Amazon Fine Food Reviews Analysis

[1]. Reading Data

[1.1] Loading the data

```
%matplotlib inline
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')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.moun
```

```
!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
```

```
import pandas as pd
```

```
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	

```
import sqlite3
```

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

```
filter_data=pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 """,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 (525814, 10)
```

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessD
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	

```
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
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recu
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horri

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

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

```
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 time in ascending order
sorted_data=filter_data.sort_values('Time', axis=0, ascending=True, inplace=False, kind='quicksort',
```

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

```
(364173, 10)
```

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

```
69.25890143662969
```

```
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()
```

```
(364171, 10)
1    307061
0     57110
Name: Score, dtype: int64
```

[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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're drivi
==================================================
I can't believe that you can actually buy Coke products on Amazon!<br /><br />If I was g
==================================================
I bought some of this tea when I was in Seattle and I have been dying to get more.  It r
==================================================
Needed these for several different dishes.  Very nice product.  I would order these agai
==================================================
```

```
# 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)
```

```
# 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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're drivi
==================================================
I can't believe that you can actually buy Coke products on Amazon!If I was going to orde
==================================================
I bought some of this tea when I was in Seattle and I have been dying to get more.  It r
==================================================
Needed these for several different dishes.  Very nice product.  I would order these agai
```

```
# 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)
```

```
I bought some of this tea when I was in Seattle and I have been dying to get more.  It r
==================================================
```

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

```
print(sent_0)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're drivi
```

```
# 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%|██████████| 364171/364171 [02:24<00:00, 2512.75it/s]
```

```
preprocessed_reviews[1500]
```

```
'bought tea seattle dying get really best tea ever great hot cold'
```

[4] Featurization

[4.1] BAG OF WORDS

```
#BoW
count_vect = CountVectorizer() #in scikit-learn
count_vect.fit(preprocessed_reviews)
print("some feature names ", count_vect.get_feature_names()[:10])
print('='*50)
```

```
final_counts = count_vect.transform(preprocessed_reviews)
print("the type of count vectorizer ",type(final_counts))
print("the shape of out text BOW vectorizer ",final_counts.get_shape())
print("the number of unique words ", final_counts.get_shape()[1])
```

```
some feature names  ['aa', 'aaa', 'aaaa', 'aaaaa', 'aaaaaa', 'aaaaaaaaaaa', 'aaaaaaaaaaa
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (364171, 116756)
the number of unique words  116756
```

[4.3] TF-IDF

```
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
tf_idf_vect.fit(preprocessed_reviews)
print("some sample features(unique words in the corpus)",tf_idf_vect.get_feature_names()[0:10])
print('='*50)

final_tf_idf = tf_idf_vect.transform(preprocessed_reviews)
print("the type of count vectorizer ",type(final_tf_idf))
print("the shape of out text TFIDF vectorizer ",final_tf_idf.get_shape())
print("the number of unique words including both unigrams and bigrams ", final_tf_idf.get_shape()[1]
```

```
some sample features(unique words in the corpus) ['aa', 'aaa', 'aaaaa', 'aaah', 'aafco',
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (364171, 203034)
the number of unique words including both unigrams and bigrams  203034
```

Applying Multinomial Naive Bayes

[5.1] Applying Naive Bayes on BOW

```
X=preprocessed_reviews[0:100000]
y=np.array(final['Score'][0:100000])
```

```
#Breaking into Train and test
X_train = X[:60000]
X_cv = X[60000:80000]
X_test = X[80000:]
y_train = np.array(final['Score'][:60000])
y_cv = np.array(final['Score'][60000:80000])
y_test = np.array(final['Score'][80000:100000])
```

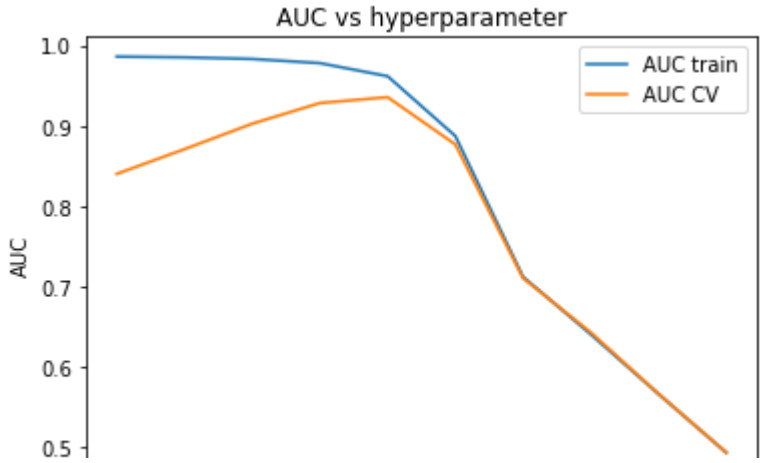
```
len(y_test)
```

```
20000
```

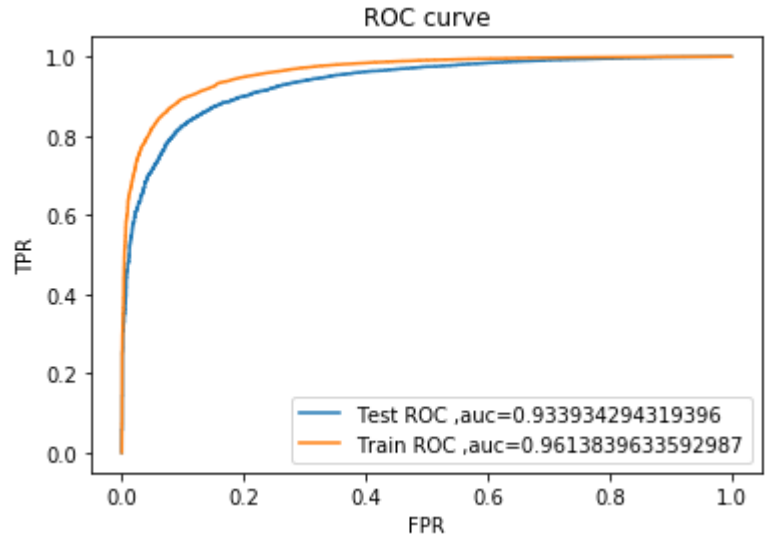
```
from sklearn.model_selection import train_test_split
from sklearn import preprocessing

#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:  (60000, 45723)
Test Data Size:  (20000, 45723)
CV Data Size : (20000, 45723)
```

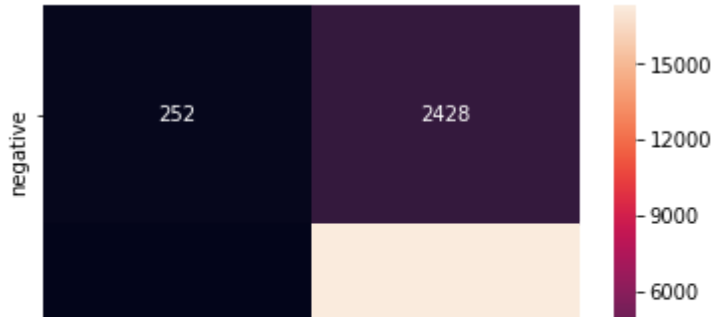
```
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math

alpha = [10000,1000,100,10,1,0.1,0.01,0.001,0.0001,0.00001]

train_auc = []
cv_auc = []

for i in alpha:
    clf = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    clf.fit(X_train,y_train)
    prob_cv = clf.predict_proba(X_cv)[:,1]
    cv_auc.append(roc_auc_score(y_cv,prob_cv))
    prob_train = clf.predict_proba(X_train)[:,1]
    train_auc.append(roc_auc_score(y_train,prob_train))
optimal_alpha= alpha[cv_auc.index(max(cv_auc))]
alpha=[math.log(x) for x in alpha]

#plot auc vs alpha
x = plt.subplot( )
x.plot(alpha, train_auc, label='AUC train')
x.plot(alpha, cv_auc, label='AUC CV')
plt.title('AUC vs hyperparameter')
plt.xlabel('alpha')
plt.ylabel('AUC')
x.legend()
plt.show()

print('optimal alpha for which auc is maximum : ',optimal_alpha)
```




```
#Testing AUC on Test data
clf = MultinomialNB(alpha = optimal_alpha)
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)


#plot 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 curve')
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 0.933934294319396
AUC on Train data is 0.9613839633592987
---------------------------
```




```
results=pd.DataFrame(columns=['Featuraization', 'Classifier' ,'alpha', 'Train-AUC', 'Test-AUC' ])
new = ['BOW','MultinomialNB',0.1,0.9613,0.9339]
results.loc[0] = new
```

[5.1.1] Top 10 important features of positive class

```
# Please write all the code with proper documentation
clf = MultinomialNB(alpha=0.1)
clf.fit(X_train,y_train)
features = clf.feature_log_prob_
feature_names = count_vect.get_feature_names()
negative_features = np.argsort(features[0])[::-1]
positive_features = np.argsort(features[1])[::-1]
print("Top 10 important features of positive class from BOW")
for i in list(positive_features[0:10]):
  print(feature_names[i])
```

```
Top 10 important features of positive class from BOW
not
great
good
like
tea
```

[5.1.2] Top 10 important features of negative class

```
print("Top 10 important features of Negatit class from BOW")
for i in list(negative_features[0:10]):
  print(feature_names[i])
```

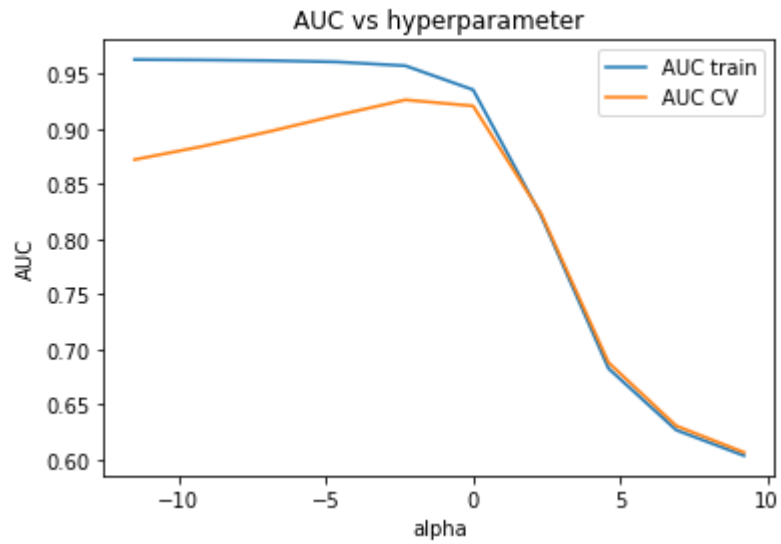
```
Top 10 important features of Negatit class from BOW
not
like
taste
product
would
one
good
flavor
no
tea
```

[5.2] Applying Naive Bayes on TFIDF

```
tf_idf_vect = TfidfVectorizer( min_df=10)

#Breaking into Train, CV  and test
#Breaking into Train and test
X_train = X[:60000]
X_cv = X[60000:80000]
X_test = X[80000:]
y_train = np.array(final['Score'][:60000])
y_cv = np.array(final['Score'][60000:80000])
y_test = np.array(final['Score'][80000:100000])


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:  (60000, 9597)
Test Data Size:  (20000, 9597)
CV Data Size : (20000, 9597)
```

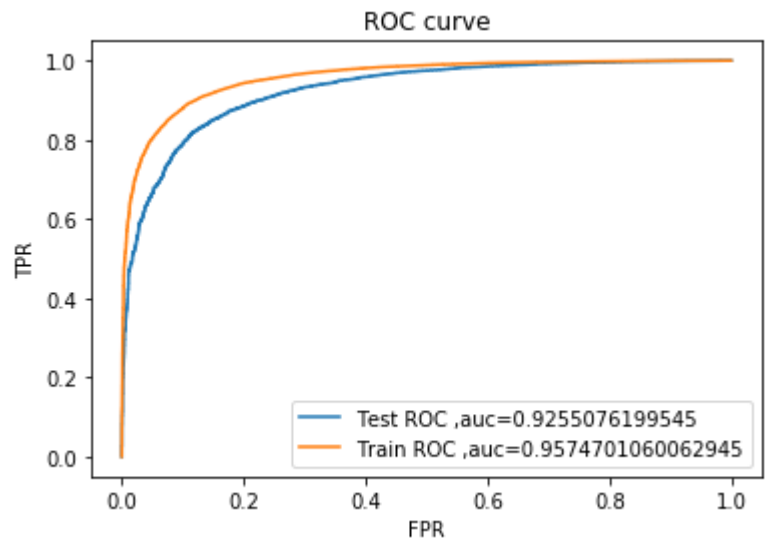
```
alpha = [10000,1000,100,10,1,0.1,0.01,0.001,0.0001,0.00001]

train_auc = []
cv_auc = []

for i in alpha:
    clf = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    clf.fit(X_train,y_train)
    prob_cv = clf.predict_proba(X_cv)[:,1]
    cv_auc.append(roc_auc_score(y_cv,prob_cv))
    prob_train = clf.predict_proba(X_train)[:,1]
    train_auc.append(roc_auc_score(y_train,prob_train))
optimal_alpha= alpha[cv_auc.index(max(cv_auc))]
alpha=[math.log(x) for x in alpha]

#plot auc vs alpha
x = plt.subplot( )
x.plot(alpha, train_auc, label='AUC train')
x.plot(alpha, cv_auc, label='AUC CV')
plt.title('AUC vs hyperparameter')
plt.xlabel('alpha')
plt.ylabel('AUC')
x.legend()
plt.show()

print('optimal alpha for which auc is maximum : ',optimal_alpha)
```



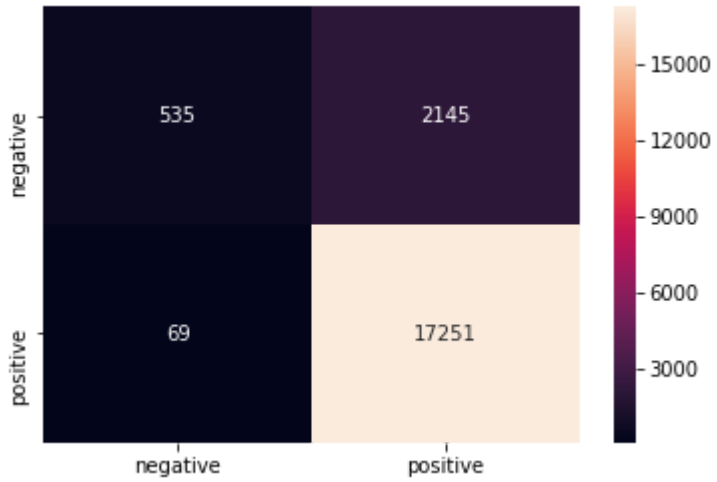

```
optimal alpha for which auc is maximum :  0.1
```

```
#Testing AUC on Test data
clf = MultinomialNB(alpha = optimal_alpha)
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)

#plot 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 curve')
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 0.9255076199545
AUC on Train data is 0.9574701060062945
----------------------------
```




```
new = ['tf-idf','MultinomialNB',0.1,0.9574,0.9255]
results.loc[1] = new
```

[5.2.1] Top 10 important features of positive class

```
# Please write all the code with proper documentation
```

```
clf = MultinomialNB(alpha=0.1)
clf.fit(X_train,y_train)
features = clf.feature_log_prob_
feature_names = tf_idf_vect.get_feature_names()
negative_features = np.argsort(features[0])[::-1]
positive_features = np.argsort(features[1])[::-1]
print("Top 10 important features of positive class from TFIDF")
for i in list(positive_features[0:10]):
    print(feature_names[i])
```

```
Top 10 important features of positive class from TFIDF
not
great
tea
good
like
love
product
taste
flavor
one
```

[5.2.2] Top 10 important features of negative class

```
# Please write all the code with proper documentation
print("Top 10 important features of negative class from TFIDF")
for i in list(negative_features[0:10]):
    print(feature_names[i])
```

```
Top 10 important features of negative class from TFIDF
not
like
product
would
taste
one
flavor
no
good
tea
```

Performance Table

```
results
```

	Featuraization	Classifier	alpha	Train-AUC	Test-AUC
0	BOW	MultinomialNB	0.1	0.9613	0.9339
1	tf-idf	MultinomialNB	0.1	0.9574	0.9255

[6] Conclusions

1. Naive Bayes is one of the best algorithem
2. The best thing about Naive Bayes it much quicker than algorithms amazingly fast training time
3. Best Model is BOW with auc score of 0.9339