-Za-z]+', ' ', sentance)
    # https://gist.github.com/sebleier/554280
    sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwords)
    preprocessed_reviews.append(sentance.strip())
```

```
100%|██████████| 87773/87773 [00:34<00:00, 2556.12it/s]
```

```
preprocessed_reviews[1500]
```

```
'way hot blood took bite jig lol'
```

[5] Random Forests

[5.1] Applying RF

[5.1.1] Applying Random Forests on BOW

```
X=preprocessed_reviews
y=np.array(final['Score'])
```

```
from sklearn.model_selection import train_test_split
from sklearn import preprocessing

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

count_vect = CountVectorizer()
count_vect.fit(X_train) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train =count_vect.transform(X_train)
X_cv = count_vect.transform(X_cv)
X_test = count_vect.transform(X_test)

#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

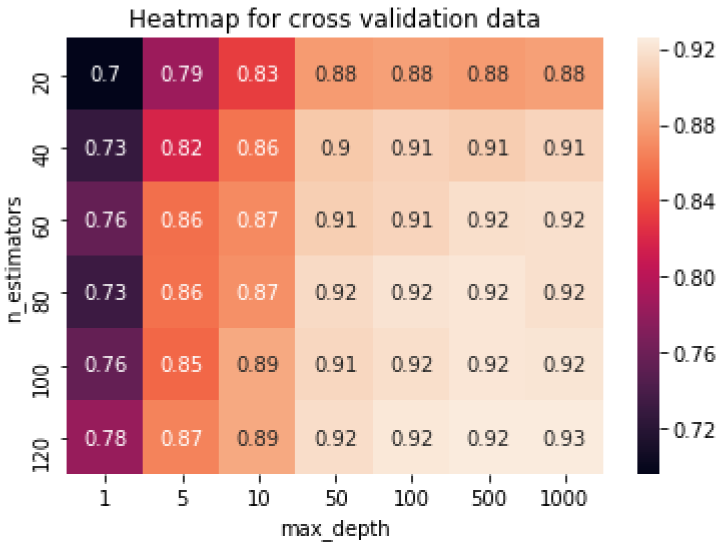
```
Train Data Size:  (56174, 44625)
Test Data Size:  (17555, 44625)
CV Data Size : (14044, 44625)
```

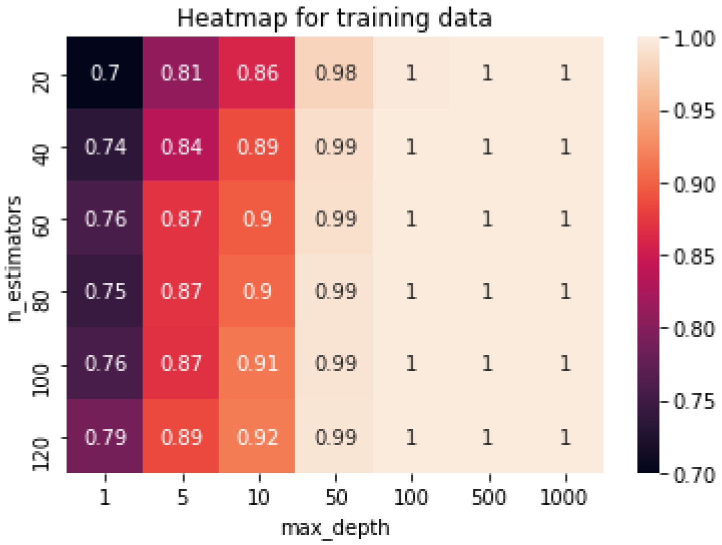
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV

dept = [1, 5, 10, 50, 100, 500, 1000]
n_estimators =  [20, 40, 60, 80, 100, 120]


param_grid={'n_estimators':n_estimators , 'max_depth':dept}
clf = RandomForestClassifier()
model = GridSearchCV(clf,param_grid,scoring='roc_auc',n_jobs=-1,cv=3)
model.fit(X_train,y_train)
print("optimal n_estimators",model.best_estimator_.n_estimators)
print("optimal max_depth",model.best_estimator_.max_depth)
```

```
optimal n_estimators 120
optimal max_depth 1000
```

```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
```

```
for n in n_estimators:
    for d in dept:
        clf = RandomForestClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```

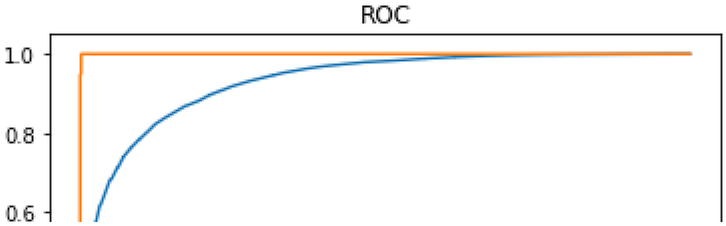




```
optimal_n_estimators = model.best_estimator_.n_estimators
optimal_max_depth = model.best_estimator_.max_depth
```

```
1000
```

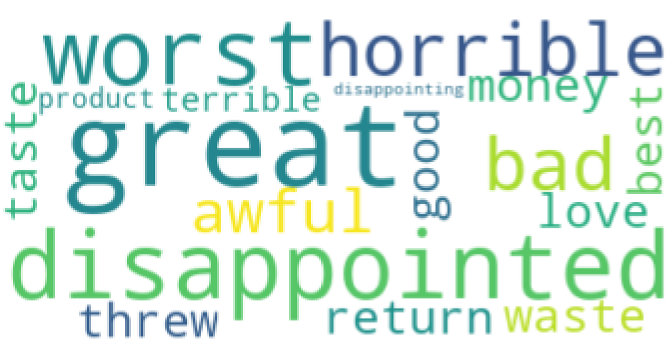
```
#training our model for max_depth=1000,n_estimators = 120
clf = RandomForestClassifier(max_depth = optimal_max_depth,n_estimators = optimal_n_estimators)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
results=pd.DataFrame(columns=['Featuraization', 'Classifier' ,'max_depth','n_estimators', 'Train-AUC
new = ['BOW','RandomForestClassifier',1000,120,0.9999,0.9300]
results.loc[0] = new
```

[5.1.2] Wordcloud of top 20 important features from SET 1

```
# worldcloud of top 20 important features
all_features = count_vect.get_feature_names()
data = ''
feat = clf.feature_importances_
features = np.argsort(feat)[::-1]
for i in features[0:20]:
    data += all_features[i]
    data += ' '


from wordcloud import WordCloud
wordcloud = WordCloud(background_color="white").generate(data)

# Display the generated image:
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



[5.1.3] Applying Random Forests on TFIDF, SET 2

```
X=preprocessed_reviews
y=np.array(final['Score'])

from sklearn.model_selection import train_test_split
from sklearn import preprocessing

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
```

```
tf_idf_vect.fit(X_train) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train = tf_idf_vect.transform(X_train)
X_cv = tf_idf_vect.transform(X_cv)
X_test = tf_idf_vect.transform(X_test)

#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

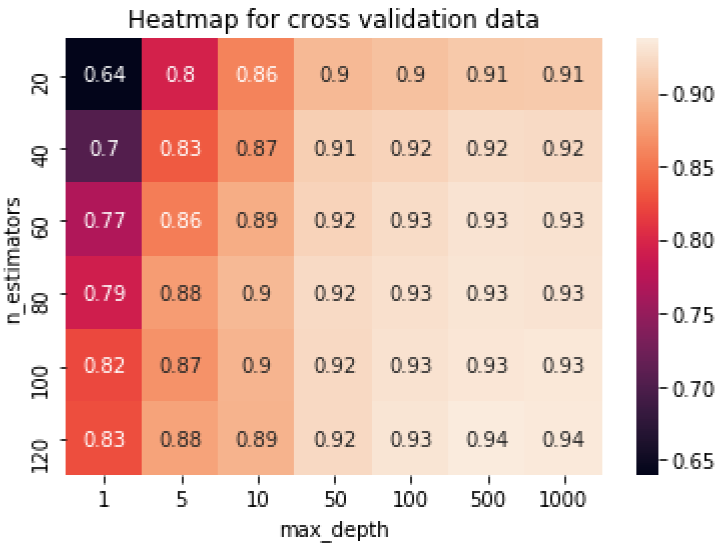
```
Train Data Size:  (56174, 33248)
Test Data Size:  (17555, 33248)
CV Data Size : (14044, 33248)
```

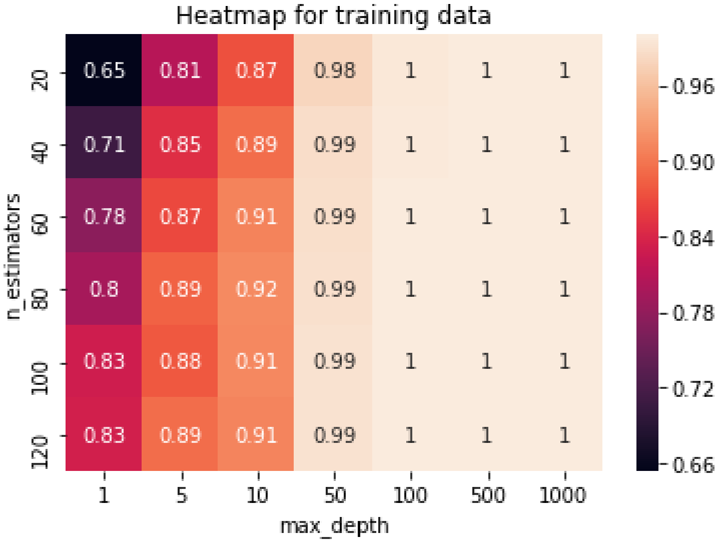
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV

dept = [1, 5, 10, 50, 100, 500, 1000]
n_estimators =  [20, 40, 60, 80, 100, 120]


param_grid={'n_estimators':n_estimators , 'max_depth':dept}
clf = RandomForestClassifier()
model = GridSearchCV(clf,param_grid,scoring='roc_auc',n_jobs=-1,cv=3)
model.fit(X_train,y_train)
print("optimal n_estimators",model.best_estimator_.n_estimators)
print("optimal max_depth",model.best_estimator_.max_depth)

optimal_n_estimators = model.best_estimator_.n_estimators
optimal_max_depth = model.best_estimator_.max_depth
```

```
optimal n_estimators 120
optimal max_depth 500
```

```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = RandomForestClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
```

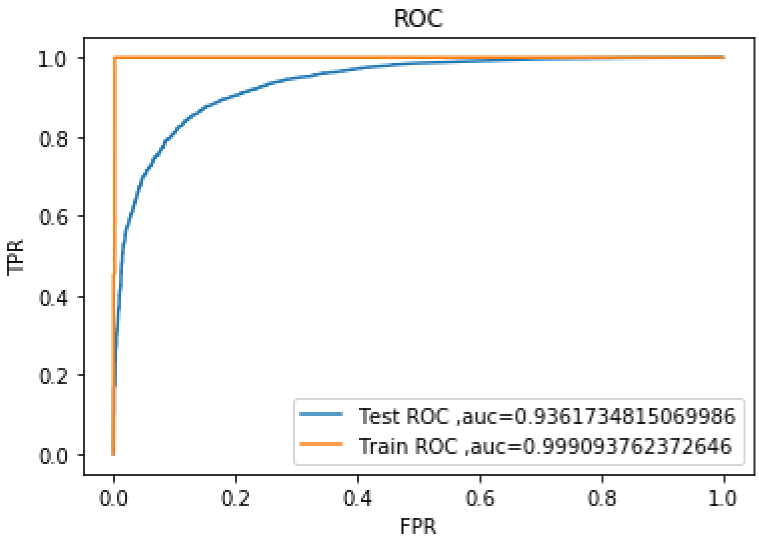
```
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```



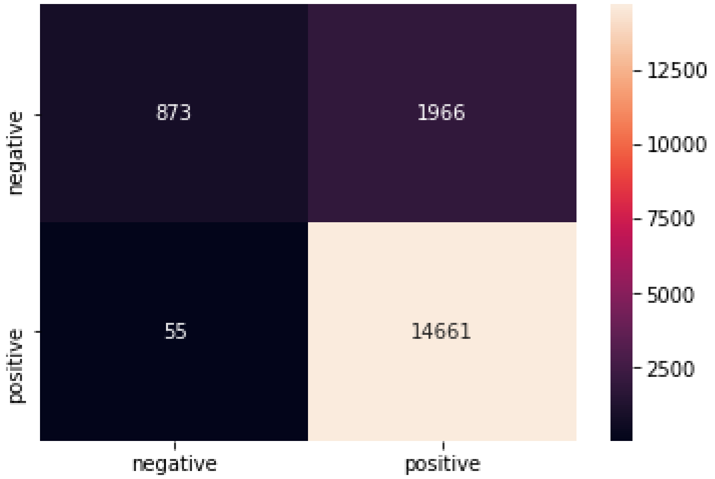


```
#training our model for max_depth=50,min_samples_split=500
clf = RandomForestClassifier(max_depth = optimal_max_depth,n_estimators = optimal_n_estimators)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()
```

```
print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
AUC on Test data is 0.9361734815069986
AUC on Train data is 0.999093762372646
---------------------------
```

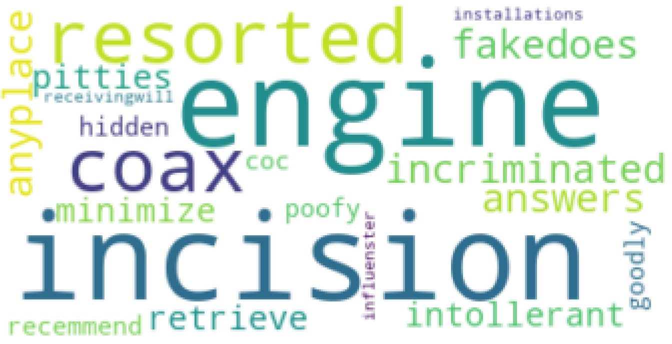


```
new = ['tf_idf','RandomForestClassifier',500,120,0.9990,0.9361]
results.loc[1] = new
```

[5.1.4] Wordcloud of top 20 important features from SET 2

```
# worldcloud of top 20 important features
all_features = count_vect.get_feature_names()
data = ''
```

```
feat = clf.feature_importances_
features = np.argsort(feat)[::-1]
for i in features[0:20]:
    data += all_features[i]
    data += ' '


from wordcloud import WordCloud
wordcloud = WordCloud(background_color="white").generate(data)

# Display the generated image:
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```



[5.1.5] Applying Random Forests on AVG W2V, SET 3

```
X=preprocessed_reviews
y=np.array(final['Score'])


#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

list_of_sentance_train=[]
for sentance in X_train:
    list_of_sentance_train.append(sentance.split())
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
sent_vectors_train = [];
for sent in tqdm(list_of_sentance_train):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
print(len(sent_vectors_train))
print(len(sent_vectors_train[0]))
```

```
100%|██████████| 56174/56174 [01:44<00:00, 539.77it/s]56174
50
```

```
#for cross validation we can use same w2v models and w2v words
list_of_sentance_cv=[]
for sentance in X_cv:
    list_of_sentance_cv.append(sentance.split())
sent_vectors_cv = [];
for sent in tqdm(list_of_sentance_cv):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_cv.append(sent_vec)
print(len(sent_vectors_cv))
print(len(sent_vectors_cv[0]))
```

```
100%|██████████| 14044/14044 [00:27<00:00, 515.51it/s]14044
50
```

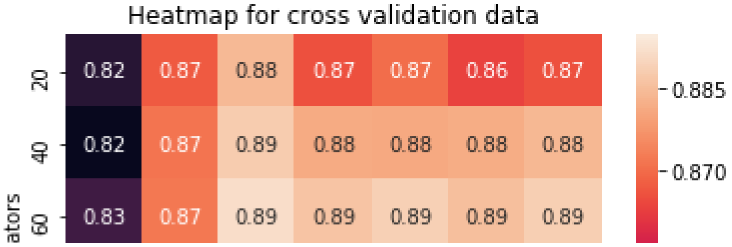
```
#for test data
list_of_sentance_test=[]
for sentance in X_test:
    list_of_sentance_test.append(sentance.split())
sent_vectors_test = [];
for sent in tqdm(list_of_sentance_test):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_test.append(sent_vec)
print(len(sent_vectors_test))
print(len(sent_vectors_test[0]))
```

```
100%|██████████| 17555/17555 [00:32<00:00, 536.21it/s]17555
50
```

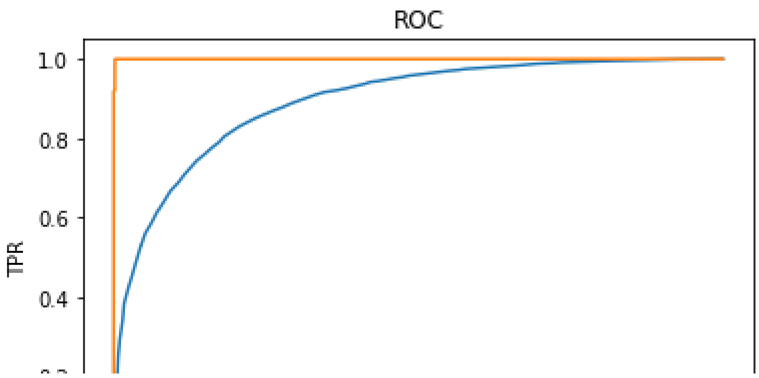
```
X_train = sent_vectors_train
X_cv = sent_vectors_cv
X_test = sent_vectors_test

dept = [1, 5, 10, 50, 100, 500, 1000]
n_estimators =  [20, 40, 60, 80, 100, 120]


param_grid={'n_estimators':n_estimators , 'max_depth':dept}
clf = RandomForestClassifier()
model = GridSearchCV(clf,param_grid,scoring='roc_auc',n_jobs=-1,cv=3)
model.fit(X_train,y_train)
print("optimal n_estimators",model.best_estimator_.n_estimators)
print("optimal max_depth",model.best_estimator_.max_depth)

optimal_n_estimators = model.best_estimator_.n_estimators
optimal_max_depth = model.best_estimator_.max_depth
```

```
optimal n_estimators 120
optimal max_depth 100
```

```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = RandomForestClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```



```
clf = RandomForestClassifier(max_depth = optimal_max_depth,n_estimators = optimal_n_estimators)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
new = ['AVG W2V','RandomForestClassifier',100,120,0.9998,0.8928]
results.loc[2] = new
```

[5.1.6] Applying Random Forests on TFIDF W2V, SET 4

```
    AUC on Train data is 0.99984953798294994
```

```
X=preprocessed_reviews
y=np.array(final['Score'])

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)


list_of_sentance_train=[]
for sentance in X_train:
    list_of_sentance_train.append(sentance.split())
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2),min_df=10, max_features=500)

tf_idf_matrix=tf_idf_vect.fit_transform(X_train)


tfidf_feat = tf_idf_vect.get_feature_names()
dictionary = dict(zip(tf_idf_vect.get_feature_names(), list(tf_idf_vect.idf_)))

#for train data

tfidf_sent_vectors_train = [];
row=0;
for sent in tqdm(list_of_sentance_train):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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%|██████████| 56174/56174 [02:18<00:00, 404.22it/s]
```

```
#for cross validation data and test we will use same words and models of train
list_of_sentance_cv=[]
for sentance in X_cv:
    list_of_sentance_cv.append(sentance.split())
tfidf_sent_vectors_cv = [];
row=0;
for sent in tqdm(list_of_sentance_cv):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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_cv.append(sent_vec)
    row += 1
```

```
100%|██████████| 14044/14044 [00:34<00:00, 401.35it/s]
```

```
#for test data
list_of_sentance_test=[]
for sentance in X_test:
    list_of_sentance_test.append(sentance.split())
tfidf_sent_vectors_test = [];
row=0;
for sent in tqdm(list_of_sentance_test):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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%|██████████| 17555/17555 [00:42<00:00, 412.62it/s]
```

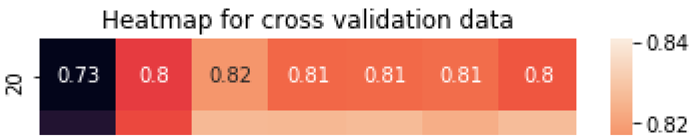
```
X_train = tfidf_sent_vectors_train
X_cv = tfidf_sent_vectors_cv
X_test = tfidf_sent_vectors_test
```

```
dept = [1, 5, 10, 50, 100, 500, 1000]
n_estimators =  [20, 40, 60, 80, 100, 120]
```

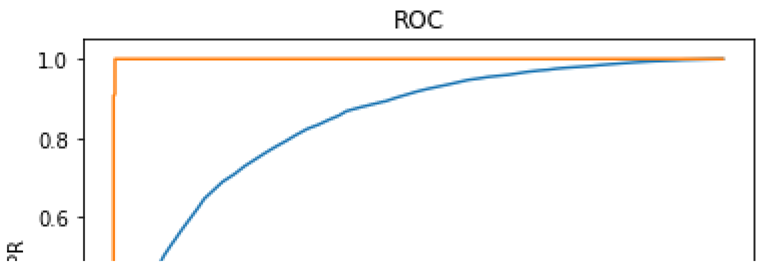
```
param_grid={'n_estimators':n_estimators , 'max_depth':dept}
clf = RandomForestClassifier()
model = GridSearchCV(clf,param_grid,scoring='roc_auc',n_jobs=-1,cv=3)
model.fit(X_train,y_train)
print("optimal n_estimators",model.best_estimator_.n_estimators)
print("optimal max_depth",model.best_estimator_.max_depth)

optimal_n_estimators = model.best_estimator_.n_estimators
optimal_max_depth = model.best_estimator_.max_depth
```

```
optimal n_estimators 120
optimal max depth 100
```

```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = RandomForestClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```



```
#training our model for max_depth=50,min_samples_split=500
clf = RandomForestClassifier(max_depth = optimal_max_depth,n_estimators = optimal_n_estimators)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
new = ['tf_idf w2v','RandomForestClassifier',100,120,0.9997,0.8381]
results.loc[3] = new
```

[5.2] Applying GBDT using XGBOOST

[5.2.1] Applying XGBOOST on BOW, SET 1

```
    --------------------------

X=preprocessed_reviews
y=np.array(final['Score'])
X = X[0:30000]
y = y[0:30000]
```

```
from sklearn.model_selection import train_test_split
from sklearn import preprocessing

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

count_vect = CountVectorizer()
count_vect.fit(X_train) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train =count_vect.transform(X_train)
X_cv = count_vect.transform(X_cv)
X_test = count_vect.transform(X_test)

#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

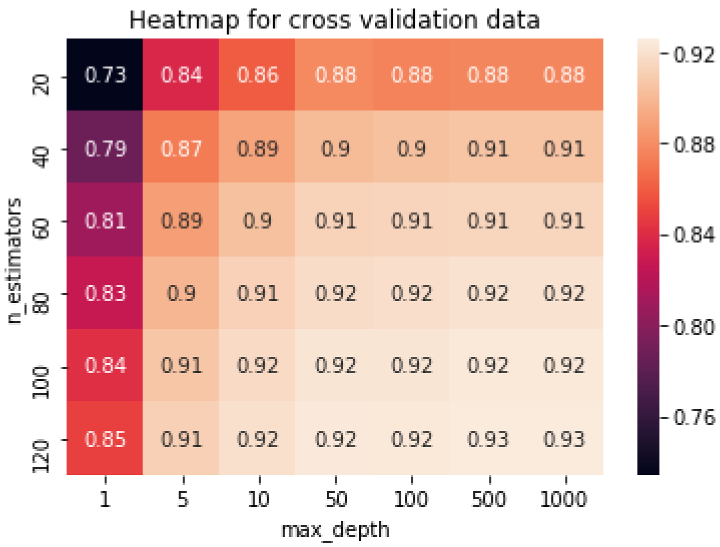
```
Train Data Size:  (19200, 26398)
Test Data Size:  (6000, 26398)
CV Data Size : (4800, 26398)
```

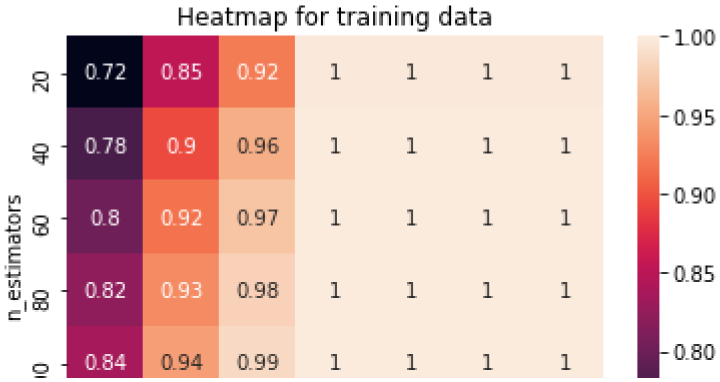
```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV

dept = [1, 5, 10, 50, 100, 500, 1000]
n_estimators =  [20, 40, 60, 80, 100, 120]
```

```
param_grid={'n_estimators':n_estimators , 'max_depth':dept}
clf = XGBClassifier()
model = GridSearchCV(clf,param_grid,scoring='roc_auc',n_jobs=-1,cv=3)
model.fit(X_train,y_train)
print("optimal n_estimators",model.best_estimator_.n_estimators)
print("optimal max_depth",model.best_estimator_.max_depth)

optimal_n_estimators = model.best_estimator_.n_estimators
optimal_max_depth = model.best_estimator_.max_depth
```

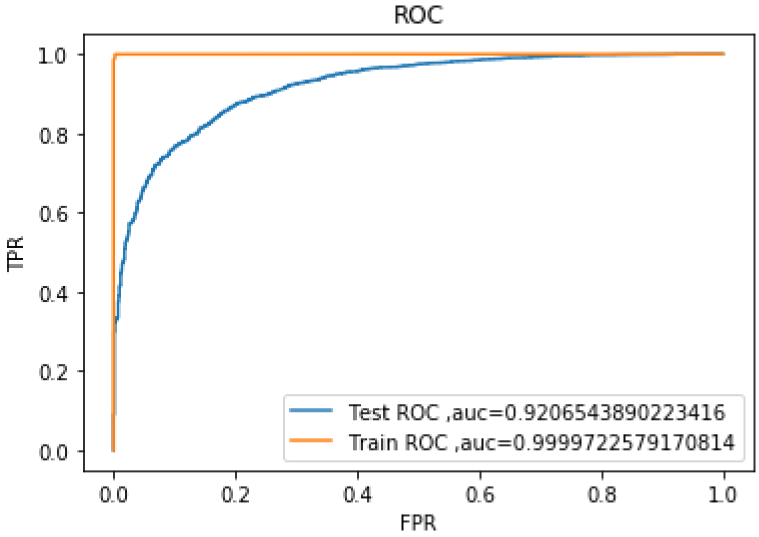
```
optimal n_estimators 120
optimal max_depth 50
```

```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = XGBClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))
optimal_depth=Y[cv_auc.index(max(cv_auc))]
optimal_n_estimator=X[cv_auc.index(max(cv_auc))]

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```

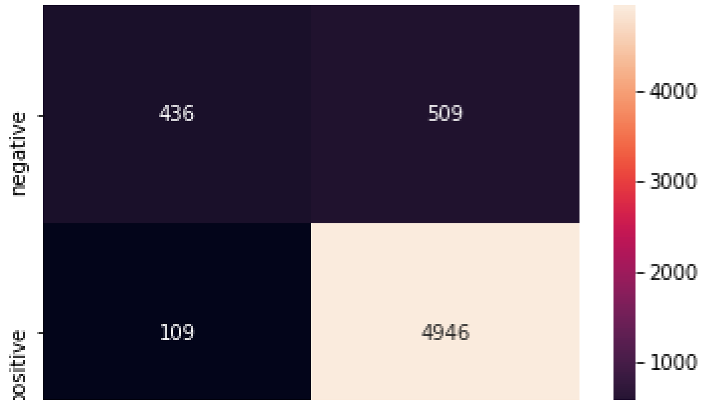




```
#training our model for max_depth=50,min_samples_split=500
clf = XGBClassifier(max_depth = 50,n_estimators = 120)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
AUC on Test data is 0.9206543890223416
AUC on Train data is 0.9999722579170814
-----------------------------
```



```
results_1=pd.DataFrame(columns=['Featuraization', 'Classifier' ,'max_depth','n_estimators', 'Train-A
new = ['BOW','XGBClassifier',50,120,0.9999,0.9206]
results_1.loc[0] = new
```

[5.2.2] Applying XGBOOST on TFIDF, SET 2

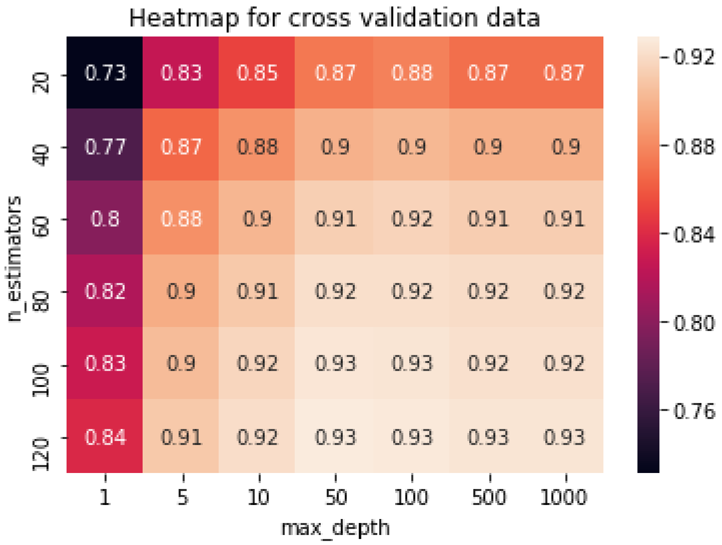
```
X=preprocessed_reviews
y=np.array(final['Score'])
X = X[0:30000]
y = y[0:30000]

from sklearn.model_selection import train_test_split
from sklearn import preprocessing

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
tf_idf_vect.fit(X_train) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train = tf_idf_vect.transform(X_train)
X_cv = tf_idf_vect.transform(X_cv)
X_test = tf_idf_vect.transform(X_test)
```

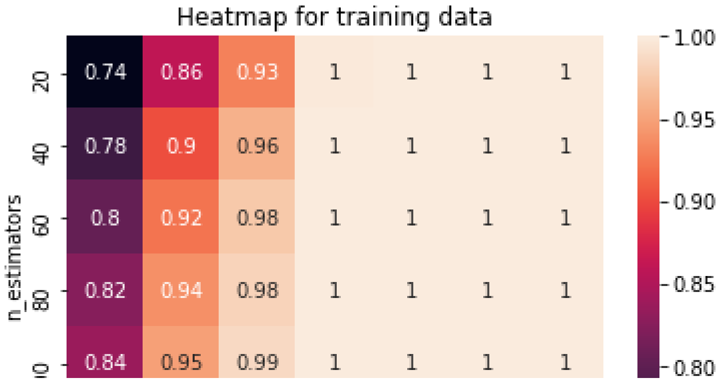
```
#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

```
Train Data Size:  (19200, 11062)
Test Data Size:  (6000, 11062)
CV Data Size : (4800, 11062)
```

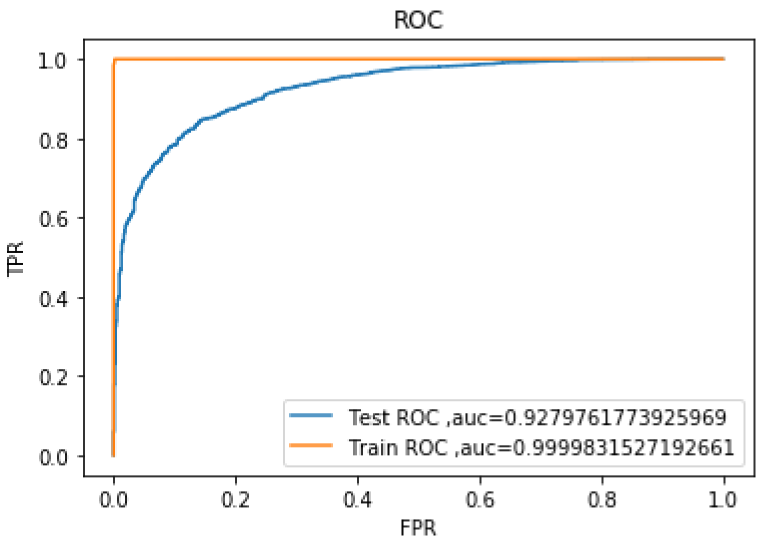
```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = XGBClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))
optimal_depth=Y[cv_auc.index(max(cv_auc))]
optimal_n_estimator=X[cv_auc.index(max(cv_auc))]

print('optimal depth : ',optimal_depth)
print('optimal n_estimator : ',optimal_n_estimator)


#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```

```
optimal depth :  50
optimal n_estimator :  120
```

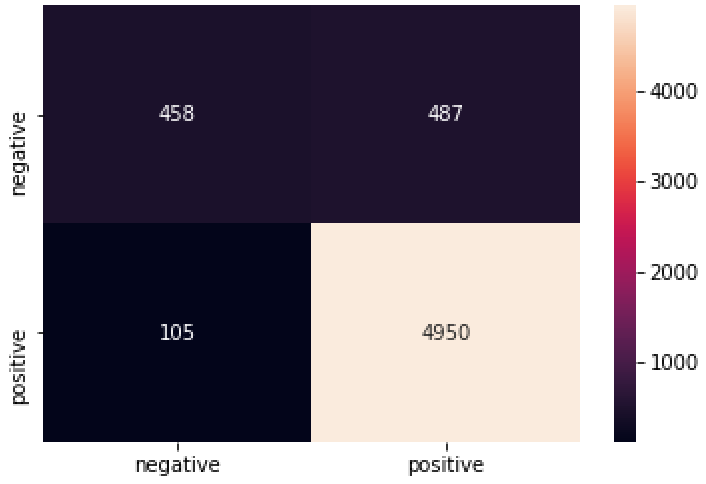




```
#training our model for max_depth=50,min_samples_split=500
clf = XGBClassifier(max_depth = optimal_depth,n_estimators = optimal_n_estimator)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
AUC on Test data is 0.9279761773925969
AUC on Train data is 0.9999831527192661
---------------------------
```



```
new = ['tf_idf','XGBClassifier',50,120,0.9999,0.9279]
results_1.loc[1] = new
```

[5.2.3] Applying XGBOOST on AVG W2V, SET 3

```
X=preprocessed_reviews
y=np.array(final['Score'])
X = X[0:30000]
y = y[0:30000]


#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)

list_of_sentance_train=[]
for sentance in X_train:
    list_of_sentance_train.append(sentance.split())
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
sent_vectors_train = [];
for sent in tqdm(list_of_sentance_train):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
print(len(sent_vectors_train))
print(len(sent_vectors_train[0]))
```

```
100%|██████████| 19200/19200 [00:30<00:00, 636.06it/s]19200
50
```

```
#for cross validation we can use same w2v models and w2v words
list_of_sentance_cv=[]
for sentance in X_cv:
    list_of_sentance_cv.append(sentance.split())
sent_vectors_cv = [];
for sent in tqdm(list_of_sentance_cv):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_cv.append(sent_vec)
print(len(sent_vectors_cv))
print(len(sent_vectors_cv[0]))
```

```
100%|██████████| 4800/4800 [00:07<00:00, 630.71it/s]4800
50
```

```
#for test data
list_of_sentance_test=[]
for sentance in X_test:
    list_of_sentance_test.append(sentance.split())
sent_vectors_test = [];
for sent in tqdm(list_of_sentance_test):
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_test.append(sent_vec)
print(len(sent_vectors_test))
print(len(sent_vectors_test[0]))
```

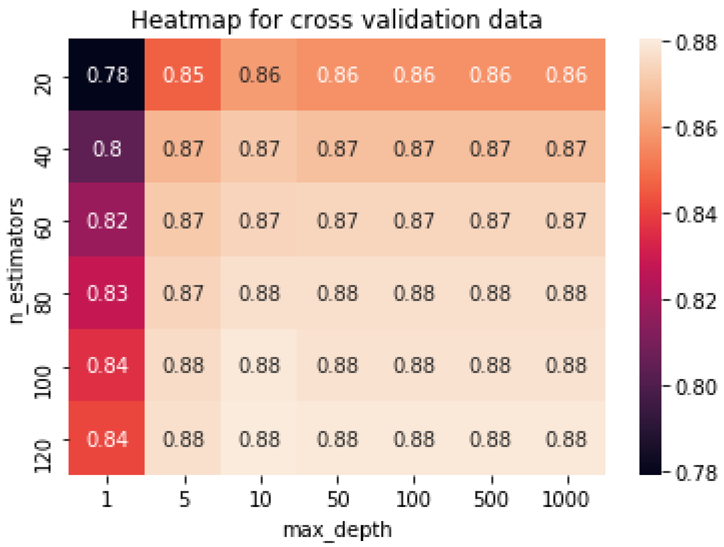
```
100%|██████████| 6000/6000 [00:09<00:00, 629.20it/s]6000
50
```

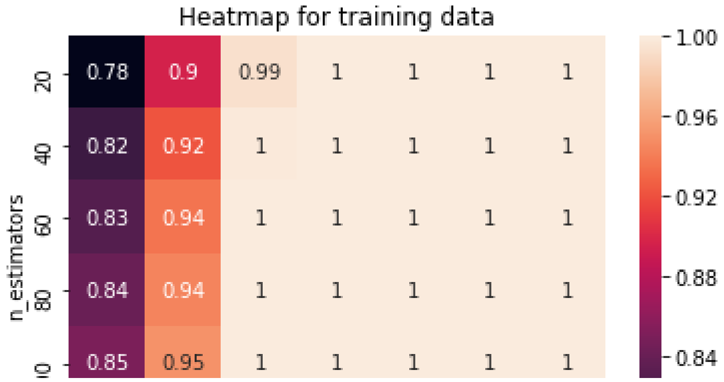
```
X_train = sent_vectors_train
X_cv = sent_vectors_cv
X_test = sent_vectors_test

#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

```
Train Data Size:  (19200, 50)
Test Data Size:  (6000, 50)
CV Data Size : (4800, 50)
```

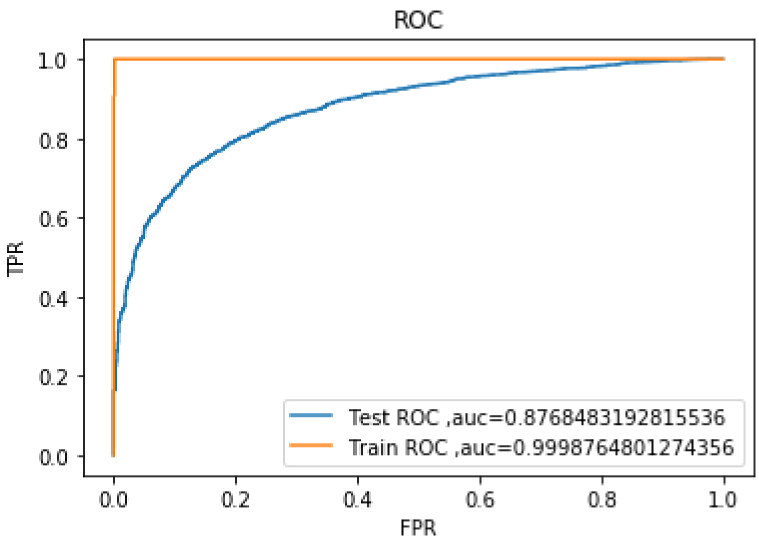
```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = XGBClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))
optimal_depth=Y[cv_auc.index(max(cv_auc))]
optimal_n_estimator=X[cv_auc.index(max(cv_auc))]

print('optimal depth : ',optimal_depth)
print('optimal n_estimator : ',optimal_n_estimator)


#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```

```
optimal depth :  10
optimal n_estimator :  120
```

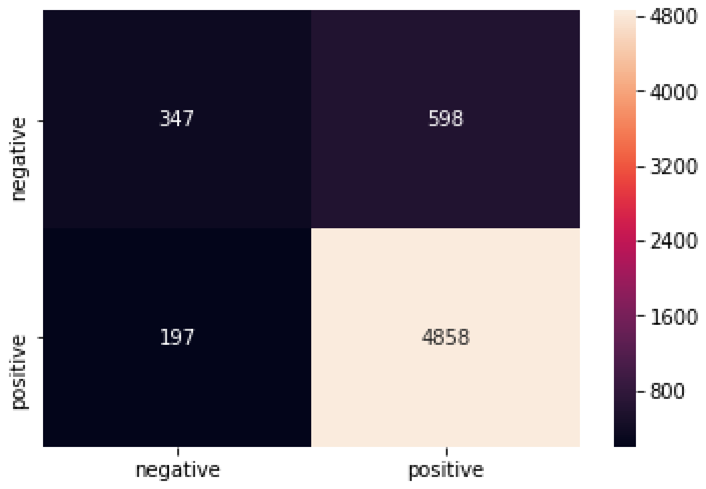




```
#training our model for max_depth=50,min_samples_split=500
clf = XGBClassifier(max_depth = optimal_depth,n_estimators = optimal_n_estimator)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
AUC on Test data is 0.8768483192815536
AUC on Train data is 0.9998764801274356
---------------------------
```



```
new = ['AVG W2V','XGBClassifier',10,120,0.9998,0.8768]
results_1.loc[2] = new
```

[5.2.4] Applying XGBOOST on TFIDF W2V, SET 4

```
X=preprocessed_reviews
y=np.array(final['Score'])
X = X[0:30000]
y = y[0:30000]

#Breaking into Train and test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2)


list_of_sentance_train=[]
for sentance in X_train:
    list_of_sentance_train.append(sentance.split())
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2),min_df=10, max_features=500)

tf_idf_matrix=tf_idf_vect.fit_transform(X_train)
```

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

#for train data

tfidf_sent_vectors_train = [];
row=0;
for sent in tqdm(list_of_sentance_train):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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%|██████████| 19200/19200 [00:41<00:00, 461.50it/s]
```

```
#for cross validation data and test we will use same words and models of train
list_of_sentance_cv=[]
for sentance in X_cv:
    list_of_sentance_cv.append(sentance.split())
tfidf_sent_vectors_cv = [];
row=0;
for sent in tqdm(list_of_sentance_cv):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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_cv.append(sent_vec)
    row += 1
```

```
100%|██████████| 4800/4800 [00:11<00:00, 435.45it/s]
```

```
#for test data
list_of_sentance_test=[]
for sentance in X_test:
    list_of_sentance_test.append(sentance.split())
tfidf_sent_vectors_test = [];
row=0;
for sent in tqdm(list_of_sentance_test):
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[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
```

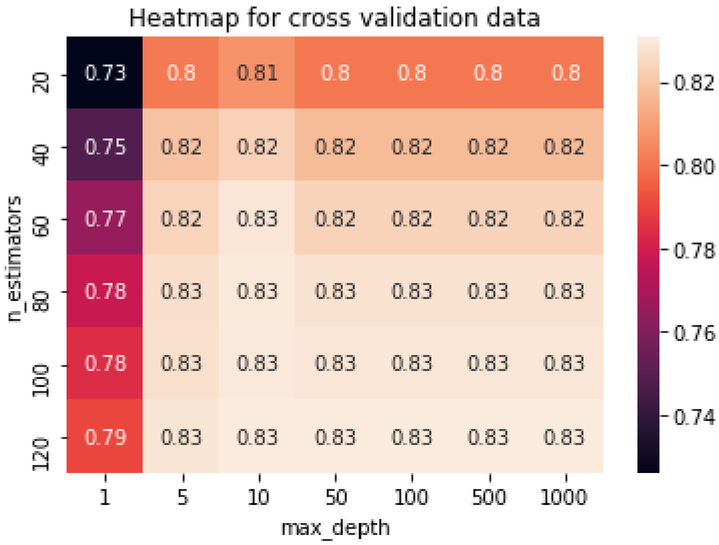
```
100%|██████████| 6000/6000 [00:13<00:00, 440.83it/s]
```

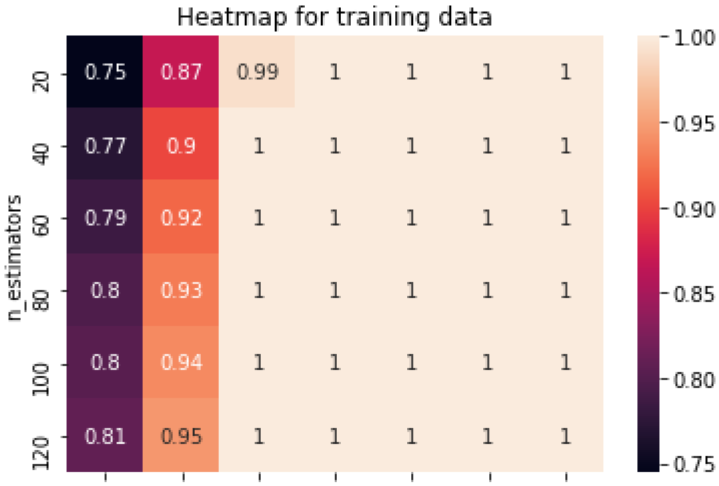
```
X_train = tfidf_sent_vectors_train
X_cv = tfidf_sent_vectors_cv
X_test = tfidf_sent_vectors_test

#Normalize Data
X_train = preprocessing.normalize(X_train)
print("Train Data Size: ",X_train.shape)

#Normalize Data
X_test = preprocessing.normalize(X_test)
print("Test Data Size: ",X_test.shape)

X_cv = preprocessing.normalize(X_cv)
print("CV Data Size :", X_cv.shape)
```

```
Train Data Size:  (19200, 50)
Test Data Size:  (6000, 50)
CV Data Size : (4800, 50)
```

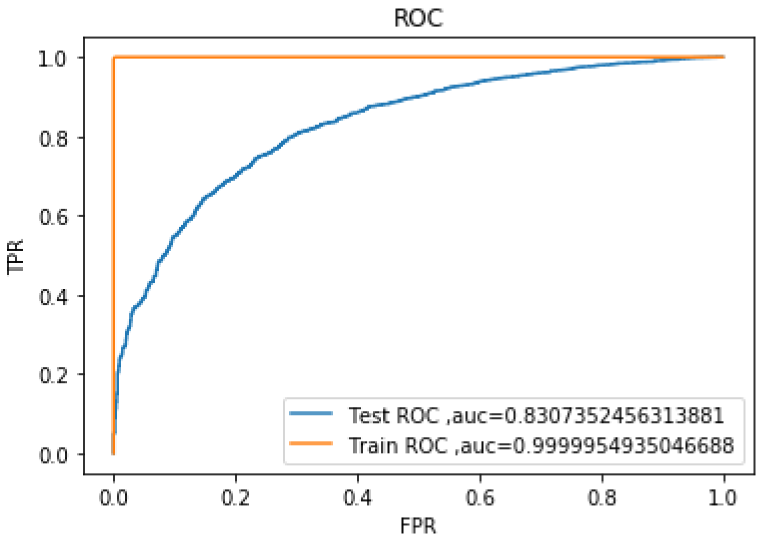
```
import seaborn as sns
X = []
Y = []
cv_auc = []
train_auc = []
for n in n_estimators:
    for d in dept:
        clf = XGBClassifier(max_depth = d,n_estimators = n)
        clf.fit(X_train,y_train)
        pred_cv = clf.predict_proba(X_cv)[:,1]
        pred_train = clf.predict_proba(X_train)[:,1]
        X.append(n)
        Y.append(d)
        cv_auc.append(roc_auc_score(y_cv,pred_cv))
        train_auc.append(roc_auc_score(y_train,pred_train))

optimal_depth=Y[cv_auc.index(max(cv_auc))]
optimal_n_estimator=X[cv_auc.index(max(cv_auc))]

print('optimal depth : ',optimal_depth)
print('optimal n_estimator : ',optimal_n_estimator)

#Heatmap for cross validation data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': cv_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for cross validation data')
plt.show()

#Heatmap for training data
data = pd.DataFrame({'n_estimators': X, 'max_depth': Y, 'AUC': train_auc})
data_pivoted = data.pivot("n_estimators", "max_depth", "AUC")
ax = sns.heatmap(data_pivoted,annot=True)
plt.title('Heatmap for training data')
plt.show()
```

```
optimal depth :  50
optimal n_estimator :  120
```

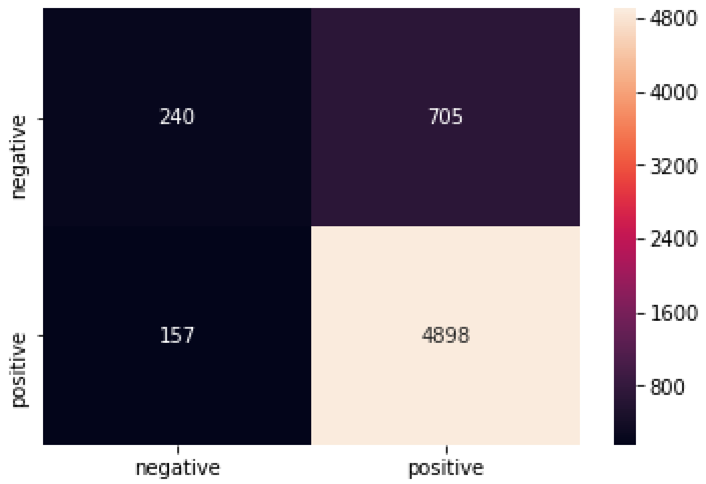




```
#training our model for max_depth=50,min_samples_split=500
clf = XGBClassifier(max_depth = optimal_depth,n_estimators = optimal_n_estimator)
clf.fit(X_train,y_train)
pred_test =clf.predict_proba(X_test)[:,1]
fpr1, tpr1, thresholds1 = metrics.roc_curve(y_test, pred_test)
pred_train = clf.predict_proba(X_train)[:,1]
fpr2,tpr2,thresholds2=metrics.roc_curve(y_train,pred_train)

#ROC curve
x = plt.subplot( )
x.plot(fpr1, tpr1, label='Test ROC ,auc='+str(roc_auc_score(y_test,pred_test)))
x.plot(fpr2, tpr2, label='Train ROC ,auc='+str(roc_auc_score(y_train,pred_train)))
plt.title('ROC')
plt.xlabel('FPR')
plt.ylabel('TPR')
x.legend()
plt.show()

print("AUC on Test data is " +str(roc_auc_score(y_test,pred_test)))
print("AUC on Train data is " +str(roc_auc_score(y_train,pred_train)))

print("---------------------------")

# Code for drawing seaborn heatmaps
class_names = ['negative','positive']
df_heatmap = pd.DataFrame(confusion_matrix(y_test, pred_test.round()), index=class_names, columns=cl
fig = plt.figure( )
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
```



```
AUC on Test data is 0.8307352456313881
AUC on Train data is 0.9999954935046688
---------------------------
```



```
new = ['TFIDF W2V','XGBClassifier',50,120,0.9998,0.8307]
results_1.loc[3] = new
```

Performance Table

```
results
```

	Featuraization	Classifier	max_depth	n_estimators	Train-AUC	Test-AUC
0	BOW	RandomForestClassifier	1000	120	0.9999	0.9300

```
results_1
```

	Featuraization	Classifier	max_depth	n_estimators	Train-AUC	Test-AUC
0	BOW	XGBClassifier	50	120	0.9999	0.9206
1	tf_idf	XGBClassifier	50	120	0.9999	0.9279
2	AVG W2V	XGBClassifier	10	120	0.9998	0.8768
3	TFIDF W2V	XGBClassifier	50	120	0.9998	0.8307

[6] Conclusions

1. Random Forest is one of the best algorithm
2. Random Forest and XG Boost works very well if we have small amount data
3. XBGClassifier time complexity is very high compared to Random forest classifier
4. Random Forest classifier gave best results AUC score = 0.9361 with tf_idf featuraization , max_depth = 500, a