Amazon_Fine_Food_Reviews_Analysis_KNN

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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

        from sklearn.neighbors import KNeighborsClassifier
        from sklearn.cross_validation import train_test_split
        from sklearn.model_selection import TimeSeriesSplit
        from sklearn.metrics import roc_auc_score
```

```
C:\Users\rites\Anaconda3\lib\site-packages\sklearn\cross_validation.py:41: DeprecationWarning:
  "This module will be removed in 0.20.", DeprecationWarning)
```

```
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

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 100

# 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-R11O5J5ZVQE25C  B005HG9ET0            Penguin Chick  1346889600      5
        4  #oc-R12KPBODL2B5ZD  B007OSBE1U   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=Fals
```

```
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')
         sent_0 = soup.get_text()
         print(sent_0)
         print("="*50)

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

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

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

```
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 [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)
             phrase = re.sub(r"wont","will not",phrase) # in some words aposthepe is missing
             phrase = re.sub(r"its","it is",phrase)
             phrase = re.sub(r"Its","It is",phrase)
```

```
        phrase = re.sub(r"isnt","is 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_0 = decontracted(sent_0)
print(sent_0)
print("="*50)
```

```
My dogs loves this chicken but it is a product from China, so we will not be buying it anymore
==================================================
```

In [19]:
```
#remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
sent_4900 = re.sub("\S*\d\S*", "", sent_4900).strip()
print(sent_4900)
```

```
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are afraic
```

In [20]:
```
#remove special character: https://stackoverflow.com/a/5843547/4084039
sent_4900 = re.sub('[^A-Za-z0-9]+', ' ', sent_4900)
print(sent_4900)
```

```
My dog LOVES these treats They tend to have a very strong fish oil smell So if you are afraid c
```

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', 'l
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'c
```

```
                    'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'ar
                    'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too
                    's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'r
                    've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't"
                    "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mig
                    "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't",
                    'won', "won't", 'wouldn', "wouldn't"])
```

In [22]:
```
# Combining all the above stundents
import itertools
from tqdm import tqdm
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentence in tqdm(final['Text'].values):
    sentence = re.sub(r"http\S+", "", sentence)
    sentence = BeautifulSoup(sentence, 'lxml').get_text()
    sentence = decontracted(sentence)
    sentence = re.sub("\S*\d\S*", "", sentence).strip()
    sentence = re.sub('[^A-Za-z]+', ' ', sentence)

    #https://www.analyticsvidhya.com/blog/2014/11/text-data-cleaning-steps-python/
    # This removes words such as aawwww or happpyyy or awsooommmee etc
    sentence = ''.join(''.join(s)[:2] for _, s in itertools.groupby(sentence))

    # https://gist.github.com/sebleier/554280
    sentence = ' '.join(e.lower() for e in sentence.split() if e.lower() not in stopwo
    preprocessed_reviews.append(sentence.strip())
```

```
100%|| 87773/87773 [01:07<00:00, 1301.29it/s]
```

In [23]:
```
smpl = " aaaaww aaaww aaa aawwww"
sent = ''.join(''.join(s)[:2] for _, s in itertools.groupby(smpl))
print(sent)
```

```
 aaww aaww aa aaww
```

In [24]:
```
preprocessed_reviews[4900]
```

Out[24]:
```
'dog loves treats tend strong fish oil smell afraid fishy smell not get think dog like
```

[3.2] Preprocessing Review Summary

In [25]:
```
## Similartly performing preprocessing for review summary also.

preprocessed_summary=[]

for sent in tqdm(final['Summary'].values):
```

```
        sent = re.sub(r"http\S+","",sent)
        sent = BeautifulSoup(sent,'lxml').get_text()
        sent = decontracted(sent)
        sent = re.sub(r"\S+\d\S+","",sent).strip()
        sent = re.sub(r"[^A-Za-z0]+"," ",sent)

        #https://www.analyticsvidhya.com/blog/2014/11/text-data-cleaning-steps-python/
        # This removes words such as aawwww or happpyyy or awsooommmee etc
        sent = ''.join(''.join(s)[:2] for _, s in itertools.groupby(sent))

        # https://gist.github.com/sebleier/554280
        sent = ' '.join(w.lower() for w in sent.split() if w.lower() not in stopwords)
        preprocessed_summary.append(sent.strip())
```

```
100%|| 87773/87773 [00:34<00:00, 2512.46it/s]
```

In [26]:
```
preprocessed_summary[4900]
```

Out[26]:
```
'great value'
```

In [27]:
```
final['Summary'].values[4900]
```

Out[27]:
```
'Great value'
```

In [28]:
```
# Removing those words which are of lenght 2
# This will remove non relevant words then we will perform featurization
cleaned_reviews = []
for sent in preprocessed_reviews:
    sentence = ' '.join(w for w in sent.split() if len(w)>2)
    cleaned_reviews.append(sentence.strip())
```

In [29]:
```
print(cleaned_reviews[0])
```

```
dogs loves chicken product china not buying anymore hard find chicken products made usa one no
```

In [30]:
```
final["Cleaned_review"] = cleaned_reviews
final.head(5)
```

Out[30]:
```
          Id   ProductId          UserId        ProfileName  \
22620  24750  2734888454  A13ISQV0U9GZIC           Sandikaye
22621  24751  2734888454  A1C298ITT645B6  Hugh G. Pritchard
70677  76870  B00002N8SM  A19Q006CSFT011           Arlielle
70676  76869  B00002N8SM  A1FYH4S02BW7FN           wonderer
70675  76868  B00002N8SM   AUE8TB5VHS6ZV      eyeofthestorm

       HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
22620                     1                       1      0  1192060800
```

```
22621                       0                         0       1  1195948800
70677                       0                         0       0  1288396800
70676                       0                         0       0  1290038400
70675                       0                         0       0  1306972800

                                          Summary  \
22620                               made in china
22621                           Dog Lover Delites
70677                     only one fruitfly stuck
70676  Doesn't work!! Don't waste your money!!
70675                              A big rip off

                                                    Text  \
22620  My dogs loves this chicken but its a product f...
22621  Our dogs just love them.  I saw them in a pet ...
70677  I had an infestation of fruitflies, they were ...
70676  Worst product I have gotten in long time. Woul...
70675  I wish I'd read the reviews before making this...

                                          Cleaned_review
22620  dogs loves chicken product china not buying an...
22621  dogs love saw pet store tag attached regarding...
70677  infestation fruitflies literally everywhere fl...
70676  worst product gotten long time would rate star...
70675  wish would read reviews making purchase basica...
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

In [36]:
```
#BoW
count_vect1 = CountVectorizer() #in scikit-learn
count_vect1.fit(cleaned_reviews)
print("some feature names ", count_vect1.get_feature_names()[:10])
print('='*50)

final_counts = count_vect1.transform(cleaned_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  ['aaa', 'aaah', 'aaahh', 'aaaww', 'aachen', 'aadp', 'aaf', 'aafco', 'aah',
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (87773, 54095)
the number of unique words  54095
```

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

In [37]:
```
#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 numbers min_df=10, max_features=5000, of your choice
count_vect2 = CountVectorizer(ngram_range=(1,2), min_df=5)
final_bigram_counts = count_vect2.fit_transform(cleaned_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_
bigram_features = count_vect2.get_feature_names()
print(bigram_features[:10])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (87773, 112780)
the number of unique words including both unigrams and bigrams  112780
['aafco', 'aback', 'abandon', 'abandoned', 'abc', 'abdomen', 'abdominal', 'abdominal pain', 'al
```

5.3 [4.3] TF-IDF

In [38]:
```
# tfidf on unigrams
tf_idf_vect1 = TfidfVectorizer()
tf_idf_vect1.fit(cleaned_reviews)
print("some sample features(unique words in the corpus)",tf_idf_vect1.get_feature_name
print('='*50)

final_tf_idf1 = tf_idf_vect1.transform(cleaned_reviews)
print("the type of count vectorizer ",type(final_tf_idf1))
print("the shape of out text TFIDF vectorizer ",final_tf_idf1.get_shape())
print("the number of unique words including both unigrams and bigrams ", final_tf_idf
```

```
some sample features(unique words in the corpus) ['aaa', 'aaah', 'aaahh', 'aaaww', 'aachen', 'a
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (87773, 54095)
the number of unique words including both unigrams and bigrams  54095
```

In [39]:
```
# Tfidf on bigrams
tf_idf_vect2 = TfidfVectorizer(ngram_range=(1,2),min_df=3)
tf_idf_vect2.fit(cleaned_reviews)
print("some sample features(unique words in the corpus)",tf_idf_vect2.get_feature_name
print('='*50)
```

```
final_tf_idf2 = tf_idf_vect2.transform(cleaned_reviews)
print("the type of count vectorizer ",type(final_tf_idf2))
print("the shape of out text TFIDF vectorizer ",final_tf_idf2.get_shape())
print("the number of unique words including both unigrams and bigrams ", final_tf_idf2
```

```
some sample features(unique words in the corpus) ['aafco', 'aafco dog', 'aah', 'aahs', 'aback'
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (87773, 213055)
the number of unique words including both unigrams and bigrams  213055
```

5.4 [4.4] Word2Vec

In [40]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentence=[]
for sentence in tqdm(cleaned_reviews):
    list_of_sentence.append(sentence.split())
```

```
100%|| 87773/87773 [00:00<00:00, 107758.27it/s]
```

In [32]:
```
outfile = open("list_of_sentence","wb")
pickle.dump(list_of_sentence,outfile)
outfile.close()
```

In [41]:
```
# 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
# 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_sentence,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
```

```
[('fantastic', 0.8564410209655762), ('good', 0.8339499235153198), ('terrific', 0.82935595512390
==================================================
[('greatest', 0.8057908415794373), ('tastiest', 0.7508324384689331), ('best', 0.71000838279724
```

```
In [42]: 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  17061
sample words  ['dogs', 'loves', 'chicken', 'product', 'china', 'not', 'buying', 'anymore', 'ha
```

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

[4.4.1.1] Avg W2v

```
In [52]: # 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 list_of_sentence: # 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
             sent_vectors.append(sent_vec)
         print(len(sent_vectors))
         print(len(sent_vectors[0]))
```

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

    KeyboardInterrupt                         Traceback (most recent call last)
```

```
<ipython-input-52-6e7e3cb11537> in <module>()
      8         if word in w2v_words:
      9             vec = w2v_model.wv[word]
---> 10             sent_vec += vec
     11             cnt_words += 1
     12     if cnt_words != 0:


KeyboardInterrupt:
```

[4.4.1.2] TFIDF weighted W2v

In [43]:
```python
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer()
tf_idf_matrix = model.fit_transform(cleaned_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 [44]:
```python
# 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 l
row=0;
for sent in list_of_sentence: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        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 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
    tfidf_sent_vectors.append(sent_vec)
    row += 1
```

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

KeyboardInterrupt                         Traceback (most recent call last)
```

```
    <ipython-input-44-acbebc07d9a9> in <module>()
     16             # sent.count(word) = tf values of word in this review
     17             tf_idf = dictionary[word]*(sent.count(word)/len(sent))
---> 18             sent_vec += (vec * tf_idf)
     19             weight_sum += 1
     20     if weight_sum != 0:


    KeyboardInterrupt:
```

In [45]:
```
print(len(tfidf_sent_vectors))
print(len(tfidf_sent_vectors[0]))
```

```
64957
50
```

In [46]:
```
# 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")
    print("Confusion matrix")
    plt.figure(figsize=(4,4))
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabel
    plt.show()
```

In [47]:
```
# Function to plot roc curve

def plot_roc_curve(Y_test,predict_y_test,Y_train,predict_y_train):
    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="Validation AUC")
    plt.plot(fpr2,tpr2,label="Train AUC")
    plt.xlabel("fpr")
    plt.ylabel("tpr")
    plt.legend()
    plt.show()
```

In [48]:
```
# Plotting graph of auc and parameter for training and cross validation error
param = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
```

```python
def plot_knn_vs_auc(train_auc_list,cv_auc_list):
    plt.plot(param,train_auc_list,label="Train AUC")
    plt.xlabel("Parameter for K-NN")
    plt.ylabel("Area Under Curve")
    plt.plot(param,cv_auc_list,label="Validation AUC")
    plt.legend()
    plt.show()
```

6 [5] Assignment 3: KNN

Apply Knn(brute force version) on these feature sets

SET 1:Review text, preprocessed one converted into vectors using (BOW)

SET 2:Review text, preprocessed one converted into vectors using (TFIDF)

SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)

SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)

Apply Knn(kd tree version) on these feature sets NOTE: sklearn implementation of kd-tree accepts only dense matrices, you need to convert the sparse matrices of CountVectorizer/TfidfVectorizer into dense matices. You can convert sparse matrices to dense using .toarray() attribute. For more information please visit this link

SET 5:Review text, preprocessed one converted into vectors using (BOW) but with restriction on maximum features generated.

```
        </li>
        <li><font color='red'>SET 6:</font>Review text, preprocessed one converted into vector
        <pre>
            tf_idf_vect = TfidfVectorizer(min_df=10, max_features=500)
            tf_idf_vect.fit(preprocessed_reviews)
        </pre>
        </li>
        <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(find best K)</strong>
    <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>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='train_cv_auc.JPG' width=300px></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.c
<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 KNN brute force

6.1.1 [5.1.1] Applying KNN brute force on BOW, SET 1

```
In [49]: from sklearn.cross_validation import train_test_split

         # cleaned_reviews contains all the required reviews
         # Splitting cleaned_reviews into train and test dataset

         X = cleaned_reviews
         Y = final['Score']

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

```
61441 61441 26332 26332
```

```
In [50]: # Now we will vectorize train and test datasets separately using BagofWords
         # Use fit_transform to vectorize train dataset and transform to vectorize test datase
         count_vect2 = CountVectorizer(max_features=2000)
         X_train = count_vect2.fit_transform(X_train)
         X_test = count_vect2.transform(X_test)
         print(X_train.shape,X_test.shape)
```

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

```
In [52]: # In this section we will calculate training error.
         # To calculate training error you have to train model using training data and
         # Then test the same model on trainig data and compare the predicted labels with actu
         from sklearn.model_selection import TimeSeriesSplit
         from sklearn.metrics import roc_auc_score
         from sklearn.neighbors import KNeighborsClassifier

         param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
         train_auc_list1 = []   # This contains area under curve value of first batch correspo
         train_auc_list2 = []   # for second batch
         train_auc_list3 = []   # for third batch

         # Testing whole training data at once takes a lot of memory which takes a lot of time
         # There fore we are dividing training data into 3 parts and then we will calculate AU

         x_train_1 = X_train[0:20000][:] # Row 0 to 19999 and all columns
         x_train_2 = X_train[20000:40000][:]
         x_train_3 = X_train[40000:61441][:]

         y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
         y_train_2 = Y_train[20000:40000][:]
         y_train_3 = Y_train[40000:61441][:]

         # Calculating training error for first batch
         for k in tqdm(range(1,30,2)):
             clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
             clf.fit(x_train_1,y_train_1)

             pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive 

             auc = roc_auc_score(y_train_1,pre_probab)
             train_auc_list1.append(auc)

         # Calculating training error for second batch
         for k in tqdm(range(1,30,2)):
             clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
             clf.fit(x_train_2,y_train_2)

             pre_probab = clf.predict_proba(x_train_2)[:,1]

             auc = roc_auc_score(y_train_2,pre_probab)
             train_auc_list2.append(auc)


         # Calculating training error for third batch
```

```
    for k in tqdm(range(1,30,2)):
        clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
        clf.fit(x_train_3,y_train_3)

        pre_probab = clf.predict_proba(x_train_3)[:,1]

        auc = roc_auc_score(y_train_3,pre_probab)
        train_auc_list3.append(auc)
```

```
100%|| 15/15 [10:10<00:00, 35.93s/it]
100%|| 15/15 [06:07<00:00, 24.80s/it]
100%|| 15/15 [06:35<00:00, 25.38s/it]
```

In [53]:
```
# Combining training result of each batch together
train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_auc
```

In [54]:
```
# We will do time based splitting and do 10 fold cross validation
# This is done as reviews keeps changing with time and hence time based splitting is


# Time series object
tscv = TimeSeriesSplit(n_splits=10)

cv_auc_list = [] # will contain cross validation AUC corresponding to each k

for k in range(1,30,2):
    # KNN Classifier
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='brute',leaf_size=30)
    i=0
    auc=0.0
    for train_index,test_index in tscv.split(X_train):
        x_train = X_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
        y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
        x_test = X_train[train_index[-1]:test_index[-1]][:] # row from train_index to
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

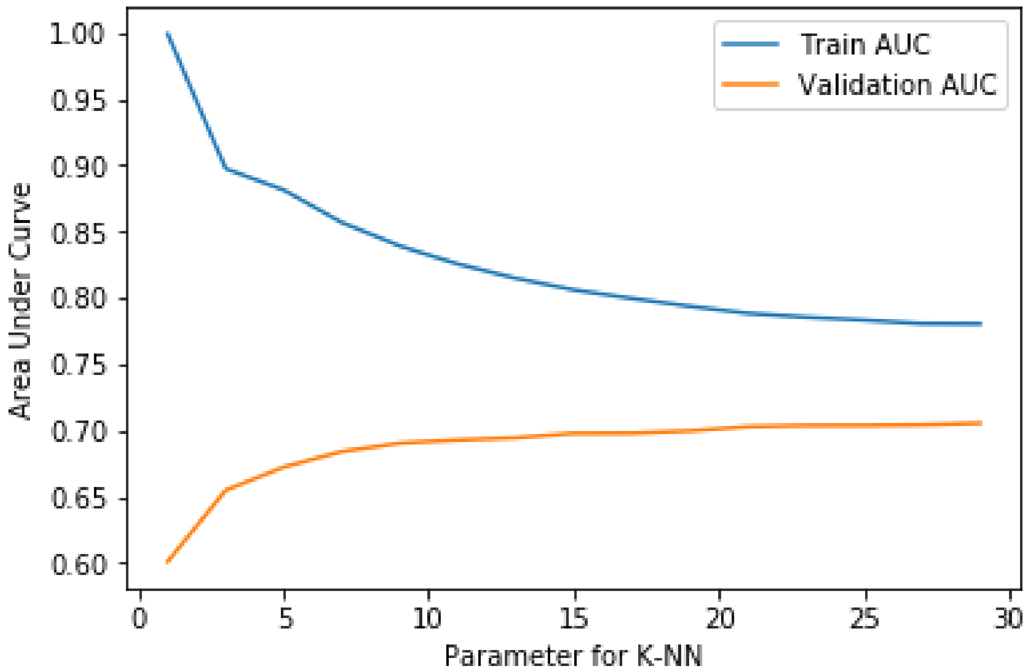
        clf.fit(x_train,y_train)

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

    cv_auc_list.append(auc/i) # Storing AUC value
```

In [55]:
```
import matplotlib.pyplot as plt
```

```
# Plotting graph of auc and parameter for training and cross validation error
plot_knn_vs_auc(train_auc_list,cv_auc_list)
```



Observing the graph we will select a k for which AUC is not very high in training error plot to avoid overfitting and select a k for which AUC is not very low in Cross-validation error to avoid underfitting. Therefore we are selecting k = 25 .

```
In [56]: # Training final model on best auc and taking k = 25

         # Training one model with all the data hangs the PC .
         # Therefore we will divide data into 3 parts and then train three seperate models.
         final_clf1 = KNeighborsClassifier(n_neighbors=25,algorithm='brute',leaf_size=30)
         final_clf1.fit(x_train_1,y_train_1)
         predict_probab_1 = final_clf1.predict_proba(X_test)[:,1] # This returns only probabil
         predict_y1 = final_clf1.predict(X_test)
         predict_y_train1 = final_clf1.predict(x_train_1)

         final_clf2 = KNeighborsClassifier(n_neighbors=25,algorithm='brute',leaf_size=30)
         final_clf2.fit(x_train_2,y_train_2)
         predict_probab_2 = final_clf2.predict_proba(X_test)[:,1] # This returns only probabil
         predict_y2 = final_clf2.predict(X_test)
         predict_y_train2 = final_clf2.predict(x_train_2)

         final_clf3 = KNeighborsClassifier(n_neighbors=25,algorithm='brute',leaf_size=30)
         final_clf3.fit(x_train_3,y_train_3)
         predict_probab_3 = final_clf3.predict_proba(X_test)[:,1] # This returns only probabil
```

```
predict_y3 = final_clf3.predict(X_test)
predict_y_train3 = final_clf3.predict(x_train_3)

# Now merging,n_jobs=3 all the three probability scores into one

predict_probab = [(x+y+z)/3 for x,y,z in zip(predict_probab_1,predict_probab_2,predic



auc = roc_auc_score(Y_test,predict_probab)
print("Final AUC is ::{:.2f}".format(auc))
```

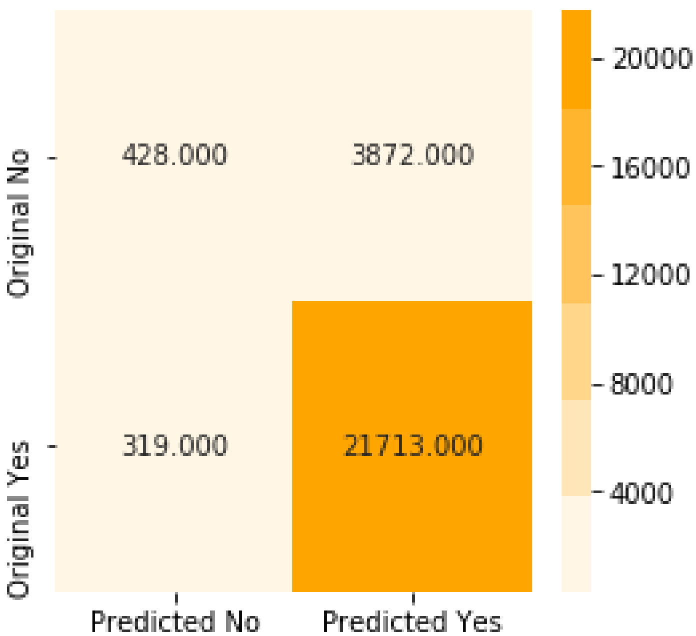
```
Final AUC is ::0.73
```

In [57]:
```
# combining labels predicted by all the models
predict_y = [1 if (x+y+z)>= 2 else 0 for x,y,z in zip(predict_y1,predict_y2,predict_y3
```

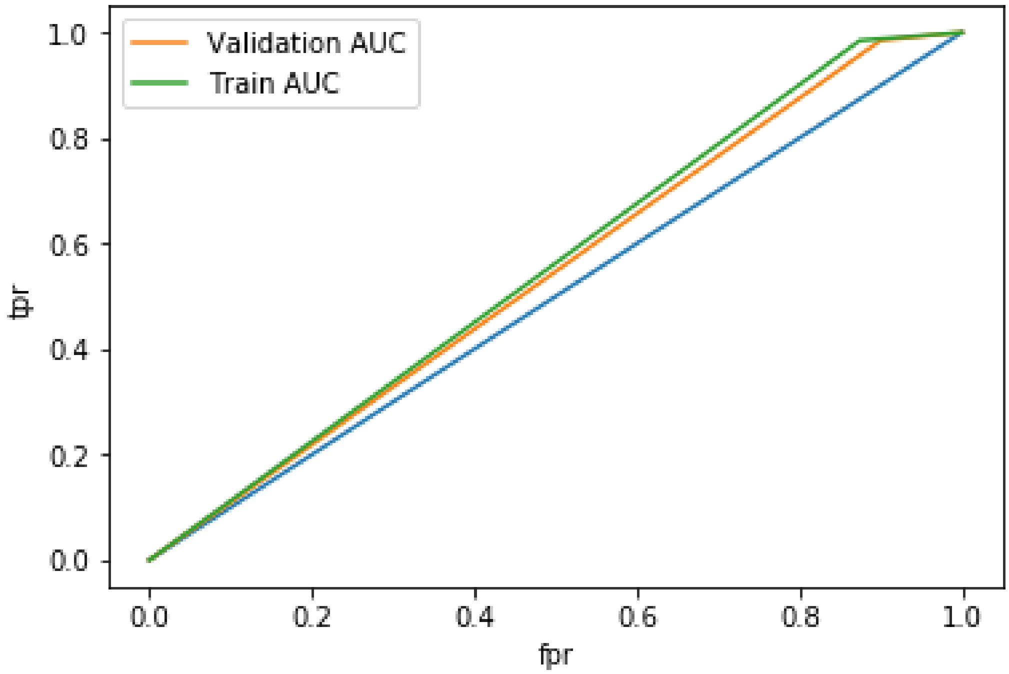
In [58]:
```
# Combining results of train dataset evaluation
predict_y_train = np.concatenate((predict_y_train1,predict_y_train2),axis=None)
predict_y_train = np.concatenate((predict_y_train,predict_y_train3),axis=None)
```

In [59]:
```
# Plotting confusion matrix
confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```



```
In [60]: # Plotting ROC Curve
         plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.1.2 [5.1.2] Applying KNN brute force on TFIDF

```
In [99]: # In this section Tfidf will be used for vectorization
         # Splitting datasets into train and test datasets

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

         # Initializinf TFidf
         tf_idf_vect2 = TfidfVectorizer(max_features=2000)
         # Now we will vectorize train and test datasets separately using Tfidf
         # Use fit_transform to vectorize train dataset and transform to vectorize test datase
         X_train = tf_idf_vect2.fit_transform(X_train)
         X_test = tf_idf_vect2.transform(X_test)
```

```
In [100]: param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
          train_auc_list1 = []    # This contains area under curve value of first batch correspo
          train_auc_list2 = []    # for second batch
          train_auc_list3 = []    # for third batch

          # Testing whole training data at once takes a lot of memory which takes a lot of tim
          # There fore we are dividing training data into 3 parts and then we will calculate A
```

```
x_train_1 = X_train[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = X_train[20000:40000][:]
x_train_3 = X_train[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in range(1,30,2):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in range(1,30,2):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
    clf.fit(x_train_2,y_train_2)

    pre_probab = clf.predict_proba(x_train_2)[:,1]

    auc = roc_auc_score(y_train_2,pre_probab)
    train_auc_list2.append(auc)


# Calculating training error for third batch
for k in range(1,30,2):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute",leaf_size=30)
    clf.fit(x_train_3,y_train_3)

    pre_probab = clf.predict_proba(x_train_3)[:,1]

    auc = roc_auc_score(y_train_3,pre_probab)
    train_auc_list3.append(auc)

# Combining training result of each batch together
train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_au
```

In [101]:

```
# Performing time series split cross validation

auc_list=[]

for k in range(1,30,2):
    # KNN Classifier
```

```
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='brute',leaf_size=30,n_jobs=3)
    i=0
    auc=0.0
    for train_index,test_index in tscv.split(X_train):
        x_train = X_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
        y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
        x_test = X_train[train_index[-1]:test_index[-1]][:] # row from train_index t
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

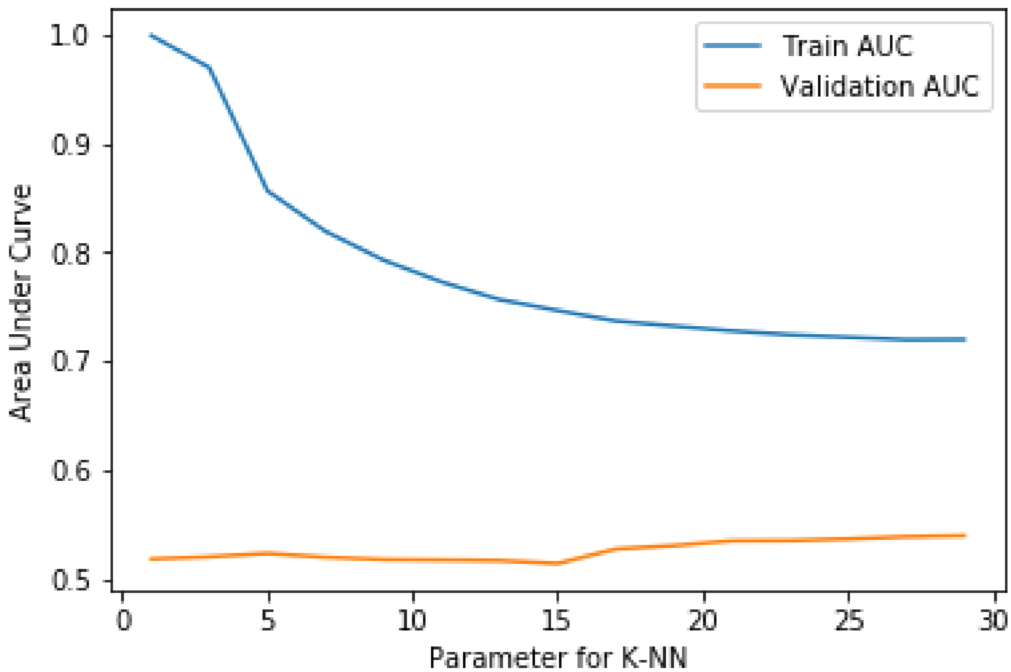
        clf.fit(x_train,y_train)

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


    auc_list.append(auc/i)
```

```
In [102]: import matplotlib.pyplot as plt

          # Plotting graph of auc and parameter for training and cross validation error
          plot_knn_vs_auc(train_auc_list,auc_list)
```



In [103]:
```
# Training final model on best auc and taking k = 21

# Training one model with all the data hangs the PC .
# Therefore we will divide data into 3 parts and then train three seperate models.
final_clf1 = KNeighborsClassifier(n_neighbors=21,algorithm='brute',leaf_size=30)
final_clf1.fit(x_train_1,y_train_1)
predict_probab_1 = final_clf1.predict_proba(X_test)[:,1] # This returns only probabi
predict_y1 = final_clf1.predict(X_test)
predict_y_train1 = final_clf1.predict(x_train_1)

final_clf2 = KNeighborsClassifier(n_neighbors=21,algorithm='brute',leaf_size=30)
final_clf2.fit(x_train_2,y_train_2)
predict_probab_2 = final_clf2.predict_proba(X_test)[:,1] # This returns only probabi
predict_y2 = final_clf2.predict(X_test)
predict_y_train2 = final_clf2.predict(x_train_2)

final_clf3 = KNeighborsClassifier(n_neighbors=21,algorithm='brute',leaf_size=30)
final_clf3.fit(x_train_3,y_train_3)
predict_probab_3 = final_clf3.predict_proba(X_test)[:,1] # This returns only probabi
predict_y3 = final_clf3.predict(X_test)
predict_y_train3 = final_clf3.predict(x_train_3)

# Now merging all the three probability scores into one
predict_probab = [(x+y+z)/3 for x,y,z in zip(predict_probab_1,predict_probab_2,predic
predict_y = [1 if(x+y+x>= 2) else 0 for x,y,z in zip(predict_y1,predict_y2,predict_y3

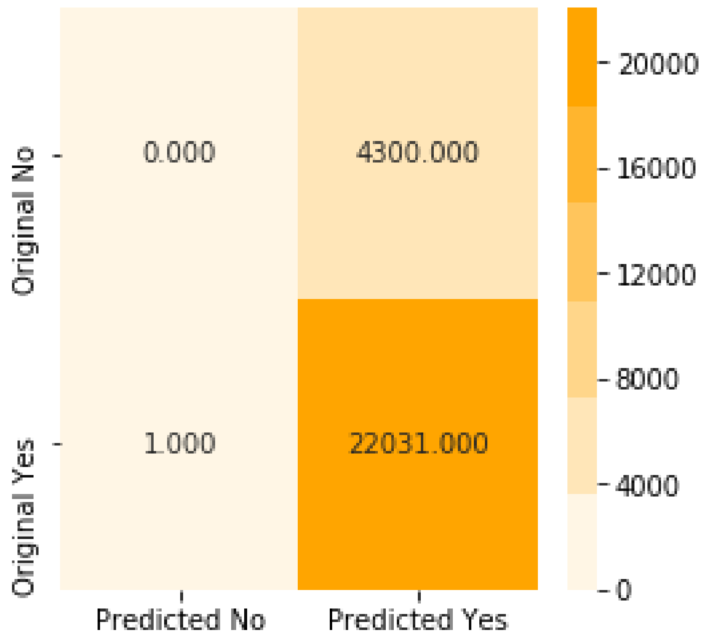
# Combining results of train dataset evaluation
predict_y_train = np.concatenate((predict_y_train1,predict_y_train2),axis=None)
predict_y_train = np.concatenate((predict_y_train,predict_y_train3),axis=None)

auc = roc_auc_score(Y_test,predict_probab)
print("Final AUC is ::{:.2f}".format(auc))
```

```
Final AUC is ::0.51
```

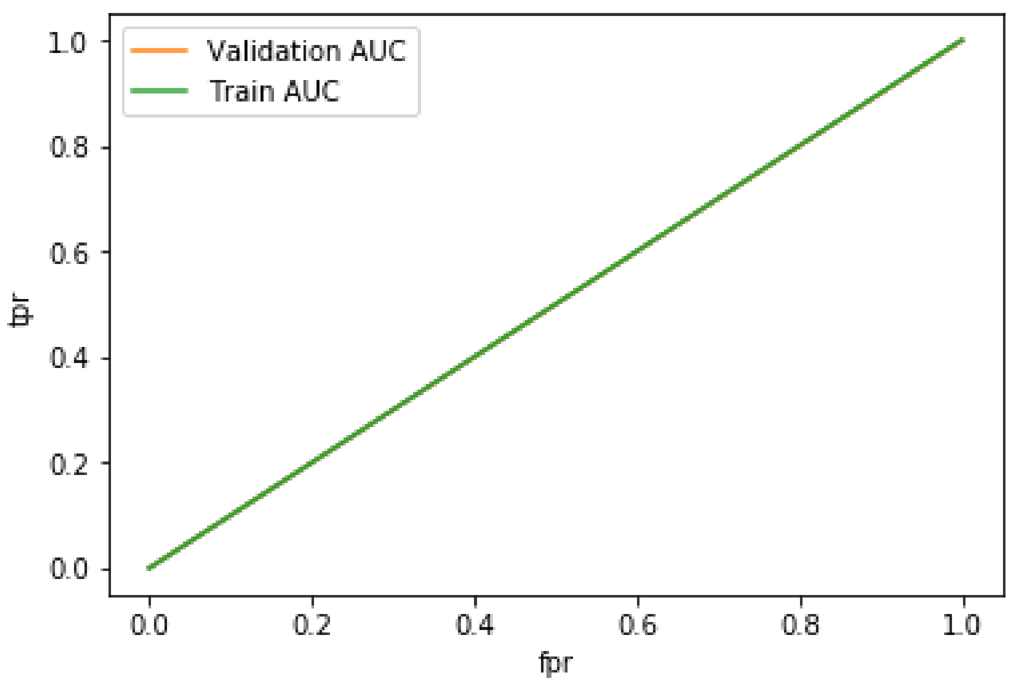
In [104]:
```
# plotting confusion matrix
confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```



In [105]: *# Plotting roc curve*

```
plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.1.3 [5.1.3] Applying KNN brute force on AVG W2V, SET 3

In [106]:
```
# In this section avg_w2v will be used for vectorization
# Splitting datasets into train and test datasets
Y = final['Score']
X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentence,Y,test_size=0.3,ran
print(X_train[0])
```

```
['use', 'beans', 'espresso', 'machine', 'love', 'taste', 'straight', 'espresso', 'coffee', 'fi
```

In [107]:
```
# Now we will vectorize train dataset usin avg_w2v
train_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this li
for sent in X_train: # for each review/sentence
    sent_vec = np.zeros(50) # 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]))
```

```
61441
50
```

In [108]:
```
# Vectorization of test dataset using avg_w2v

test_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this lis
for sent in X_test: # for each review/sentence
    sent_vec = np.zeros(50) # 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]))
```

```
26332
50
```

```
In [109]: param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
          train_auc_list1 = []   # This contains area under curve value of first batch correspo
          train_auc_list2 = []   # for second batch
          train_auc_list3 = []   # for third batch

          # Testing whole training data at once takes a lot of memory which takes a lot of tim
          # There fore we are dividing training data into 3 parts and then we will calculate A

          x_train_1 = train_sent_vectors[0:20000][:] # Row 0 to 19999 and all columns
          x_train_2 = train_sent_vectors[20000:40000][:]
          x_train_3 = train_sent_vectors[40000:61441][:]

          y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
          y_train_2 = Y_train[20000:40000][:]
          y_train_3 = Y_train[40000:61441][:]

          # Calculating training error for first batch
          for k in tqdm(range(1,30,2)):
              clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute")
              clf.fit(x_train_1,y_train_1)

              pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

              auc = roc_auc_score(y_train_1,pre_probab)
              train_auc_list1.append(auc)

          # Calculating training error for second batch
          for k in tqdm(range(1,30,2)):
              clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute")
              clf.fit(x_train_2,y_train_2)

              pre_probab = clf.predict_proba(x_train_2)[:,1]

              auc = roc_auc_score(y_train_2,pre_probab)
              train_auc_list2.append(auc)


          # Calculating training error for third batch
          for k in tqdm(range(1,30,2)):
              clf = KNeighborsClassifier(n_neighbors=k,algorithm="brute")
              clf.fit(x_train_3,y_train_3)

              pre_probab = clf.predict_proba(x_train_3)[:,1]

              auc = roc_auc_score(y_train_3,pre_probab)
              train_auc_list3.append(auc)

100%|| 15/15 [02:54<00:00, 12.03s/it]
```

```
100%|| 15/15 [02:50<00:00, 11.73s/it]
100%|| 15/15 [03:19<00:00, 14.13s/it]
```

In [110]:
```
# Combining training result of each batch together
train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_au
```

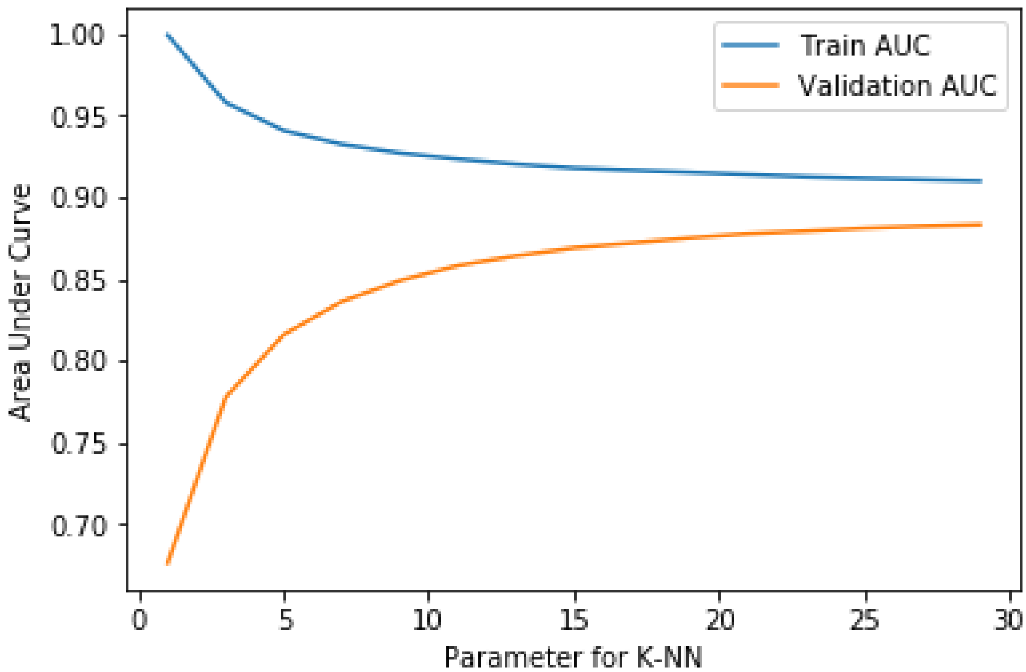
In [111]:
```
# 10 fold cross validation using time series splitting
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=10)
auc_list=[]

for k in range(1,30,2):
    # KNN Classifier
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='brute',leaf_size=30)
    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(ex
        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 tr
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

        clf.fit(x_train,y_train)

        predict_probab = clf.predict_proba(x_test)[:,1]
        i += 1
        auc += roc_auc_score(y_test,predict_probab)
    auc_list.append(auc/i)
```

In [113]:
```
# Plotting graph of auc and parameter for training and cross validation error
plot_knn_vs_auc(train_auc_list,auc_list)
```



In [115]:
```
# Training final model on best auc and taking k = 25

# Training one model with all the data hangs the PC .
# Therefore we will divide data into 3 parts and then train three seperate models.
final_clf1 = KNeighborsClassifier(n_neighbors=30,algorithm='brute',leaf_size=40)
final_clf1.fit(x_train_1,y_train_1)
predict_probab_1 = final_clf1.predict_proba(test_sent_vectors)[:,1] # This returns o
predict_y1 = final_clf1.predict(test_sent_vectors)
predict_y_train1 = final_clf1.predict(x_train_1)

final_clf2 = KNeighborsClassifier(n_neighbors=30,algorithm='brute',leaf_size=40)
final_clf2.fit(x_train_2,y_train_2)
predict_probab_2 = final_clf2.predict_proba(test_sent_vectors)[:,1] # This returns o
predict_y2 = final_clf2.predict(test_sent_vectors)
predict_y_train2 = final_clf2.predict(x_train_2)

final_clf3 = KNeighborsClassifier(n_neighbors=30,algorithm='brute',leaf_size=40)
final_clf3.fit(x_train_3,y_train_3)
predict_probab_3 = final_clf3.predict_proba(test_sent_vectors)[:,1] # This returns o
predict_y3 = final_clf3.predict(test_sent_vectors)
predict_y_train3 = final_clf3.predict(x_train_3)

# Now merging all the three probability scores into one
predict_probab = [(x+y+z)/3 for x,y,z in zip(predict_probab_1,predict_probab_2,predic
```

```
predict_y = [1 if(x+y+x>= 2) else 0 for x,y,z in zip(predict_y1,predict_y2,predict_y3
auc = roc_auc_score(Y_test,predict_probab)
print("Final AUC is ::{:.2f}".format(auc))
```

```
Final AUC is ::0.90
```

```
In [116]: predict_y_train = [] # will store predicted class labels of combined predicted label

          # Combining predicted labels of train dataset evaluation
          # Appending predicted labels of first model
          for i in predict_y_train1:
              predict_y_train.append(i)

          # Appending predicted labels of second model
          for i in predict_y_train2:
              predict_y_train.append(i)

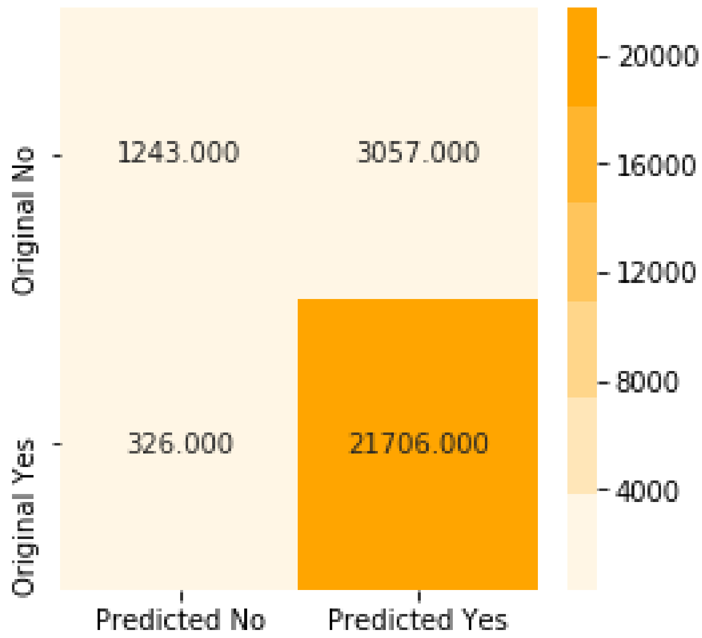
          # Appending predicted labels of third model
          for i in predict_y_train3:
              predict_y_train.append(i)

          print(len(predict_y_train))
```

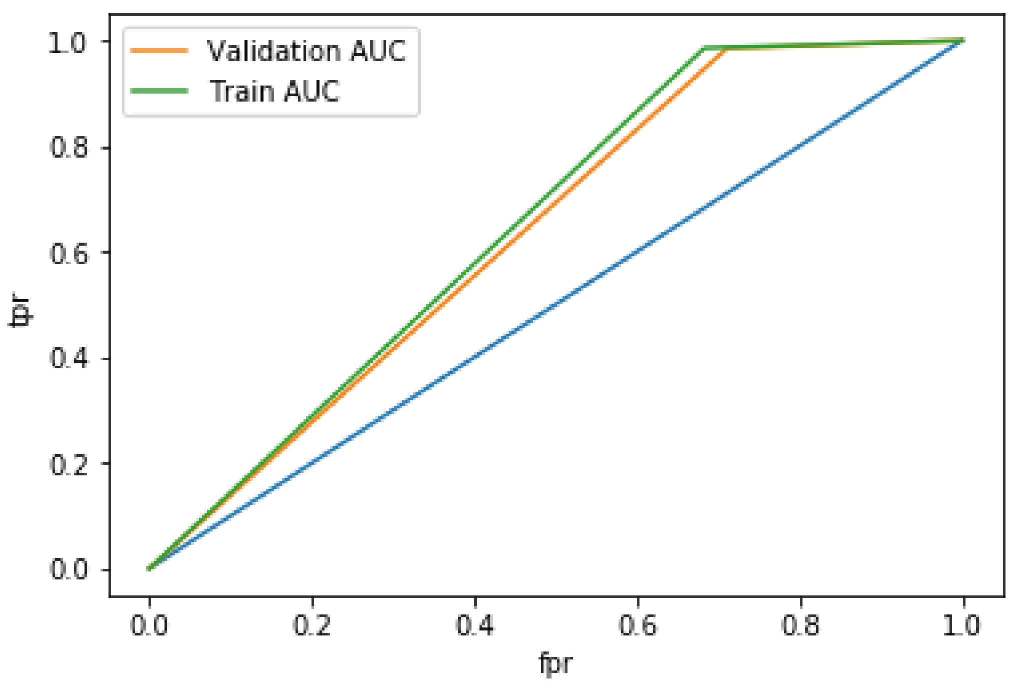
```
61441
```

```
In [117]: # Plotting confusion matrix
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```




```
In [118]: # Plotting roc
          plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.1.4 [5.1.4] Applying KNN brute force on TFIDF W2V

In [103]:
```
Y = final['Score'] # Contains labels of data points
X_train,X_test,Y_train,Y_test = train_test_split(cleaned_reviews,Y,test_size=0.3,ranc
```

In [104]:
```
# Vectorizing train dataset using tfidf
model = TfidfVectorizer()
model.fit_transform(X_train)
tfidf_feat1 = model.get_feature_names()

# This will map word with their tfidf only for train dataset
dictionary1 = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [105]:
```
# Vectorizing test dataset using tfidf
model.transform(X_test)
tfidf_feat2 = model.get_feature_names()

# This will map word with their tfidf only for test dataset
dictionary2 = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [106]:
```
# Vectorizing train dataset

# TF-IDF weighted Word2Vec
 # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfid

train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in

for sent in 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 tfidf_feat1:
            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 = dictionary1[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)
```

In [107]:
```
# TF-IDF weighted Word2Vec
# Vectorizing test dataset.

test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
```

```
    for sent in 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 tfidf_feat2:
                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 = dictionary2[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)
```

In [108]:
```
# Calculating training error .
# Because of large amount of data. we are processing data into three batches here.
# After processing all the results of these batches are merged into one .

train_auc_list1 = []   # This contains area under curve value of first batch correspo
train_auc_list2 = []   # for second batch
train_auc_list3 = []   # for third batch

# Testing whole training data at once takes a lot of memory which takes a lot of tim
# There fore we are dividing training data into 3 parts and then we will calculate A

x_train_1 = train_tfidf_sent_vectors[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = train_tfidf_sent_vectors[20000:40000][:]
x_train_3 = train_tfidf_sent_vectors[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in tqdm(range(1,30,2)):
```

```
        clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
        clf.fit(x_train_2,y_train_2)

        pre_probab = clf.predict_proba(x_train_2)[:,1]

        auc = roc_auc_score(y_train_2,pre_probab)
        train_auc_list2.append(auc)


    # Calculating training error for third batch
    for k in tqdm(range(1,30,2)):
        clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
        clf.fit(x_train_3,y_train_3)

        pre_probab = clf.predict_proba(x_train_3)[:,1]

        auc = roc_auc_score(y_train_3,pre_probab)
        train_auc_list3.append(auc)

    # Combining results together.
    train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_au
```

```
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 80%|                    | 12/15 [05:15<01:18, 26.08s/it]
 87%|               | 13/15 [05:42<00:52, 26.32s/it]
 93%|         | 14/15 [06:09<00:26, 26.56s/it]
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 40%| | 6/15 [02:41<04:08, 27.65s/it]
 47%| | 7/15 [03:05<03:32, 26.55s/it]
 53%| | 8/15 [03:30<03:02, 26.00s/it]
 60%| | 9/15 [03:54<02:32, 25.47s/it]
 67%| | 10/15 [04:18<02:04, 25.00s/it]
 73%| | 11/15 [04:43<01:40, 25.19s/it]
 80%| | 12/15 [05:07<01:14, 24.84s/it]
 87%| | 13/15 [05:31<00:49, 24.57s/it]
 93%| | 14/15 [05:57<00:24, 24.78s/it]
100%|| 15/15 [06:24<00:00, 25.64s/it]

In [109]:
```
# 10 fold cross validation using time series splitting

auc_list = []

for k in tqdm(range(1,30,2)):
    # KNN Classifier
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='kd_tree',leaf_size=30,n_jobs=
    i=0
    auc=0.0
    for train_index,test_index in tscv.split(train_tfidf_sent_vectors):
        x_train = train_sent_vectors[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 = train_sent_vectors[train_index[-1]:test_index[-1]][:] # row from tr
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

        clf.fit(x_train,y_train)

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

```
            auc_list.append(auc/i) # Averaging auc for all 10 folds .
```

```
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  7%|                                                                              | 1/15 [02:43<
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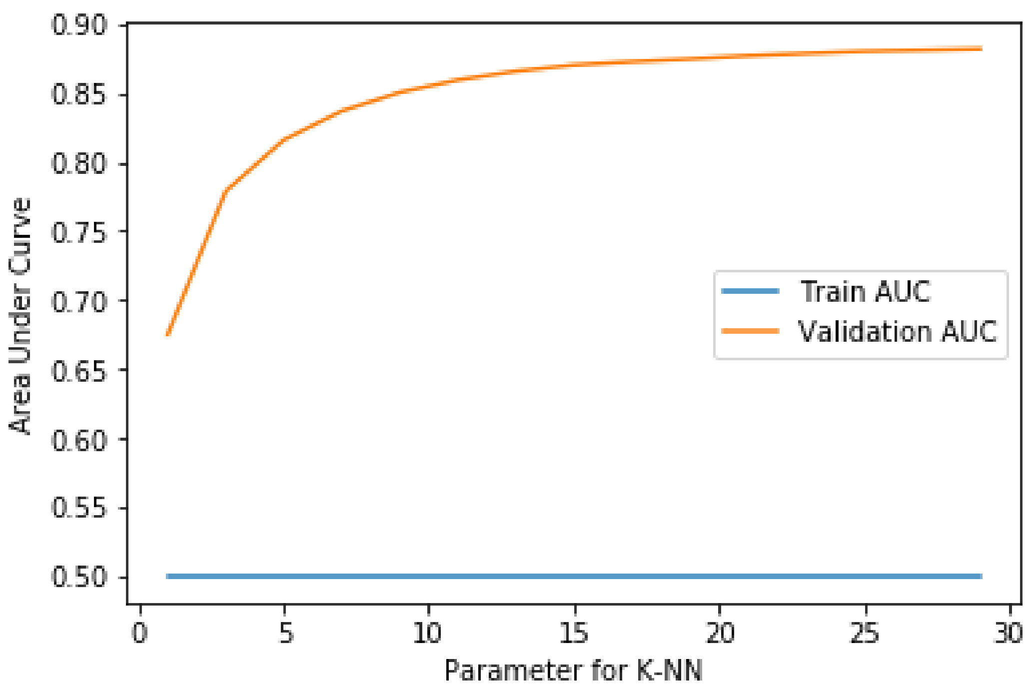
 20%|                                                                   | 3/15 [07:57<32:11, 160
 27%|                                                              | 4/15 [11:04<30:56, 168.76s/i
 33%|                                                        | 5/15 [14:04<28:42, 172.27s/it]
 40%|                                                   | 6/15 [16:44<25:15, 168.38s/it]
 47%|                                             | 7/15 [19:38<22:41, 170.18s/it]
 53%|                                        | 8/15 [22:56<20:49, 178.50s/it]
 60%|                                  | 9/15 [26:18<18:32, 185.44s/it]
 67%|                             | 10/15 [29:36<15:47, 189.45s/it]
 73%|                       | 11/15 [32:27<12:15, 183.88s/it]
 80%|                  | 12/15 [35:19<09:00, 180.10s/it]
 87%|            | 13/15 [38:11<05:55, 177.94s/it]
 93%|       | 14/15 [41:06<02:57, 177.06s/it]
100%|| 15/15 [44:01<00:00, 176.22s/it]
```

In [110]:
```
# Plotting graph of auc and parameter for training and cross validation error
plot_knn_vs_auc(train_auc_list,auc_list)
```



In [111]:
```
30# Training final model on best auc and taking k = 10
```

```
# Training one model with all the data hangs the PC .
# Therefore we will divide data into 3 parts and then train three seperate models.
x_train_1 = train_tfidf_sent_vectors[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = train_tfidf_sent_vectors[20000:40000][:]
x_train_3 = train_tfidf_sent_vectors[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]


final_clf1 = KNeighborsClassifier(n_neighbors=30,algorithm='kd_tree',leaf_size=40,n_
final_clf1.fit(x_train_1,y_train_1)
predict_probab_1 = final_clf1.predict_proba(test_tfidf_sent_vectors)[:,1] # This ret
predict_y_train1 = list(final_clf1.predict(x_train_1))

final_clf2 = KNeighborsClassifier(n_neighbors=30,algorithm='kd_tree',leaf_size=40,n_
final_clf2.fit(x_train_2,y_train_2)
predict_probab_2 = final_clf2.predict_proba(test_tfidf_sent_vectors)[:,1] # This ret
predict_y_train2 = list(final_clf1.predict(x_train_2))

final_clf3 = KNeighborsClassifier(n_neighbors=30,algorithm='kd_tree',leaf_size=40,n_
final_clf3.fit(x_train_3,y_train_3)
predict_probab_3 = final_clf3.predict_proba(test_tfidf_sent_vectors)[:,1] # This ret
predict_y_train3 = final_clf1.predict(x_train_3)

# Now merging all the three probability scores into one

predict_probab = [(x+y+z)/3 for x,y,z in zip(predict_probab_1,predict_probab_2,predic
predict_y = [1 if(x+y+z>=2) else 0 for x,y,z in zip(predict_probab_1,predict_probab_

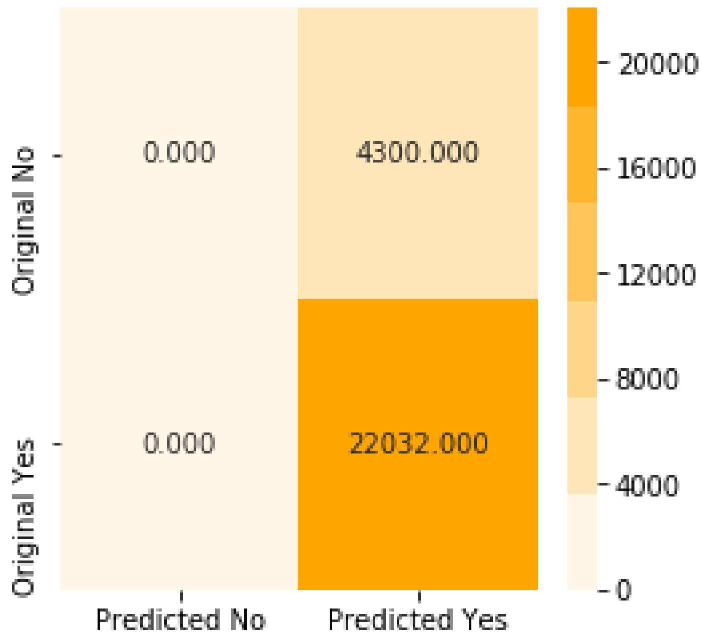
# Combining results for train dataset
predict_y_train = np.concatenate((predict_y_train1,predict_y_train2),axis=None)
predict_y_train = np.concatenate((predict_y_train,predict_y_train3),axis=None)

auc = roc_auc_score(Y_test,predict_probab)
print("Final AUC is ::{:.2f}".format(auc))
```

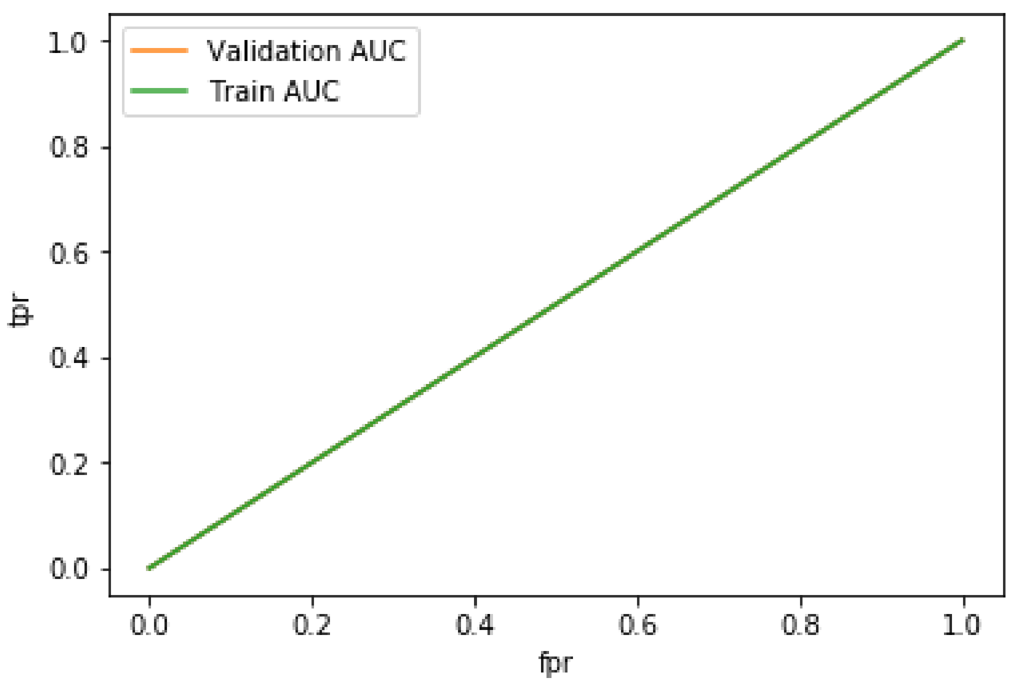
```
Final AUC is ::0.50
```

In [112]:
```
# Plotting confusion matrix
confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```



In [113]:
```
# Plotting roc curve
plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.2 [5.2] Applying KNN kd-tree

6.2.1 [5.2.1] Applying KNN kd-tree on BOW, SET 5

In [61]:
```
# Kd tree works slow for high dimensional data.
# Therefore taking top 5000 features
from sklearn.cross_validation import train_test_split
count_vect = CountVectorizer(max_features=5000)

X = cleaned_reviews
Y = final["Score"]
# Splitting data into train and test dataset
X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
print(len(X_train),len(X_test))
```

```
61441 26332
```

In [62]:
```
# Vectorizing train and test dataset seperately
X_train = count_vect.fit_transform(X_train)
print(X_train.shape)

X_test = count_vect.transform(X_test)
print(X_test.shape)
```

```
(61441, 5000)
(26332, 5000)
```

In [63]:
```
# Since kd Tree dont take sparse matrix .
# Therefore we are converting sparse to dense matrxi using TruncatedSVD
from sklearn.decomposition import TruncatedSVD

# Initializing TruncatedSVD
# Too many features takes a lot of time . Therefore taking 500 features only
svd = TruncatedSVD(n_components=200,algorithm='randomized',n_iter=50,random_state=42)
X_train = svd.fit_transform(X_train)
X_test = svd.fit_transform(X_test)
print(X_train.shape,X_test.shape)
```

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

In [66]:
```
# Calculating training error .
# Because of large amount of data. we are processing data into three batches here.
# After processing all the results of these batches are merged into one .

param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
train_auc_list1 = []   # This contains area under curve value of first batch correspo
train_auc_list2 = []   # for stqdm(econd batch
```

```
train_auc_list3 = []   # for third batch

# Testing whole training data at once takes a lot of memory which takes a lot of time
# There fore we are dividing training data into 3 parts and then we will calculate AU

x_train_1 = X_train[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = X_train[20000:40000][:]
x_train_3 = X_train[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40)
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40)
    clf.fit(x_train_2,y_train_2)

    pre_probab = clf.predict_proba(x_train_2)[:,1]

    auc = roc_auc_score(y_train_2,pre_probab)
    train_auc_list2.append(auc)


# Calculating training error for third batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40)
    clf.fit(x_train_3,y_train_3)

    pre_probab = clf.predict_proba(x_train_3)[:,1]

    auc = roc_auc_score(y_train_3,pre_probab)
    train_auc_list3.append(auc)
```

```
100%|| 15/15 [2:16:40<00:00, 595.11s/it]
100%|| 15/15 [1:52:25<00:00, 427.10s/it]
100%|| 15/15 [1:02:25<00:00, 273.88s/it]
```

```
In [67]: train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_auc

In [68]: # Performing 10 fold cross validation on time split data

         tscv = TimeSeriesSplit(n_splits=10)
         auc_list1 = []

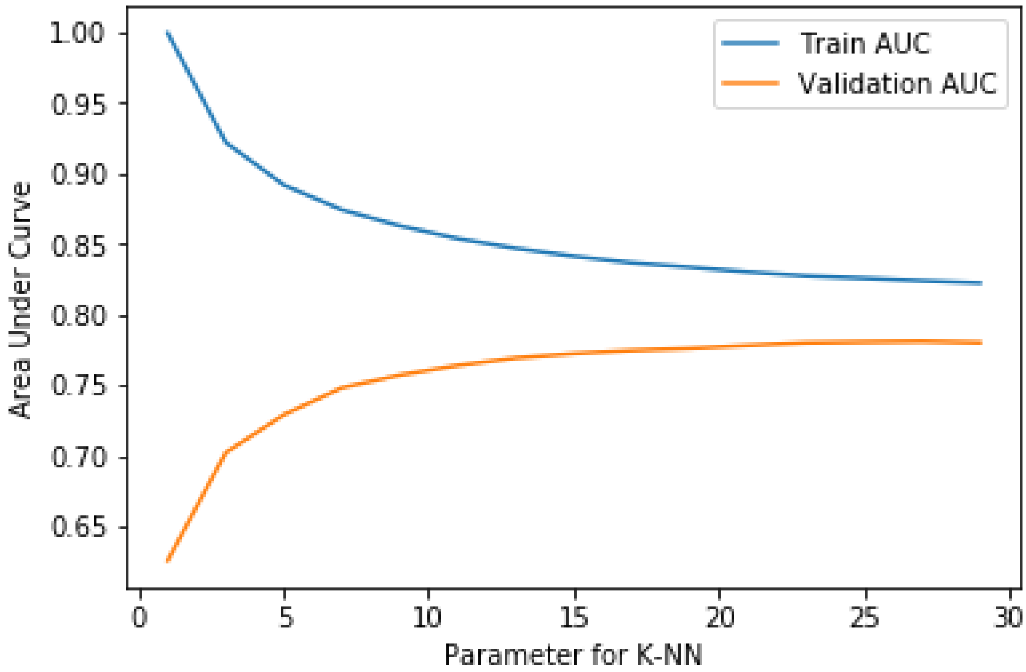
         for k in range(1,30,2):
             clf1 = KNeighborsClassifier(n_neighbors=k,algorithm='kd_tree',leaf_size=40)
             auc1 = 0.0
             i1=0
             for train_index,test_index in tscv.split(X_train):
                 x_train = X_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = X_train[train_index[-1]:test_index[-1]][:] # row from train_index to
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 clf1.fit(x_train,y_train)

                 predict_probab1 = clf1.predict_proba(x_test)[:,1]
                 i1 += 1
                 auc1 += roc_auc_score(y_test,predict_probab1)

             auc_list1.append(auc1/i1)


In [70]: # Plotting graph of auc and parameter for training and cross validation error
         plot_knn_vs_auc(train_auc_list,auc_list1)
```



In [75]:
```
# Training final model on best auc and taking k = 25

final_clf = KNeighborsClassifier(n_neighbors=25,algorithm='kd_tree',leaf_size=40)
final_clf.fit(X_train,Y_train)
predict_probab = final_clf.predict_proba(X_test)[:,1] # This returns only probability
predict_y = final_clf.predict(X_test)

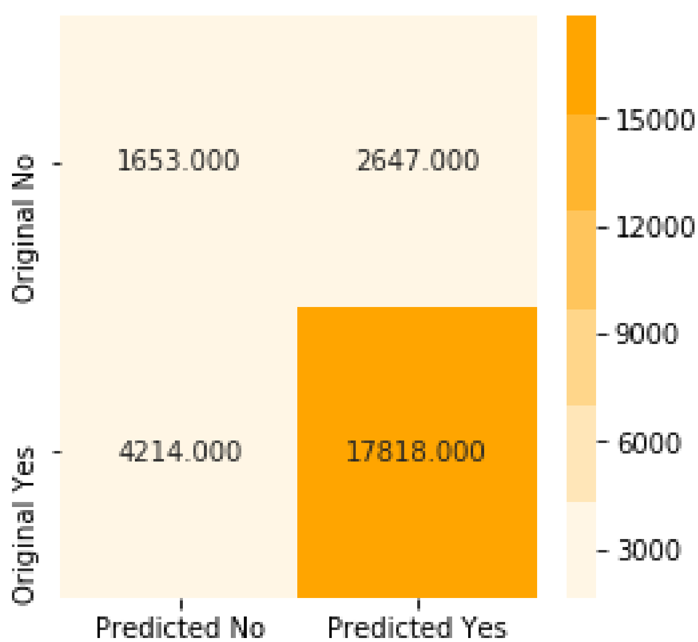
auc = roc_auc_score(Y_test,predict_probab)
print("Final AUC is ::{:.2f}".format(auc))
```

```
Final AUC is ::0.63
```

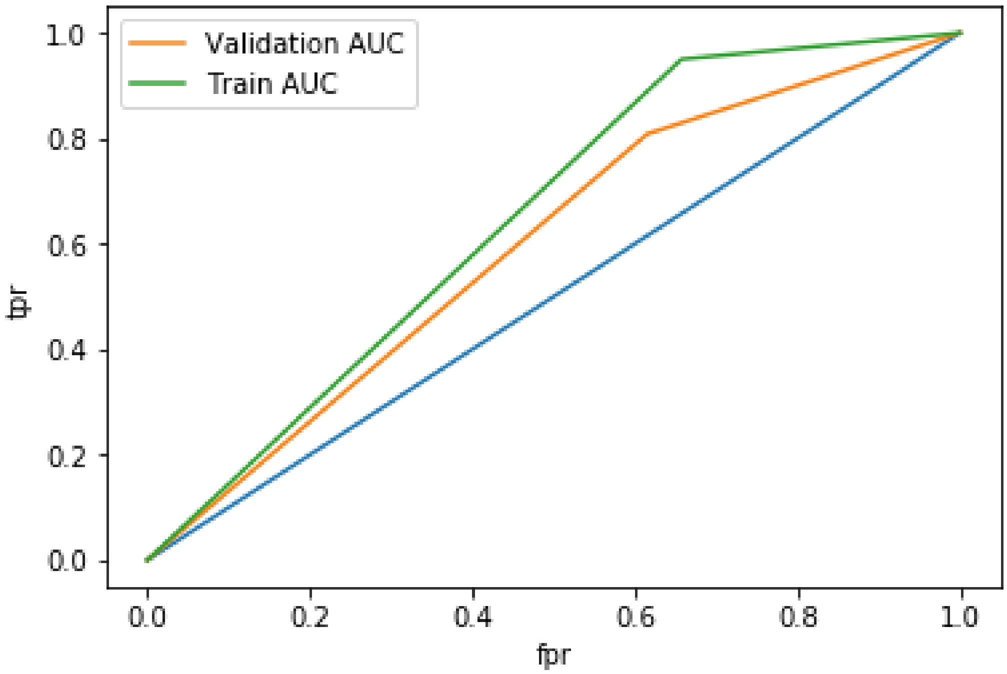
In [72]:
```
predict_y_train = final_clf.predict(X_train)
```

In [76]:
```
# Plotting confusion matrix
confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```



In [77]:
```
# Plotting roc curve
plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.2.2 [5.2.2] Applying KNN kd-tree on TFIDF, SET 6

In [78]:
```
# In this section Tfidf will be used for vectorization
# Splitting datasets into train and test datasets

X = final['Cleaned_review']
Y = final['Score']
tf_idf_vect = TfidfVectorizer(max_features=300)

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

# Now we will vectorize train and test datasets separately using Tfidf
# Use fit_transform to vectorize train dataset and transform to vectorize test datase
X_train = tf_idf_vect.fit_transform(X_train)
X_test = tf_idf_vect.transform(X_test)
```

In [79]:
```
from sklearn.decomposition import TruncatedSVD
svd = TruncatedSVD(n_components=200,algorithm='randomized',n_iter=50,random_state=42)
X_train = svd.fit_transform(X_train)
X_test = svd.fit_transform(X_test)
print(X_train.shape,X_test.shape)
```

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

In [80]:
```
param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
train_auc_list1 = []   # This contains area under curve value of first batch correspo
train_auc_list2 = []   # for second batch
train_auc_list3 = []   # for third batch

# Testing whole training data at once takes a lot of memory which takes a lot of time
# There fore we are dividing training data into 3 parts and then we will calculate AU

x_train_1 = X_train[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = X_train[20000:40000][:]
x_train_3 = X_train[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_2,y_train_2)

    pre_probab = clf.predict_proba(x_train_2)[:,1]

    auc = roc_auc_score(y_train_2,pre_probab)
    train_auc_list2.append(auc)


# Calculating training error for third batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_3,y_train_3)

    pre_probab = clf.predict_proba(x_train_3)[:,1]

    auc = roc_auc_score(y_train_3,pre_probab)
    train_auc_list3.append(auc)
```

```
100%|| 15/15 [19:36<00:00, 84.13s/it]
```

```
100%|| 15/15 [20:11<00:00, 90.45s/it]
100%|| 15/15 [27:46<00:00, 117.68s/it]
```

```
In [81]: train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_auc
```

```
In [84]: # Performing 10 fold cross validation on time split data

         tscv = TimeSeriesSplit(n_splits=10)
         auc_list1 = []

         for k in tqdm(range(1,30,2)):
             clf1 = KNeighborsClassifier(n_neighbors=k,algorithm='kd_tree',leaf_size=40,n_jobs=
             auc1 = 0.0
             i1=0
             for train_index,test_index in tscv.split(X_train):
                 x_train = X_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = X_train[train_index[-1]:test_index[-1]][:] # row from train_index to
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

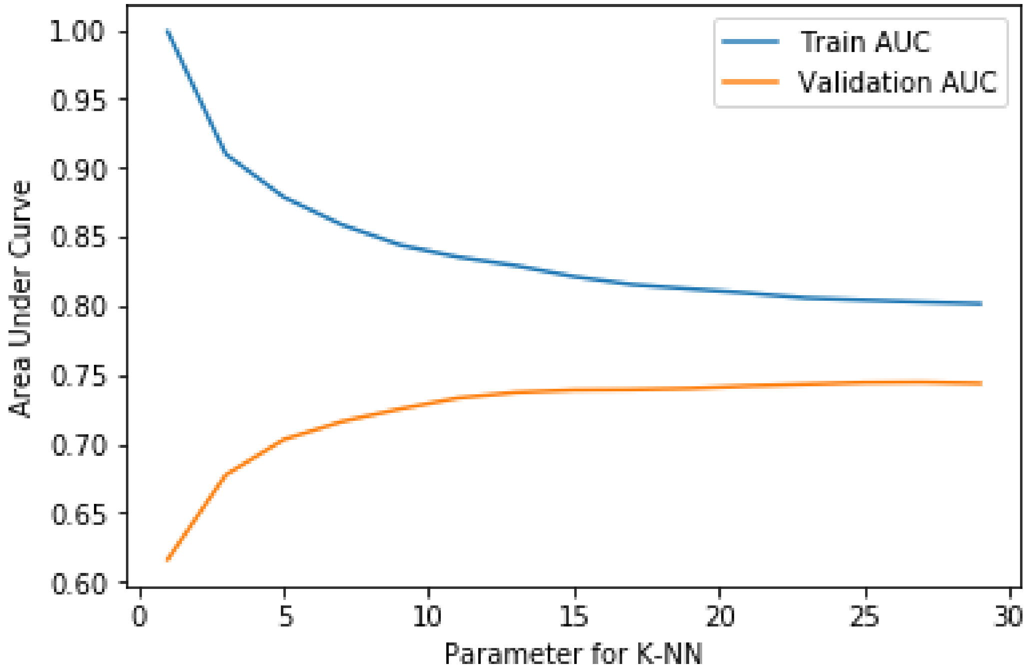
                 clf1.fit(x_train,y_train)

                 predict_probab1 = clf1.predict_proba(x_test)[:,1]
                 i1 += 1
                 auc1 += roc_auc_score(y_test,predict_probab1)

             auc_list1.append(auc1/i1)
```

```
  0%|
  7%|                                                                                    | 1/15 [07:01<1
 13%|                                                                               | 2/15 [15:38<1:37:3
 20%|                                                                          | 3/15 [23:22<1:30:51, 45
 27%|                                                                    | 4/15 [30:44<1:22:38, 450.80s/
 33%|                                                               | 5/15 [38:05<1:14:37, 447.76s/it]
 40%|                                                          | 6/15 [45:23<1:06:43, 444.88s/it]
 47%|                                                     | 7/15 [52:40<59:00, 442.60s/it]
 53%|                                                | 8/15 [59:58<51:27, 441.07s/it]
 60%|                                          | 9/15 [1:07:20<44:08, 441.48s/it]
 67%|                                    | 10/15 [1:14:42<36:48, 441.66s/it]
 73%|                               | 11/15 [1:22:05<29:27, 442.00s/it]
 80%|                         | 12/15 [1:29:51<22:27, 449.24s/it]
 87%|                    | 13/15 [1:37:14<14:54, 447.18s/it]
 93%|               | 14/15 [1:45:34<07:43, 463.07s/it]
100%|| 15/15 [1:52:53<00:00, 455.96s/it]
```

```
In [85]: # Plotting graph of auc and parameter for training and cross validation error
         plot_knn_vs_auc(train_auc_list,auc_list1)
```




```
In [86]: # Training final model on best auc and taking k = 11

         final_clf = KNeighborsClassifier(n_neighbors=24,algorithm='kd_tree',leaf_size=30,n_jol

         final_clf.fit(X_train,Y_train)

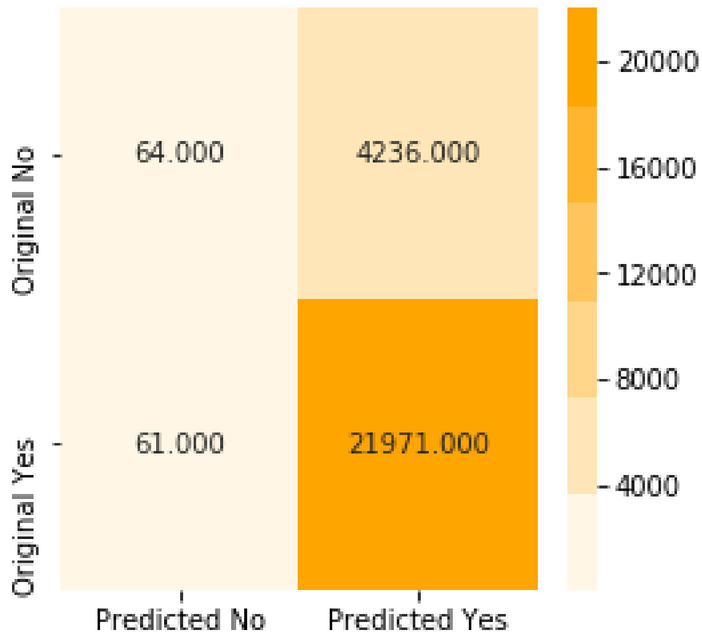
         predict_probab = final_clf.predict_proba(X_test)[:,1] # This returns only probability
         predict_y = final_clf.predict(X_test)
         auc = roc_auc_score(Y_test,predict_probab)
         print("Final AUC is {:.2f}".format(auc))

Final AUC is 0.57


In [89]: predict_y_train = final_clf.predict(X_train)

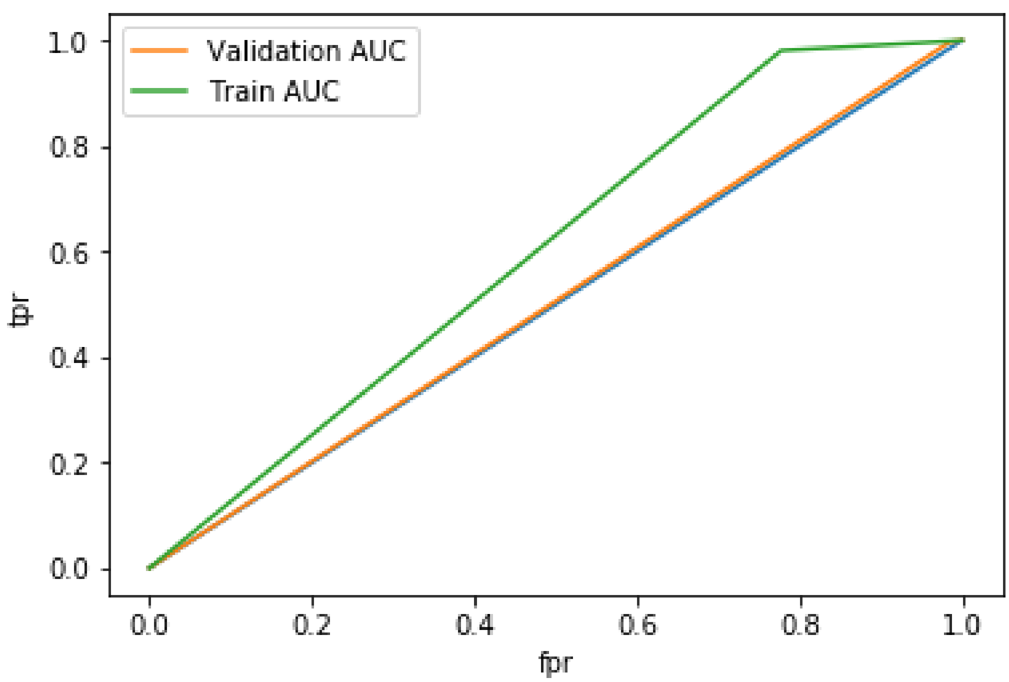
In [87]: # Plotting confusion matrix
         confusion_matrix_plot(Y_test,predict_y)

Confusion matrix
```



In [90]: # Plotting roc curve

```
plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.2.3 [5.2.3] Applying KNN kd-tree on AVG W2V, SET 3

In [91]:
```
# Splitting data into train and test.
Y = final['Score']
X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentence,Y,test_size=0.3,ranc
```

In [92]:
```
# Now we will vectorize train dataset usin avg_w2v
train_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this lis
for sent in X_train: # 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
    train_sent_vectors.append(sent_vec)
print(len(train_sent_vectors))
print(len(train_sent_vectors[0]))
```

```
61441
50
```

In [93]:
```
# Vectorization of test dataset using avg_w2v

test_sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in X_test: # 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
    test_sent_vectors.append(sent_vec)
print(len(test_sent_vectors))
print(len(test_sent_vectors[0]))
```

```
26332
50
```

In [94]:
```
param_list = [1,3,5,7,9,11,13,15,17,19,21,23,25,27,29]
train_auc_list1 = []   # This contains area under curve value of first batch correspo
```

```
train_auc_list2 = []   # for second batch
train_auc_list3 = []   # for third batch

# Testing whole training data at once takes a lot of memory which takes a lot of time
# There fore we are dividing training data into 3 parts and then we will calculate AU

x_train_1 = train_sent_vectors[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = train_sent_vectors[20000:40000][:]
x_train_3 = train_sent_vectors[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
    clf.fit(x_train_2,y_train_2)

    pre_probab = clf.predict_proba(x_train_2)[:,1]

    auc = roc_auc_score(y_train_2,pre_probab)
    train_auc_list2.append(auc)


# Calculating training error for third batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=30,n_jobs=
    clf.fit(x_train_3,y_train_3)

    pre_probab = clf.predict_proba(x_train_3)[:,1]

    auc = roc_auc_score(y_train_3,pre_probab)
    train_auc_list3.append(auc)

# Combining the result into one.
train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_au
```

```
  0%|
  7%|                                                                              | 1/15 [00:0
 13%|                                                                         | 2/15 [00:39<02:3
 20%|                                                                   | 3/15 [01:19<04:03, 20
 27%|                                                             | 4/15 [01:59<04:50, 26.41s/i
 33%|                                                        | 5/15 [02:39<05:05, 30.53s/it]
 40%|                                                  | 6/15 [03:19<04:59, 33.30s/it]
 47%|                                             | 7/15 [04:00<04:43, 35.42s/it]
 53%|                                       | 8/15 [04:42<04:22, 37.52s/it]
 60%|                                  | 9/15 [05:23<03:51, 38.58s/it]
 67%|                            | 10/15 [06:05<03:17, 39.48s/it]
 73%|                      | 11/15 [06:46<02:40, 40.17s/it]
 80%|                 | 12/15 [07:28<02:01, 40.64s/it]
 87%|            | 13/15 [08:09<01:21, 40.60s/it]
 93%|      | 14/15 [08:59<00:43, 43.47s/it]
100%|| 15/15 [09:50<00:00, 45.65s/it]

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 33%|                                                        | 5/15 [03:14<06:10, 37.08s/it]
 40%|                                                  | 6/15 [04:03<06:07, 40.79s/it]
 47%|                                             | 7/15 [04:53<05:47, 43.50s/it]
 53%|                                       | 8/15 [05:42<05:16, 45.19s/it]
 60%|                                  | 9/15 [06:32<04:39, 46.54s/it]
 67%|                            | 10/15 [07:23<03:59, 47.92s/it]
 73%|                      | 11/15 [08:15<03:16, 49.11s/it]
 80%|                 | 12/15 [09:05<02:27, 49.32s/it]
 87%|            | 13/15 [09:56<01:39, 49.92s/it]
 93%|      | 14/15 [10:46<00:49, 49.84s/it]
100%|| 15/15 [11:36<00:00, 50.08s/it]

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 60%|                                  | 9/15 [07:26<05:20, 53.40s/it]
 67%|                            | 10/15 [08:23<04:33, 54.67s/it]
 73%|                      | 11/15 [09:17<03:37, 54.47s/it]
 80%|                 | 12/15 [10:12<02:43, 54.45s/it]
```

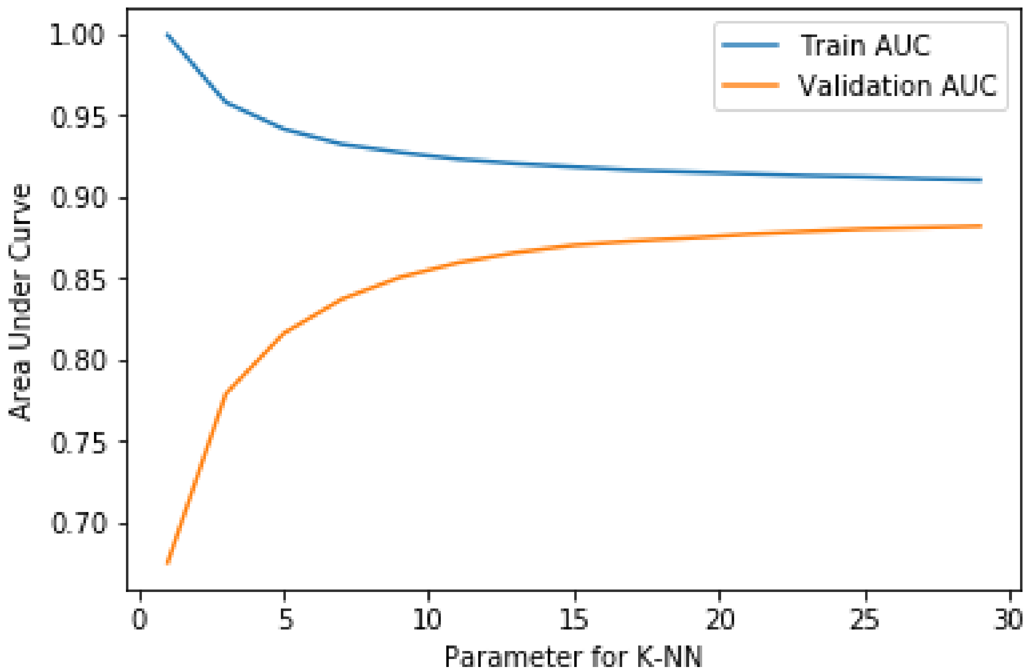
 87%| | 13/15 [11:08<01:50, 55.12s/it]
 93%| | 14/15 [12:06<00:55, 55.89s/it]
100%|| 15/15 [13:05<00:00, 56.76s/it]

In [95]:
```
# 10 fold cross validation using time series splitting
# Here X_train is train_sent_vectors and X_test is test_sent_vectors
# Here vectorization results of previous section is used . Only KNN algorithm is chan
tscv = TimeSeriesSplit(n_splits=10)
auc_list=[]
for k in range(1,30,2):
    # KNN Classifier
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='kd_tree',leaf_size=40,n_jobs=
    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(exc
        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 tra
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

        clf.fit(x_train,y_train)
        predict_probab = clf.predict_proba(x_test)[:,1]
        #print(len(x_test),len(y_test),len(predict_probab))
        i += 1
        auc += roc_auc_score(y_test,predict_probab)

    auc_list.append(auc/i)
```

In [96]:
```
# Plotting graph of auc and parameter for training and cross validation error
plot_knn_vs_auc(train_auc_list,auc_list)
```




```
In [97]: # Training the final model
         final_clf = KNeighborsClassifier(n_neighbors=25,algorithm='kd_tree',leaf_size=30,n_jol

         final_clf.fit(train_sent_vectors,Y_train)

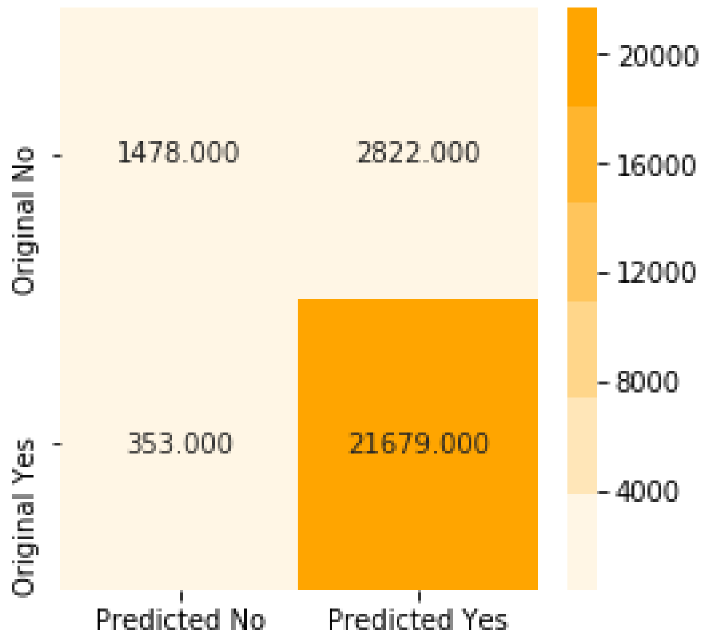
         predict_probab = final_clf.predict_proba(test_sent_vectors)[:,1] # Returns the class p
         predict_y = final_clf.predict(test_sent_vectors)
         predict_y_train = final_clf.predict(train_sent_vectors)
         auc = roc_auc_score(Y_test,predict_probab)

         print("Final AUC is {:.2f}".format(auc))
```

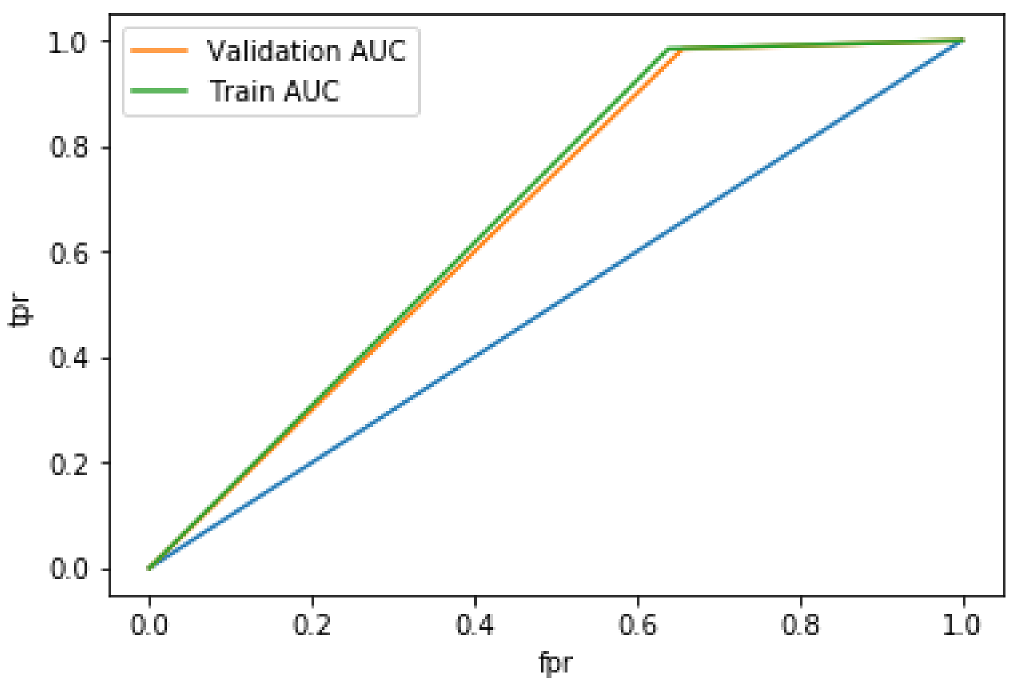
```
Final AUC is 0.89
```

```
In [98]: # Plotting confusion matrix
         confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```




```
In [101]: ## Plotting roc curve
          plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



6.2.4 [5.2.4] Applying KNN kd-tree on TFIDF W2V, SET 4

In [114]:
```
# Using vectorized data from previous section

# Calculating training error .
# Because of large amount of data. we are processing data into three batches here.
# After processing all the results of these batches are merged into one .

train_auc_list1 = []   # This contains area under curve value of first batch correspo
train_auc_list2 = []   # for second batch
train_auc_list3 = []   # for third batch

# Testing whole training data at once takes a lot of memory which takes a lot of tim
# There fore we are dividing training data into 3 parts and then we will calculate A

x_train_1 = train_tfidf_sent_vectors[0:20000][:] # Row 0 to 19999 and all columns
x_train_2 = train_tfidf_sent_vectors[20000:40000][:]
x_train_3 = train_tfidf_sent_vectors[40000:61441][:]

y_train_1 = Y_train[0:20000][:] # Row 0 to 19999 and all columns
y_train_2 = Y_train[20000:40000][:]
y_train_3 = Y_train[40000:61441][:]

# Calculating training error for first batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_1,y_train_1)

    pre_probab = clf.predict_proba(x_train_1)[:,1] # Returns probability of positive

    auc = roc_auc_score(y_train_1,pre_probab)
    train_auc_list1.append(auc)

# Calculating training error for second batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_2,y_train_2)

    pre_probab = clf.predict_proba(x_train_2)[:,1]

    auc = roc_auc_score(y_train_2,pre_probab)
    train_auc_list2.append(auc)


# Calculating training error for third batch
for k in tqdm(range(1,30,2)):
    clf = KNeighborsClassifier(n_neighbors=k,algorithm="kd_tree",leaf_size=40,n_jobs=
    clf.fit(x_train_3,y_train_3)
```

```
            pre_probab = clf.predict_proba(x_train_3)[:,1]

            auc = roc_auc_score(y_train_3,pre_probab)
            train_auc_list3.append(auc)

        # Combining results together.
        train_auc_list = [(x+y+z)/3 for x,y,z in zip(train_auc_list1,train_auc_list2,train_au
```

```
  0%|
  7%|                                                                           | 1/15 [00:1
 13%|                                                                      | 2/15 [00:35<03:5
 20%|                                                                | 3/15 [00:56<03:44, 18
 27%|                                                          | 4/15 [01:16<03:30, 19.17s/i
 33%|                                                    | 5/15 [01:37<03:16, 19.65s/it]
 40%|                                              | 6/15 [01:57<02:59, 19.92s/it]
 47%|                                         | 7/15 [02:18<02:41, 20.13s/it]
 53%|                                   | 8/15 [02:38<02:21, 20.20s/it]
 60%|                              | 9/15 [02:59<02:02, 20.43s/it]
 67%|                        | 10/15 [03:21<01:44, 20.80s/it]
 73%|                  | 11/15 [03:43<01:24, 21.01s/it]
 80%|             | 12/15 [04:05<01:04, 21.51s/it]
 87%|        | 13/15 [04:28<00:43, 21.75s/it]
 93%|  | 14/15 [04:49<00:21, 21.61s/it]
100%|| 15/15 [05:10<00:00, 21.46s/it]

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 13%|                                                                      | 2/15 [00:42<04:
 20%|                                                                | 3/15 [01:03<04:12, 21
 27%|                                                          | 4/15 [01:24<03:50, 21.00s/i
 33%|                                                    | 5/15 [01:45<03:31, 21.19s/it]
 40%|                                              | 6/15 [02:08<03:15, 21.73s/it]
 47%|                                         | 7/15 [02:29<02:51, 21.48s/it]
 53%|                                   | 8/15 [02:51<02:29, 21.43s/it]
 60%|                              | 9/15 [03:13<02:10, 21.75s/it]
 67%|                        | 10/15 [03:35<01:48, 21.70s/it]
 73%|                  | 11/15 [03:57<01:27, 21.76s/it]
 80%|             | 12/15 [04:18<01:04, 21.67s/it]
 87%|        | 13/15 [04:39<00:43, 21.58s/it]
 93%|  | 14/15 [05:01<00:21, 21.49s/it]
100%|| 15/15 [05:21<00:00, 21.28s/it]

  0%|
  7%|                                                                           | 1/15 [00:2
 13%|                                                                      | 2/15 [00:54<05:
 20%|                                                                | 3/15 [01:22<05:30, 27
```

```
 27%|                                                             | 4/15 [01:49<05:03, 27.59s/i
 33%|                                                        | 5/15 [02:17<04:35, 27.55s/it]
 40%|                                                  | 6/15 [02:43<04:05, 27.26s/it]
 47%|                                             | 7/15 [03:11<03:38, 27.27s/it]
 53%|                                       | 8/15 [03:39<03:12, 27.51s/it]
 60%|                                  | 9/15 [04:06<02:45, 27.52s/it]
 67%|                            | 10/15 [04:34<02:17, 27.50s/it]
 73%|                      | 11/15 [05:01<01:49, 27.27s/it]
 80%|                 | 12/15 [05:27<01:21, 27.07s/it]
 87%|            | 13/15 [05:54<00:54, 27.08s/it]
 93%|      | 14/15 [06:21<00:27, 27.05s/it]
100%|| 15/15 [06:50<00:00, 27.43s/it]
```

In [115]:
```
# 10 fold cross validation using time series splitting
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit()
auc_list = []

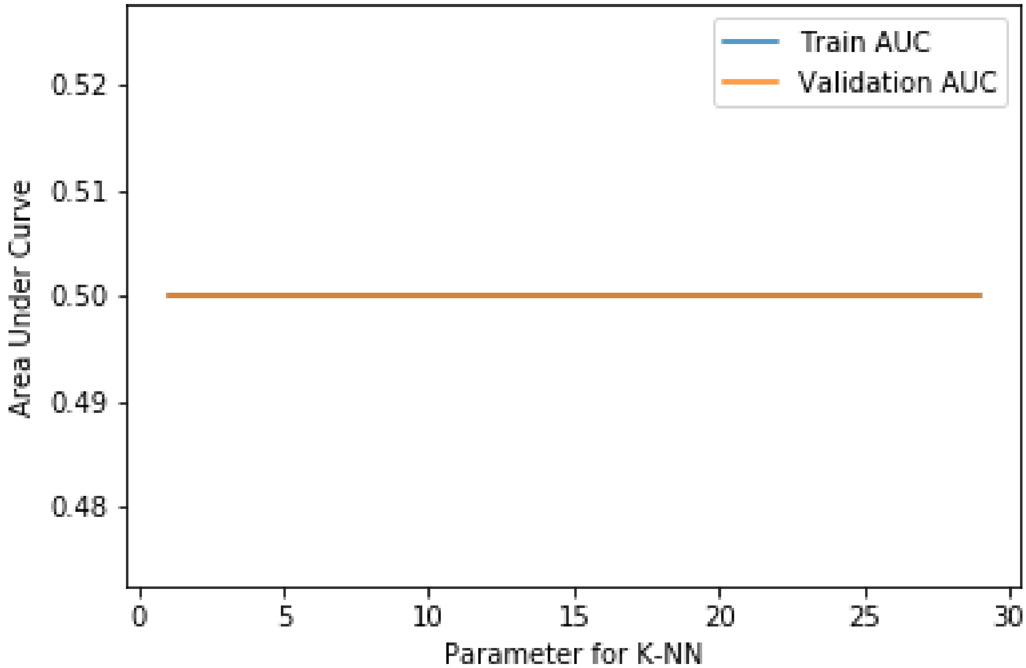
for k in range(1,30,2):
    # KNN Classifier
    clf = KNeighborsClassifier(n_neighbors=k,algorithm='kd_tree',leaf_size=40,n_jobs
    i=0
    auc=0.0
    for train_index,test_index in tscv.split(train_tfidf_sent_vectors):
        x_train = train_tfidf_sent_vectors[0:train_index[-1]][:] # row 0 to train_in
        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]][:] # row f
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

        clf.fit(x_train,y_train)

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

    auc_list.append(auc/i) # Averaging auc for all 10 folds .
```

In [117]:
```
# Plotting graph of auc and parameter for training and cross validation error
plot_knn_vs_auc(train_auc_list,auc_list)
```




```
In [118]: # Training the final model
          final_clf = KNeighborsClassifier(n_neighbors=11,algorithm='kd_tree',leaf_size=40,n_jo

          final_clf.fit(train_tfidf_sent_vectors,Y_train)

          predict_probab = final_clf.predict_proba(test_tfidf_sent_vectors)[:,1] # Returns the

          auc = roc_auc_score(Y_test,predict_probab)

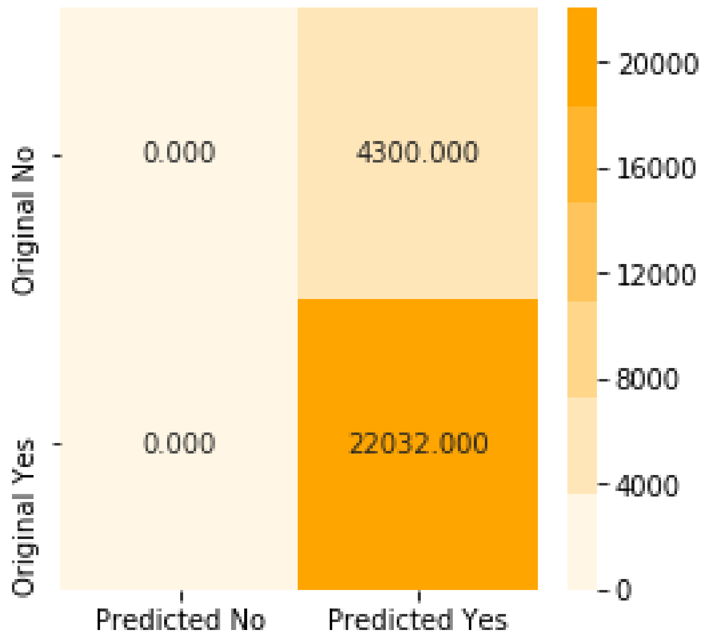
          print("AUC of model is {:.2f}".format(auc))
```

```
AUC of model is 0.50
```

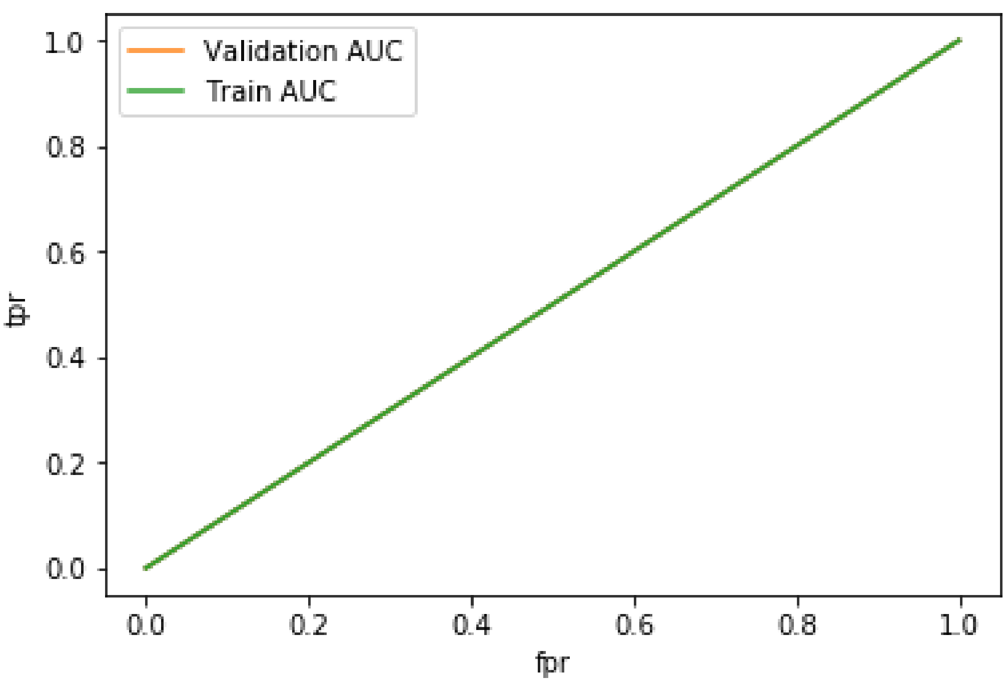
```
In [119]: # Train and test prediction
          predict_y = final_clf.predict(test_tfidf_sent_vectors)
          predict_y_train = final_clf.predict(train_tfidf_sent_vectors)
```

```
In [120]: # Plotting confusion matrix , precision and recall matrix
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion matrix
```




```
In [121]: # Plotting ROC Curve
          plot_roc_curve(Y_test,predict_y,Y_train,predict_y_train)
```



7 [6] Conclusions

```
In [1]: from prettytable import PrettyTable

        x = PrettyTable()


        x.field_names = ["Model Type","Best K","AUC",]

        x.add_row(["BOW","21","0.67"])
        x.add_row(["TfIdf","25","0.51"])
        x.add_row(["Avg W2V","17","0.87"])
        x.add_row(["TfIdf Weighted W2V","21","0.50"])
        print(x)
```

```
+--------------------+--------+------+
|     Model Type     | Best K | AUC  |
+--------------------+--------+------+
|        BOW         |   21   | 0.67 |
|       TfIdf        |   25   | 0.51 |
|      Avg W2V       |   17   | 0.87 |
| TfIdf Weighted W2V |   21   | 0.50 |
+--------------------+--------+------+
```