09AmazonFineFoodReviewsAnalysis_RF1

May 27, 2019

1 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 considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

2 [1]. Reading Data

2.1 [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 efficiently.

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

```
In [1]: %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
```

```
In [2]: # using SQLite Table to read data.
        con = sqlite3.connect('database.sqlite')

        # filtering only positive and negative reviews i.e.
        # not taking into consideration those reviews with Score=3
        # SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 500000 data point
        # you can change the number to any other number based on your computing power

        # filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 5
        # for tsne assignment you can take 5k data points

        filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 1000

        # Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negativ
        def partition(x):
            if x < 3:
                return 0
            return 1

        #changing reviews with score less than 3 to be positive and vice-versa
        actualScore = filtered_data['Score']
        positiveNegative = actualScore.map(partition)
        filtered_data['Score'] = positiveNegative
        print("Number of data points in our data", filtered_data.shape)
        filtered_data.head(3)
```

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

```
Out[2]:    Id   ProductId          UserId                      ProfileName  \
        0   1  B001E4KFG0  A3SGXH7AUHU8GW                       delmartian
        1   2  B00813GRG4  A1D87F6ZCVE5NK                           dll pa
        2   3  B000LQOCH0   ABXLMWJIXXAIN  Natalia Corres "Natalia Corres"

           HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
        0                     1                       1      1  1303862400
        1                     0                       0      0  1346976000
        2                     1                       1      1  1219017600

                         Summary                                               Text
        0  Good Quality Dog Food  I have bought several of the Vitality canned d...
        1      Not as Advertised  Product arrived labeled as Jumbo Salted Peanut...
        2  "Delight" says it all  This is a confection that has been around a fe...
```

```
In [3]: display = pd.read_sql_query("""
        SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
        FROM Reviews
        GROUP BY UserId
        HAVING COUNT(*)>1
        """, con)

In [4]: print(display.shape)
        display.head()
```

```
(80668, 7)
```

```
Out[4]:                UserId   ProductId             ProfileName        Time  Score  \
        0  #oc-R115TNMSPFT9I7  B007Y59HVM                 Breyton  1331510400      2
```

```
1  #oc-R11D9D7SHXIJB9  B005HG9ET0  Louis E. Emory "hoppy"  1342396800      5
2  #oc-R11DNU2NBKQ23Z  B007Y59HVM        Kim Cieszykowski  1348531200      1
3  #oc-R1105J5ZVQE25C  B005HG9ET0           Penguin Chick  1346889600      5
4  #oc-R12KPBODL2B5ZD  B0070SBE1U   Christopher P. Presta  1348617600      1

                                                Text  COUNT(*)
0  Overall its just OK when considering the price...         2
1  My wife has recurring extreme muscle spasms, u...         3
2  This coffee is horrible and unfortunately not ...         2
3  This will be the bottle that you grab from the...         3
4  I didnt like this coffee. Instead of telling y...         2
```

```
In [5]: display[display['UserId']=='AZY10LLTJ71NX']
```

```
Out[5]:               UserId   ProductId                    ProfileName        Time  \
        80638  AZY10LLTJ71NX  B006P7E5ZI  undertheshrine "undertheshrine"  1334707200

               Score                                              Text  COUNT(*)
        80638      5  I was recommended to try green tea extract to ...         5
```

```
In [6]: display['COUNT(*)'].sum()
```

```
Out[6]: 393063
```

3 [2] Exploratory Data Analysis

3.1 [2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

```
In [7]: display= pd.read_sql_query("""
        SELECT *
        FROM Reviews
        WHERE Score != 3 AND UserId="AR5J8UI46CURR"
        ORDER BY ProductID
        """, con)
        display.head()
```

```
Out[7]:        Id   ProductId         UserId      ProfileName  HelpfulnessNumerator  \
        0   78445  B000HDL1RQ  AR5J8UI46CURR  Geetha Krishnan                     2
        1  138317  B000HDOPYC  AR5J8UI46CURR  Geetha Krishnan                     2
        2  138277  B000HDOPYM  AR5J8UI46CURR  Geetha Krishnan                     2
        3   73791  B000HDOPZG  AR5J8UI46CURR  Geetha Krishnan                     2
        4  155049  B000PAQ75C  AR5J8UI46CURR  Geetha Krishnan                     2

           HelpfulnessDenominator  Score        Time  \
        0                       2      5  1199577600
```

```
1                        2      5  1199577600
2                        2      5  1199577600
3                        2      5  1199577600
4                        2      5  1199577600

                                 Summary  \
0  LOACKER QUADRATINI VANILLA WAFERS
1  LOACKER QUADRATINI VANILLA WAFERS
2  LOACKER QUADRATINI VANILLA WAFERS
3  LOACKER QUADRATINI VANILLA WAFERS
4  LOACKER QUADRATINI VANILLA WAFERS

                                                Text
0  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
1  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
2  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
3  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
4  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
```

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8) ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

```
In [8]: #Sorting data according to ProductId in ascending order
        sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=Fal
```

```
In [9]: #Deduplication of entries
        final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep=
        final.shape
```

```
Out[9]: (87775, 10)
```

```
In [10]: #Checking to see how much % of data still remains
         (final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

```
Out[10]: 87.775
```

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

```
In [11]: display= pd.read_sql_query("""
         SELECT *
         FROM Reviews
         WHERE Score != 3 AND Id=44737 OR Id=64422
         ORDER BY ProductID
         """, con)

         display.head()

Out[11]:       Id   ProductId          UserId             ProfileName  \
         0  64422  B000MIDROQ  A161DK06JJMCYF  J. E. Stephens "Jeanne"
         1  44737  B001EQ55RW  A2V0I904FH7ABY                      Ram

            HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
         0                     3                       1      5  1224892800
         1                     3                       2      4  1212883200

                                                 Summary  \
         0            Bought This for My Son at College
         1  Pure cocoa taste with crunchy almonds inside

                                                      Text
         0  My son loves spaghetti so I didn't hesitate or...
         1  It was almost a 'love at first bite' - the per...

In [12]: final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]

In [13]: #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)


Out[13]: 1    73592
         0    14181
         Name: Score, dtype: int64
```

4 [3] Preprocessing

4.1 [3.1]. Preprocessing Review Text

Now that we have finished deduplication our data requires some preprocessing before we go on further with analysis and making the prediction model.

Hence in the Preprocessing phase we do the following in the order below:-

1. Begin by removing the html tags

2. Remove any punctuations or limited set of special characters like , or . or # etc.
3. Check if the word is made up of english letters and is not alpha-numeric
4. Check to see if the length of the word is greater than 2 (as it was researched that there is no adjective in 2-letters)
5. Convert the word to lowercase
6. Remove Stopwords
7. Finally Snowball Stemming the word (it was obsereved to be better than Porter Stemming)

After which we collect the words used to describe positive and negative reviews

```
In [14]: # 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.  Its
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste
==================================================
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 afraid
==================================================
```

```
In [15]: # 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.  Its
```

```
In [16]: # https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all
         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.  Its
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste
==================================================
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 afrai
```

```
In [17]: # 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
```

```
In [18]: 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
==================================================
```

```
In [19]: #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.  Its
```

```
In [20]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
         print(sent_1500)
```

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

```
In [21]: # 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', 'ourselve
                     "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him'
                     'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself',
                     'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', '
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'a
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'throug
                     'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', '
                     'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'a
                     'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'to
                     's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", '
                     've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't
                     "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mi
                     "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't",
                     'won', "won't", 'wouldn', "wouldn't"])
```

```
In [22]: # 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 stopw
            preprocessed_reviews.append(sentance.strip())
```

```
100%|| 87773/87773 [00:51<00:00, 1690.25it/s]
```

```
In [23]: preprocessed_reviews[1500]
```

```
Out[23]: 'way hot blood took bite jig lol'
```

[3.2] Preprocessing Review Summary

```
In [24]: preprocessed_summary = []
         # tqdm is for printing the status bar
         try:
             for sentance in final['Summary'].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 s
                 preprocessed_summary.append(sentance.strip())
         except:
             pass
```

```
C:\Users\rites\Anaconda3\lib\site-packages\bs4\__init__.py:219: UserWarning: "b'...'" looks li
  ' Beautiful Soup.' % markup)
C:\Users\rites\Anaconda3\lib\site-packages\bs4\__init__.py:219: UserWarning: "b'...'" looks li
  ' Beautiful Soup.' % markup)
C:\Users\rites\Anaconda3\lib\site-packages\bs4\__init__.py:219: UserWarning: "b'...'" looks li
  ' Beautiful Soup.' % markup)
C:\Users\rites\Anaconda3\lib\site-packages\bs4\__init__.py:219: UserWarning: "b'...'" looks li
  ' Beautiful Soup.' % markup)
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

```
In [25]: #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', 'aaaaaaaaaaaa', 'a
==================================================
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
```

5.2 [4.2] Bi-Grams and n-Grams.

```
In [26]: #bi-gram, tri-gram and n-gram

         #removing stop words like "not" should be avoided before building n-grams
         # count_vect = CountVectorizer(ngram_range=(1,2))
         # please do read the CountVectorizer documentation http://scikit-learn.org/stable/mod

         # you can choose these numebrs min_df=10, max_features=5000, of your choice
         count_vect = CountVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
         final_bigram_counts = count_vect.fit_transform(preprocessed_reviews)
         print("the type of count vectorizer ",type(final_bigram_counts))
         print("the shape of out text BOW vectorizer ",final_bigram_counts.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_bigram_
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (364171, 5000)
the number of unique words including both unigrams and bigrams  5000
```

5.3 [4.3] TF-IDF

```
In [27]: 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_name
         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
```

```
some sample features(unique words in the corpus) ['aa', 'aaa', 'aaaaa', 'aaah', 'aafco', 'ab',
==================================================
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
```

5.4 [4.4] Word2Vec

```
In [77]: # Train your own Word2Vec model using your own text corpus
         i=0
         list_of_sentance=[]
         for sentance in preprocessed_reviews:
             list_of_sentance.append(sentance.split())
```

```
In [29]: # Using Google News Word2Vectors

         # in this project we are using a pretrained model by google
         # its 3.3G file, once you load this into your memory
         # it occupies ~9Gb, so please do this step only if you have >12G of ram
         # we will provide a pickle file wich contains a dict ,
         # and it contains all our courpus words as keys and  model[word] as values
         # To use this code-snippet, download "GoogleNews-vectors-negative300.bin"
         # from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/edit
         # it's 1.9GB in size.


         # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
         # you can comment this whole cell
         # or change these varible according to your need

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(list_of_sentance,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
```

```
[('good', 0.8547688722610474), ('awesome', 0.8541616201400757), ('terrific', 0.854150891304016
==================================================
[('greatest', 0.7951465845108032), ('nastiest', 0.7538052797317505), ('best', 0.69903028011322
```

```
In [30]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  23202
sample words  ['bulgur', 'negate', 'top', 'xxx', 'satiety', 'vera', 'suppressant', 'gripes', '
```

5.5 [4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

```
In [0]: # average Word2Vec
        # compute average word2vec for each review.
        sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
        for sent in tqdm(list_of_sentance): # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need to
            cnt_words =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                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.append(sent_vec)
        print(len(sent_vectors))
        print(len(sent_vectors[0]))
```

```
100%|| 4986/4986 [00:03<00:00, 1330.47it/s]


4986
50
```

[4.4.1.2] TFIDF weighted W2v

```
In [31]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         model = TfidfVectorizer()
         tf_idf_matrix = model.fit_transform(preprocessed_reviews)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [0]: # TF-IDF weighted Word2Vec
        tfidf_feat = model.get_feature_names() # tfidf words/col-names
        # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

        tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this li
        row=0;
        for sent in tqdm(list_of_sentance): # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length
            weight_sum =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                if word in w2v_words and word in tfidf_feat:
                    vec = w2v_model.wv[word]
        #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                    # to reduce the computation we are
                    # dictionary[word] = idf value of word in whole courpus
                    # sent.count(word) = tf valeus of word in this review
                    tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                    sent_vec += (vec * tf_idf)
                    weight_sum += tf_idf
            if weight_sum != 0:
                sent_vec /= weight_sum
            tfidf_sent_vectors.append(sent_vec)
            row += 1
```

```
100%|| 4986/4986 [00:20<00:00, 245.63it/s]
```

```
In [25]: # Function to plot confusion matrix
         def confusion_matrix_plot(test_y, predict_y):
             # C stores the confusion matrix
             C = confusion_matrix(test_y, predict_y)


             # Class labels
             labels_x = ["Predicted No","Predicted Yes"]
             labels_y = ["Original No","Original Yes"]

             cmap=sns.light_palette("orange")
             plt.figure(figsize=(4,4))
             sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabel
             plt.title("Confusion Matrix")
             plt.show()
```

```
In [26]: # Function to plot roc curve

         def plot_roc_curve(Y_test,predict_y_test,Y_train,predict_y_train):
             plt.figure(figsize=(10,5))
             fpr1,tpr1,threshold1 = roc_curve(Y_test,predict_y_test) # For test dataset
```

```
        fpr2,tpr2,threshold2 = roc_curve(Y_train,predict_y_train) # For train dataset

        plt.plot([0,1],[0,1])
        plt.plot(fpr1,tpr1,label="Test AUC")
        plt.plot(fpr2,tpr2,label="Train AUC")
        plt.xlabel("False Positive Rate")
        plt.ylabel("True Positive Rate")
        plt.legend(loc = 'lower right')
        plt.title("Reciever Operating Characteristic")
        plt.grid()
        plt.show()
```

```
In [53]: def plot_train_auc_heatmap(C):
             labels_y =['5','10','50','100','200','500','1000']
             labels_x= ['2','3','4','5','6','7','8','9','10']

             cmap=sns.light_palette("orange")
             #print("AUC on train dataset")
             plt.figure(figsize=(11,8))
             sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabels
             plt.xlabel("Max Depth")
             plt.ylabel("n_estimators")
             plt.title("AUC on train dataset")
             plt.show()
```

```
In [54]: def plot_test_auc_heatmap(C):
             labels_y =['5','10','50','100','200','500','1000']
             labels_x= ['2','3','4','5','6','7','8','9','10']

             cmap=sns.light_palette("orange")
             #print("AUC on train dataset")
             plt.figure(figsize=(11,8))
             sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabels
             plt.xlabel("Max Depth")
             plt.ylabel("n_estimators")
             plt.title("AUC on CV dataset")
             plt.show()
```

```
In [30]: def xg_plot_train_auc_heatmap(C):
             labels_y =['5','10','50','100','200','500','1000']
             labels_x= ['2','3','4','5','6','7','8','9','10']

             cmap=sns.light_palette("orange")
             #print("AUC on train dataset")
             plt.figure(figsize=(10,8))
             sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabels
             plt.xlabel("Max Depth")
             plt.ylabel("n_estimators")
             plt.title("AUC on train dataset")
             plt.show()
```

```
In [31]: def xg_plot_test_auc_heatmap(C):
            labels_y =['5','10','50','100','200','500','1000']
            labels_x= ['2','3','4','5','6','7','8','9','10']

            cmap=sns.light_palette("orange")
            #print("AUC on train dataset")
            plt.figure(figsize=(10,8))
            sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabel
            plt.xlabel("Max Depth")
            plt.ylabel("n_estimators")
            plt.title("AUC on CV dataset")
            plt.show()
```

6 [5] Assignment 9: Random Forests

```
<li><strong>Apply Random Forests & GBDT on these feature sets</strong>
    <ul>
        <li><font color='red'>SET 1:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 2:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 3:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 4:</font>Review text, preprocessed one converted into vector
    </ul>
</li>
<br>
<li><strong>The hyper paramter tuning (Consider two hyperparameters: n_estimators & max_depth)
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaico
<li>Find the best hyper paramter using k-fold cross validation or simple cross validation data
<li>Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this t
    </ul>
</li>
<br>
<li><strong>Feature importance</strong>
    <ul>
<li>Get top 20 important features and represent them in a word cloud. Do this for BOW & TFIDF.
    </ul>
</li>
<br>
<li><strong>Feature engineering</strong>
    <ul>
<li>To increase the performance of your model, you can also experiment with with feature engin
        <ul>
        <li>Taking length of reviews as another feature.</li>
        <li>Considering some features from review summary as well.</li>
    </ul>
    </ul>
</li>
<br>
<li><strong>Representation of results</strong>
    <ul>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='3d_plot.JPG' width=500px> with X-axis as <strong>n_estimators</strong>, Y-axis as <s
        <p style="text-align:center;font-size:30px;color:red;"><strong>(or)</strong></p> <br>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='heat_map.JPG' width=300px> <a href='https://seaborn.pydata.org/generated/seaborn.hea
<li>You choose either of the plotting techniques out of 3d plot or heat map</li>
<li>Once after you found the best hyper parameter, you need to train your model with it, and fi
<img src='train_test_auc.JPG' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.
<img src='confusion_matrix.png' width=300px></li>
    </ul>
</li>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table fo
    <img src='summary.JPG' width=400px>
</li>
    </ul>
```

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

6.1 [5.1] Applying RF

6.1.1 [5.1.1] Applying Random Forests on BOW, SET 1

```
In [33]: # initializing count vectorizer
         count_vect = CountVectorizer()

         # Splitting data into train and test dataset
         from sklearn.model_selection import train_test_split
         X = preprocessed_reviews # Getting datapoints
         Y = final['Score'] # Geting labeels
         X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
         print(len(X_train))
         print(len(X_test))
```

```
61441
26332
```

```
In [34]: # Vectorizing train and test dataset
         bow_train_vect = count_vect.fit_transform(X_train)
         bow_test_vect = count_vect.transform(X_test)
```

```
In [55]: n_estimators = [5,10,50,100,200,500,1000]
         max_depth = [2,3,4,5,6,7,8,9,10]
```

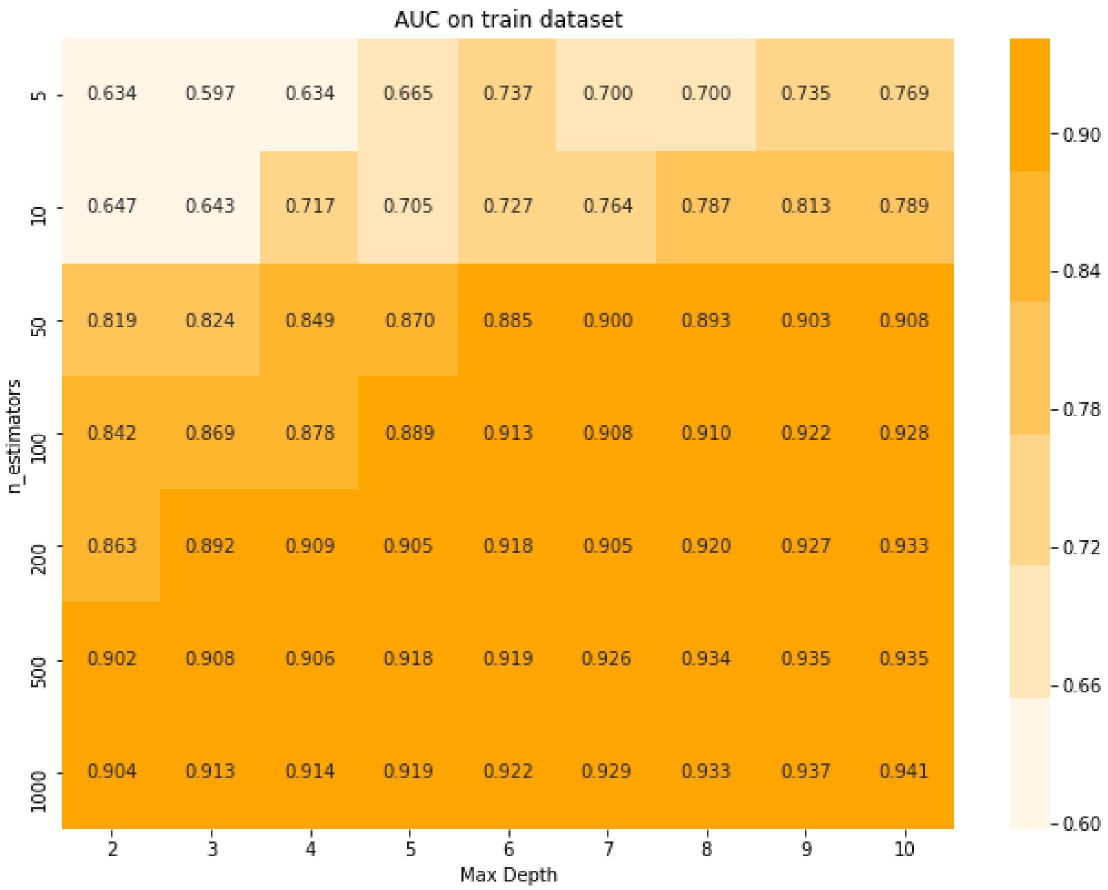
```
In [36]: from sklearn.ensemble import RandomForestClassifier
```

```
In [56]: # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

         from sklearn.ensemble import RandomForestClassifier
         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
                 clf.fit(bow_train_vect,Y_train)

                 predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probability
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [07:03<00:00, 97.31s/it]
```

```
In [57]: # Plotting plot of AUC for each combination of hyper parameters
         print("Training AUC")
         plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

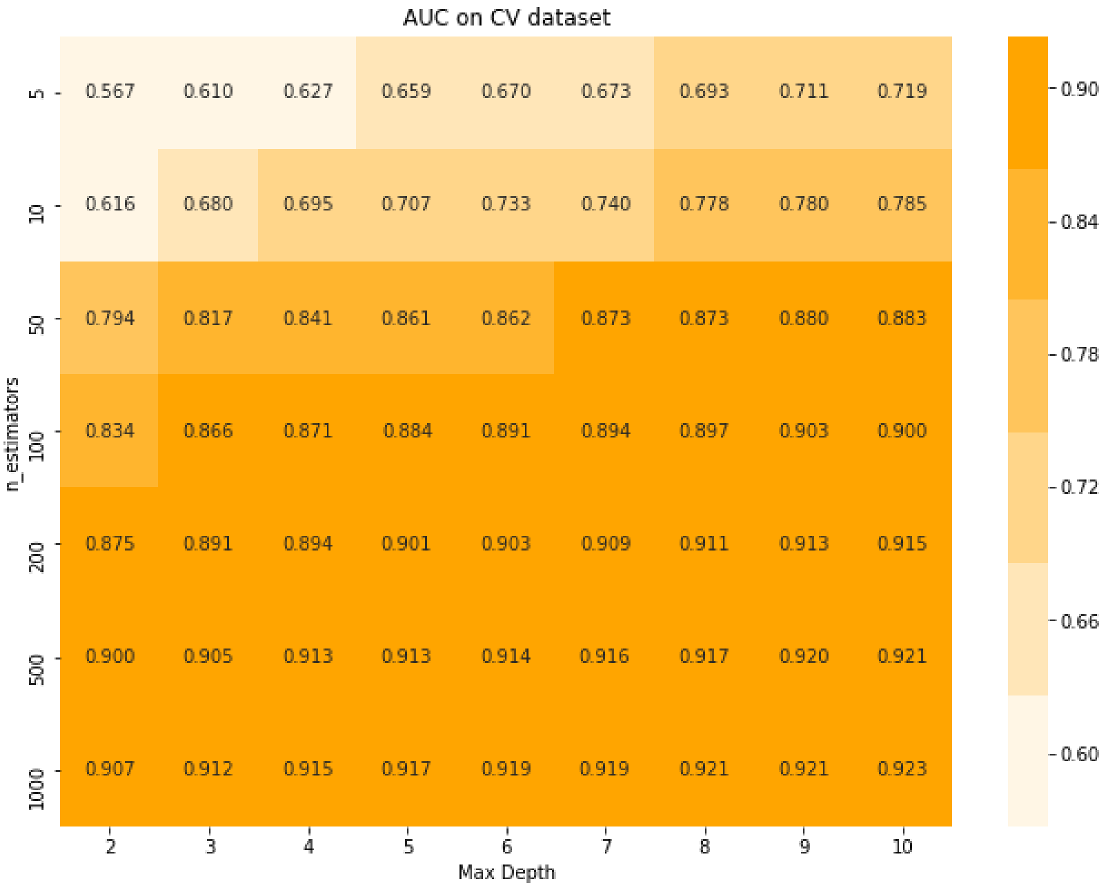


In [58]:
```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 5-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(bow_train_vect):
            x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(exc
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
            x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tra
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [38:42<00:00, 540.03s/it]
```

In [59]:
```
# Plotting plot of AUC for each combination of hyper parameters
print("Cross-validation AUC")
plot_test_auc_heatmap(cv_auc)
```

```
Cross-validation AUC
```

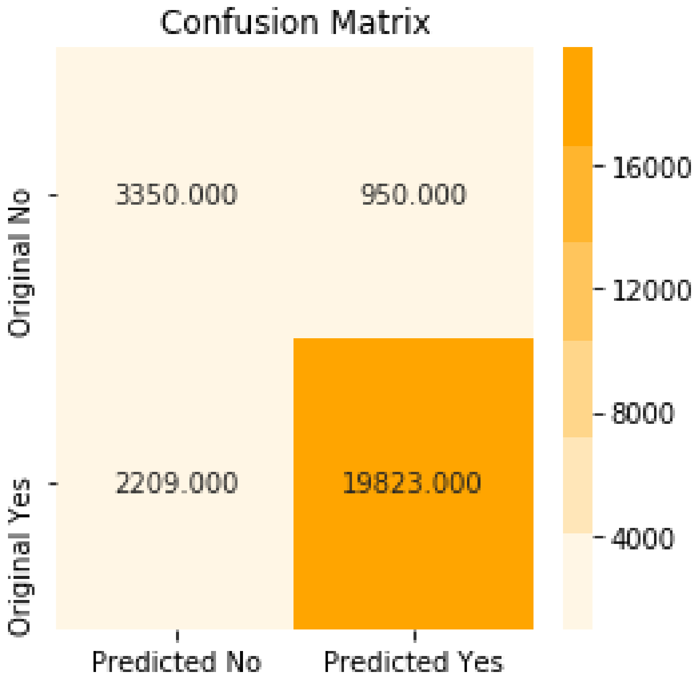


```
In [60]: # Training the final model on best hyper-parameters
         clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='ba
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)
         predict_y_train = clf.predict(bow_train_vect)

         probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posit
         probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for pos
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.927
```

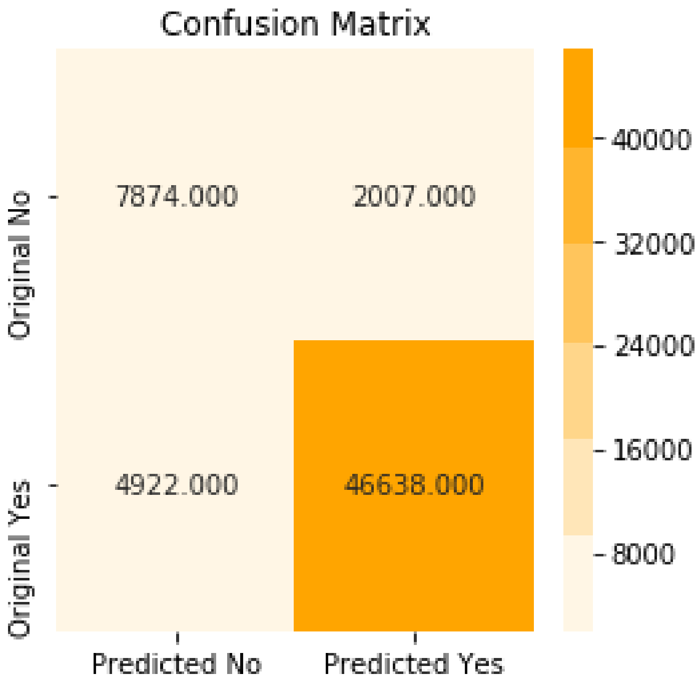
```
In [61]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

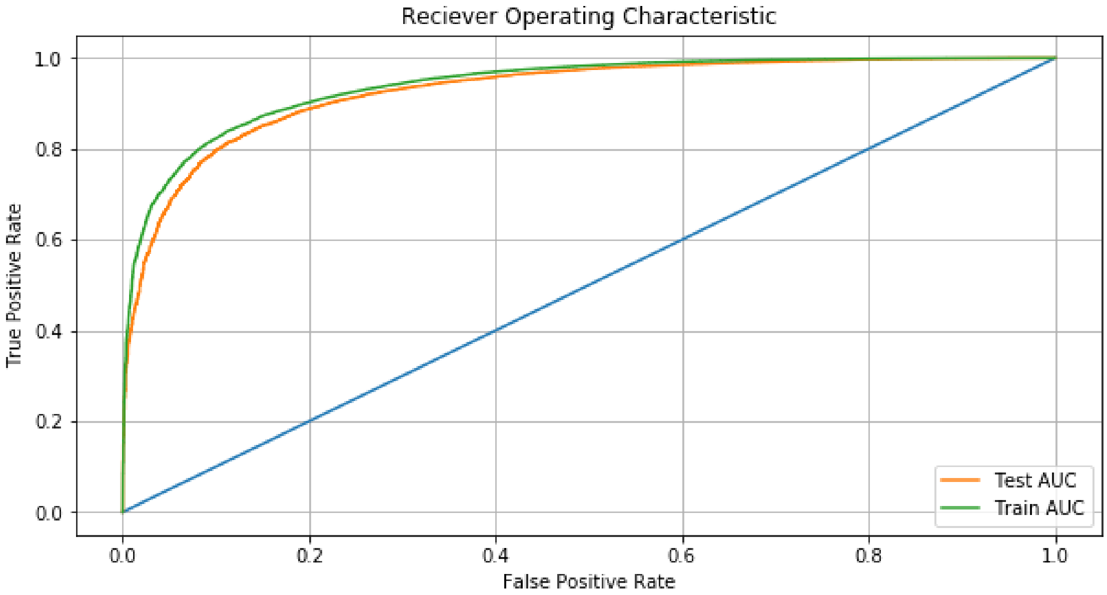


```
In [62]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```

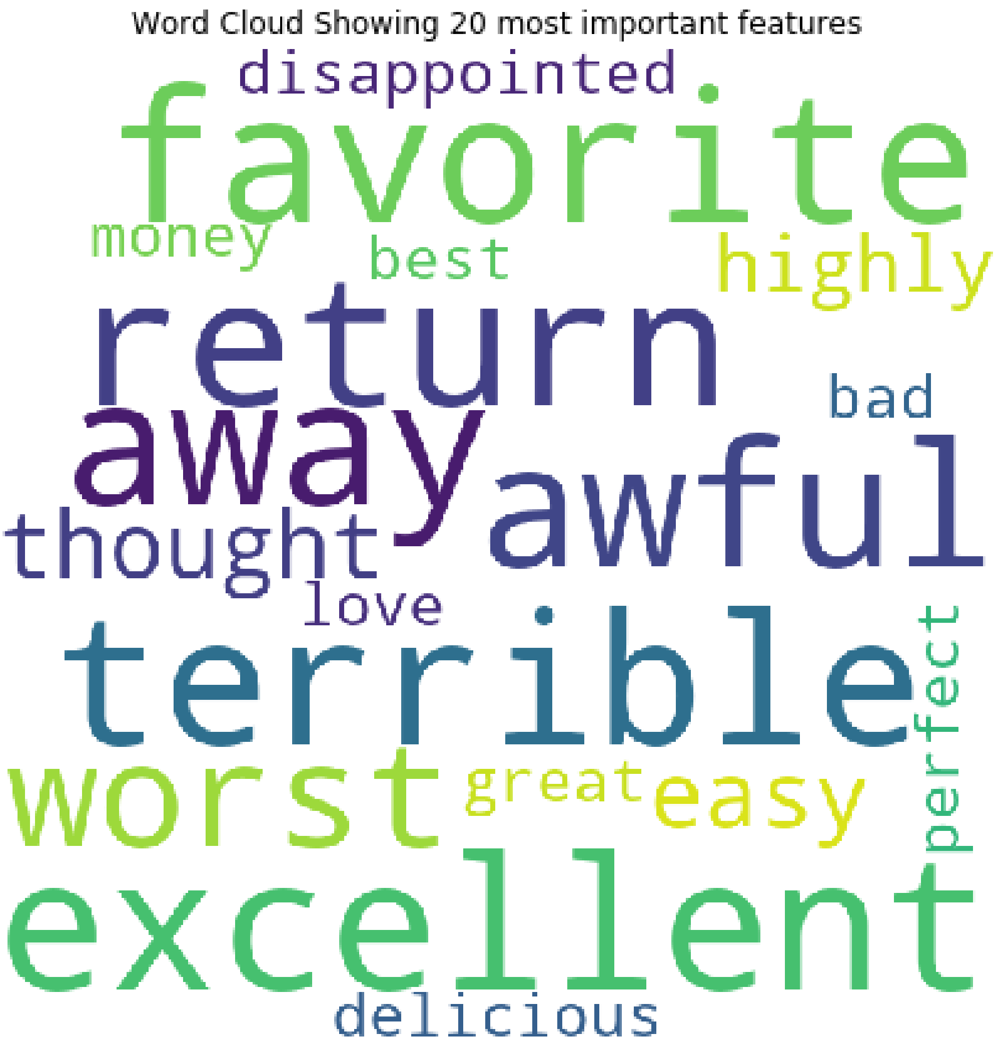


```
In [63]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.1.2 [5.1.2] Wordcloud of top 20 important features from SET 1

```
In [64]: from wordcloud import WordCloud, STOPWORDS
         import matplotlib.pyplot as plt
         import pandas as pd

         stopwords = set(STOPWORDS)

         # Getting all the feature names
         all_feat = count_vect.get_feature_names()
         # Getting index of top 20 features.
         top_20_feat_index = clf.feature_importances_.argsort()[-20:]

         top_20_feat = [all_feat[i] for i in top_20_feat_index]

         feat_str = ' '
         for wrd in top_20_feat:
             feat_str = feat_str + wrd + ' '



         wordcloud = WordCloud(width = 600, height = 600,
                         background_color ='white',
                         stopwords = stopwords,
                         min_font_size = 6).generate(feat_str)

         # plot the WordCloud image
         plt.figure(figsize = (6, 6), facecolor = None)
         plt.imshow(wordcloud)
         plt.axis("off")
         plt.tight_layout(pad = 0)
         plt.title("Word Cloud Showing 20 most important features")

         plt.show()
```



6.1.3 [5.1.3] Applying Random Forests on TFIDF, SET 2

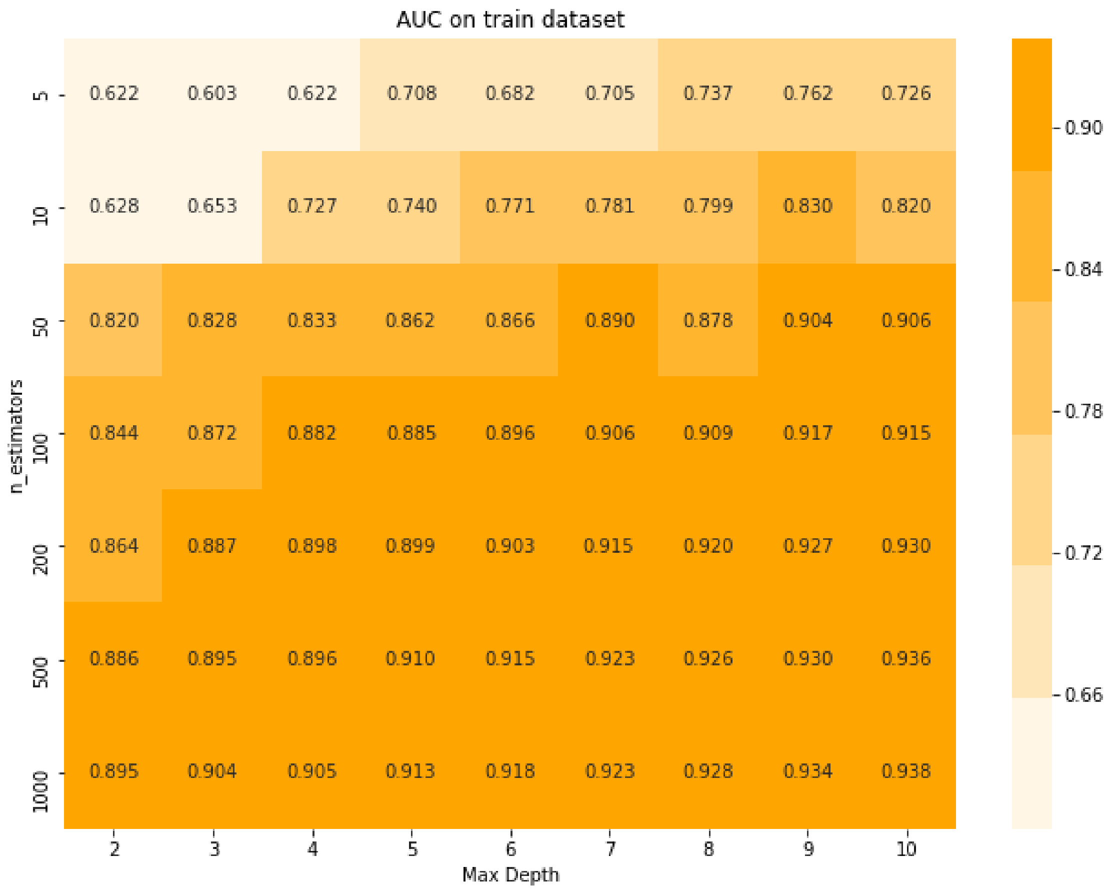
```
In [47]: # Initializing Tfidf Vectorizer
         tfidf_vect = TfidfVectorizer()

         # Vectorizing train and test dataset
         tfidf_train_vect = tfidf_vect.fit_transform(X_train)
         tfidf_test_vect = tfidf_vect.transform(X_test)
```

```
In [65]: # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))
```

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

        i=0 # To keep count of rows.
        j=0 # To kepe count of columns.
        for k in tqdm(n_estimators):
            j=0 # Reinitializing column to zero for each row
            for s in max_depth:
                clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
                clf.fit(tfidf_train_vect,Y_train)

                predict_probab = clf.predict_proba(tfidf_train_vect)[:,1] # returns probabili
                auc = roc_auc_score(Y_train,predict_probab)
                train_auc[i][j] = auc
                j  =j+1 # incrementing the col index at the end of each iteration.
            i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [07:17<00:00, 102.62s/it]
```

```
In [66]: # Plotting plot of AUC for each combination of hyper parameters
         plot_train_auc_heatmap(train_auc)
```

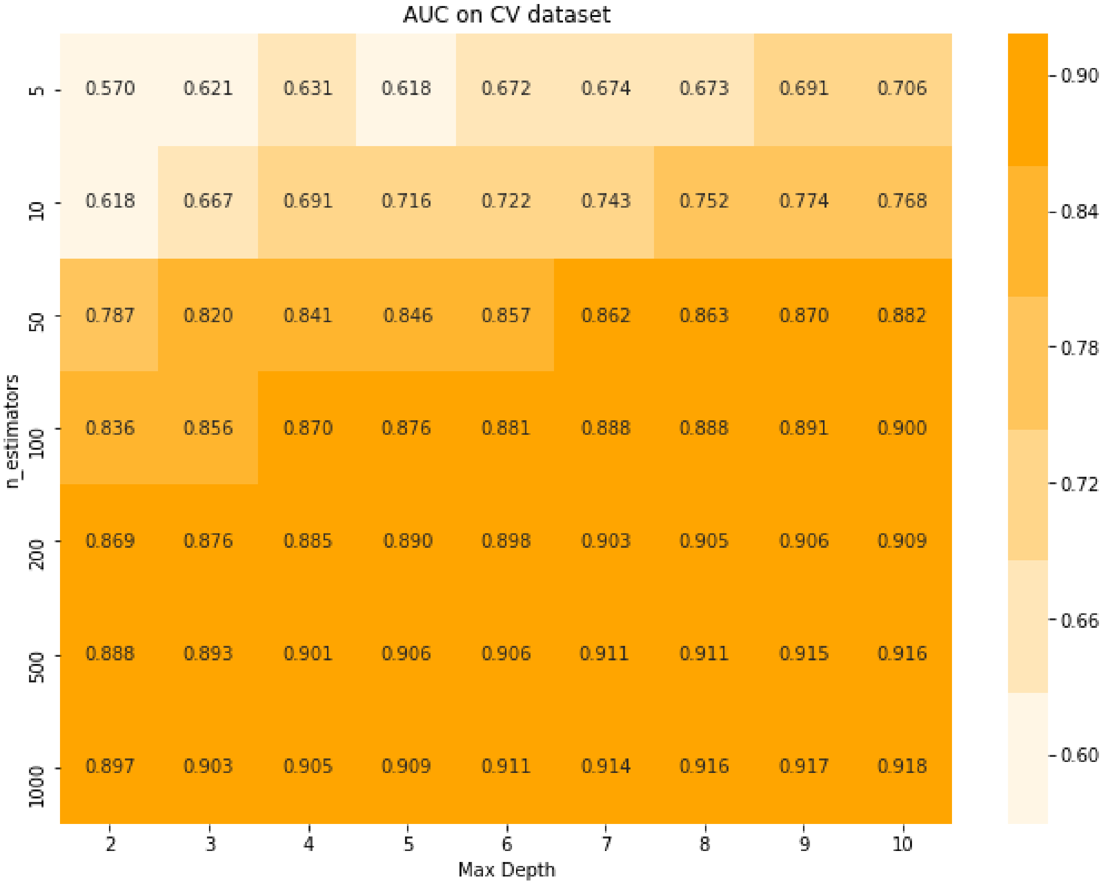


```
In [67]: # Time series object
         from sklearn.model_selection import TimeSeriesSplit
         tscv = TimeSeriesSplit(n_splits=5)

         # In this section we will perform 5-fold Cross validation on timse series split data

         cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
         m=0 # For row index
         n=0 # For col index
         for k in tqdm(n_estimators):
             n=0
             for s in max_depth:
                 # Deecision Tree Classifier
                 clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
                 i=0
                 auc=0.0
                 for train_index,test_index in tscv.split(tfidf_train_vect):
                     x_train = tfidf_train_vect[0:train_index[-1]][:] # row 0 to train_index(e
                     y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
```

```
            x_test = tfidf_train_vect[train_index[-1]:test_index[-1]][:] # row from t
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [38:38<00:00, 546.43s/it]
```

In [68]:
```
# Plotting plot of AUC for each combination of hyper parameters
plot_test_auc_heatmap(cv_auc)
```

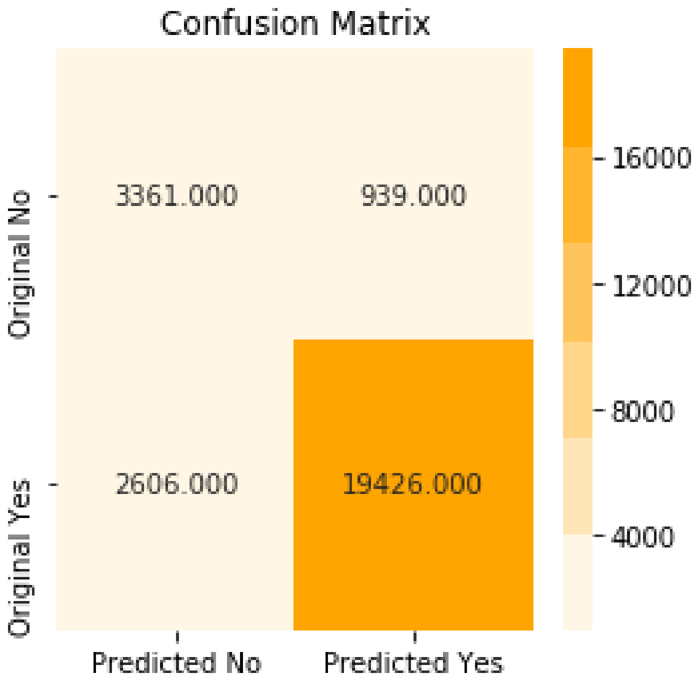


In [70]:
```
# Training the final model on best hyper-parameters
clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='ba
clf.fit(tfidf_train_vect,Y_train)

predict_y_test = clf.predict(tfidf_test_vect)
predict_y_train = clf.predict(tfidf_train_vect)

probab_y_test = clf.predict_proba(tfidf_test_vect)[:,1] # returns probability for pos
probab_y_train = clf.predict_proba(tfidf_train_vect)[:,1] # returns probability for p
auc = roc_auc_score(Y_test,probab_y_test)

print("Auc of Tfidf Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Tfidf Vectorized Model is 0.918
```

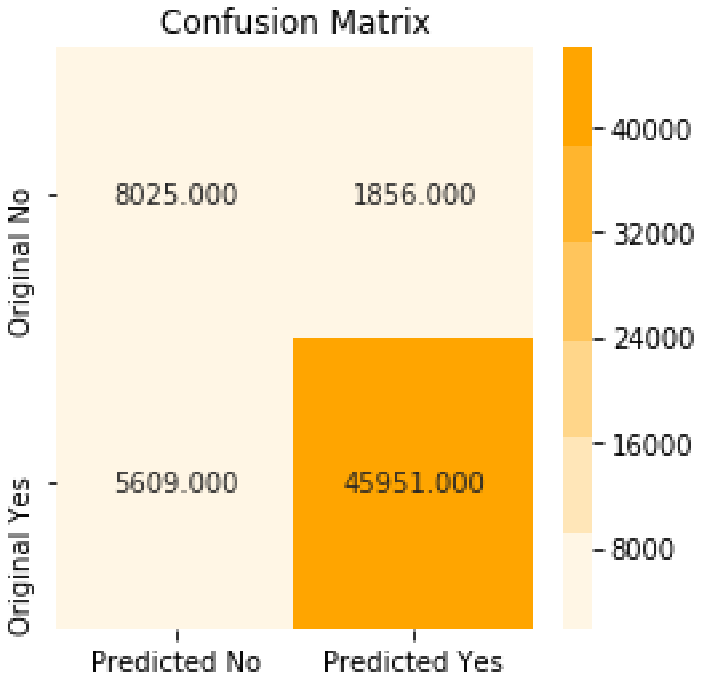
```
In [71]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

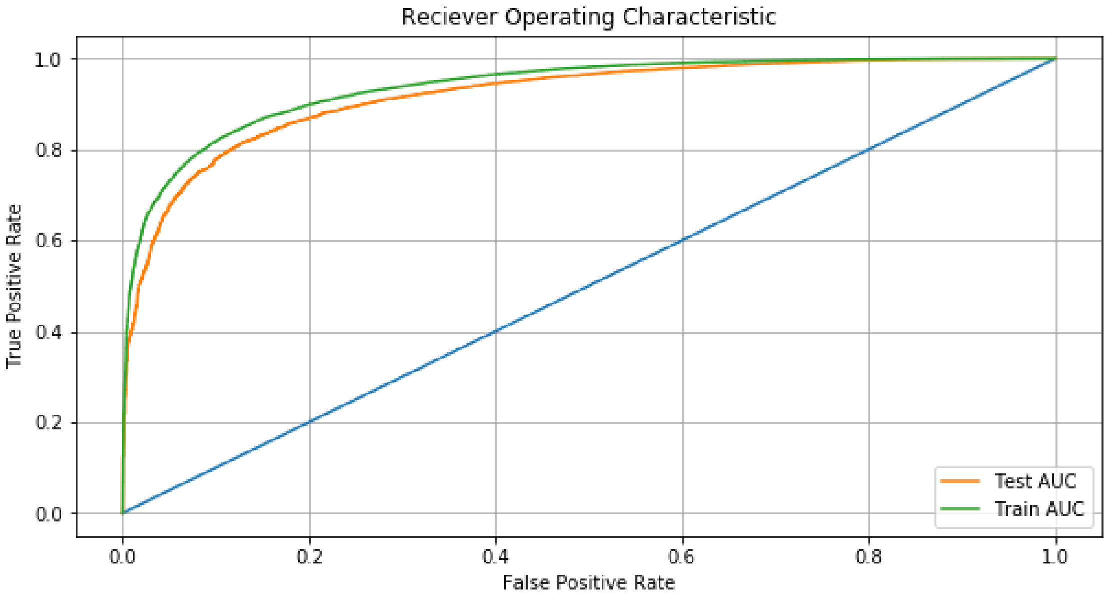


```
In [73]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```

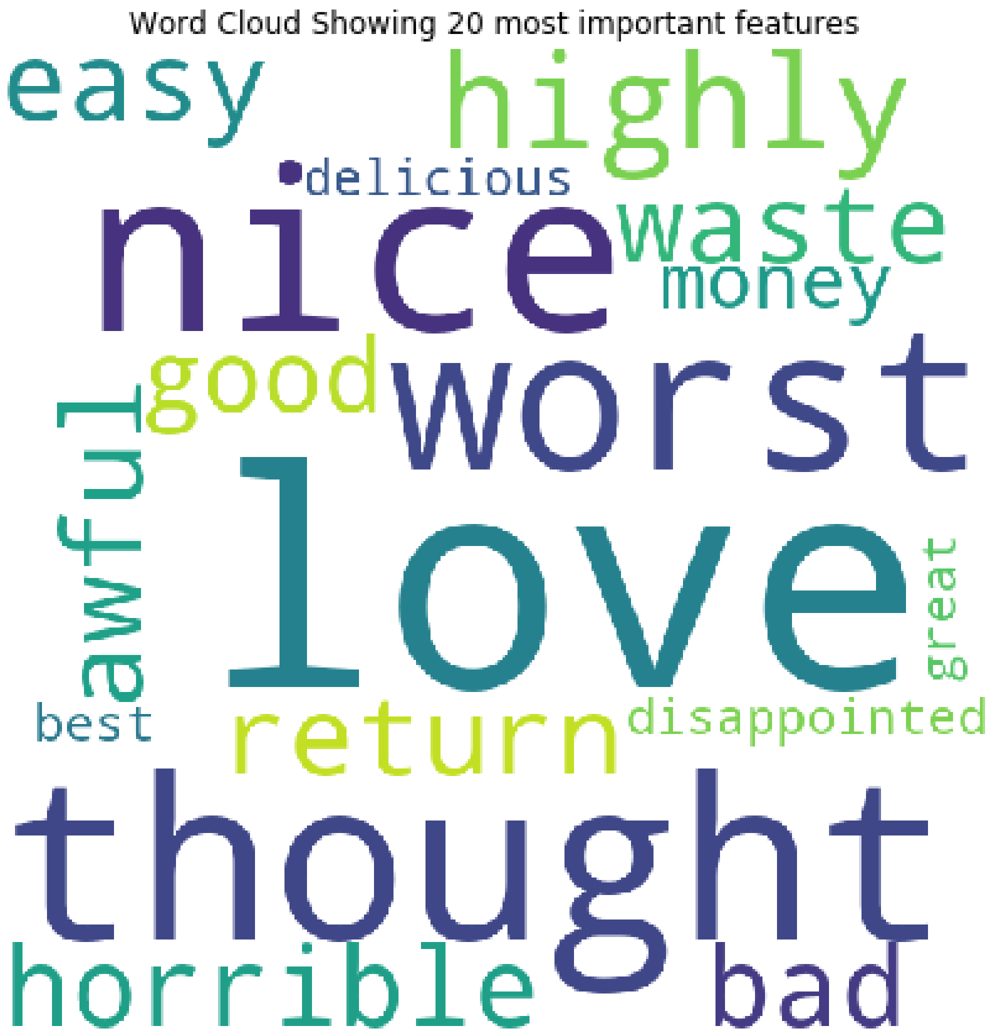


```
In [74]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.1.4 [5.1.4] Wordcloud of top 20 important features from SET 2

In [75]:
```
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd

stopwords = set(STOPWORDS)

# Getting all the feature names
all_feat = tfidf_vect.get_feature_names()
# Getting index of top 20 features.
top_20_feat_index = clf.feature_importances_.argsort()[-20:]

top_20_feat = [all_feat[i] for i in top_20_feat_index]

feat_str = ' '
for wrd in top_20_feat:
    feat_str = feat_str + wrd + ' '



wordcloud = WordCloud(width = 600, height = 600,
                background_color ='white',
                stopwords = stopwords,
                min_font_size = 6).generate(feat_str)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.title("Word Cloud Showing 20 most important features")

plt.show()
```



6.1.5 [5.1.5] Applying Random Forests on AVG W2V, SET 3

```
In [78]: # Splitting data into train and test dataset

         X = list_of_sentance

         X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)

In [79]: # Train Word2vec model on train dataset and use this for test dataset vectorization
         # Training word2Vec model on traain dataset and will use same for test dataset
         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True
```

```
    if want_to_train_w2v:
        # min_count = 5 considers only words that occured atleast 5 times
        w2v_model=Word2Vec(X_train,min_count=5,size=100, workers=4)
        print(w2v_model.wv.most_similar('great'))
        print('='*50)
        print(w2v_model.wv.most_similar('worst'))

    elif want_to_use_google_w2v and is_your_ram_gt_16g:
        if os.path.isfile('GoogleNews-vectors-negative300.bin'):
            w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
            print(w2v_model.wv.most_similar('great'))
            print(w2v_model.wv.most_similar('worst'))
        else:
            print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
```

```
[('fantastic', 0.7750309705734253), ('awesome', 0.774991512298584), ('good', 0.753565907478332
==================================================
[('greatest', 0.7874018549919128), ('best', 0.7049573063850403), ('tastiest', 0.63057738542556
```

```
In [80]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  14819
sample words  ['use', 'beans', 'espresso', 'machine', 'love', 'taste', 'straight', 'coffee', '
```

```
In [81]: # average Word2Vec
         # compute average word2vec for each review of training dataset

         train_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this lis
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(100) # as word vectors are of zero length 50, you might need
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             train_sent_vectors.append(sent_vec)
         print(len(train_sent_vectors))
         print(len(train_sent_vectors[0]))
```

```
100%|| 61441/61441 [10:24<00:00, 98.37it/s]
```

```
61441
100
```

```
In [82]: test_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(100) # as word vectors are of zero length 50, you might need
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             test_sent_vectors.append(sent_vec)
         print(len(test_sent_vectors))
         print(len(test_sent_vectors[0]))
```

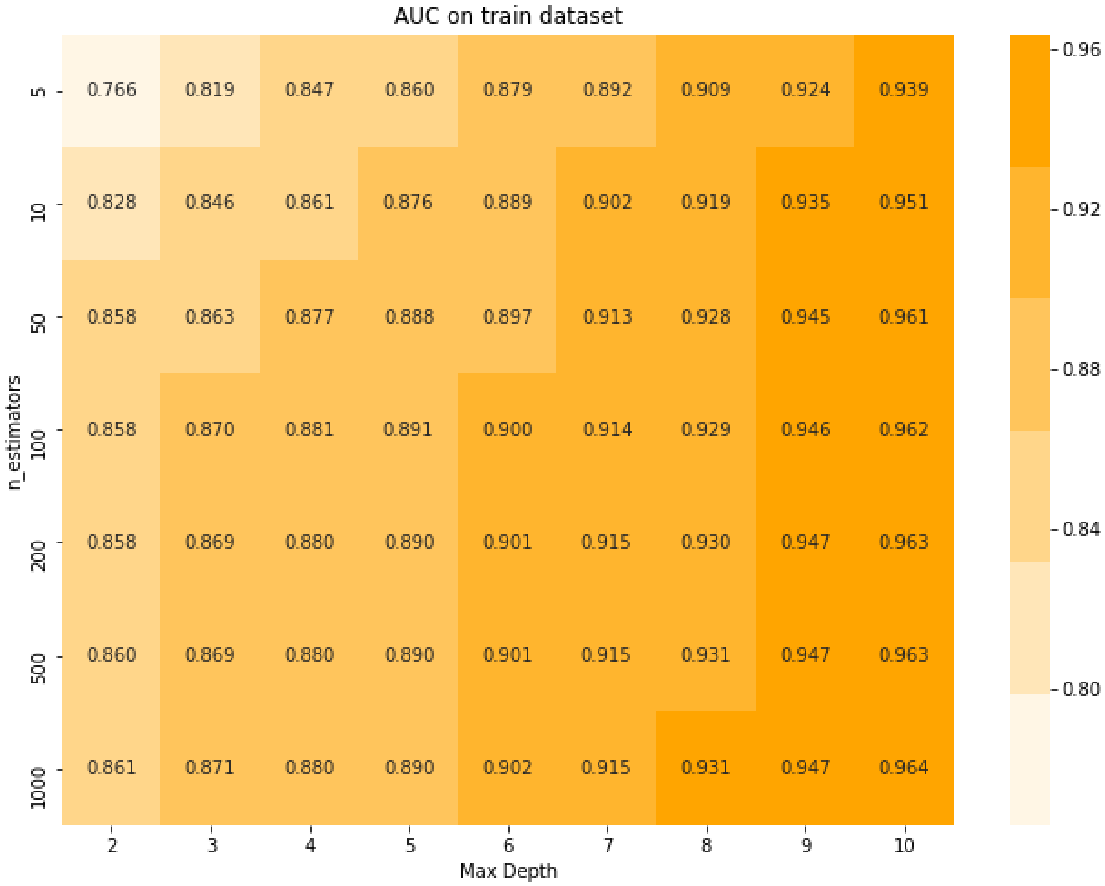
```
100%|| 26332/26332 [04:29<00:00, 97.87it/s]


26332
100
```

```
In [83]: # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

         from sklearn.ensemble import RandomForestClassifier
         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
                 clf.fit(train_sent_vectors,Y_train)

                 predict_probab = clf.predict_proba(train_sent_vectors)[:,1] # returns probabi
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [59:26<00:00, 833.04s/it]
```

```
In [84]: # Plotting plot of AUC for each combination of hyper parameters
         print("Training AUC")
         plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```



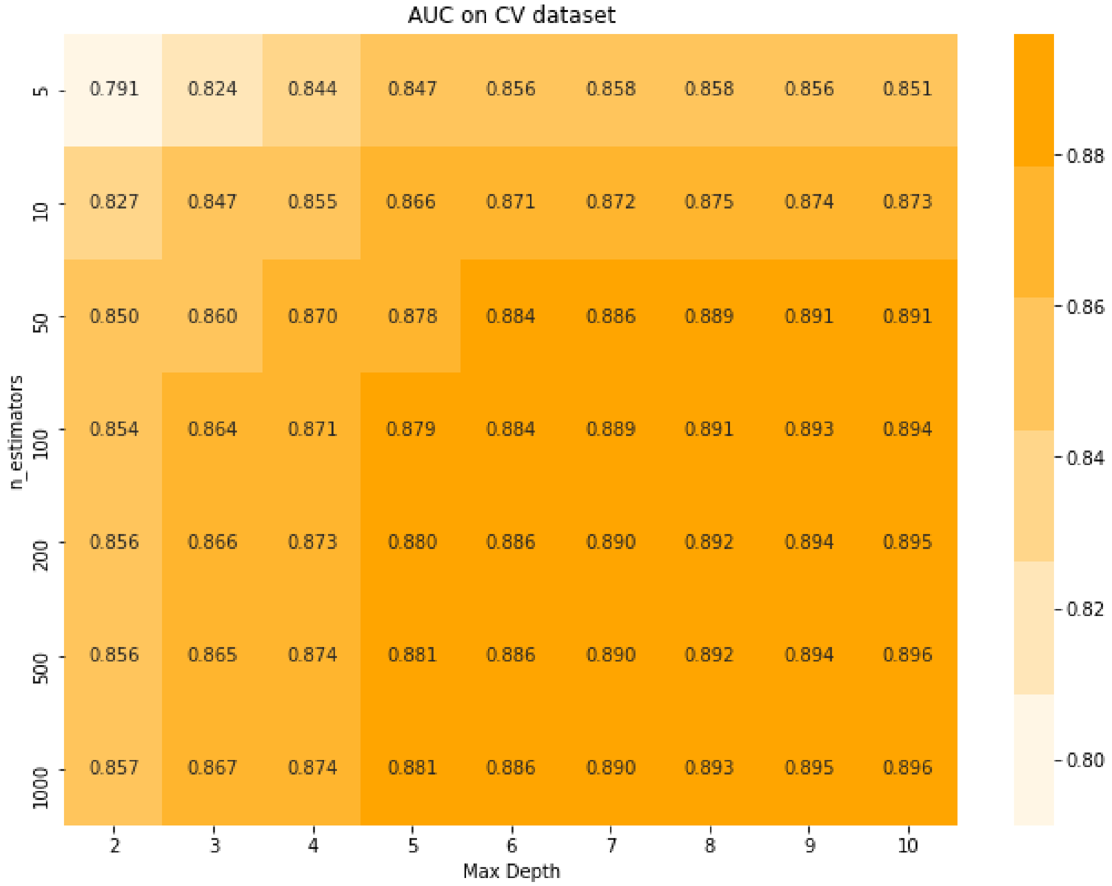
```
In [85]: # Time series object
         from sklearn.model_selection import TimeSeriesSplit
         tscv = TimeSeriesSplit(n_splits=5)

         # In this section we will perform 5-fold Cross validation on timse series split data

         cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
         m=0 # For row index
         n=0 # For col index
         for k in tqdm(n_estimators):
```

```
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(train_sent_vectors):
            x_train = train_sent_vectors[0:train_index[-1]][:] # row 0 to train_index
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
            x_test = train_sent_vectors[train_index[-1]:test_index[-1]][:] # row from
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [1:49:18<00:00, 1581.07s/it]
```

```
In [86]: # Plotting plot of AUC for each combination of hyper parameters
         print("Cross-Validation AUC")
         plot_test_auc_heatmap(cv_auc)
```

```
Cross-Validation AUC
```

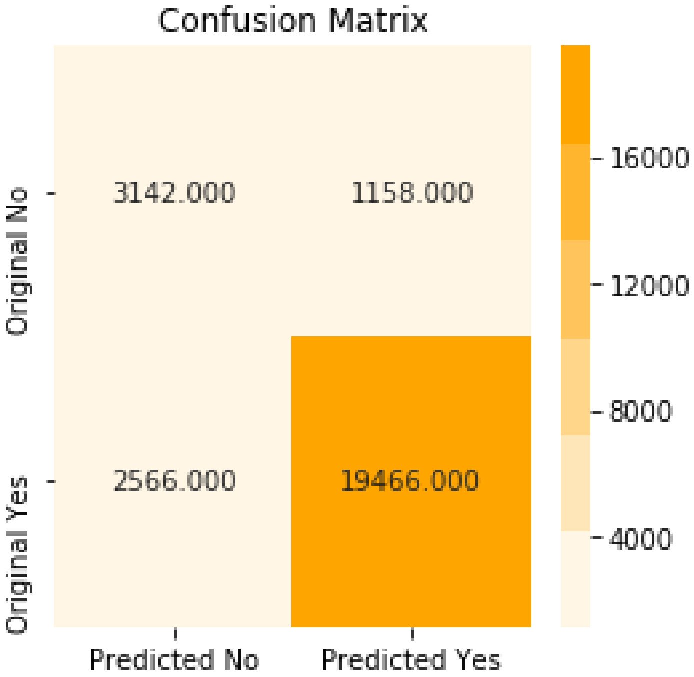


```
In [87]: # Training the final model on best hyper-parameters
         clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='ba
         clf.fit(train_sent_vectors,Y_train)

         predict_y_test = clf.predict(test_sent_vectors)
         predict_y_train = clf.predict(train_sent_vectors)

         probab_y_test = clf.predict_proba(test_sent_vectors)[:,1] # returns probability for p
         probab_y_train = clf.predict_proba(train_sent_vectors)[:,1] # returns probability for
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.903
```

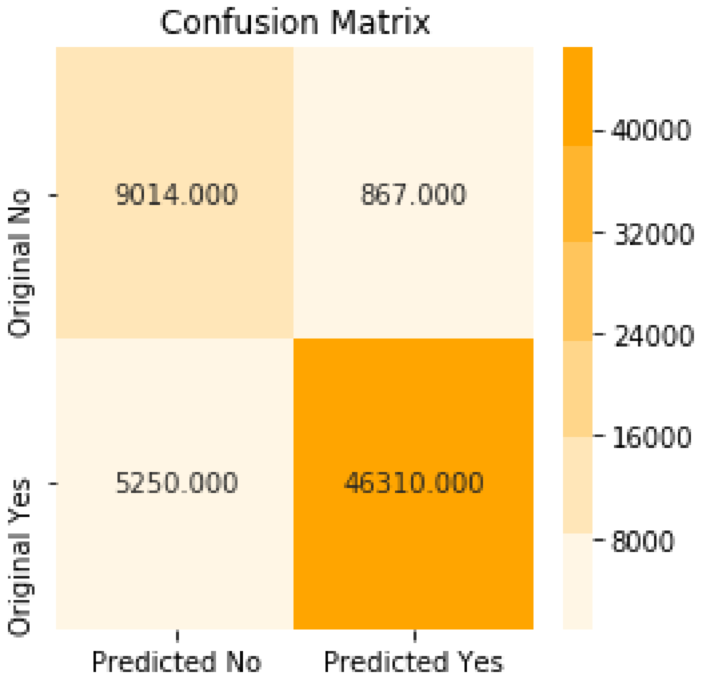
```
In [88]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

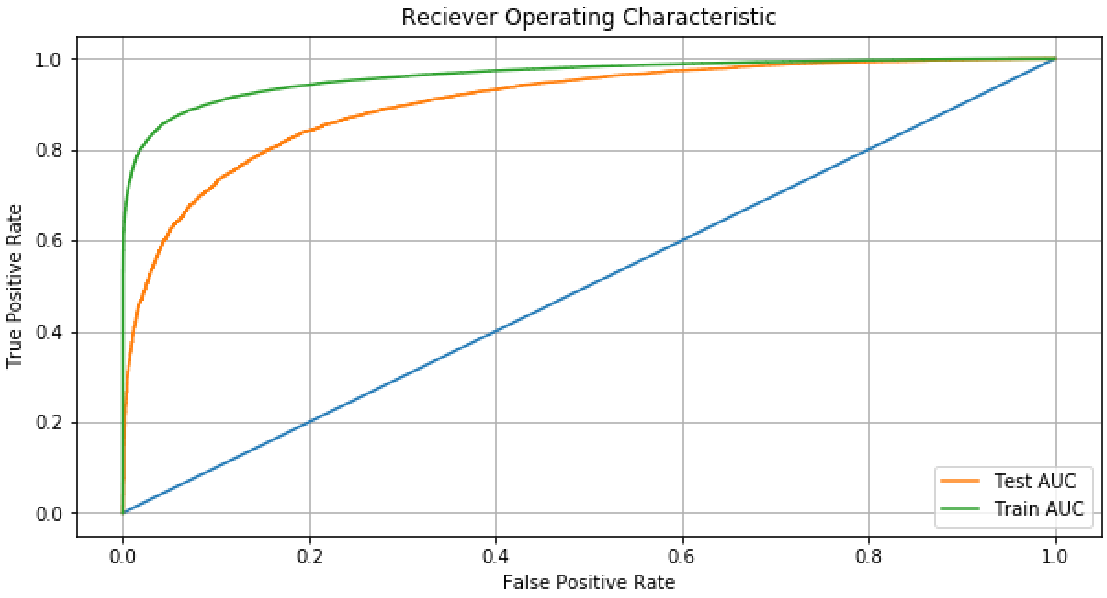


```
In [90]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [91]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.1.6 [5.1.6] Applying Random Forests on TFIDF W2V, SET 4

```
In [92]: # X_train contains sentences for training and X_test contains sentances for testing t
         # Calculating TfidfW2V for X_train
         from sklearn.model_selection import train_test_split
         Y = final['Score']

         X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3

         model = TfidfVectorizer()
         train_tfidf_matrix = model.fit_transform(X_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [93]: # Training word2Vec model on traain dataset and will use same for test dataset
         w2v_train = []
         for sent in X_train:
             w2v_train.append(sent.split())

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(w2v_train,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, t
```

```
[('awesome', 0.8300073146820068), ('fantastic', 0.8280240297317505), ('good', 0.82190024852752
==================================================
[('greatest', 0.8129244446754456), ('best', 0.7069724202156067), ('experienced', 0.70177918672
```

```
In [94]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  14819
sample words  ['use', 'beans', 'espresso', 'machine', 'love', 'taste', 'straight', 'coffee', '
```

```
In [95]: list_of_sentence=[]
         for sent in preprocessed_reviews:
             list_of_sentence.append(sent.split())
```

```
In [96]: X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentence,Y,test_size=0.3,rand
```

```
In [97]: # TF-IDF weighted Word2Vec for X_train
         train_tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review of X_train is
         row=0;
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in train_tfidf_feat:
                     vec = w2v_model.wv[word]
                     #tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf values of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             train_tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 61441/61441 [42:50<00:00, 15.12it/s]
```

```
In [98]: # TF-IDF weighted Word2Vec for X_test
         test_tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review of X_train is
         row=0;
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in test_tfidf_feat:
                     vec = w2v_model.wv[word]
         #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
```

```
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += 1
    if weight_sum != 0:
        sent_vec /= weight_sum
    test_tfidf_sent_vectors.append(sent_vec)
    row += 1
```

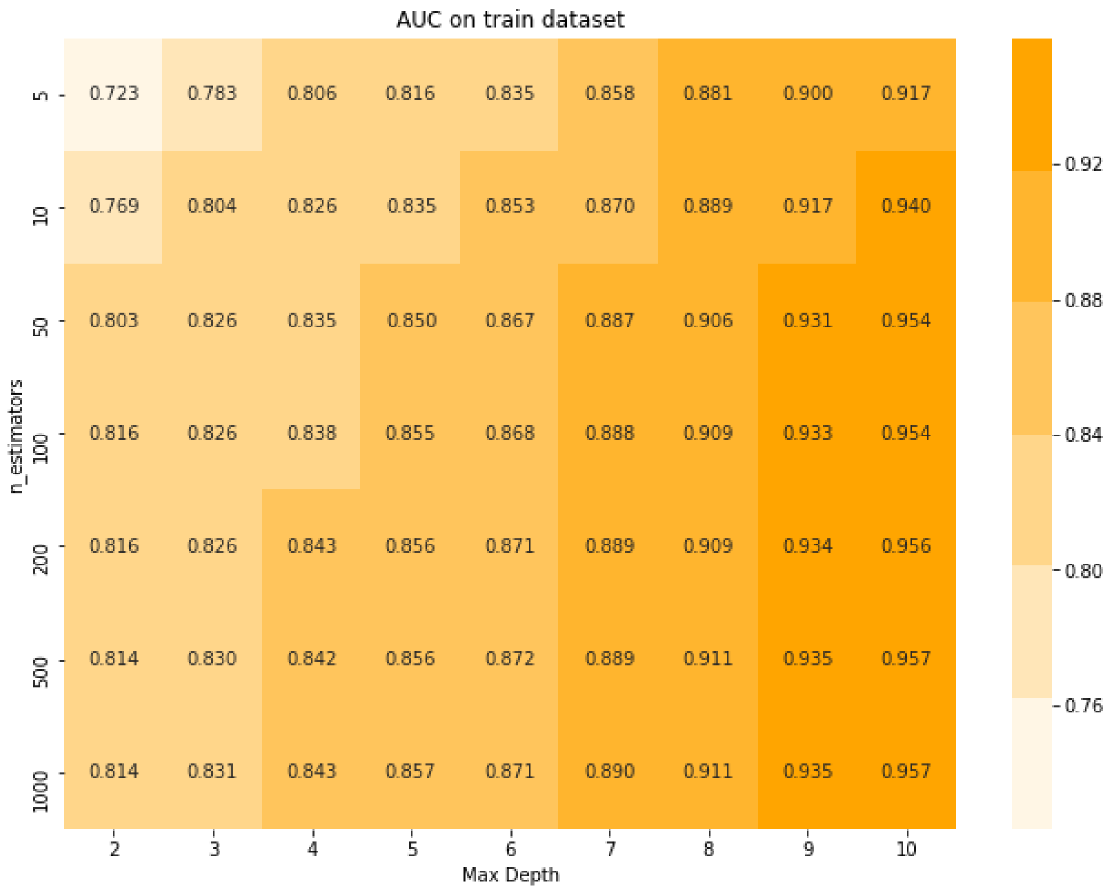
```
100%|| 26332/26332 [17:37<00:00, 24.91it/s]
```

```
In [99]: # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

         from sklearn.ensemble import RandomForestClassifier
         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weigh
                 clf.fit(train_tfidf_sent_vectors,Y_train)

                 predict_probab = clf.predict_proba(train_tfidf_sent_vectors)[:,1] # returns p
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [34:06<00:00, 490.34s/it]
```

```
In [100]: # Plotting plot of AUC for each combination of hyper parameters
          print("Training AUC")
          plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

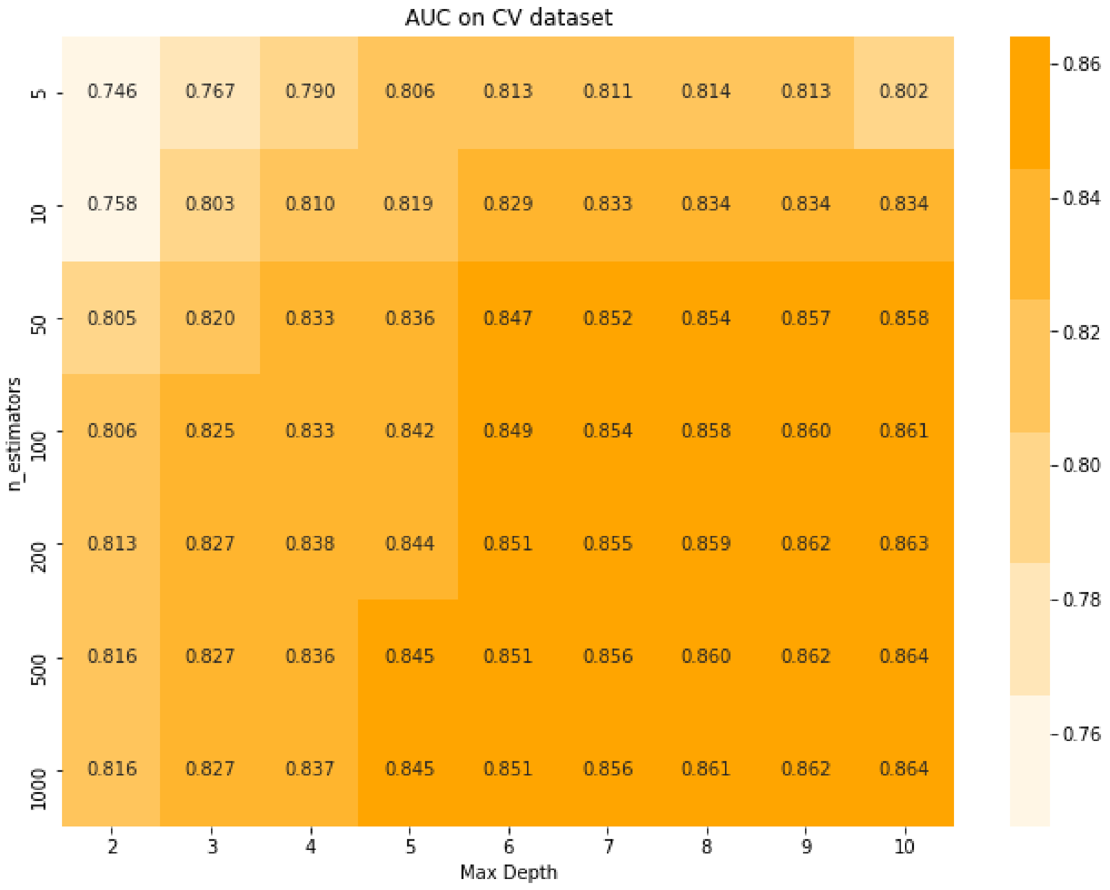


In [101]:
```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 3-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross v
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weig
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(train_tfidf_sent_vectors):
            x_train = train_tfidf_sent_vectors[0:train_index[-1]][:] # row 0 to trai
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding
            x_test = train_tfidf_sent_vectors[train_index[-1]:test_index[-1]][:] # r
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_ind

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability fo
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [46:41<00:00, 668.63s/it]
```

In [102]:
```
# Plotting plot of AUC for each combination of hyper parameters
print("Cross-Validation AUC")
plot_test_auc_heatmap(cv_auc)
```

```
Cross-Validation AUC
```

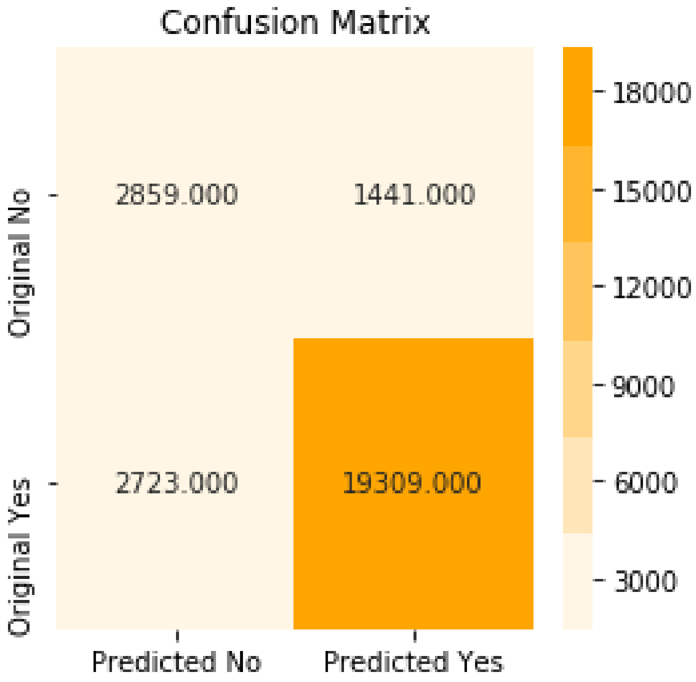


```
In [103]: # Training the final model on best hyper-parameters
          clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='
          clf.fit(train_tfidf_sent_vectors,Y_train)

          predict_y_test = clf.predict(test_tfidf_sent_vectors)
          predict_y_train = clf.predict(train_tfidf_sent_vectors)

          probab_y_test = clf.predict_proba(test_tfidf_sent_vectors)[:,1] # returns probabilit
          probab_y_train = clf.predict_proba(train_tfidf_sent_vectors)[:,1] # returns probabil
          auc = roc_auc_score(Y_test,probab_y_test)

          print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.874
```

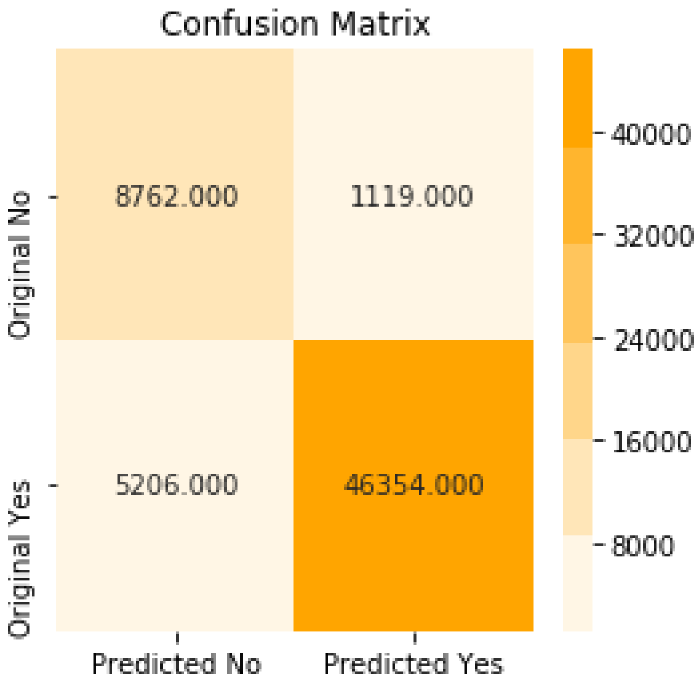
```
In [104]: # Plotting confusion matrix for train
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

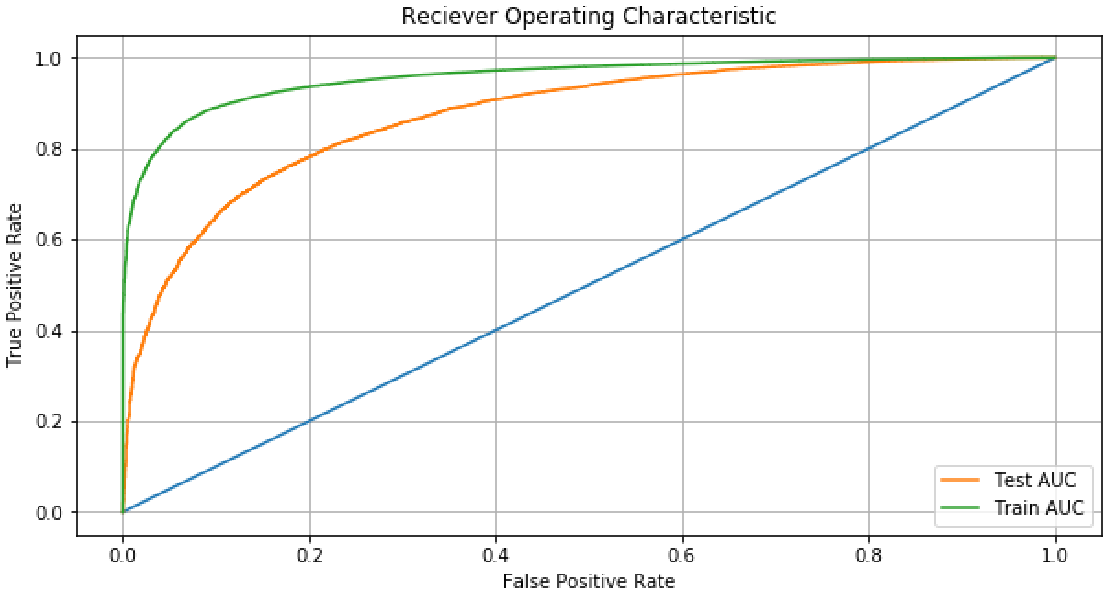


```
In [105]: # Plotting confusion matrix for test
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [106]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.2 [5.2] Applying GBDT using XGBOOST

6.2.1 [5.2.1] Applying XGBOOST on BOW, SET 1

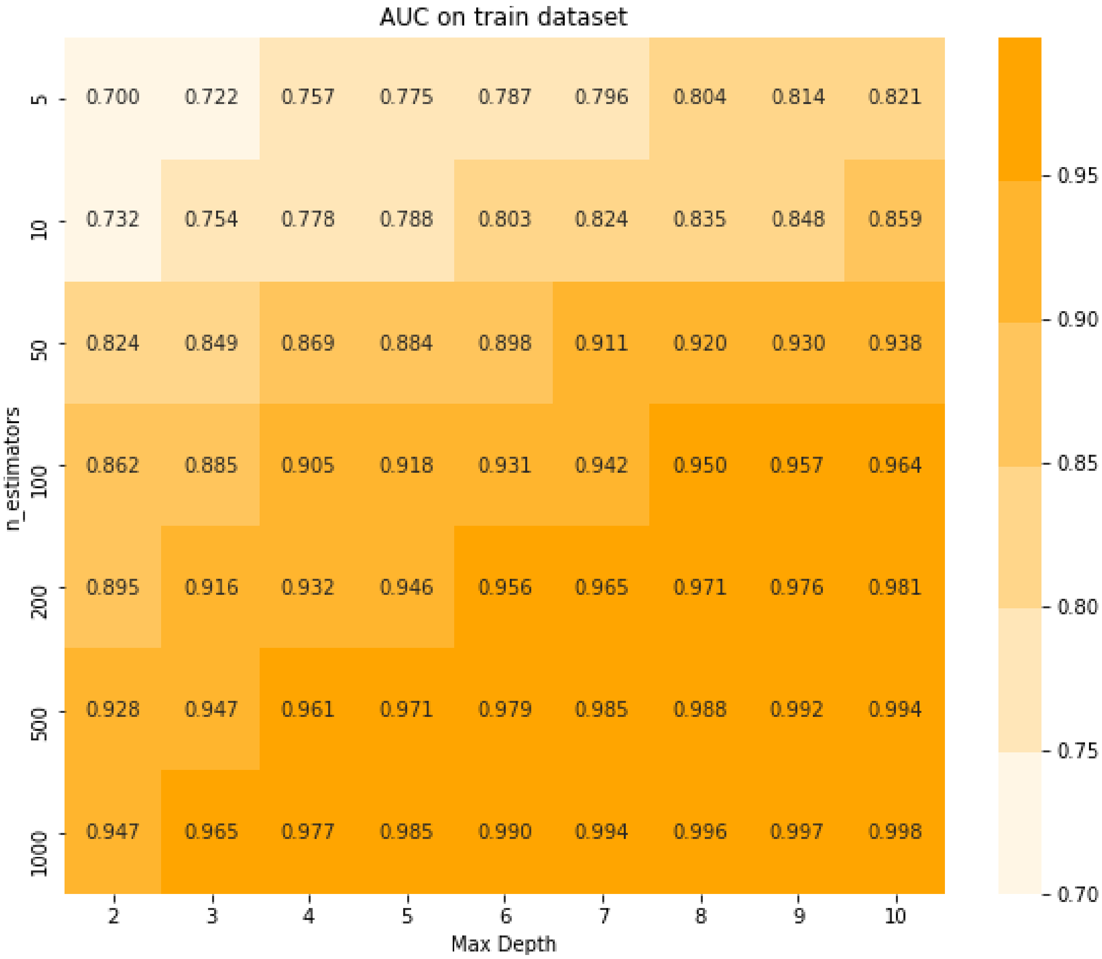
```
In [37]: n_estimators = [5,10,50,100,200,500,1000]
         max_depth = [2,3,4,5,6,7,8,9,10]
```

```
In [38]: from xgboost import XGBClassifier

         # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf=XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
                 clf.fit(bow_train_vect,Y_train)

                 predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probability
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [22:32<00:00, 314.95s/it]
```

```
In [39]: # Plotting plot of AUC for each combination of hyper parameters
         print("Training AUC")
         xg_plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

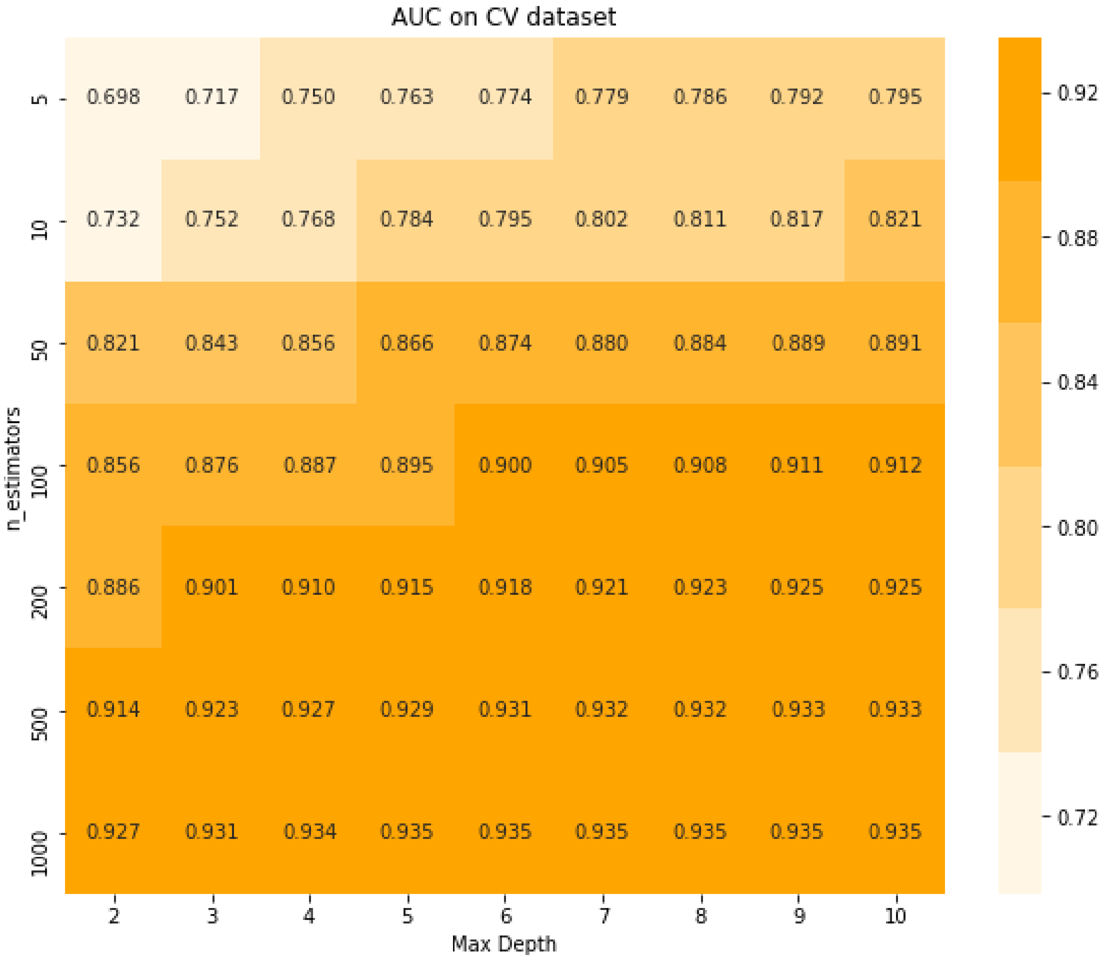


```
In [40]: from sklearn.ensemble import RandomForestClassifier
         from sklearn.metrics import roc_auc_score
         from xgboost import XGBClassifier
         # Time series object
         from sklearn.model_selection import TimeSeriesSplit
         tscv = TimeSeriesSplit(n_splits=3)

         # In this section we will perform 5-fold Cross validation on timse series split data

         cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
         m=0 # For row index
         n=0 # For col index
         for k in tqdm(n_estimators):
             n=0
             for s in max_depth:
                 # XGB Classifier
                 clf=XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
```

```
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(bow_train_vect):
            x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(exc
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
            x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tra
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
/usr/local/lib/python3.5/site-packages/sklearn/ensemble/weight_boosting.py:29: DeprecationWarn
  from numpy.core.umath_tests import inner1d
100%|| 7/7 [49:03<00:00, 692.41s/it]
```

```
In [50]: # Plotting plot of AUC for each combination of hyper parameters
         xg_plot_test_auc_heatmap(cv_auc)
```



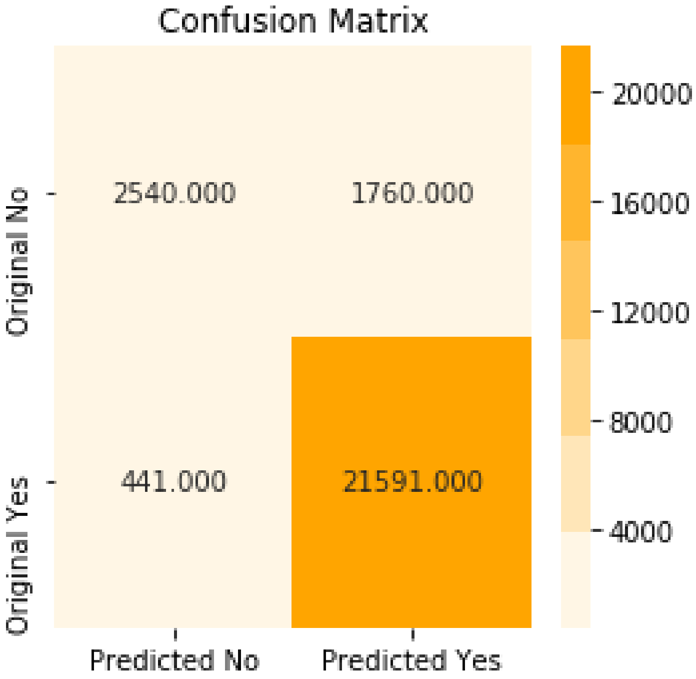
```
In [42]: import warnings
         warnings.filterwarnings(module='sklearn*', action='ignore', category=DeprecationWarni
```

```
In [43]: # Training the final model on best hyper-parameters
         clf = XGBClassifier(n_estimators=1000,max_depth=5,n_jobs=-1)
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)
         predict_y_train = clf.predict(bow_train_vect)

         probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posit
         probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for pos
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.943
```

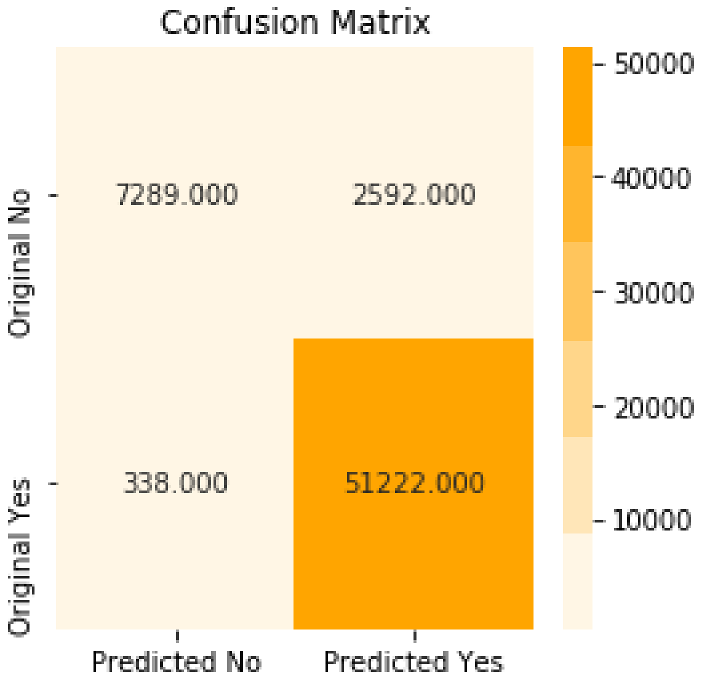
```
In [44]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

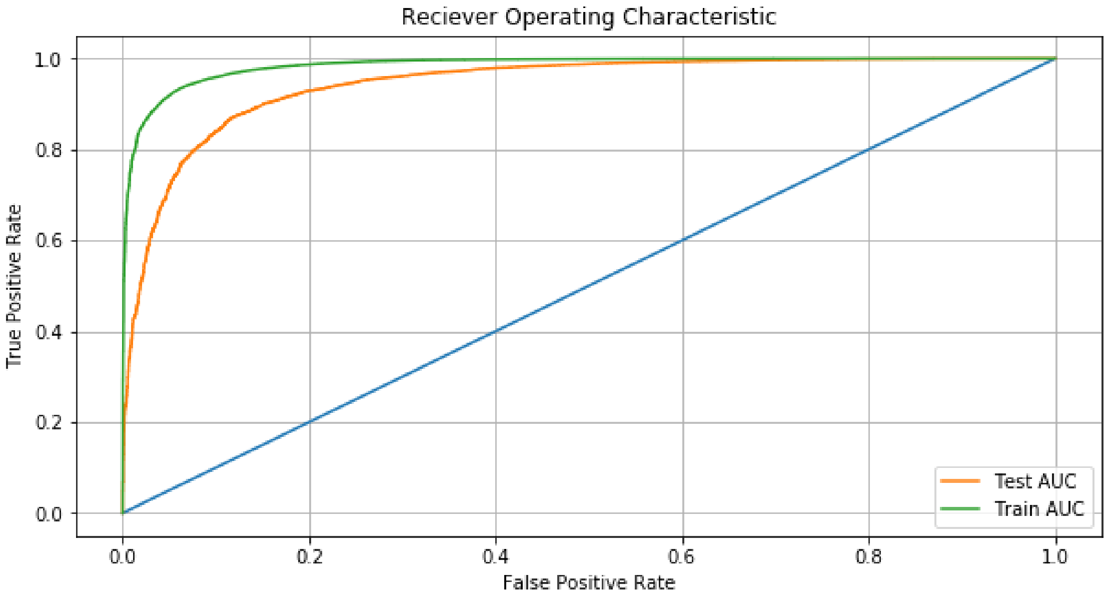


```
In [45]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [46]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



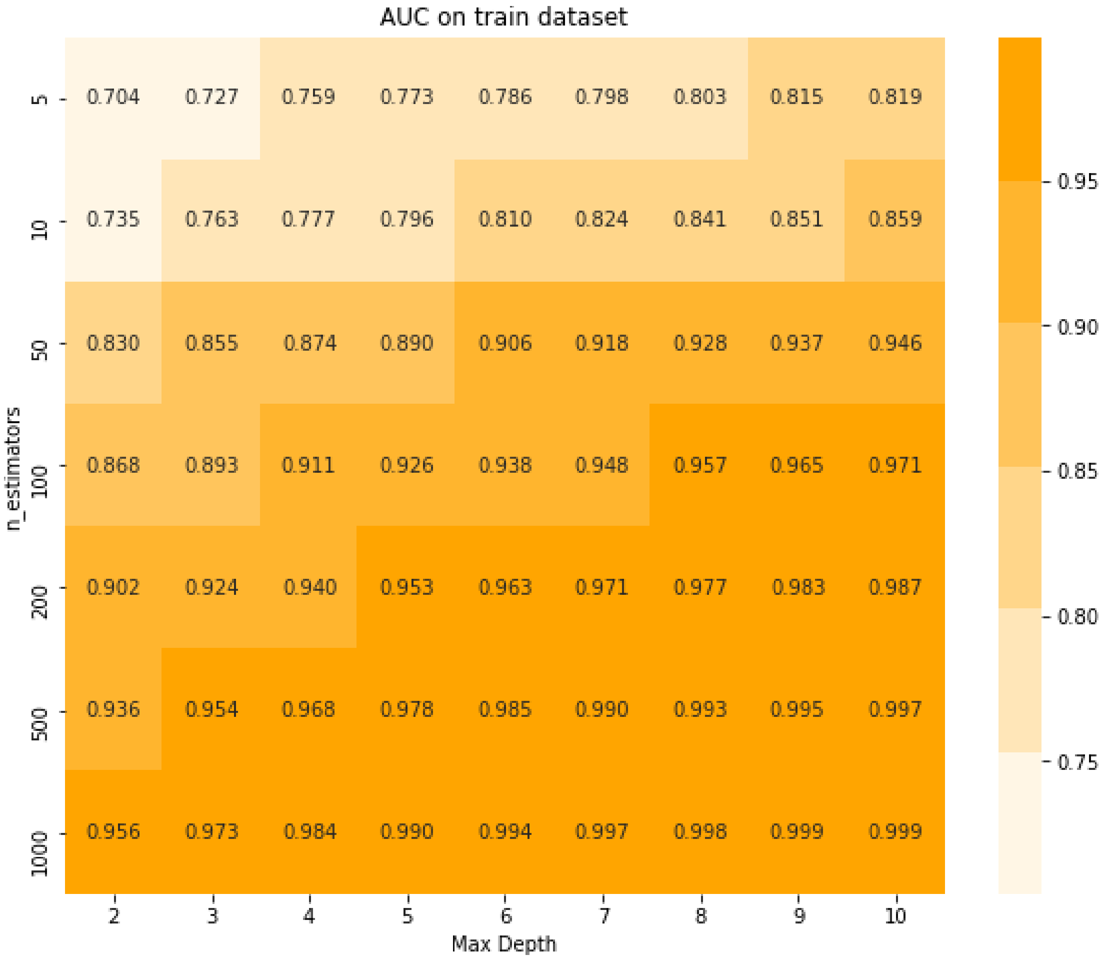
6.2.2 [5.2.2] Applying XGBOOST on TFIDF, SET 2

```
In [47]: # Initializing Tfidf Vectorizer
         tfidf_vect = TfidfVectorizer()

         # Vectorizing train and test dataset
         tfidf_train_vect = tfidf_vect.fit_transform(X_train)
         tfidf_test_vect = tfidf_vect.transform(X_test)
```

```
In [48]: from xgboost import XGBClassifier

         # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

         from sklearn.ensemble import RandomForestClassifier
         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf=XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
                 clf.fit(tfidf_train_vect,Y_train)

                 predict_probab = clf.predict_proba(tfidf_train_vect)[:,1] # returns probabili
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [40:21<00:00, 569.93s/it]
```

```
In [51]: # Plotting plot of AUC for each combination of hyper parameters
         xg_plot_train_auc_heatmap(train_auc)
```

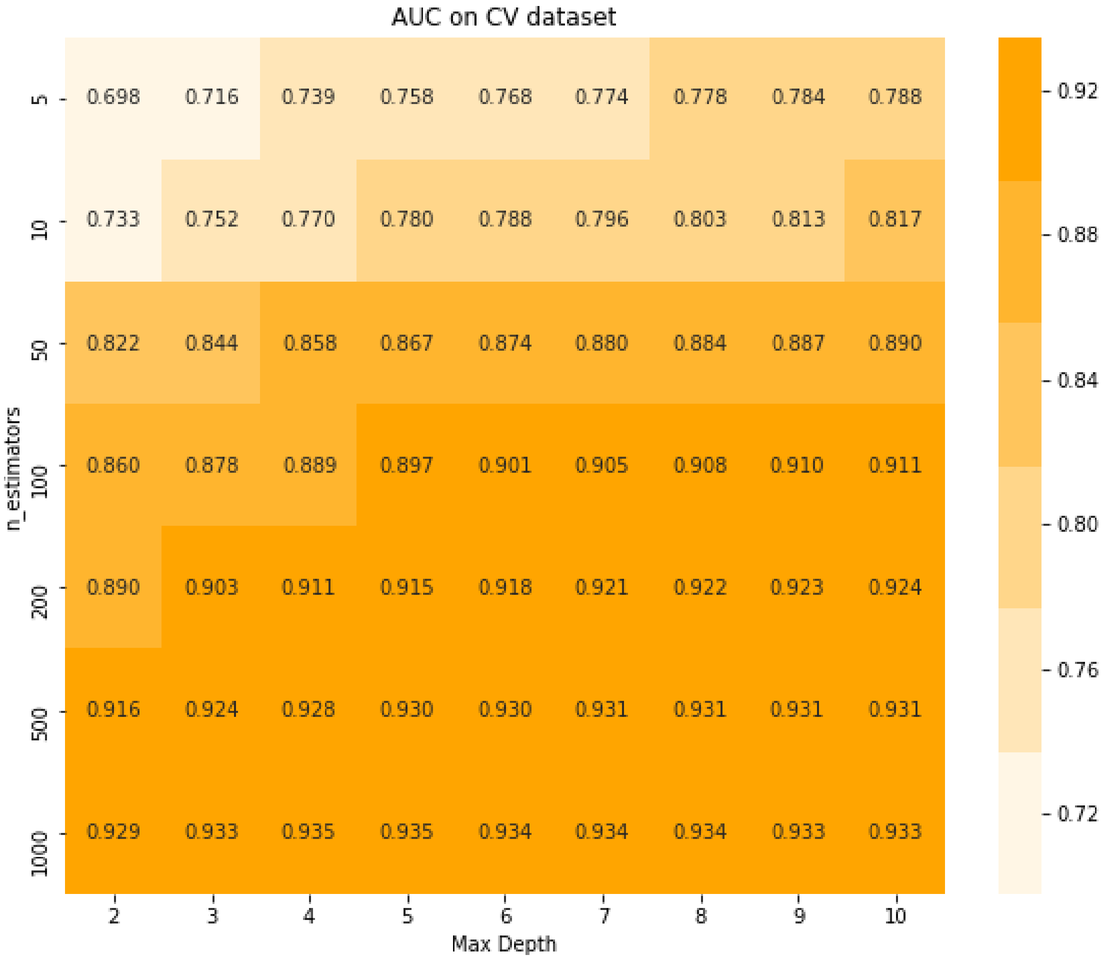


In [52]:
```
from sklearn.metrics import roc_auc_score
from xgboost import XGBClassifier
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 5-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # XGB Classifier
        clf=XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
        i=0
```

```
                auc=0.0
                for train_index,test_index in tscv.split(tfidf_train_vect):
                    x_train = tfidf_train_vect[0:train_index[-1]][:] # row 0 to train_index(e
                    y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                    x_test = tfidf_train_vect[train_index[-1]:test_index[-1]][:] # row from t
                    y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

                    clf.fit(x_train,y_train)

                    predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
                    i += 1
                    auc += roc_auc_score(y_test,predict_probab)

                cv_auc[m][n] = auc/i # Storing AUC value
                n = n+1 # Incrementing col index after each iteration
            m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [2:04:35<00:00, 1770.48s/it]
```

```
In [53]: # Plotting plot of AUC for each combination of hyper parameters
         xg_plot_test_auc_heatmap(cv_auc)
```

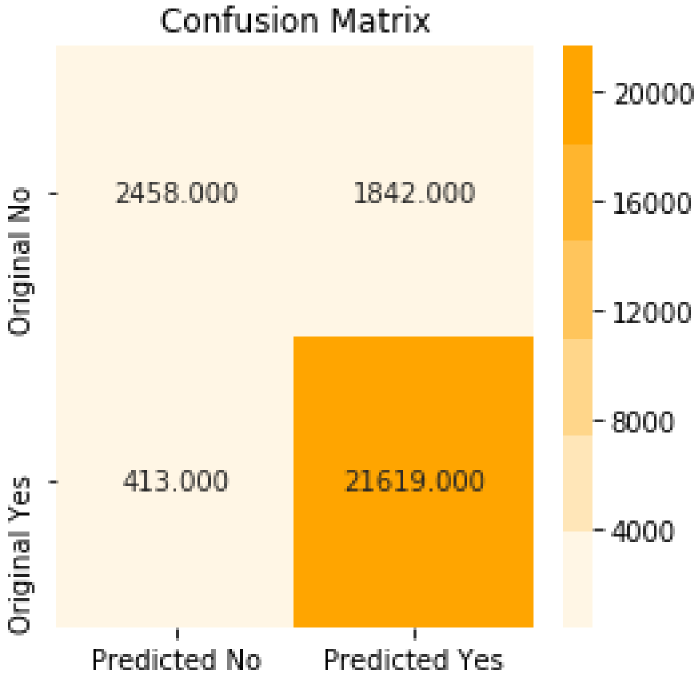


```
In [85]: # Training the final model on best hyper-parameters
         clf = XGBClassifier(n_estimators=1000,max_depth=4,n_jobs=-1)
         clf.fit(tfidf_train_vect,Y_train)

         predict_y_test = clf.predict(tfidf_test_vect)
         predict_y_train = clf.predict(tfidf_train_vect)

         probab_y_test = clf.predict_proba(tfidf_test_vect)[:,1] # returns probability for pos
         probab_y_train = clf.predict_proba(tfidf_train_vect)[:,1] # returns probability for p
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Tfidf Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Tfidf Vectorized Model is 0.946
```

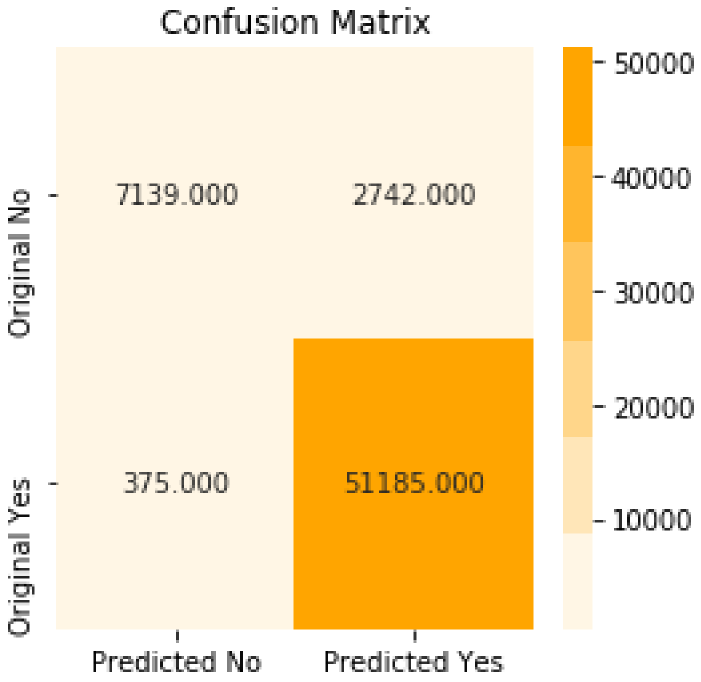
```
In [86]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

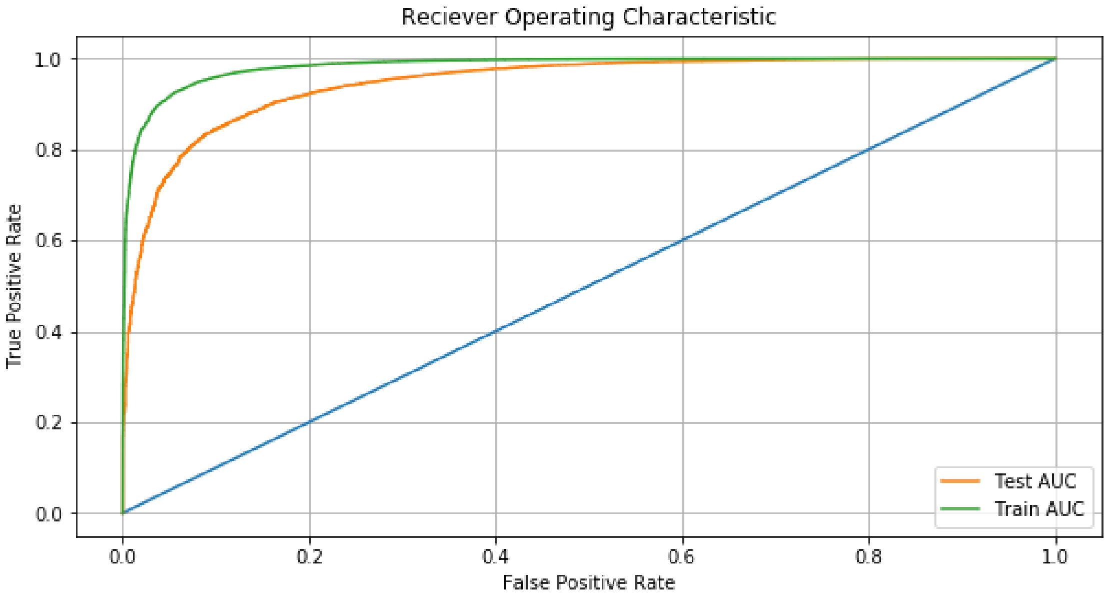


```
In [87]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [88]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.2.3 [5.2.3] Applying XGBOOST on AVG W2V, SET 3

```
In [54]: list_of_sentence=[]
         for sent in preprocessed_reviews:
             list_of_sentence.append(sent.split())
```

```
In [55]: import warnings
         warnings.filterwarnings(module='sklearn*', action='ignore', category=DeprecationWarni
```

```
In [56]: # Splitting data into train and test dataset

         X = list_of_sentence

         X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
```

```
In [57]: # Train Word2vec model on train dataset and use this for test dataset vectorization
         # Training word2Vec model on traain dataset and will use same for test dataset
         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(X_train,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.b
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
```

```
[('good', 0.8390023708343506), ('awesome', 0.8284731507301331), ('fantastic', 0.81432235240936
==================================================
[('greatest', 0.780515193939209), ('best', 0.7210771441459656), ('experienced', 0.669311761856
```

```
In [58]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  14819
sample words  ['flake', 'holding', 'carnivorous', 'soldier', 'anchor', 'overpowering', 'buddie
```

```
In [59]: # average Word2Vec
         # compute average word2vec for each review of training dataset

         train_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this lis
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need t
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             train_sent_vectors.append(sent_vec)
         print(len(train_sent_vectors))
         print(len(train_sent_vectors[0]))
```

```
100%|| 61441/61441 [12:40<00:00, 80.79it/s]

61441
50
```

```
In [60]: test_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need t
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             test_sent_vectors.append(sent_vec)
         print(len(test_sent_vectors))
         print(len(test_sent_vectors[0]))
```

```
100%|| 26332/26332 [05:34<00:00, 78.75it/s]

26332
50
```

In [61]:

```
# XgBoost dont take list as training data hence converting list of avg word2vec to pa
import pandas as pd
# For train dataset
train_avg_w2v = pd.DataFrame(train_sent_vectors,columns=["f"+str(i) for i in range(1,5

# For test dataset
test_avg_w2v = pd.DataFrame(test_sent_vectors,columns=["f"+str(i) for i in range(1,51
```

In [62]:

```
train_avg_w2v.head(5)
```

Out[62]:

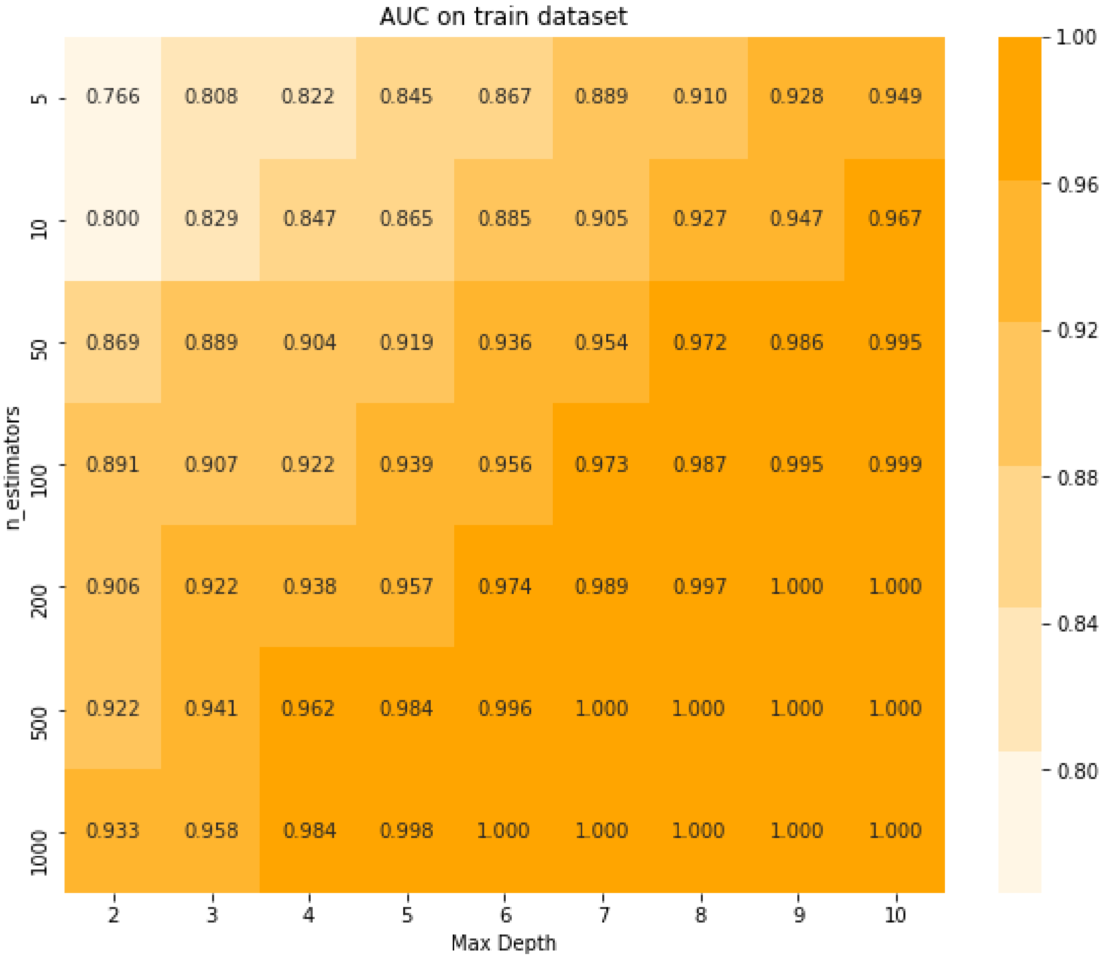
```
         f1        f2        f3        f4        f5        f6        f7  \
0 -1.560417 -0.046639  0.248266  0.287027 -0.117397  0.306847 -1.493014
1 -1.253325 -0.921579  0.271559 -0.149547  0.014046  0.160617 -0.370920
2 -0.411293  0.356491 -0.037375  0.298867  1.031745  0.614958 -0.556390
3 -0.241459 -0.041505  0.023508  0.100616 -0.176033  0.197557 -0.753765
4  0.085517  0.140958 -1.544227  0.815313  1.148897 -1.185408 -0.027636

         f8        f9       f10  ...       f41       f42       f43       f44  \
0  0.239451  0.876294  0.272031  ...  0.127697 -0.276451  1.400507  1.291518
1 -0.310893  1.330967  0.096550  ... -0.359244 -0.862469  0.530903  0.036695
2 -0.317174  0.275976  0.580415  ...  0.361931  0.050541  0.474794 -0.317919
3 -0.005021  0.388801  0.303358  ... -0.161035  0.293486  0.005340  1.607936
4 -0.318185 -0.601505  1.113308  ... -0.762762 -0.558068  0.602984  0.499654

        f45       f46       f47       f48       f49       f50
0 -1.085165 -0.880523  0.061699 -0.510285  0.281956  0.674110
1 -0.619506 -0.825178 -0.165943 -0.498222 -0.213726  0.195696
2 -0.076586 -0.473994  0.200595  0.157202 -0.043227 -0.621170
3 -0.023044 -0.115403  0.144392 -0.201287 -0.232914  0.036517
4  0.471291  1.265684  0.047255  0.502940  0.566201 -0.341998

[5 rows x 50 columns]
```

In [63]:

```
# Trainig the model and testing on train data to find AUC on train data.
# This will store the AUC for each combination of depth and min sample.
# Here row corresponds to depth and columns corresponds to min sample.
train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score

i=0 # To keep count of rows.
j=0 # To kepe count of columns.
for k in tqdm(n_estimators):
    j=0 # Reinitializing column to zero for each row
    for s in max_depth:
        clf=XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
        clf.fit(train_avg_w2v,Y_train)
        predict_probab = clf.predict_proba(train_avg_w2v)[:,1] # returns probability
        auc = roc_auc_score(Y_train,predict_probab)
        train_auc[i][j] = auc
        j  =j+1 # incrementing the col index at the end of each iteration.
    i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [31:06<00:00, 445.14s/it]
```

In [64]:
```
# Plotting plot of AUC for each combination of hyper parameters
xg_plot_train_auc_heatmap(train_auc)
```



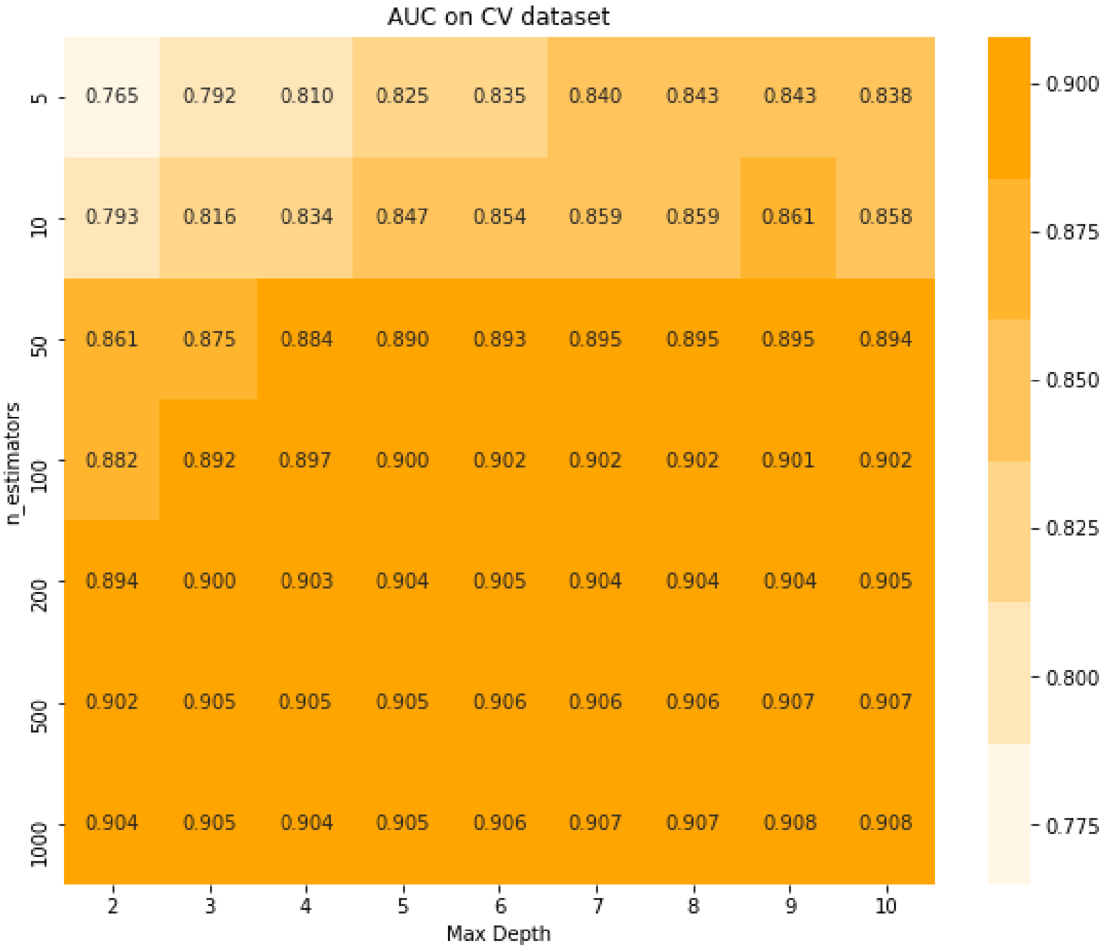
n_estimators	2	3	4	5	6	7	8	9	10
5	0.766	0.808	0.822	0.845	0.867	0.889	0.910	0.928	0.949
10	0.800	0.829	0.847	0.865	0.885	0.905	0.927	0.947	0.967
50	0.869	0.889	0.904	0.919	0.936	0.954	0.972	0.986	0.995
100	0.891	0.907	0.922	0.939	0.956	0.973	0.987	0.995	0.999
200	0.906	0.922	0.938	0.957	0.974	0.989	0.997	1.000	1.000
500	0.922	0.941	0.962	0.984	0.996	1.000	1.000	1.000	1.000
1000	0.933	0.958	0.984	0.998	1.000	1.000	1.000	1.000	1.000

In [65]:
```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)
```

```
        # In this section we will perform 5-fold Cross validation on timse series split data

        cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
        m=0 # For row index
        n=0 # For col index
        for k in tqdm(n_estimators):
            n=0
            for s in max_depth:
                # Deecision Tree Classifier
                clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
                i=0
                auc=0.0
                for train_index,test_index in tscv.split(train_avg_w2v):
                    x_train = train_avg_w2v[0:train_index[-1]][:] # row 0 to train_index(excl
                    y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                    x_test = train_avg_w2v[train_index[-1]:test_index[-1]][:] # row from trai
                    y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

                    clf.fit(x_train,y_train)

                    predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
                    i += 1
                    auc += roc_auc_score(y_test,predict_probab)

                cv_auc[m][n] = auc/i # Storing AUC value
                n = n+1 # Incrementing col index after each iteration
            m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [1:14:38<00:00, 1064.99s/it]
```

```
In [66]: # Plotting plot of AUC for each combination of hyper parameters
         xg_plot_test_auc_heatmap(cv_auc)
```

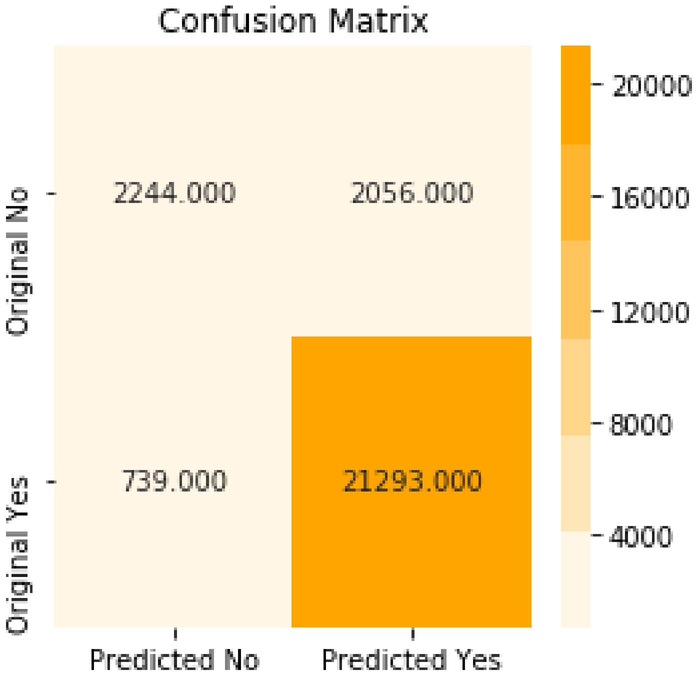


```
In [93]: # Training the final model on best hyper-parameters
         clf = XGBClassifier(n_estimators=1000,max_depth=3,n_jobs=-1)
         clf.fit(train_avg_w2v,Y_train)

         predict_y_test = clf.predict(test_avg_w2v)
         predict_y_train = clf.predict(train_avg_w2v)

         probab_y_test = clf.predict_proba(test_avg_w2v)[:,1] # returns probability for positi
         probab_y_train = clf.predict_proba(train_avg_w2v)[:,1] # returns probability for posi
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Avg Word2Vec Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Avg Word2Vec Vectorized Model is 0.913
```

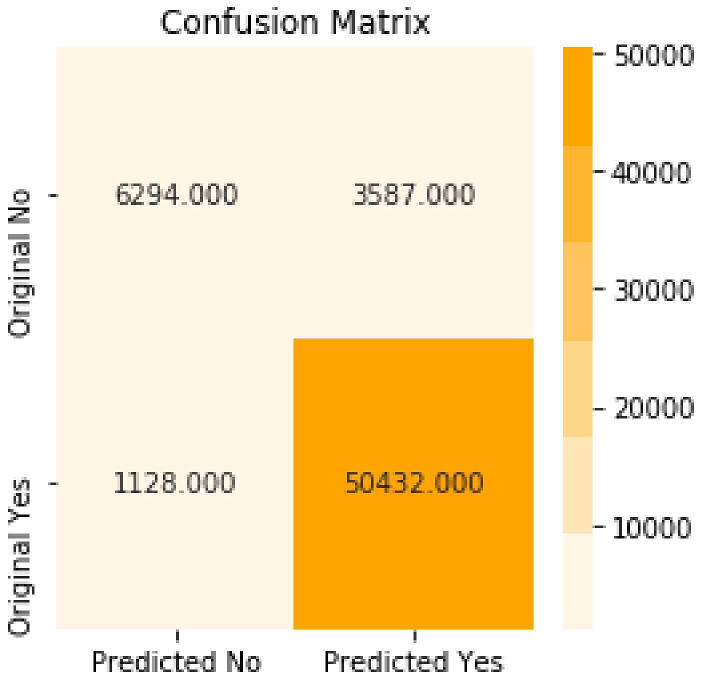
```
In [94]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

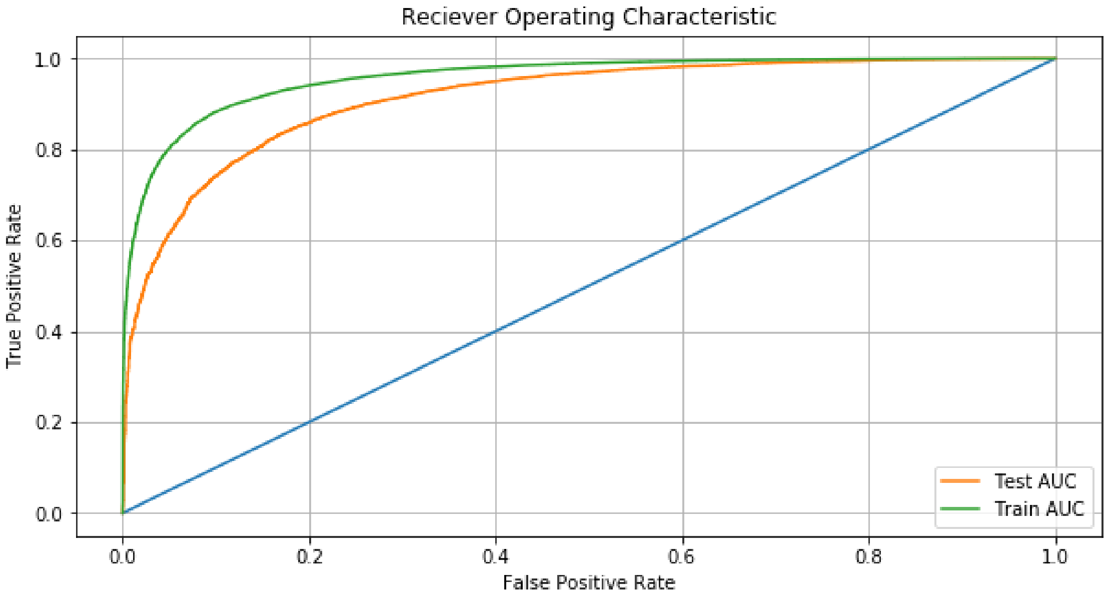


```
In [95]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [96]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



6.2.4 [5.2.4] Applying XGBOOST on TFIDF W2V, SET 4

```
In [67]: # X_train contains sentences for training and X_test contains sentances for testing th
         # Calculating TfidfW2V for X_train
         from sklearn.model_selection import train_test_split
         Y = final['Score']

         X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3

         model = TfidfVectorizer()
         train_tfidf_matrix = model.fit_transform(X_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [68]: # Training word2Vec model on traain dataset and will use same for test dataset
         w2v_train = []
         for sent in X_train:
             w2v_train.append(sent.split())

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(w2v_train,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True,
```

```
[('awesome', 0.8521878719329834), ('fantastic', 0.8364487886428833), ('good', 0.833314061164485
==================================================
[('greatest', 0.7815619707107544), ('best', 0.7260794043540955), ('tastiest', 0.66905212402343
```

```
In [69]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  14819
sample words  ['flake', 'holding', 'carnivorous', 'soldier', 'anchor', 'overpowering', 'buddies
```

```
In [70]: list_of_sentence=[]
         for sent in preprocessed_reviews:
             list_of_sentence.append(sent.split())
```

```
In [71]: X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentence,Y,test_size=0.3,rand
```

```
In [72]: # TF-IDF weighted Word2Vec for X_train
         train_tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review of X_train is
         row=0;
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in train_tfidf_feat:
                     vec = w2v_model.wv[word]
                     #tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf values of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             train_tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 61441/61441 [36:07<00:00, 28.35it/s]
```

```
In [73]: # TF-IDF weighted Word2Vec for X_test
         test_tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review of X_train is
         row=0;
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in test_tfidf_feat:
                     vec = w2v_model.wv[word]
         #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
```

```
                tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                sent_vec += (vec * tf_idf)
                weight_sum += 1
        if weight_sum != 0:
            sent_vec /= weight_sum
        test_tfidf_sent_vectors.append(sent_vec)
        row += 1
```

```
100%|| 26332/26332 [14:58<00:00, 29.31it/s]
```

```
In [74]: # Getting number of features of each data point
         print(len(train_tfidf_sent_vectors[0]))
         print(len(test_tfidf_sent_vectors[0]))
```

```
50
50
```

```
In [75]: # XgBoost dont take list as training data hence converting list of avg word2vec to pa
         import pandas as pd
         # For train dataset
         train_tfidf_avg_w2v = pd.DataFrame(train_tfidf_sent_vectors,columns=["f"+str(i) for i

         # For test dataset
         test_tfidf_avg_w2v = pd.DataFrame(test_tfidf_sent_vectors,columns=["f"+str(i) for i i
```

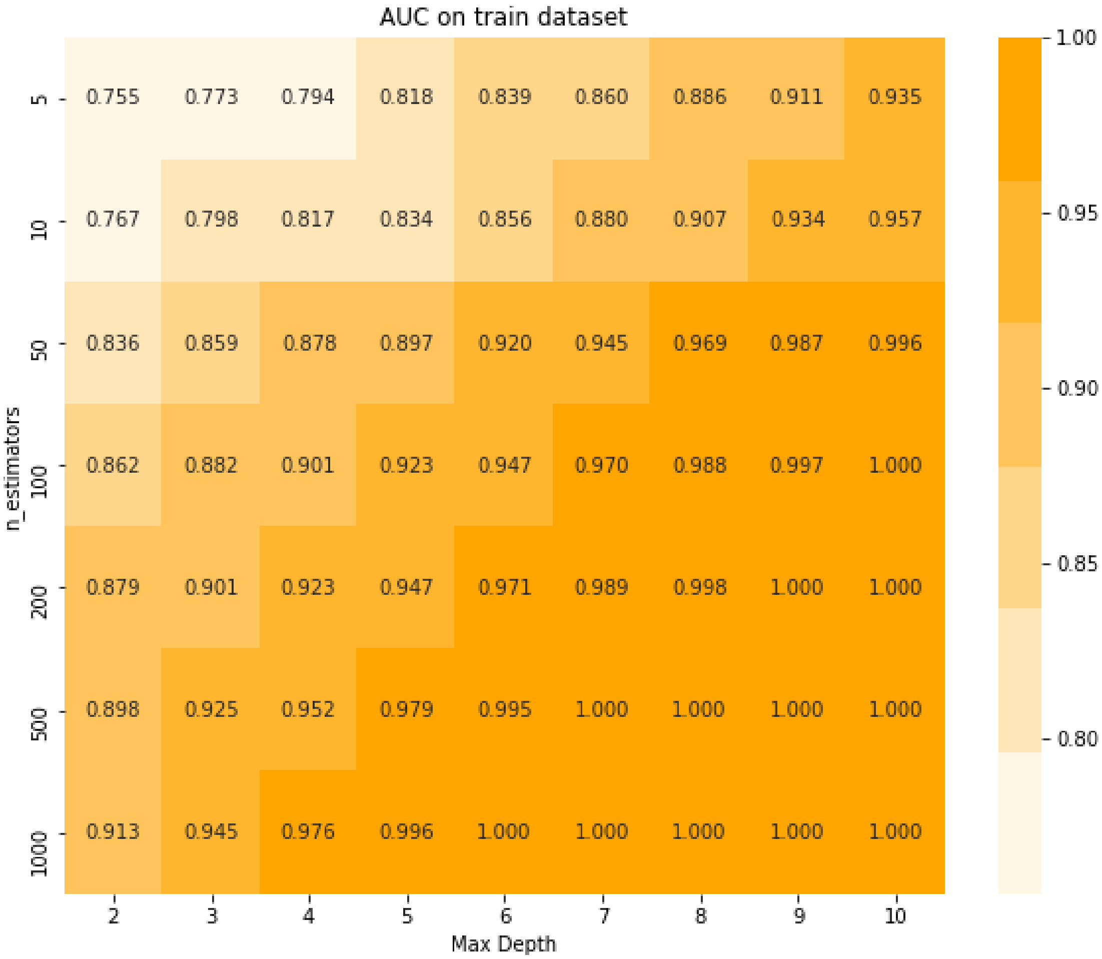
```
In [76]: train_tfidf_avg_w2v.head(5)
```

```
Out[76]:          f1        f2        f3        f4        f5        f6        f7  \
         0 -0.544891  0.030904  0.117440 -0.137547 -0.096995 -0.065314 -0.288887
         1 -0.191537 -0.109700  0.070908 -0.138145  0.008502 -0.001279 -0.204992
         2  0.044443  0.127834  0.015566  0.042355  0.192506  0.137427 -0.086910
         3  0.065350  0.169618  0.192669 -0.116854 -0.104076  0.058219 -0.279337
         4  0.175641  0.140221 -0.617364  0.328042  0.375278 -0.364321  0.167569

                  f8        f9       f10  ...       f41       f42       f43       f44  \
         0 -0.033813  0.080794  0.006863  ... -0.011866  0.043584  0.385902  0.145149
         1 -0.056842  0.158462 -0.001578  ...  0.017432 -0.138845  0.113916  0.024152
         2 -0.101672 -0.066975  0.098990  ...  0.108459 -0.019552  0.091552 -0.111097
         3  0.001525  0.104630  0.126225  ...  0.021866  0.094587  0.084503  0.585314
         4 -0.138047 -0.214873  0.566958  ... -0.362409 -0.349332  0.160916 -0.110942

                 f45       f46       f47       f48       f49       f50
         0 -0.548001 -0.123830 -0.067910 -0.335600  0.151738  0.081814
         1 -0.250449 -0.153109 -0.074682 -0.140039 -0.033990  0.018295
         2 -0.090054 -0.026667 -0.004502 -0.030629  0.035804 -0.100457
         3 -0.132620 -0.061884  0.023663 -0.056462  0.020785 -0.081664
         4  0.375153  0.585484 -0.032081 -0.016147  0.359893 -0.301511
         [5 rows x 50 columns]
```

```
In [77]: # Trainig the model and testing on train data to find AUC on train data.
         # This will store the AUC for each combination of depth and min sample.
         # Here row corresponds to depth and columns corresponds to min sample.
         train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))
         from sklearn.metrics import roc_auc_score

         i=0 # To keep count of rows.
         j=0 # To kepe count of columns.
         for k in tqdm(n_estimators):
             j=0 # Reinitializing column to zero for each row
             for s in max_depth:
                 clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
                 clf.fit(train_tfidf_avg_w2v,Y_train)

                 predict_probab = clf.predict_proba(train_tfidf_avg_w2v)[:,1] # returns probab
                 auc = roc_auc_score(Y_train,predict_probab)
                 train_auc[i][j] = auc
                 j  =j+1 # incrementing the col index at the end of each iteration.
             i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [31:40<00:00, 453.44s/it]
```

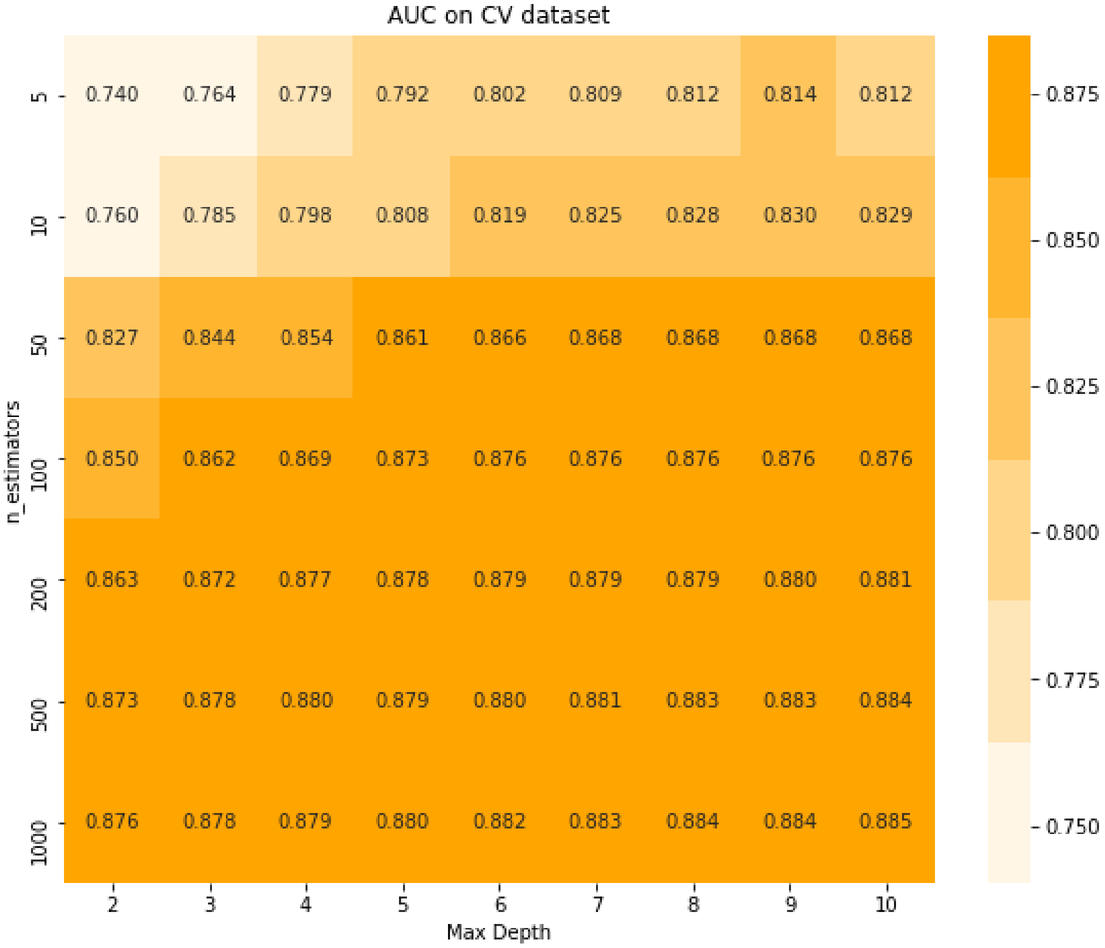
```
In [78]: # Plotting plot of AUC for each combination of hyper parameters
         xg_plot_train_auc_heatmap(train_auc)
```



In [79]:
```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 3-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross va
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(train_tfidf_avg_w2v):
            x_train = train_tfidf_avg_w2v[0:train_index[-1]][:] # row 0 to train_inde
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
            x_test = train_tfidf_avg_w2v[train_index[-1]:test_index[-1]][:] # row fro
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_inde

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability for
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [1:16:13<00:00, 1086.03s/it]
```

In [80]:
```
# Plotting plot of AUC for each combination of hyper parameters
xg_plot_test_auc_heatmap(cv_auc)
```

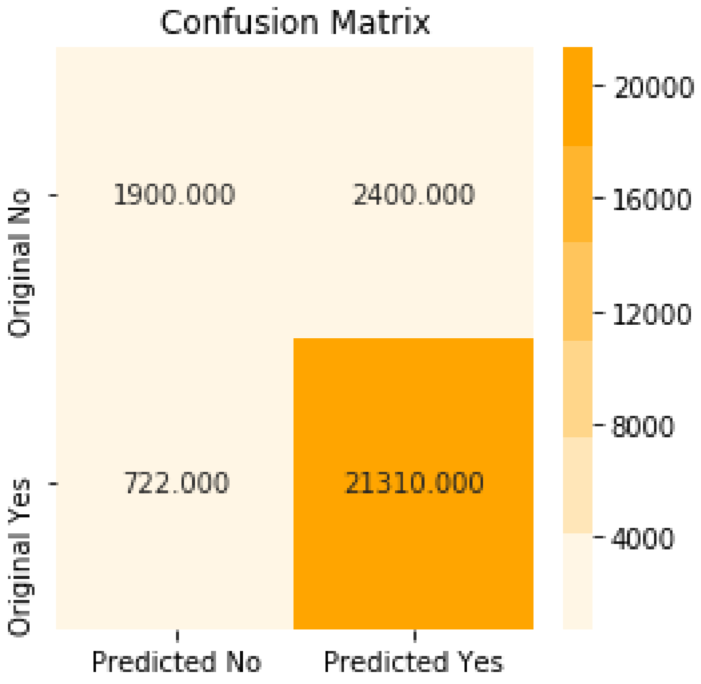


```
In [97]: # Training the final model on best hyper-parameters
         clf = XGBClassifier(n_estimators=1000,max_depth=5,n_jobs=-1)
         clf.fit(train_tfidf_avg_w2v,Y_train)

         predict_y_test = clf.predict(test_tfidf_avg_w2v)
         predict_y_train = clf.predict(train_tfidf_avg_w2v)

         probab_y_test = clf.predict_proba(test_tfidf_avg_w2v)[:,1] # returns probability for p
         probab_y_train = clf.predict_proba(train_tfidf_avg_w2v)[:,1] # returns probability fo
         auc = roc_auc_score(Y_test,probab_y_test)

         print("Auc of Avg Word2Vec Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Avg Word2Vec Vectorized Model is 0.890
```

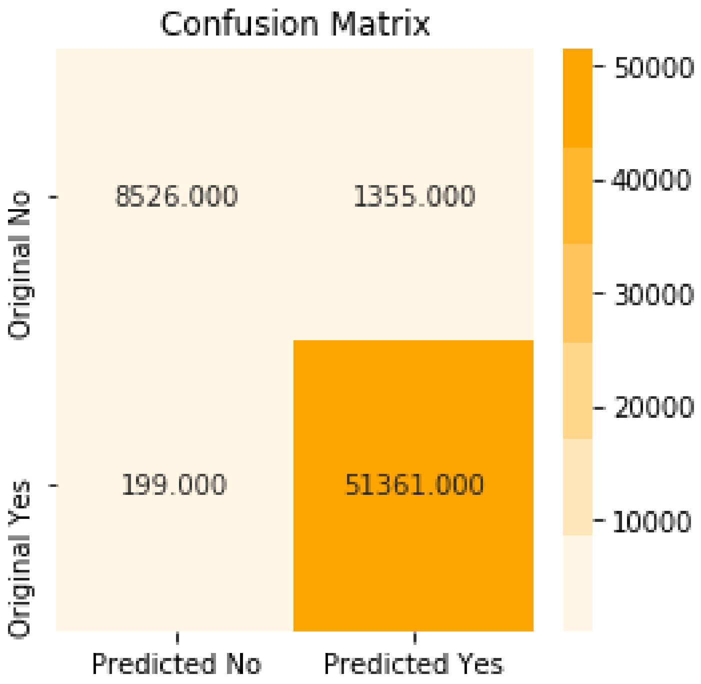
```
In [98]: # Plotting confusion matrix for train
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

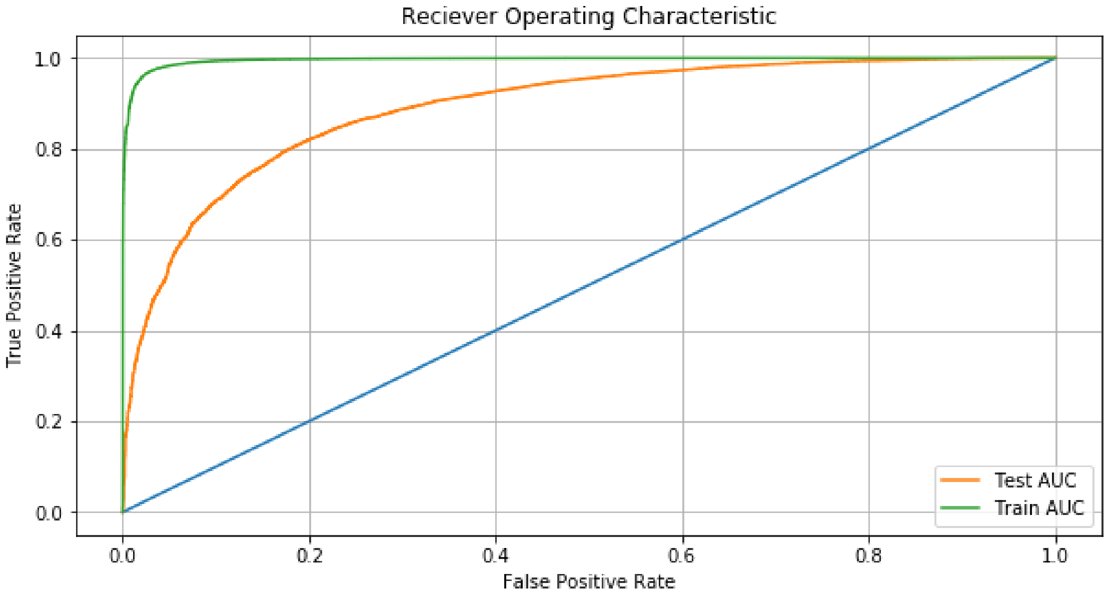


```
In [99]: # Plotting confusion matrix for test
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [100]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Feature Engineering
Using Review Length as feature

```
In [107]: # Splitting summary into train and test
          from sklearn.model_selection import train_test_split
          X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3
```

```
In [108]: # For reviews train and test dataset
          # Taking only 2000 features as training takes a lot of time
          count_vect = CountVectorizer(max_features=2000)
          # For train dataset
          bow_train_vect = count_vect.fit_transform(X_train)
          print(bow_train_vect.shape)

          # For test dataset
          bow_test_vect = count_vect.transform(X_test)
          print(bow_test_vect.shape)
```

```
(61441, 2000)
(26332, 2000)
```

```
In [109]: # Calculating and storing length of each review in train data set, in an numpy array

          train_review_len = np.zeros(len(X_train))
          i=0
          for sent in X_train:
              train_review_len[i] = len(sent)
              i += 1

          print(train_review_len.shape)
```

```
(61441,)
```

```
In [110]: # Calculating and storing length of each review in train data set, in an numpy array

          test_review_len = np.zeros(len(X_test))
          i=0
          for sent in X_test:
              test_review_len[i] = len(sent)
              i += 1

          print(test_review_len.shape)
```

```
(26332,)
```

```
In [111]: print(bow_train_vect.shape)
          print(bow_test_vect.shape)
```

```
(61441, 2000)
(26332, 2000)
```

```
In [112]: from scipy.sparse import hstack
          from scipy.sparse import coo_matrix
          from scipy.sparse import csr_matrix

          # now we will add review length as a new feature to train  data set
          # The shape of train_review_len is 254919 and hstack takes compatible matrices only
          # Making the train_review_len to bow_train_vect
          A = coo_matrix([train_review_len]).T

          bow_train_vect = hstack([bow_train_vect,A])
          print(bow_train_vect.shape)
```

```
(61441, 2001)
```

```
In [113]: # now we will add review length as a new feature to train  data set
          # Since hstack takes compatible matrices only
          # Making the test_review_len to bow_test_vect
          B = coo_matrix([test_review_len]).T
          bow_test_vect = hstack([bow_test_vect,B])
          print(bow_test_vect.shape)
```

```
(26332, 2001)
```

```
In [114]: from scipy import sparse
          # Converting bow_train_vect from scipy.sparse.coo.coo_matrix to scipy.sparse.csr.csr
          # scipy.sparse.coo.coo_matrix are not subscriptable

          bow_train_vect = sparse.csr_matrix(bow_train_vect)
          print(type(bow_train_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [115]: # Doing same as above for test dataset
          bow_test_vect = sparse.csr_matrix(bow_test_vect)
          print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [116]: # Standarizing data
          from sklearn.preprocessing import StandardScaler
          std = StandardScaler(with_mean=False)
          bow_train_vect = std.fit_transform(bow_train_vect)
          bow_test_vect = std.transform(bow_test_vect)
```

```
In [117]: import warnings
          warnings.filterwarnings("ignore",category=FutureWarning)
```

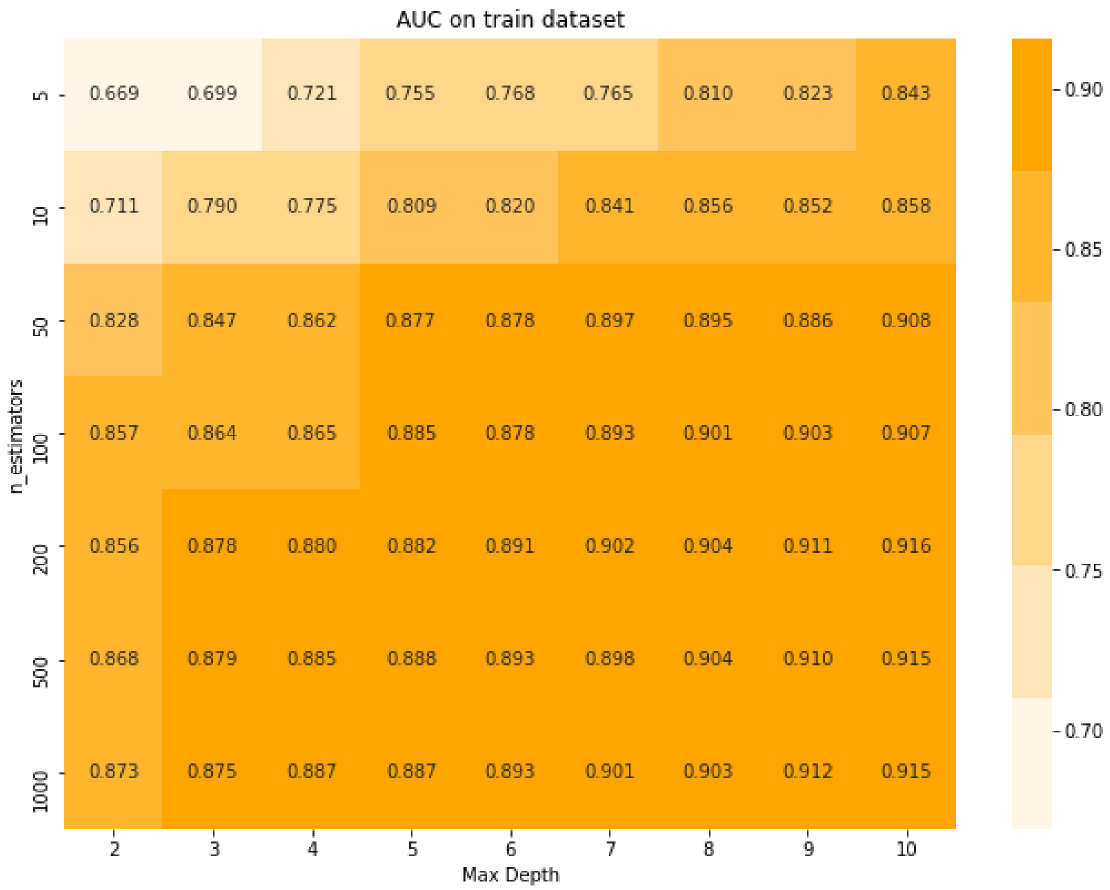
Training Random Forest Model

```
In [118]: # Trainig the model and testing on train data to find AUC on train data.
          # This will store the AUC for each combination of depth and min sample.
          # Here row corresponds to depth and columns corresponds to min sample.
          train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

          from sklearn.ensemble import RandomForestClassifier
          from sklearn.metrics import roc_auc_score

          i=0 # To keep count of rows.
          j=0 # To kepe count of columns.
          for k in tqdm(n_estimators):
              j=0 # Reinitializing column to zero for each row
              for s in max_depth:
                  clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weig
                  clf.fit(bow_train_vect,Y_train)

                  predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probabilit
                  auc = roc_auc_score(Y_train,predict_probab)
                  train_auc[i][j] = auc
                  j  =j+1 # incrementing the col index at the end of each iteration.
              i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [04:58<00:00, 70.25s/it]
```

```
In [119]: # Plotting plot of AUC for each combination of hyper parameters
          print("Training AUC")
          plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

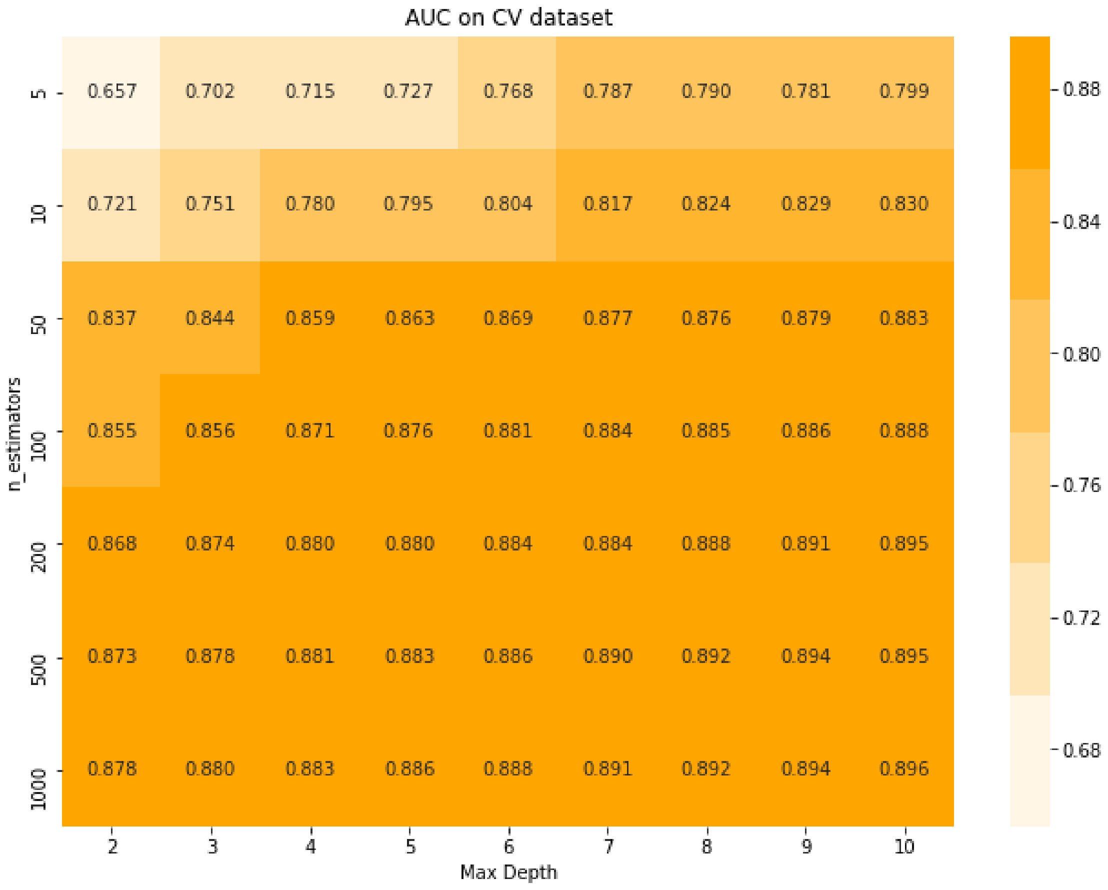


In [120]:
```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 5-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross v
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weig
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(bow_train_vect):
            x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(ex
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding
            x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tra
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_ind

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability fo
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [11:02<00:00, 151.07s/it]
```

```
In [121]: # Plotting plot of AUC for each combination of hyper parameters
          print("Validation  AUC")
          plot_test_auc_heatmap(cv_auc)
```

```
Validation  AUC
```

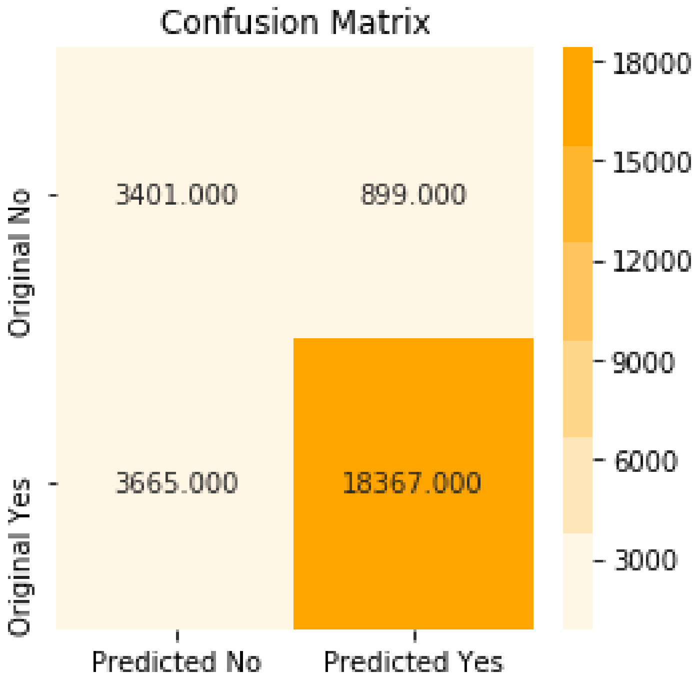


```
In [122]: # Training the final model on best hyper-parameters
          clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='
          clf.fit(bow_train_vect,Y_train)

          predict_y_test = clf.predict(bow_test_vect)
          predict_y_train = clf.predict(bow_train_vect)

          probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posi
          probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for po
          auc = roc_auc_score(Y_test,probab_y_test)

          print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.900
```

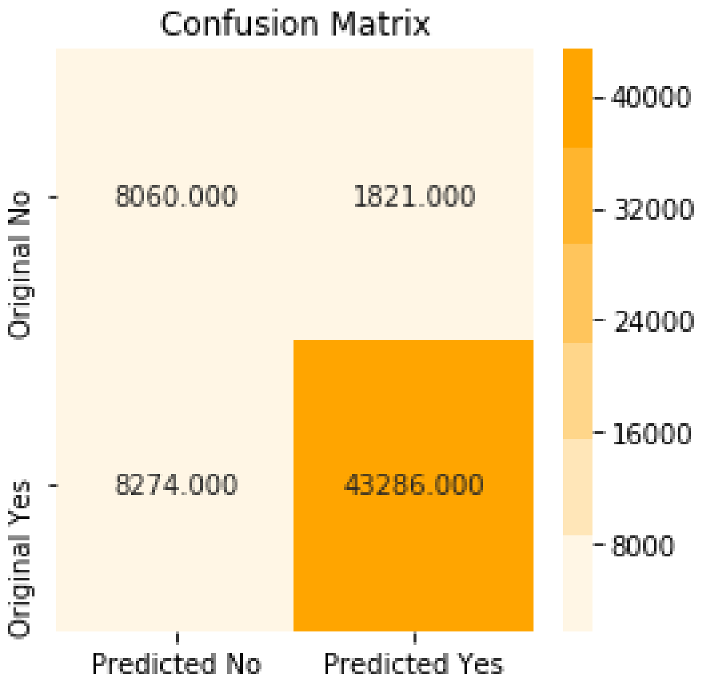
```
In [123]: # Plotting confusion matrix for train
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

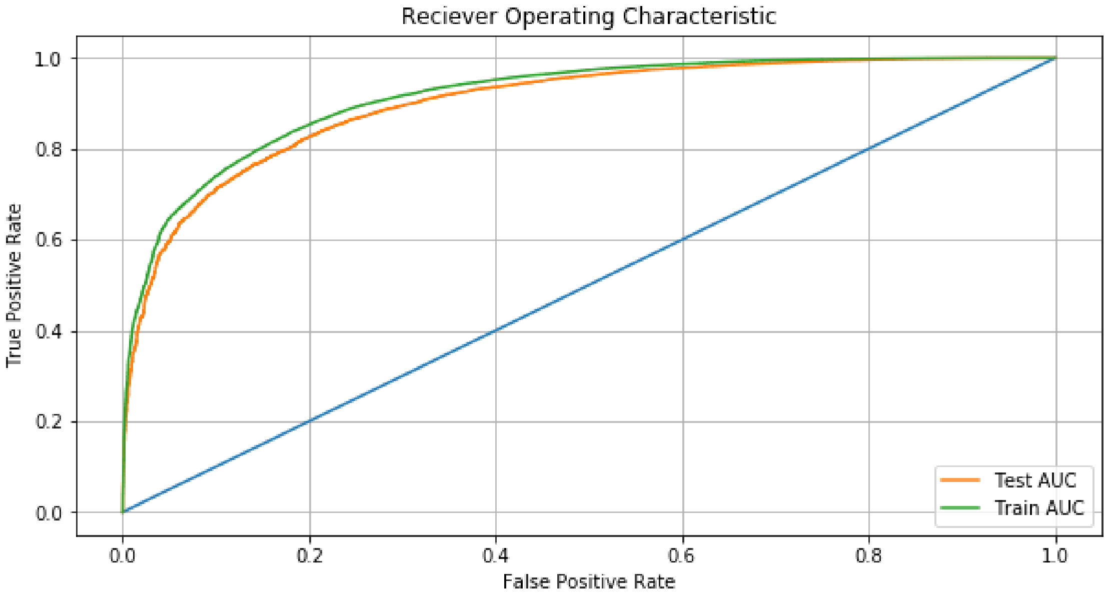


```
In [124]: # Plotting confusion matrix for test
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [125]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



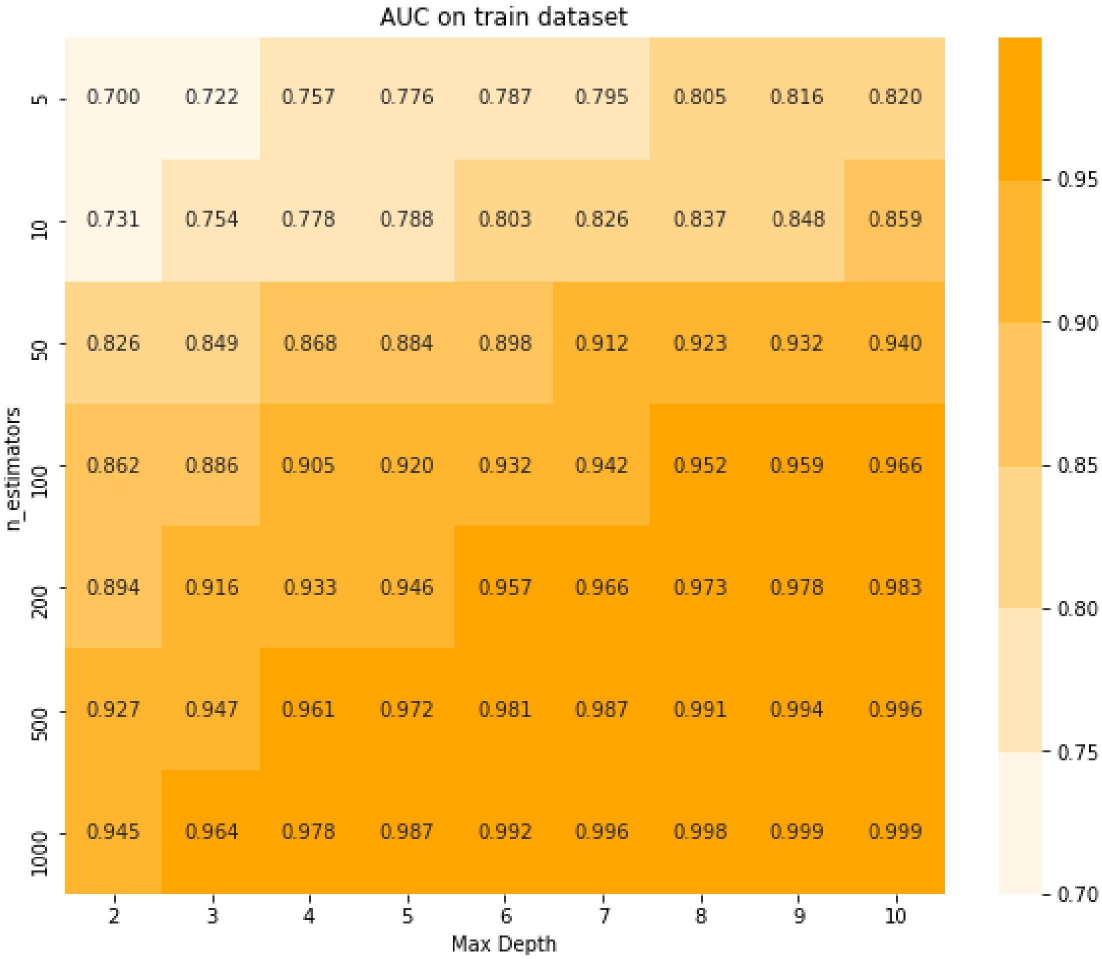
Training XGBClassifier

```
In [112]: # Trainig the model and testing on train data to find AUC on train data.
          # This will store the AUC for each combination of depth and min sample.
          # Here row corresponds to depth and columns corresponds to min sample.
          from xgboost import XGBClassifier
          train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

          from sklearn.metrics import roc_auc_score

          i=0 # To keep count of rows.
          j=0 # To kepe count of columns.
          for k in tqdm(n_estimators):
              j=0 # Reinitializing column to zero for each row
              for s in max_depth:
                  clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
                  clf.fit(bow_train_vect,Y_train)

                  predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probabilit
                  auc = roc_auc_score(Y_train,predict_probab)
                  train_auc[i][j] = auc
                  j  =j+1 # incrementing the col index at the end of each iteration.
              i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [11:52<00:00, 163.32s/it]
```

```
In [113]: # Plotting plot of AUC for each combination of hyper parameters
          print("Training AUC")
          xg_plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```



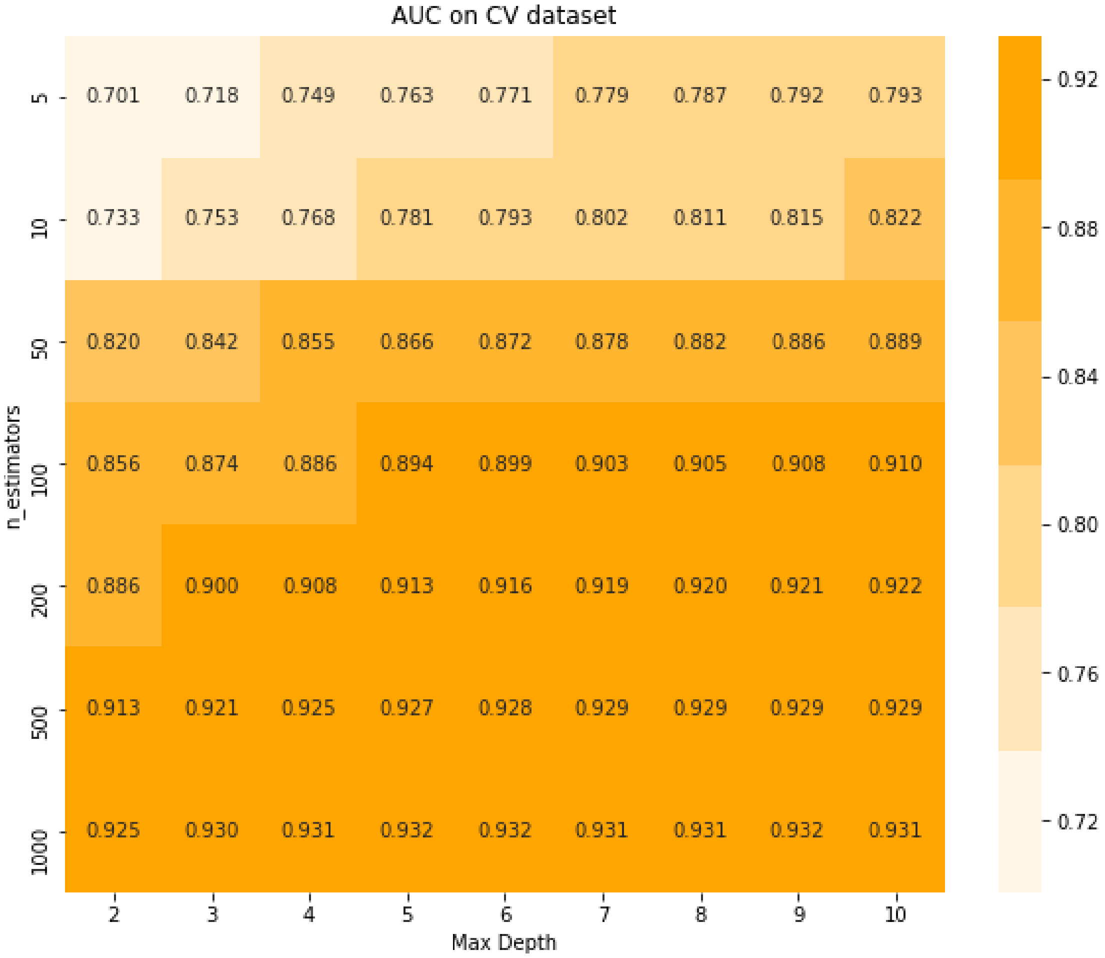
n_estimators	2	3	4	5	6	7	8	9	10
5	0.700	0.722	0.757	0.776	0.787	0.795	0.805	0.816	0.820
10	0.731	0.754	0.778	0.788	0.803	0.826	0.837	0.848	0.859
50	0.826	0.849	0.868	0.884	0.898	0.912	0.923	0.932	0.940
100	0.862	0.886	0.905	0.920	0.932	0.942	0.952	0.959	0.966
200	0.894	0.916	0.933	0.946	0.957	0.966	0.973	0.978	0.983
500	0.927	0.947	0.961	0.972	0.981	0.987	0.991	0.994	0.996
1000	0.945	0.964	0.978	0.987	0.992	0.996	0.998	0.999	0.999

In [114]:

```
# Time series object
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)

# In this section we will perform 5-fold Cross validation on timse series split data

cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross v
m=0 # For row index
n=0 # For col index
for k in tqdm(n_estimators):
    n=0
    for s in max_depth:
        # Deecision Tree Classifier
        clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1)
        i=0
        auc=0.0
        for train_index,test_index in tscv.split(bow_train_vect):
            x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(ex
            y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding
            x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tr
            y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_ind

            clf.fit(x_train,y_train)

            predict_probab = clf.predict_proba(x_test)[:,1] # returns probability fo
            i += 1
            auc += roc_auc_score(y_test,predict_probab)

        cv_auc[m][n] = auc/i # Storing AUC value
        n = n+1 # Incrementing col index after each iteration
    m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [30:52<00:00, 427.82s/it]
```

In [115]:
```
# Plotting plot of AUC for each combination of hyper parameters
xg_plot_test_auc_heatmap(cv_auc)
```

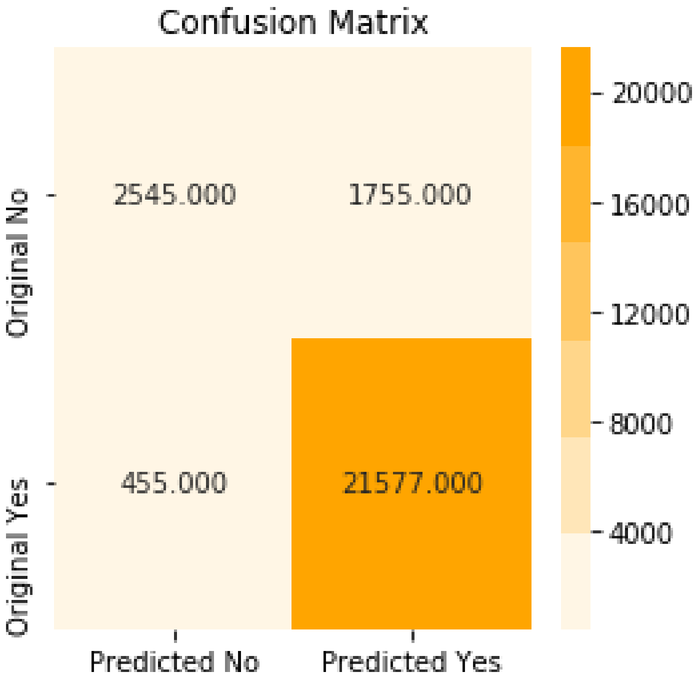


```
In [116]: # Training the final model on best hyper-parameters
          clf = XGBClassifier(n_estimators=1000,max_depth=5,n_jobs=-1)
          clf.fit(bow_train_vect,Y_train)

          predict_y_test = clf.predict(bow_test_vect)
          predict_y_train = clf.predict(bow_train_vect)

          probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posi
          probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for po
          auc = roc_auc_score(Y_test,probab_y_test)

          print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.943
```

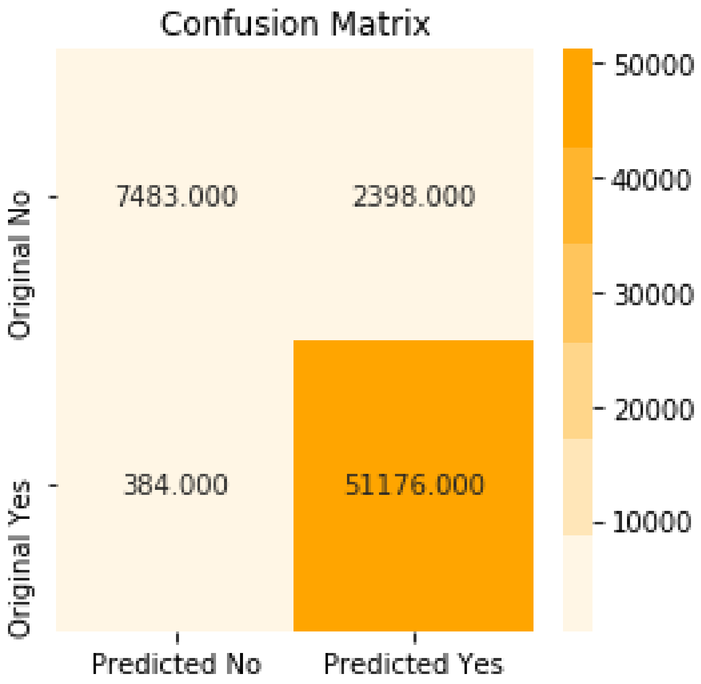
```
In [117]: # Plotting confusion matrix for train
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

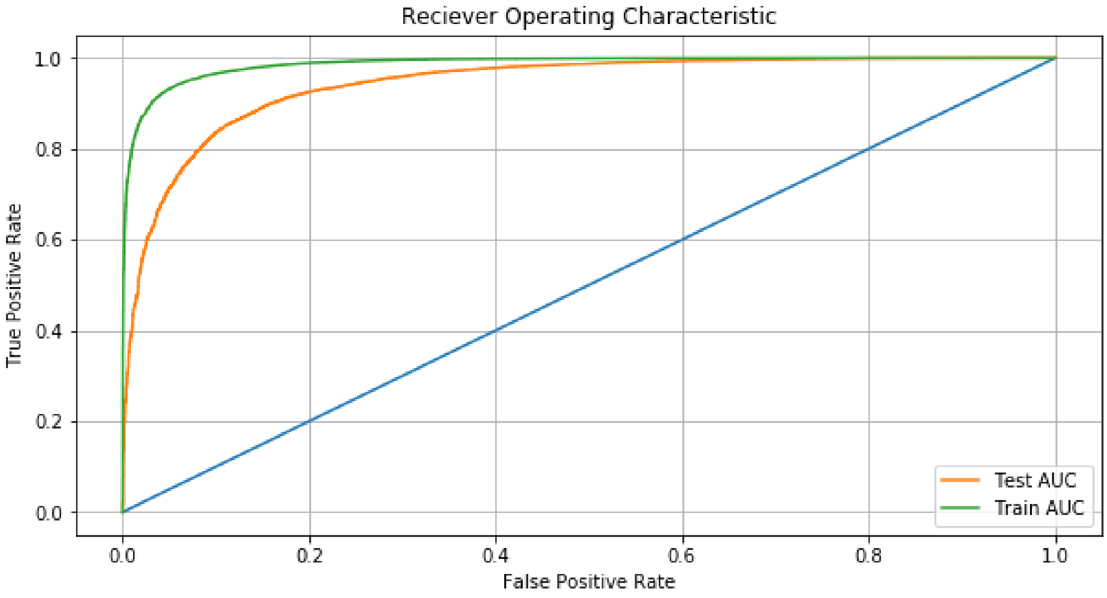


```
In [118]: # Plotting confusion matrix for test
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [119]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Review Summary As a feature

```
In [126]: train_summ,test_summ,Y_train_summ,Y_test_summ = train_test_split(preprocessed_summar
```

```
In [127]: # Using bag of words to vectorize summary
          # For train dataset
          count_vect = CountVectorizer(max_features=200)
          # For train dataset
          train_vect = count_vect.fit_transform(train_summ)
          print(train_vect.shape)

          # for test dataset
          test_vect = count_vect.transform(test_summ)
          print(test_vect.shape)
```

```
(61441, 200)
(26332, 200)
```

```
In [128]: # now we will add vectorized review as a new feature to train  data set
          bow_train_vect = hstack([bow_train_vect,train_vect])
          print(bow_train_vect.shape)
```

```
(61441, 2201)
```

```
In [129]: # now we will add vectorized review as a new feature to train  data set
          bow_test_vect = hstack([bow_test_vect,test_vect])
          print(bow_test_vect.shape)
```

```
(26332, 2201)
```

```
In [130]: # Converting bow_train_vect and bow_test_vect from scipy.sparse.coo.coo_matrix to sc
          # scipy.sparse.coo.coo_matrix are not subscriptable

          bow_train_vect = sparse.csr_matrix(bow_train_vect)
          bow_test_vect = sparse.csr_matrix(bow_test_vect)
          print(type(bow_train_vect))
          print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [131]: # Standarizing data
          from sklearn.preprocessing import StandardScaler
          std = StandardScaler(with_mean=False)
          bow_train_vect = std.fit_transform(bow_train_vect)
          bow_test_vect = std.transform(bow_test_vect)
```

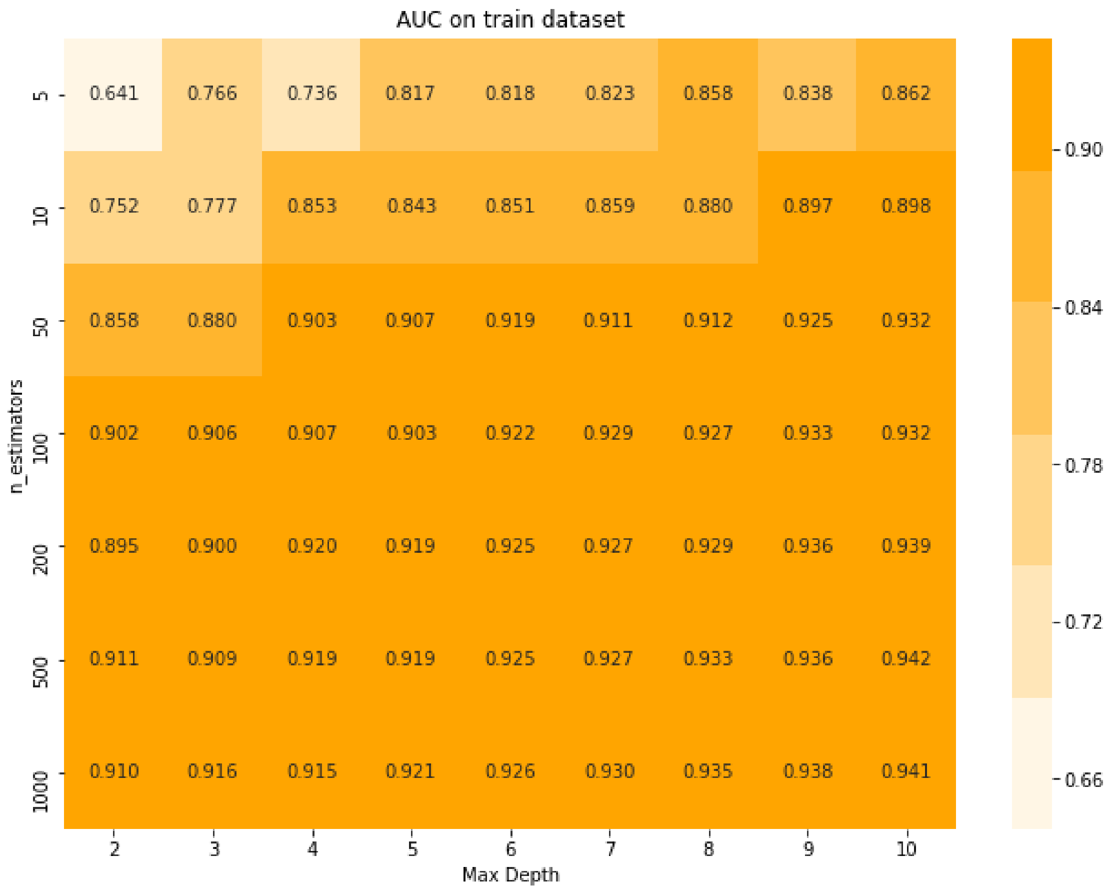
Training Random Forest Model

```
In [132]: # Trainig the model and testing on train data to find AUC on train data.
          # This will store the AUC for each combination of depth and min sample.
          # Here row corresponds to depth and columns corresponds to min sample.
          train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

          from sklearn.ensemble import RandomForestClassifier
          from sklearn.metrics import roc_auc_score

          i=0 # To keep count of rows.
          j=0 # To kepe count of columns.
          for k in tqdm(n_estimators):
              j=0 # Reinitializing column to zero for each row
              for s in max_depth:
                  clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weig
                  clf.fit(bow_train_vect,Y_train)

                  predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probabilit
                  auc = roc_auc_score(Y_train,predict_probab)
                  train_auc[i][j] = auc
                  j  =j+1 # incrementing the col index at the end of each iteration.
              i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [05:19<00:00, 75.66s/it]
```

```
In [133]: # Plotting plot of AUC for each combination of hyper parameters
          print("Training AUC")
          plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

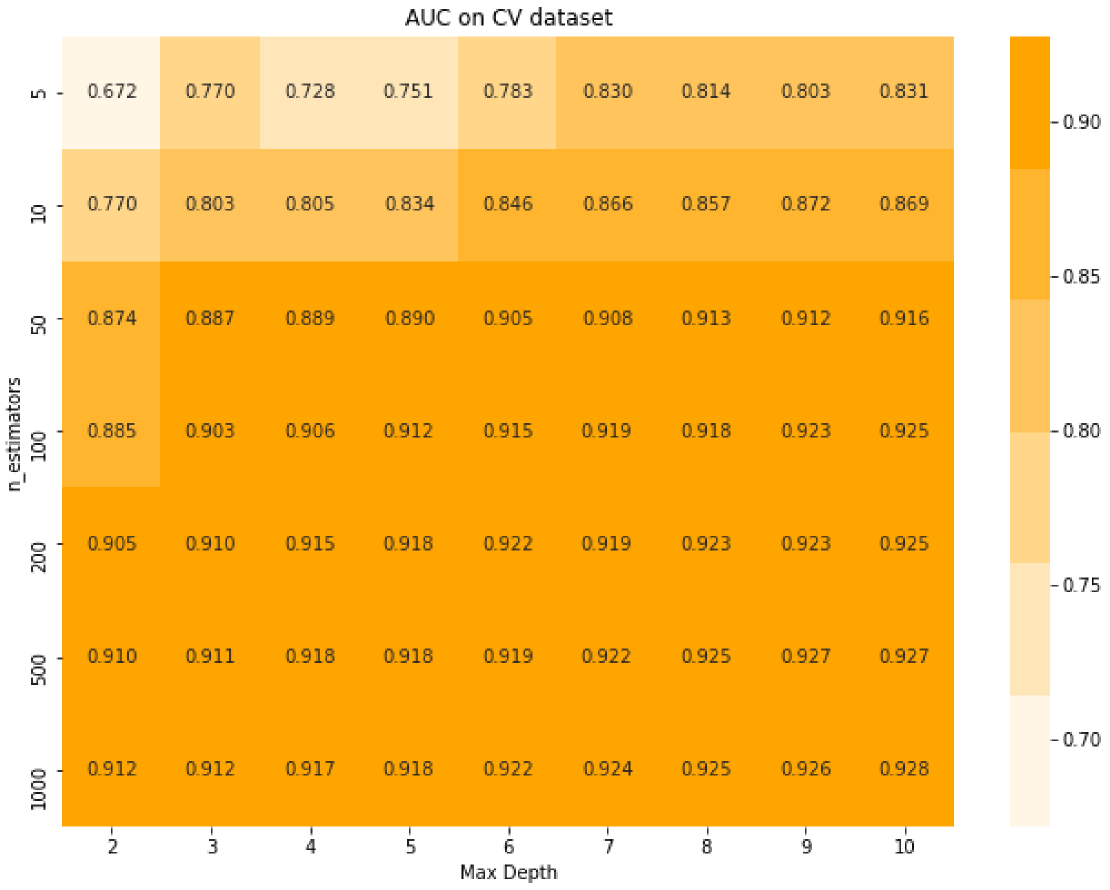


```
In [134]: # Time series object
          from sklearn.model_selection import TimeSeriesSplit
          tscv = TimeSeriesSplit(n_splits=3)

          # In this section we will perform 3-fold Cross validation on timse series split data

          cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross v
          m=0 # For row index
          n=0 # For col index
          for k in tqdm(n_estimators):
              n=0
              for s in max_depth:
                  # Deecision Tree Classifier
                  clf = RandomForestClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weig
                  i=0
                  auc=0.0
                  for train_index,test_index in tscv.split(bow_train_vect):
                      x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(ex
                      y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding
                      x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tr
                      y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_ind

                      clf.fit(x_train,y_train)

                      predict_probab = clf.predict_proba(x_test)[:,1] # returns probability fo
                      i += 1
                      auc += roc_auc_score(y_test,predict_probab)

                  cv_auc[m][n] = auc/i # Storing AUC value
                  n = n+1 # Incrementing col index after each iteration
              m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [06:53<00:00, 93.48s/it]
```

```
In [135]: # Plotting plot of AUC for each combination of hyper parameters
          print("Validation  AUC")
          plot_test_auc_heatmap(cv_auc)
```

```
Validation  AUC
```

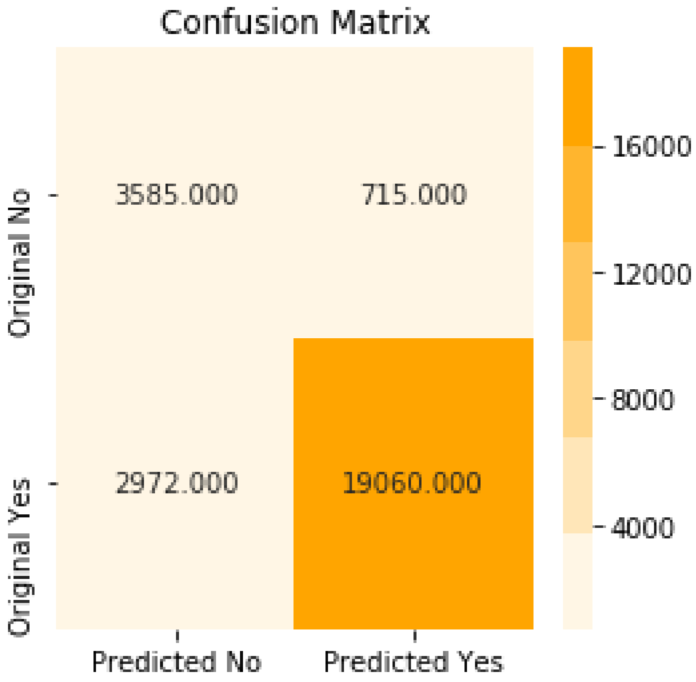


```
In [136]: # Training the final model on best hyper-parameters
          clf = RandomForestClassifier(n_estimators=1000,max_depth=10,n_jobs=-1,class_weight='b
          clf.fit(bow_train_vect,Y_train)

          predict_y_test = clf.predict(bow_test_vect)
          predict_y_train = clf.predict(bow_train_vect)

          probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posi
          probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for po
          auc = roc_auc_score(Y_test,probab_y_test)

          print("Auc of Bow Vectorized Model is {:.3f}".format(auc))
```

```
Auc of Bow Vectorized Model is 0.932
```

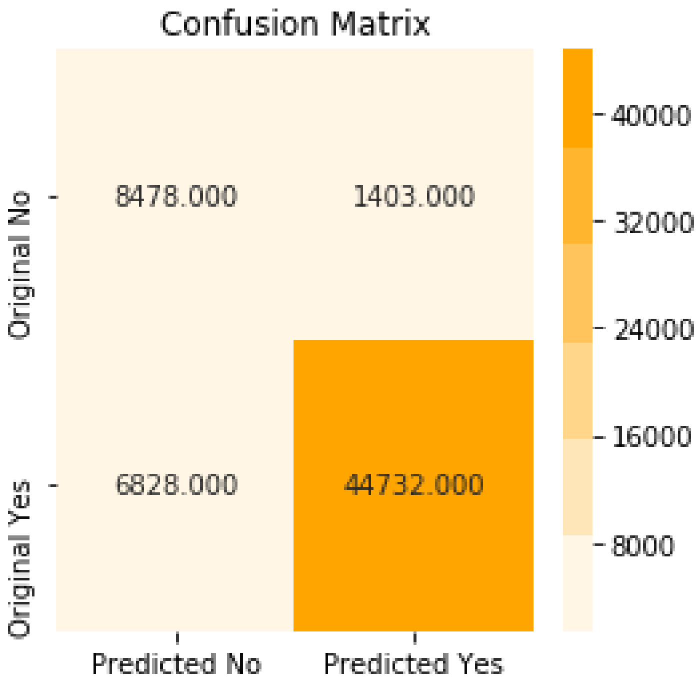
```
In [137]: # Plotting confusion matrix for train
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

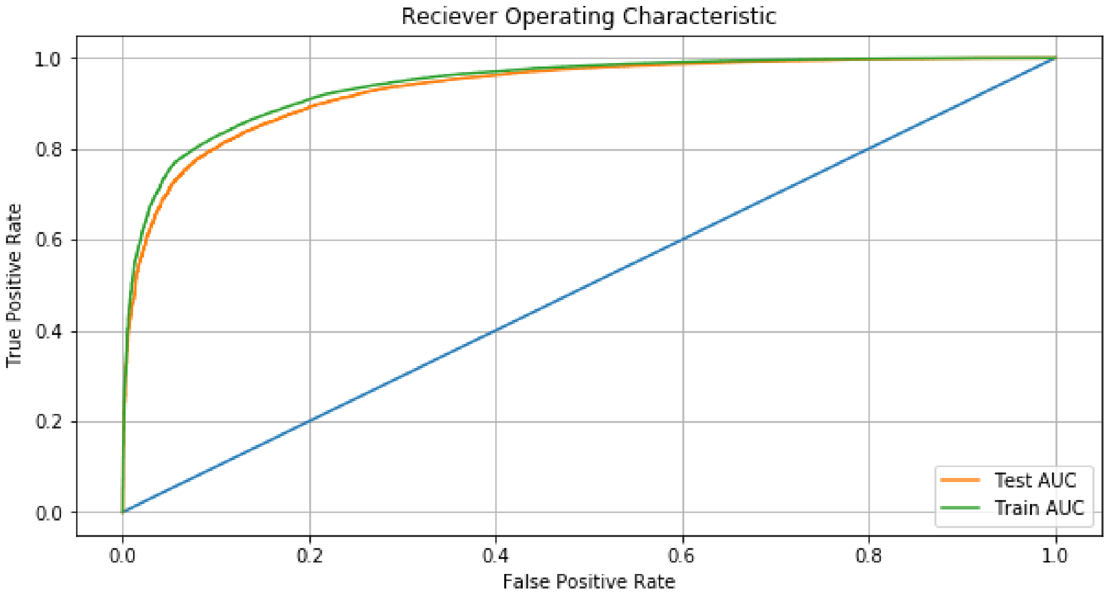


```
In [138]: # Plotting confusion matrix for test
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [139]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



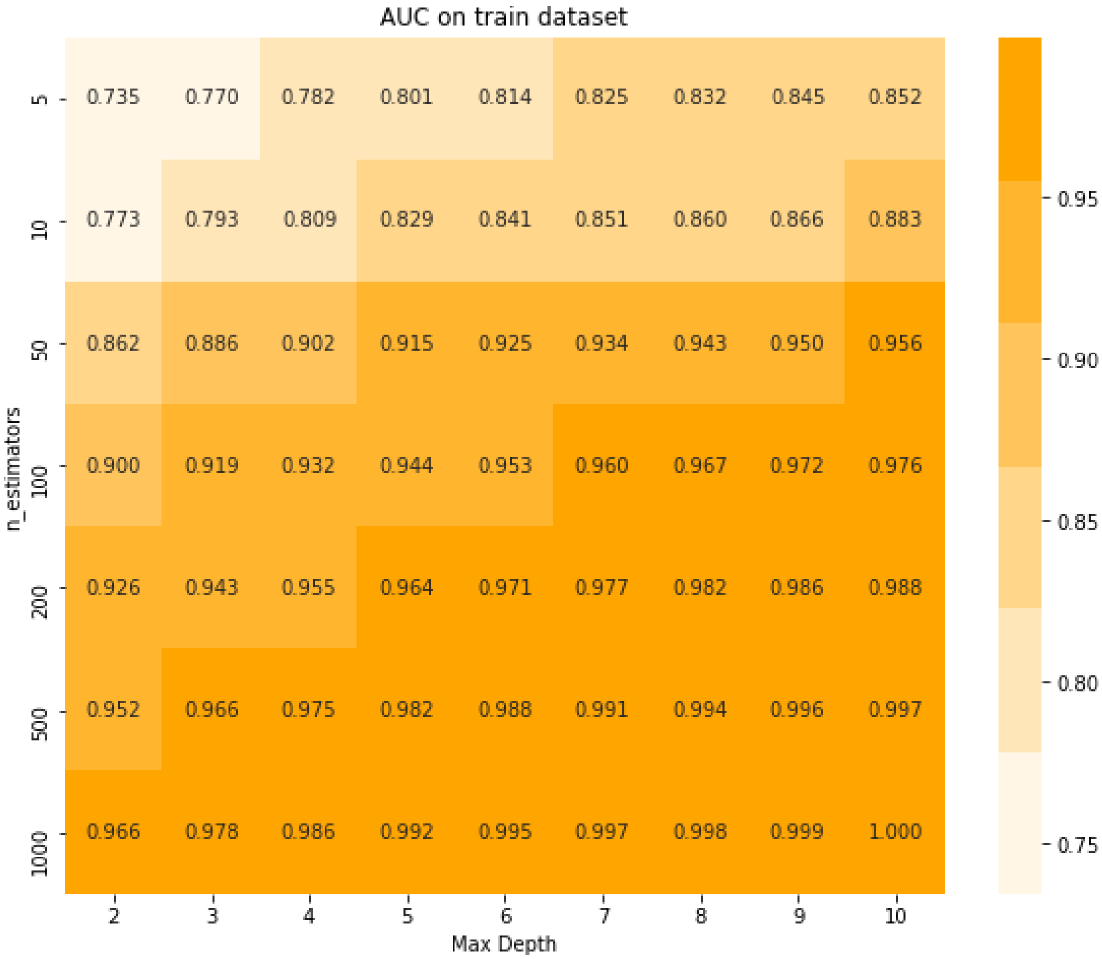
Training XGBClassifier

```
In [143]: # Trainig the model and testing on train data to find AUC on train data.
          # This will store the AUC for each combination of depth and min sample.
          # Here row corresponds to depth and columns corresponds to min sample.
          from xgboost import XGBClassifier
          train_auc = np.zeros(shape=(len(n_estimators),len(max_depth)))

          from sklearn.ensemble import RandomForestClassifier
          from sklearn.metrics import roc_auc_score

          i=0 # To keep count of rows.
          j=0 # To kepe count of columns.
          for k in tqdm(n_estimators):
              j=0 # Reinitializing column to zero for each row
              for s in max_depth:
                  clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weight='balan
                  clf.fit(bow_train_vect,Y_train)

                  predict_probab = clf.predict_proba(bow_train_vect)[:,1] # returns probabilit
                  auc = roc_auc_score(Y_train,predict_probab)
                  train_auc[i][j] = auc
                  j  =j+1 # incrementing the col index at the end of each iteration.
              i = i+1 # incrementing row index at the end of each iteration.
```

```
100%|| 7/7 [24:30<00:00, 342.86s/it]
```

```
In [144]: # Plotting plot of AUC for each combination of hyper parameters
          print("Training AUC")
          xg_plot_train_auc_heatmap(train_auc)
```

```
Training AUC
```

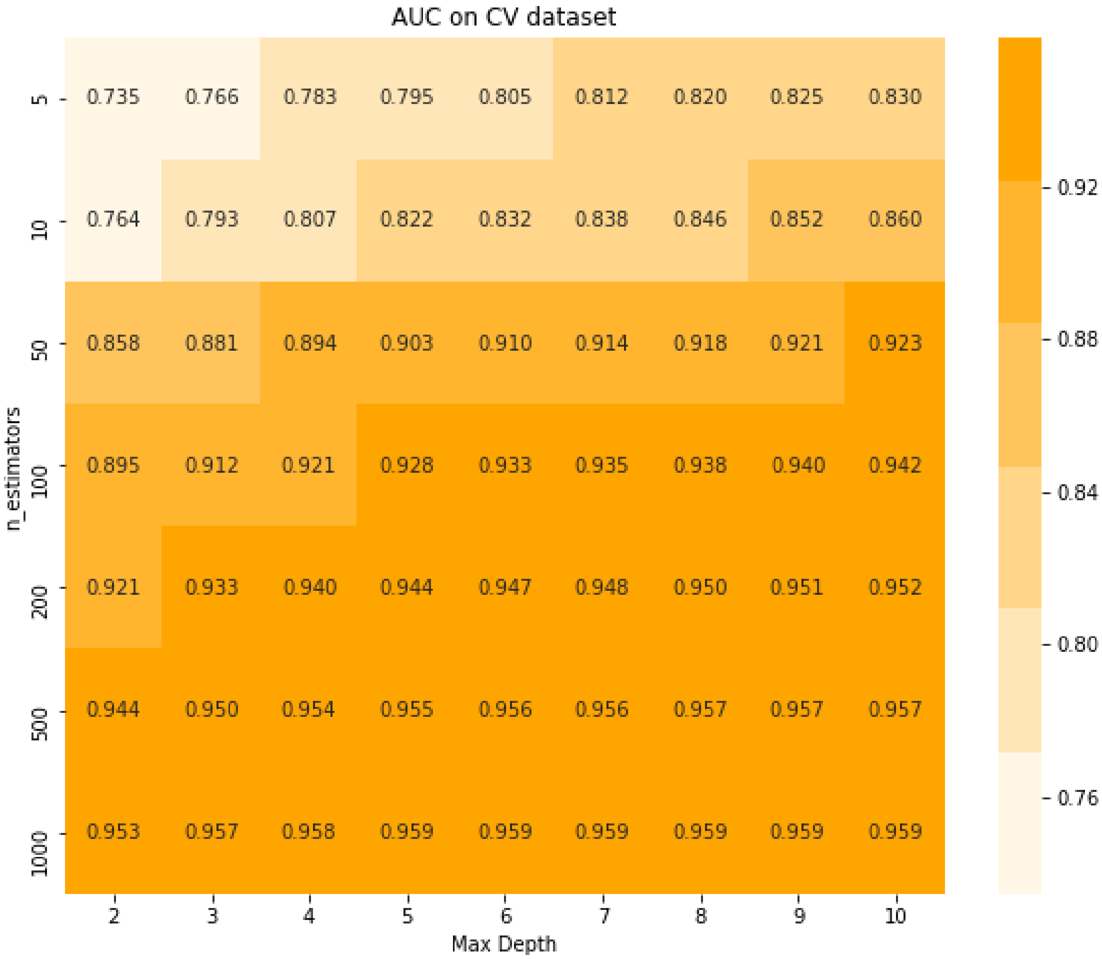


```
In [145]: # Time series object
          from sklearn.model_selection import TimeSeriesSplit
          tscv = TimeSeriesSplit(n_splits=5)

          # In this section we will perform 5-fold Cross validation on timse series split data

          cv_auc = np.zeros(shape = (len(n_estimators),len(max_depth))) # will contain cross v
          m=0 # For row index
          n=0 # For col index
          for k in tqdm(n_estimators):
              n=0
              for s in max_depth:
                  # Deecision Tree Classifier
                  clf = XGBClassifier(n_estimators=k,max_depth=s,n_jobs=-1,class_weight='balanc
                  i=0
                  auc=0.0
                  for train_index,test_index in tscv.split(bow_train_vect):
                      x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(ex
                      y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding
                      x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from tr
                      y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_ind

                      clf.fit(x_train,y_train)

                      predict_probab = clf.predict_proba(x_test)[:,1] # returns probability fo
                      i += 1
                      auc += roc_auc_score(y_test,predict_probab)

                  cv_auc[m][n] = auc/i # Storing AUC value
                  n = n+1 # Incrementing col index after each iteration
              m = m+1 # Incrementing row index after each iteration
```

```
100%|| 7/7 [1:00:29<00:00, 861.24s/it]
```

```
In [146]: # Plotting plot of AUC for each combination of hyper parameters
          print("Validation  AUC")
          xg_plot_test_auc_heatmap(cv_auc)
```

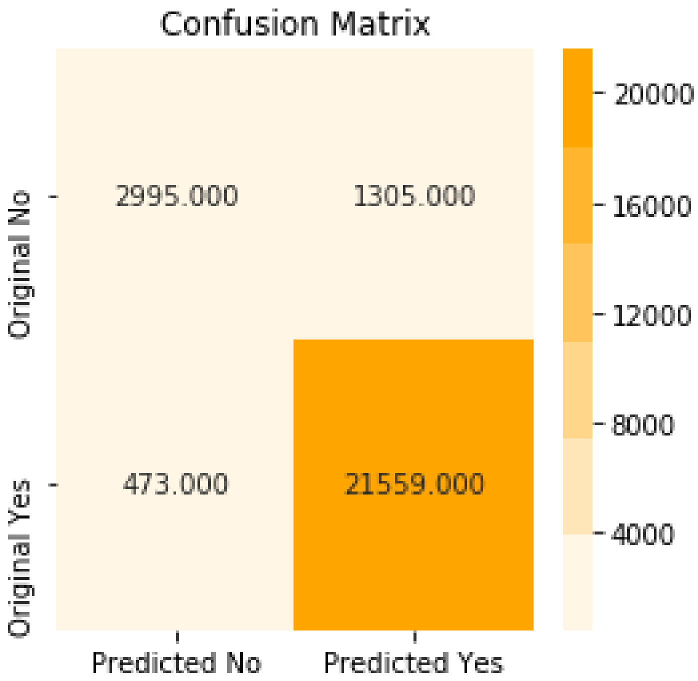
```
Validation  AUC
```



```
In [147]: # Training the final model on best hyper-parameters
          clf = XGBClassifier(n_estimators=1000,max_depth=5,n_jobs=-1,class_weight='balanced')
          clf.fit(bow_train_vect,Y_train)

          predict_y_test = clf.predict(bow_test_vect)
          predict_y_train = clf.predict(bow_train_vect)

          probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # returns probability for posi
          probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # returns probability for po
          auc = roc_auc_score(Y_test,probab_y_test)

          print("Auc of Bow Vectorized feature engineered Model is {:.3f}".format(auc))

Auc of Bow Vectorized feature engineered Model is 0.966
```

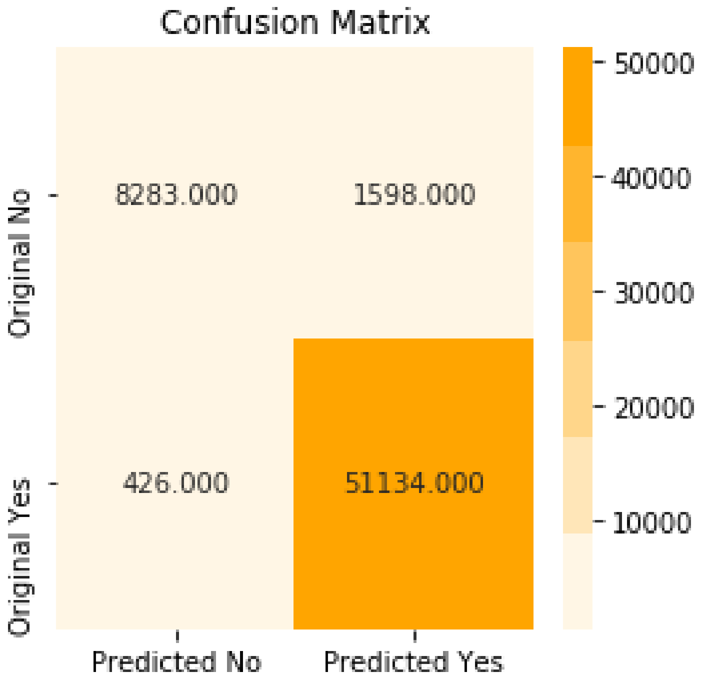
```
In [148]: # Plotting confusion matrix for train
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
```

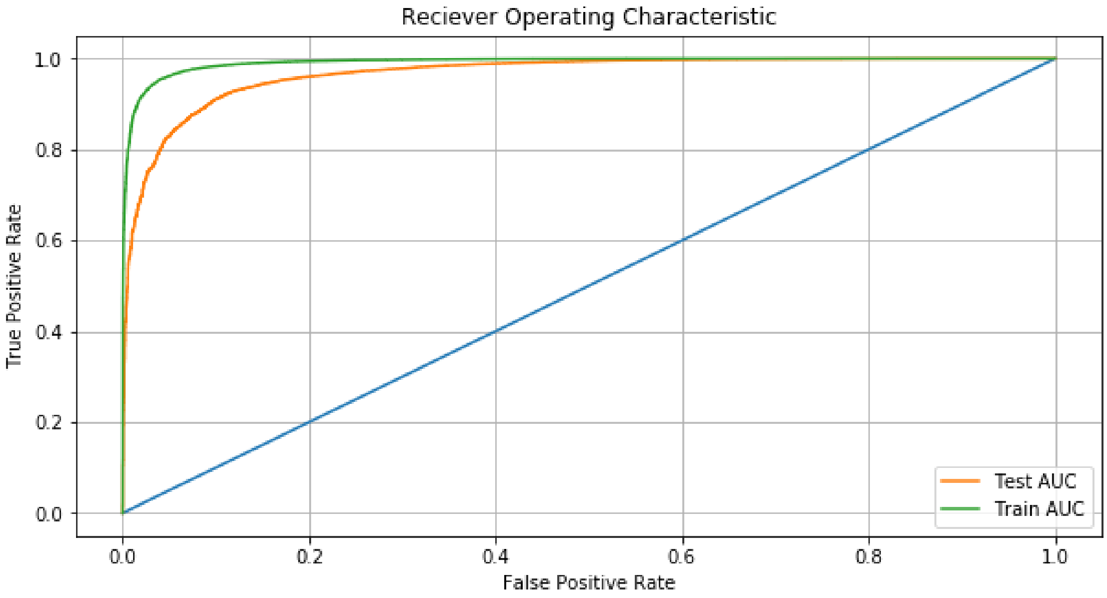


```
In [149]: # Plotting confusion matrix for test
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
```



```
In [150]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



7 [6] Conclusions

```
In [151]: from prettytable import PrettyTable

          # Initializing table object
          print("For Random Forest")
          x = PrettyTable()

          x.field_names = ["Vectorizer","Model","n_estimators","Max Depth","Area Under Curve"]

          x.add_row([ "Bow","Random Forest","1000","10","0.927" ])
          x.add_row([ "Tfidf","Random Forest","1000","10","0.918" ])
          x.add_row([ "AvgW2V","Random Forest","1000","10","0.903" ])
          x.add_row([ "Tfidf weighted W2V","Random Forest","1000","10","0.874" ])
          x.add_row([ "Bow with review length ","Random Forest","1000","10","0.900" ])
          x.add_row([ "Bow with summary feature","Random Forest","1000","10","0.932" ])
          print(x)
```

```
For Random Forest
+--------------------------+---------------+--------------+-----------+------------------+
|        Vectorizer        |     Model     | n_estimators | Max Depth | Area Under Curve |
+--------------------------+---------------+--------------+-----------+------------------+
|           Bow            | Random Forest |     1000     |     10    |      0.927       |
|          Tfidf           | Random Forest |     1000     |     10    |      0.918       |
|          AvgW2V          | Random Forest |     1000     |     10    |      0.903       |
|    Tfidf weighted W2V    | Random Forest |     1000     |     10    |      0.874       |
| Bow with review length   | Random Forest |     1000     |     10    |      0.900       |
| Bow with summary feature | Random Forest |     1000     |     10    |      0.932       |
+--------------------------+---------------+--------------+-----------+------------------+
```

```
In [152]: # Initializing table object
          print("For XGBoost")
          x = PrettyTable()

          x.field_names = ["Vectorizer","Model","n_estimators","Max Depth","Area Under Curve"]

          x.add_row([ "Bow","XGBoost","1000","5","0.943" ])
          x.add_row([ "Tfidf","XGBoost","1000","4","0.946" ])
          x.add_row([ "AvgW2V","Random Forest","1000","3","0.913" ])
          x.add_row([ "Tfidf weighted W2V","XGBoost","1000","5","0.890" ])
          x.add_row([ "Bow with review length ","XGBoost","1000","5","0.943" ])
          x.add_row([ "Bow with summary feature","XGBoost","1000","5","0.966" ])
          print(x)
```

```
For XGBoost
+--------------------------+---------------+--------------+-----------+------------------+
|        Vectorizer        |     Model     | n_estimators | Max Depth | Area Under Curve |
+--------------------------+---------------+--------------+-----------+------------------+
|           Bow            |    XGBoost    |     1000     |     5     |      0.943       |
|          Tfidf           |    XGBoost    |     1000     |     4     |      0.946       |
|          AvgW2V          | Random Forest |     1000     |     3     |      0.913       |
|    Tfidf weighted W2V    |    XGBoost    |     1000     |     5     |      0.890       |
| Bow with review length   |    XGBoost    |     1000     |     5     |      0.943       |
| Bow with summary feature |    XGBoost    |     1000     |     5     |      0.966       |
+--------------------------+---------------+--------------+-----------+------------------+
```

Explaination

We first cleaned our data by removing tags and non alphanumeric and stopwords. Then we divided our dataset into train and test dataset.

To prevent data leakage we have trained word2vec model on train data and used the same for test. We have done same in case of tfidf weighted word2vec.

To print top 20 features we have used featur_importances method to get indexes of top20 features and printed them using wordcloud.

AUC of Random Forest model is descent. Using review length as a feature improved AUC of the Random Forest model.

Using bow features extracted from review summary improved AUC of the Random Forest Model from 0.927 to 0.932

XGBoost model had far better performance then Random Forest Models.

We have to create dataframe from Bow,Tfidf.Avg W2v and TfidfW2v as XGBoost Dont take matrices as input.

For all the models we can see that the train AUC and test AUC does not differ by a large value. Hence we can conclude that our model have not overfit.

Using Summary as a feature significantly improved the AUC of Bow Trained XGBoost model to 0.966

Overall the best model is XGBoost traained on Bow vectorized in which we are using Reviews , Review length and Summary as a feature.