Amazon-Reviews-on-KNN_Final

March 4, 2019

1 Amazon Fine Food Reviews Analysis

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

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

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

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

Attribute Information:

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

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

[Q] How to determine if a review is positive or negative? [Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

2 [1]. Reading Data

2.1 [1.1] Loading the data

The dataset is available in two forms 1. .csv file 2. SQLite Database

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

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

```
In [1]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")

        import sqlite3
        import pandas as pd
        import numpy as np
        import nltk
        import string
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer

        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer

        import re
        # Tutorial about Python regular expressions: https://pymotw.com/2/re/
        import string
        from nltk.corpus import stopwords
        from nltk.stem import PorterStemmer
        from nltk.stem.wordnet import WordNetLemmatizer

        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle
        from sklearn.neighbors import KNeighborsClassifier
        from sklearn.neighbors import NearestNeighbors

        from sklearn.metrics import confusion_matrix,precision_score,recall_score,f1_score,roc_

        from tqdm import tqdm
        import os
```

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

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

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

        filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 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  B005ZBZLT4                    Breyton  1331510400      2
        1  #oc-R11D9D7SHXIJB9  B005HG9ESG  Louis E. Emory "hoppy"  1342396800      5
        2  #oc-R11DNU2NBKQ23Z  B005ZBZLT4           Kim Cieszykowski  1348531200      1
        3  #oc-R11O5J5ZVQE25C  B005HG9ESG              Penguin Chick  1346889600      5
        4  #oc-R12KPBODL2B5ZD  B007OSBEV0     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  B001ATMQK2  undertheshrine "undertheshrine"  1296691200

               Score                                               Text  COUNT(*)
        80638      5  I bought this 6 pack because for the price tha...         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
```

```
In [14]: ##Sorting data for Time Based Splitting
         time_sorted_data = final.sort_values('Time', axis=0, ascending=True, inplace=False, k


         final = time_sorted_data.take(np.random.permutation(len(final))[:50000])
         print(final.shape)
         final.head()
```

```
(50000, 10)
```

```
Out[14]:          Id   ProductId          UserId  ProfileName  HelpfulnessNumerator  \
         83782  91170  B000P3ZJ2Q  A2RUVBPNRYICVB  Deborah1018                     0
         91251  99262  B0009ETA76  A3FQ9T2G2GMRX1        Carly                     0
         87453  95191  B003UEKFS0   AC299UUMA6MYG          zen                     1
         71821  78193  B001BM399U  A3LWIP2I6550TB    X. Nguyen                     0
         51348  55785  B001W40ALW  A36G22F9S9DE91       Jackie                     1

                HelpfulnessDenominator  Score        Time                 Summary  \
         83782                       0      1  1337731200             Deborah1018
         91251                       0      1  1244419200     Increased milk supply
         87453                       1      1  1310860800                     zen
         71821                       0      1  1320364800  Best baby food out there!
         51348                       1      1  1269561600         Best Olives Ever!

                                                             Text
         83782  they where exactly what they said I sent them ...
         91251  My doctor recommended that I try Fenugreek to ...
         87453  i don't like black tea because they have a bit...
         71821  Earth's Best makes the BEST organic baby food ...
         51348  My daughter and I are addicted to these olives...
```

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 [15]: # 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)
```

```
they where exactly what they said I sent them to my mom for mothers day and she loved them they
==================================================
Definetly my favorite coffee sold by Amazon. Just bought 4 lbs. for 8 bucks a pound which is my
==================================================
This hot sauce is no joke.  I've loved spicy food since before I could walk, and can't remember
==================================================
How can I know an expiry date for this Jams?<br /><br />I couldn't find a date in any bottle.<b
==================================================
```

```
In [16]: # 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)
```

```
they where exactly what they said I sent them to my mom for mothers day and she loved them they
```

```
In [17]: # https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-
         from bs4 import BeautifulSoup

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

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

         soup = BeautifulSoup(sent_1500, 'lxml')
         text = soup.get_text()
         print(text)
```

```
        print("="*50)

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

```
they where exactly what they said I sent them to my mom for mothers day and she loved them they
==================================================
Definetly my favorite coffee sold by Amazon. Just bought 4 lbs. for 8 bucks a pound which is my
==================================================
This hot sauce is no joke.  I've loved spicy food since before I could walk, and can't remember
==================================================
How can I know an expiry date for this Jams?I couldn't find a date in any bottle.Please let me
```

```
In [18]: # https://stackoverflow.com/a/47091490/4084039
         import re

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

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

```
In [19]: sent_1500 = decontracted(sent_1500)
         print(sent_1500)
         print("="*50)
```

```
This hot sauce is no joke.  I have loved spicy food since before I could walk, and can not reme
==================================================
```

```
In [20]: #remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
         sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
         print(sent_0)
```

```
they where exactly what they said I sent them to my mom for mothers day and she loved them they
```

```
In [21]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
         print(sent_1500)
```

```
This hot sauce is no joke I have loved spicy food since before I could walk and can not rememb
```

```
In [22]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         # <br /><br /> ==> after the above steps, we are getting "br br"
         # we are including them into stop words list
         # instead of <br /> if we have <br/> these tags would have revmoved in the 1st step

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

```
In [23]: # Combining all the above stundents
         from tqdm import tqdm
         prepr_rev = []
         # tqdm is for printing the status bar
         for sentance in tqdm(final['Text'].values):
             sentance = re.sub(r"http\S+", "", sentance)
             sentance = BeautifulSoup(sentance, 'lxml').get_text()
             sentance = decontracted(sentance)
             sentance = re.sub("\S*\d\S*", "", sentance).strip()
             sentance = re.sub('[^A-Za-z]+', ' ', sentance)
             # https://gist.github.com/sebleier/554280
             sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopw
             prepr_rev.append(sentance.strip())
```

```
100%|| 50000/50000 [00:24<00:00, 2069.51it/s]
```

```
In [24]: prepr_rev[1500]
```

```
Out[24]: 'hot sauce no joke loved spicy food since could walk not remember ever eating anythin
```

```
In [25]: print(len(prepr_rev))
         final.shape

50000


Out[25]: (50000, 10)

In [26]: final ['prepr_rev']= prepr_rev
         final.head(5)

Out[26]:           Id   ProductId          UserId  ProfileName  HelpfulnessNumerator  \
         83782  91170  B000P3ZJ2Q  A2RUVBPNRYICVB  Deborah1018                     0
         91251  99262  B0009ETA76  A3FQ9T2G2GMRX1        Carly                     0
         87453  95191  B003UEKFS0   AC299UUMA6MYG          zen                     1
         71821  78193  B001BM399U  A3LWIP2I6550TB    X. Nguyen                     0
         51348  55785  B001W40ALW  A36G22F9S9DE91       Jackie                     1

                HelpfulnessDenominator  Score        Time                Summary  \
         83782                       0      1  1337731200            Deborah1018
         91251                       0      1  1244419200    Increased milk supply
         87453                       1      1  1310860800                    zen
         71821                       0      1  1320364800  Best baby food out there!
         51348                       1      1  1269561600        Best Olives Ever!

                                                             Text  \
         83782  they where exactly what they said I sent them ...
         91251  My doctor recommended that I try Fenugreek to ...
         87453  i don't like black tea because they have a bit...
         71821  Earth's Best makes the BEST organic baby food ...
         51348  My daughter and I are addicted to these olives...

                                                        prepr_rev
         83782  exactly said sent mom mothers day loved lasted...
         91251  doctor recommended try fenugreek increase milk...
         87453  not like black tea bitter taste love tea reall...
         71821  earth best makes best organic baby food ever f...
         51348  daughter addicted olives blue cheese clearly b...

In [27]: # store final table into an SQlLite table for future.
         conn = sqlite3.connect('final.sqlite')
         c=conn.cursor()
         conn.text_factory = str
         final.to_sql('Reviews', conn,  schema=None, if_exists='replace',index=True, index_labe
         conn.close()
         #Loading data
         conn = sqlite3.connect('final.sqlite')
         data=pd.read_sql_query("""select * from Reviews""",conn)
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

```
In [28]: from sklearn.model_selection import train_test_split
         #splitting data into Train, C.V and Test
         X_train, X_test, y_train, y_test = train_test_split(final ['prepr_rev'], final['Score
         X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33)
         print("Train:",X_train.shape,y_train.shape)
         print("CV:",X_cv.shape,y_cv.shape)
         print("Test:",X_test.shape,y_test.shape)
```

```
Train: (22445,) (22445,)
CV: (11055,) (11055,)
Test: (16500,) (16500,)
```

```
In [29]: vectorizer = CountVectorizer(min_df=10, max_features=500)
         vectorizer.fit(X_train)
         #vectorizer.fit(X_train) # fit has to happen only on train data
         # we use the fitted CountVectorizer to convert the text to vector
         X_train_bow = vectorizer.transform(X_train)
         X_cv_bow = vectorizer.transform(X_cv)
         X_test_bow = vectorizer.transform(X_test)
         print("After vectorizations")
         print(X_train_bow.shape, y_train.shape)
         print(X_cv_bow.shape, y_cv.shape)
         print(X_test_bow.shape, y_test.shape)
```

```
After vectorizations
(22445, 500) (22445,)
(11055, 500) (11055,)
(16500, 500) (16500,)
```

5.2 [4.3] TF-IDF

```
In [30]: vect = TfidfVectorizer(ngram_range=(1,2), min_df=10, max_features=500)
         tf_idf_vect = vect.fit(X_train)
         # we use the fitted CountVectorizer to convert the text to vector
         X_train_tfidf = tf_idf_vect.transform(X_train)
         X_cv_tfidf = tf_idf_vect.transform(X_cv)
         X_test_tfidf = tf_idf_vect.transform(X_test)
         print("After vectorizations")
         print(X_train_tfidf.shape, y_train.shape)
         print(X_cv_tfidf.shape, y_cv.shape)
         print(X_test_tfidf.shape, y_test.shape)
```

```
After vectorizations
(22445, 500) (22445,)
(11055, 500) (11055,)
(16500, 500) (16500,)
```

5.3 [4.4] Word2Vec

```
In [31]: # List of sentence in X_train text
         sent_of_train=[]
         for sent in X_train:
             sent_of_train.append(sent.split())

         # List of sentence in X_test text
         sent_of_test=[]
         for sent in X_test:
             sent_of_test.append(sent.split())

         # Train your own Word2Vec model using your own train text corpus
         # min_count = 5 considers only words that occured atleast 5 times
         w2v_model=Word2Vec(sent_of_train,min_count=5,size=50, workers=4)
         print(w2v_model.wv.most_similar('great'))
         print('='*50)
         print(w2v_model.wv.most_similar('worst'))

         w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
```

```
[('good', 0.8064497113227844), ('excellent', 0.7870410680770874), ('awesome', 0.7711895108222296
==================================================
[('smoothest', 0.8289793729782104), ('horrible', 0.7650426626205444), ('ever', 0.7644084692001З
number of words that occured minimum 5 times  9150
```

```
In [32]: 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  9150
sample words  ['bars', 'tasty', 'got', 'low', 'sales', 'price', 'much', 'less', 'overpriced',
```

5.4 [4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

```
In [33]: i=0
         list_of_sentance_cv=[]
         for sentance in X_cv:
             list_of_sentance_cv.append(sentance.split())
```

```
In [34]: # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_sentance_cv): # 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_cv.append(sent_vec)
         sent_vectors_cv = np.array(sent_vectors_cv)
         print(sent_vectors_cv.shape)
         print(sent_vectors_cv[0])
```

```
100%|| 11055/11055 [00:23<00:00, 472.46it/s]

(11055, 50)
[ 0.11423624  0.52322548  0.92737992  0.42657398  0.03149832 -0.49709554
 -0.22744501  0.77123317 -0.8727156   0.49516902  0.65777033 -0.70547067
 -0.31035827  0.61977974  0.3090385   0.31754157  0.11933282  0.53610293
 -0.14034547 -0.36208856 -0.5970275   0.14536198  0.69747322 -0.05873975
  0.4705957  -0.96374629 -0.80560572  0.76205894  0.02416955 -0.26141378
  1.30679555  0.44071176 -0.02415145 -0.39271318  0.37185064  0.41067095
  1.04710724 -0.16281124 -0.99547324 -1.69104051  0.27877323 -0.03820085
  0.34624931  0.13389229  0.0311872   0.67670954 -0.30030563 -0.65574397
 -1.32690578 -0.10916533]
```

```
In [35]: # compute average word2vec for X_test .
         test_vectors = [];
         for sent in tqdm(sent_of_test):
             sent_vec = np.zeros(50)
             cnt_words =0;
             for word in sent: #
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             test_vectors.append(sent_vec)
         test_vectors = np.array(test_vectors)

         print(test_vectors.shape)
         print(test_vectors[0])
```

```
100%|| 16500/16500 [00:35<00:00, 463.12it/s]

(16500, 50)
[-0.21650994  0.20763936  0.23225507  0.43245629 -0.03147818 -0.34158848
 -0.23489848  0.12679867  0.15458322  0.52804215 -0.32813715 -0.1358679
 -0.02285376 -0.22915929 -0.2054066   0.33587438 -0.28956964 -0.29684678
  0.05607984 -0.19122175  0.05548987  0.22762442  0.54389045 -0.32156981
 -0.21385965 -0.45756952 -0.09783928  0.14551443 -0.48427639  0.15391132
  0.69929648 -0.1097943  -0.14275275 -0.20143936 -0.25195681  0.17130008
  0.31810653 -0.36715548 -0.56052186 -0.52939431  0.56273055 -0.05734205
 -0.01385809 -0.34118139  0.05820298  0.54194045 -0.06114813  0.19944374
 -0.45926711  0.22486217]
```

```
In [36]: # compute average word2vec for X_train .
         train_vectors = [];
         for sent in tqdm(sent_of_train):
             sent_vec = np.zeros(50)
             cnt_words =0;
             for word in sent: #
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             train_vectors.append(sent_vec)

         train_vectors = np.array(train_vectors)

         print(train_vectors.shape)
         print(train_vectors[0])
```

```
100%|| 22445/22445 [00:47<00:00, 467.78it/s]

(22445, 50)
[ 0.23795041  0.56482501  0.23975698  0.47662384 -0.03241647 -0.42026585
 -0.0920234   0.60887131  0.10361548  0.69549562 -0.42657898 -0.22850905
  0.10854015 -0.43730003 -0.22391569 -0.11131373 -0.21342933 -0.09610408
 -0.10915289 -0.49629217 -0.10829031  0.36527382  0.78678009 -0.25987415
 -0.59941445  0.05826041 -0.38378821  0.2704506  -0.57303713 -0.18668537
```

```
  0.36423239 -0.03373933 -0.12033268  0.11460553 -0.0766927  -0.05885986
  0.27646326 -0.3050041  -0.4903128  -0.87627939  1.16383488  0.10803538
 -0.10990737 -0.79267004  0.08959021  0.62530343 -0.51399749  0.20063627
 -0.29426406  0.25943958]
```

[4.4.1.2] TFIDF weighted W2v

```
In [37]: tf_idf_vect = TfidfVectorizer()

         # final_tf_idf1 is the sparse matrix with row= sentence, col=word and cell_val = tfid
         final_tf_idf1 = tf_idf_vect.fit_transform(X_train)
         dictionary = dict(zip(tf_idf_vect.get_feature_names(), list(tf_idf_vect.idf_)))

         # tfidf words/col-names
         tfidf_feat = tf_idf_vect.get_feature_names()

         # compute TFIDF Weighted Word2Vec for X_test .
         tfidf_test_vectors = [];
         row=0;
         for sent in tqdm(sent_of_test):
             sent_vec = np.zeros(50)
             weight_sum =0;
             for word in sent:
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_test_vectors.append(sent_vec)

         tfidf_test_vectors = np.array(tfidf_test_vectors)
         print(tfidf_test_vectors.shape)
         print(tfidf_test_vectors[0])
```

```
100%|| 16500/16500 [06:58<00:00, 39.43it/s]


(16500, 50)
[-0.43023417  0.08085112  0.26280191  0.12586552  0.19083609 -0.18514371
 -0.28463129  0.13400232  0.16023318  0.52938326 -0.43975282 -0.12440866
 -0.11275344 -0.11934448 -0.22762588  0.45164176 -0.39158681 -0.31570446
  0.02818469 -0.17517456  0.02748073  0.26977343  0.52292236 -0.34498091
 -0.00175078 -0.44338077  0.02350666  0.06165066 -0.34236525  0.21216029
  0.78613459 -0.15390468 -0.16417371 -0.32861782 -0.2659092   0.10186823
  0.22447934 -0.40924459 -0.62742319 -0.46896159  0.32371111 -0.00329997
 -0.03767758 -0.31543755  0.09439429  0.46229863  0.03195479  0.27520308
 -0.57627453  0.09213921]
```

```
In [38]: # compute TFIDF Weighted Word2Vec for X_train .
         tfidf_train_vectors = [];
         row=0;
         for sent in tqdm(sent_of_train):
             sent_vec = np.zeros(50)
             weight_sum =0;
             for word in sent:
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_train_vectors.append(sent_vec)

         tfidf_train_vectors = np.array(tfidf_train_vectors)
         print(tfidf_train_vectors.shape)
         print(tfidf_train_vectors[0])
```

```
100%|| 22445/22445 [07:21<00:00, 50.83it/s]
```

```
(22445, 50)
[ 0.40917395  0.51609145  0.30560965  0.35250069  0.00734301 -0.39421347
 -0.09543645  0.728009   -0.09724581  0.85466854 -0.43076187 -0.13585101
 -0.06857081 -0.5797596  -0.27492372 -0.41646634 -0.09126814 -0.117861
 -0.0479078  -0.42574795 -0.31589024  0.4247003   0.86006957 -0.2709104
 -0.50717747  0.32116871 -0.42186319  0.35714914 -0.34300058 -0.36286456
  0.35645985 -0.0755837   0.0781704   0.18814762 -0.08119907 -0.23603788
  0.25133437 -0.37718325 -0.22148637 -0.93937279  1.2041414   0.34071557
 -0.01912081 -1.03047928  0.01094786  0.84018511 -0.55510452  0.20887449
 -0.40060992  0.07882321]
```

6 [5] Assignment 3: KNN

```
<li><strong>Apply Knn(brute force version) on these feature sets</strong>
    <ul>
        <li><font color='red'>SET 1:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 2:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 3:</font>Review text, preprocessed one converted into vectors
        <li><font color='red'>SET 4:</font>Review text, preprocessed one converted into vectors
    </ul>
</li>
<br>
<li><strong>Apply Knn(kd tree version) on these feature sets</strong>
    <br><font color='red'>NOTE: </font>sklearn implementation of kd-tree accepts only dense ma
    <ul>
        <li><font color='red'>SET 5:</font>Review text, preprocessed one converted into vectors
        <pre>
        count_vect = CountVectorizer(min_df=10, max_features=500)
        count_vect.fit(preprocessed_reviews)
        </pre>
        </li>
        <li><font color='red'>SET 6:</font>Review text, preprocessed one converted into vectors
        <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 vectors
        <li><font color='red'>SET 4:</font>Review text, preprocessed one converted into vectors
    </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.appliedaicou
<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 ta
    </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

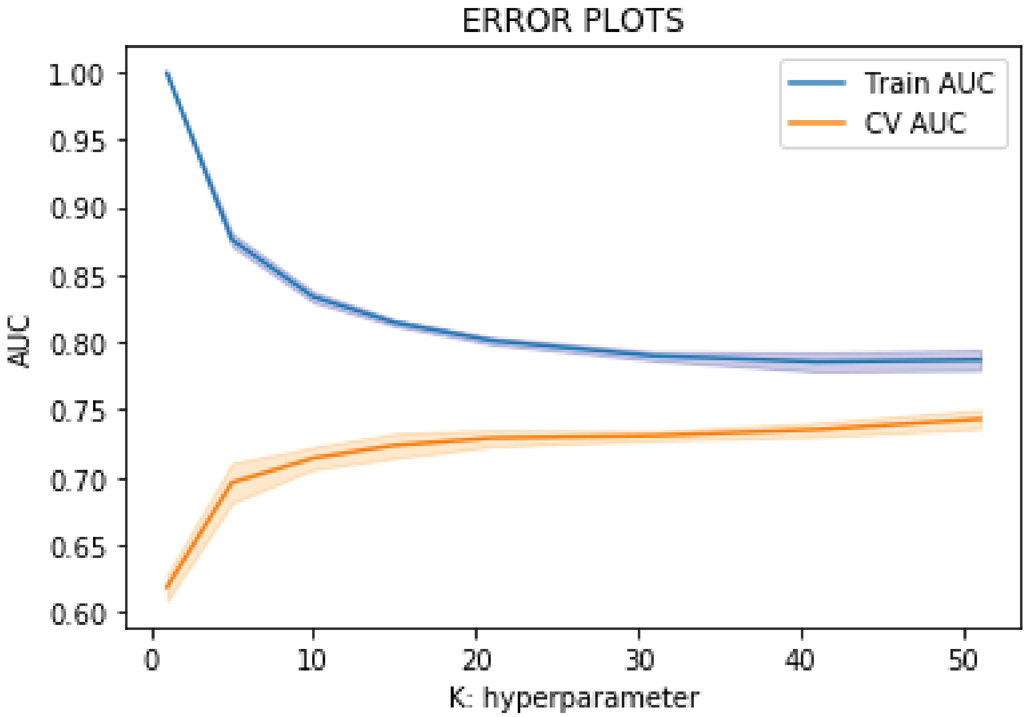
1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply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

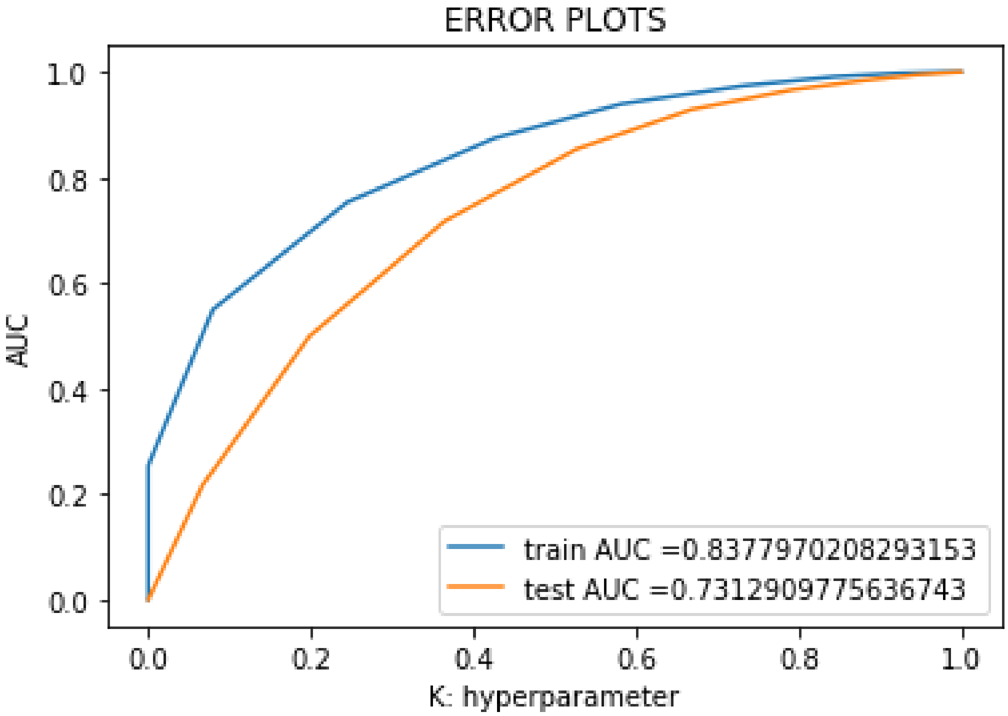
In [130]:

```python
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSear
from sklearn.model_selection import GridSearchCV

neigh = KNeighborsClassifier(algorithm='brute')
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_bow, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(K, train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='da
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



```
In [218]: best_k=10

In [219]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(X_train_bow, y_train)



          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(X_train_bow
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(X_test_bow)[:

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
```

```
        print("Train confusion matrix")
        print(confusion_matrix(y_train, neigh.predict(X_train_bow)))
        print("Test confusion matrix")
        print(confusion_matrix(y_test, neigh.predict(X_test_bow)))


        # Variables for table
        bow_brute_K = best_k
        bow_brute_train= train_auc
        bow_brute_test = cv_auc
```

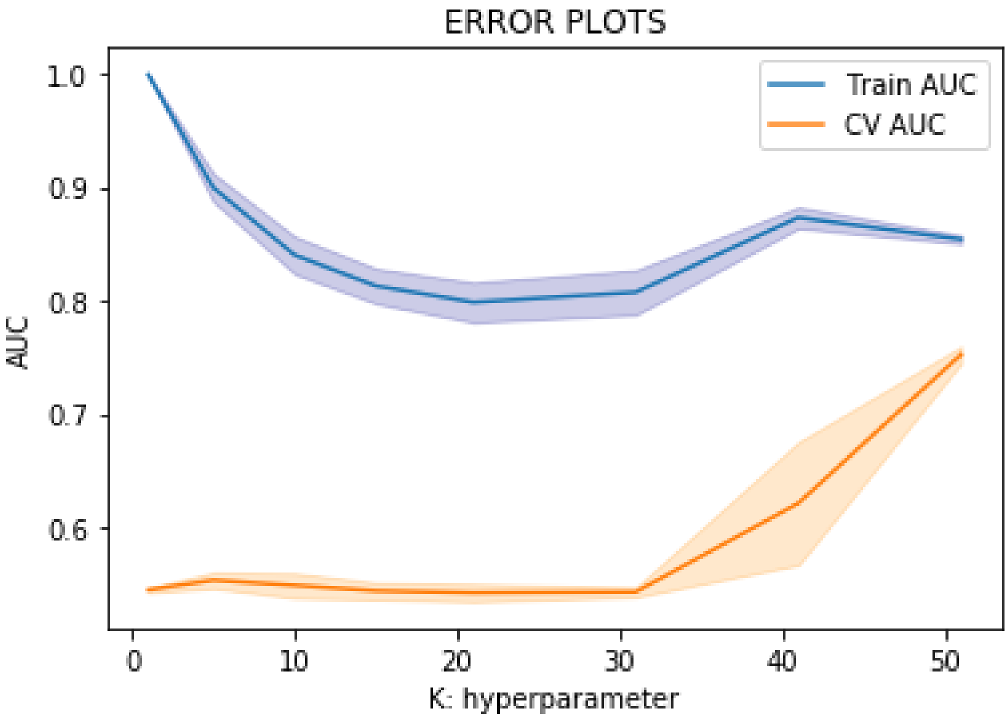


```
=======================================================================================
Train confusion matrix
[[ 1524  2125]
 [ 1132 17664]]
Test confusion matrix
[[  882  1777]
 [  981 12860]]
```

6.1.2 [5.1.2] Applying KNN brute force on TFIDF, SET 2

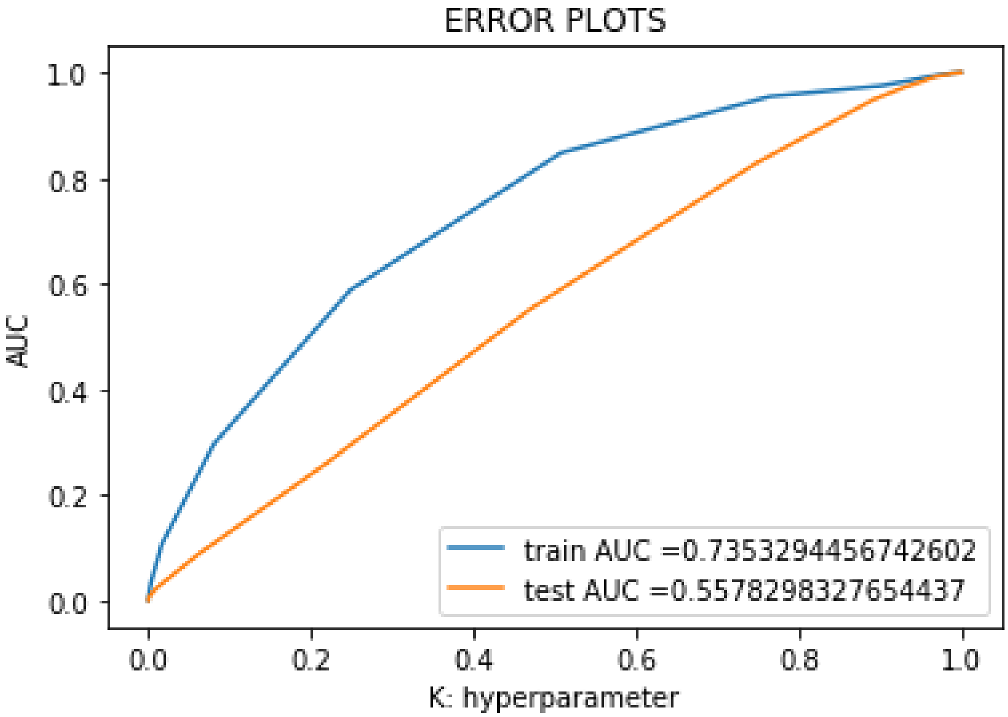
```
In [105]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSear
          from sklearn.model_selection import GridSearchCV
```

```
neigh = KNeighborsClassifier(algorithm='brute')
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(K, train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='da
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



```
In [220]: best_k = 50
```

```
In [221]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(X_train_tfidf, y_train)


          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(X_train_tf
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(X_test_tfidf)

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(X_train_tfidf)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(X_test_tfidf)))




          # Variables for table


          tfidf_brute_K = best_k
          tfidf_brute_train = train_auc
          tfidf_brute_test = cv_auc
```

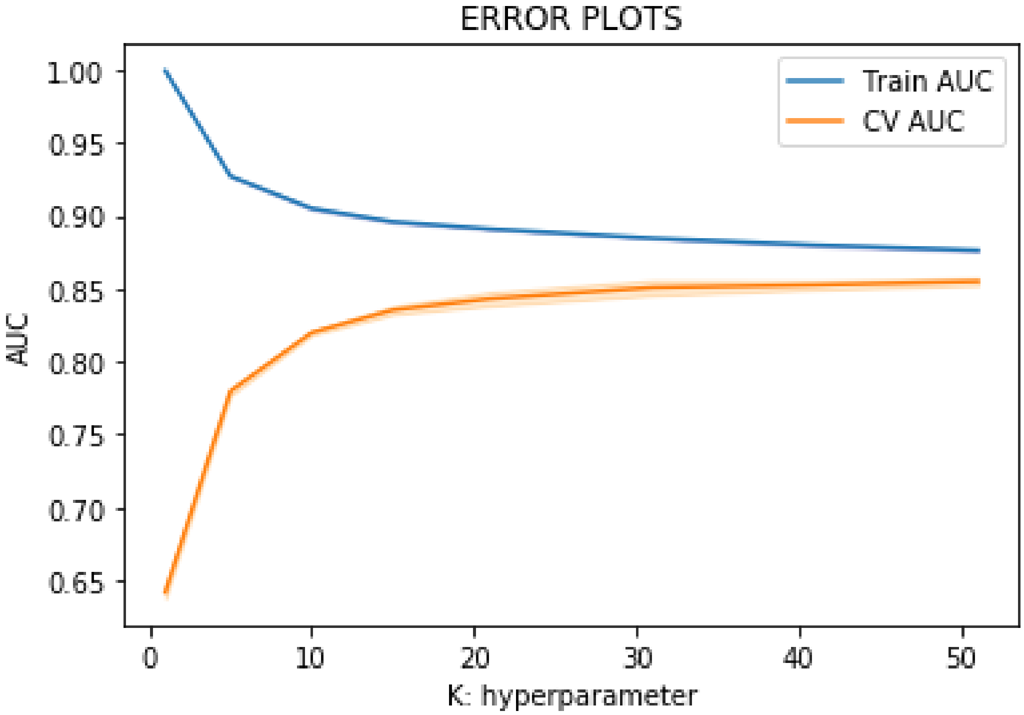


```
===============================================================================================
Train confusion matrix
[[    1  3648]
 [    0 18796]]
Test confusion matrix
[[    1  2658]
 [    0 13841]]
```

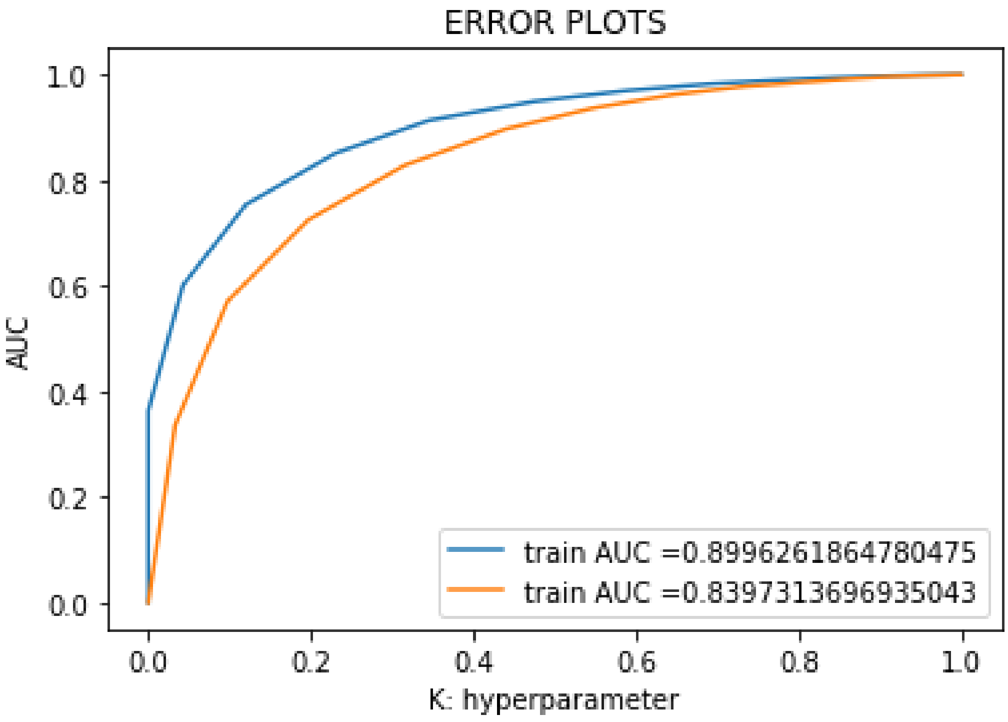
6.1.3 [5.1.3] Applying KNN brute force on AVG W2V, SET 3

```
In [48]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearc
         from sklearn.model_selection import GridSearchCV

         neigh = KNeighborsClassifier(algorithm='brute')
         parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
         clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
         clf.fit(train_vectors, y_train)

         train_auc= clf.cv_results_['mean_train_score']
         train_auc_std= clf.cv_results_['std_train_score']
         cv_auc = clf.cv_results_['mean_test_score']
         cv_auc_std= clf.cv_results_['std_test_score']
```

```
plt.plot(K, train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.2

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dar
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



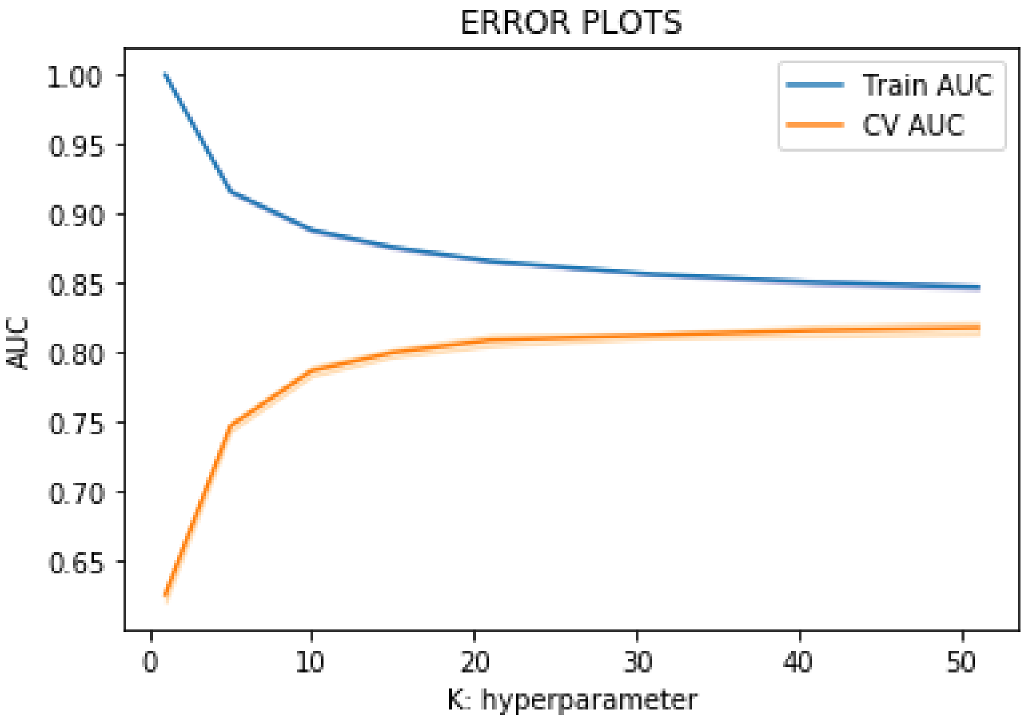
```
In [222]: best_k = 15

In [223]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(train_vectors, y_train)

          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs


          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(train_vect
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(test_vectors)
          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="train AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(train_vectors)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(test_vectors)))


          # Variables for table
          Avg_Word2Vec_brute_K = best_k
          Avg_Word2Vec_brute_train = train_auc
          Avg_word2Vec_brute_test = cv_auc
```



```
====================================================================================================
Train confusion matrix
[[ 1135  2514]
 [  333 18463]]
Test confusion matrix
[[  706  1953]
 [  304 13537]]
```

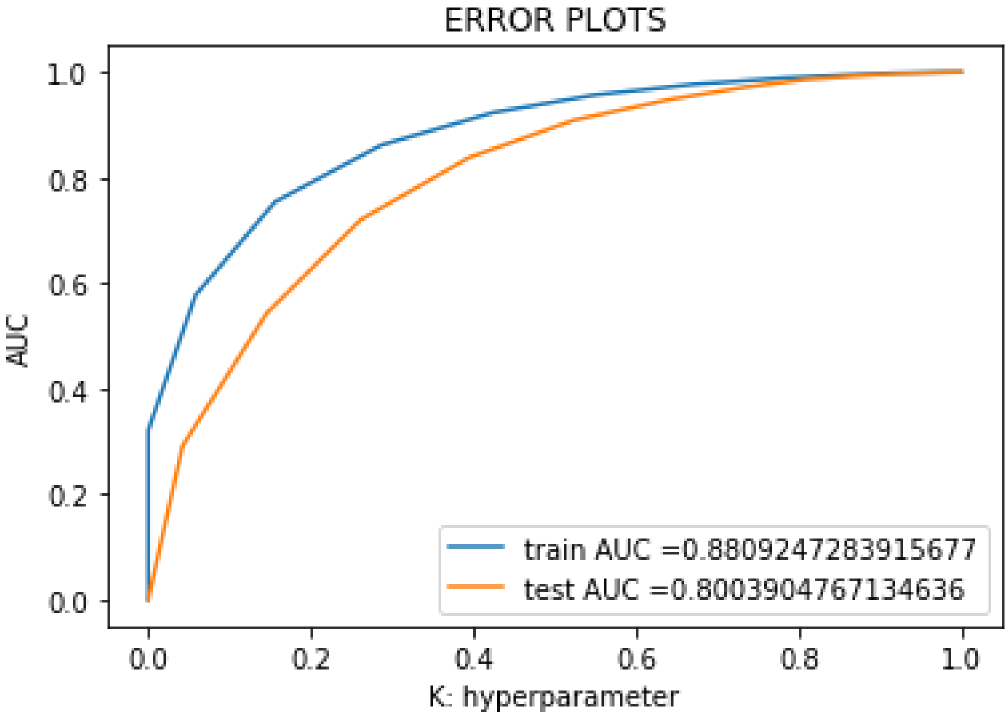
6.1.4 [5.1.4] Applying KNN brute force on TFIDF W2V, SET 4

```
In [53]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearc
         from sklearn.model_selection import GridSearchCV


         neigh = KNeighborsClassifier(algorithm='brute')
         parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
         clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
         clf.fit(tfidf_train_vectors, y_train)

         train_auc= clf.cv_results_['mean_train_score']
         train_auc_std= clf.cv_results_['std_train_score']
         cv_auc = clf.cv_results_['mean_test_score']
         cv_auc_std= clf.cv_results_['std_test_score']

         plt.plot(K, train_auc, label='Train AUC')
         # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
         plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.

         plt.plot(K, cv_auc, label='CV AUC')
         # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
         plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dar
         plt.legend()
         plt.xlabel("K: hyperparameter")
         plt.ylabel("AUC")
         plt.title("ERROR PLOTS")
         plt.show()
```



```
In [224]: best_k=14
```

```
In [225]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(tfidf_train_vectors, y_train)

          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(tfidf_trai
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(tfidf_test_ve

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(tfidf_train_vectors)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(tfidf_test_vectors)))

          # Variables for table


          TFIDF_Word2Vec_brute_K = best_k
          TFIDF_Word2Vec_brute_train = train_auc
          TFIDF_word2Vec_brute_test = cv_auc
```

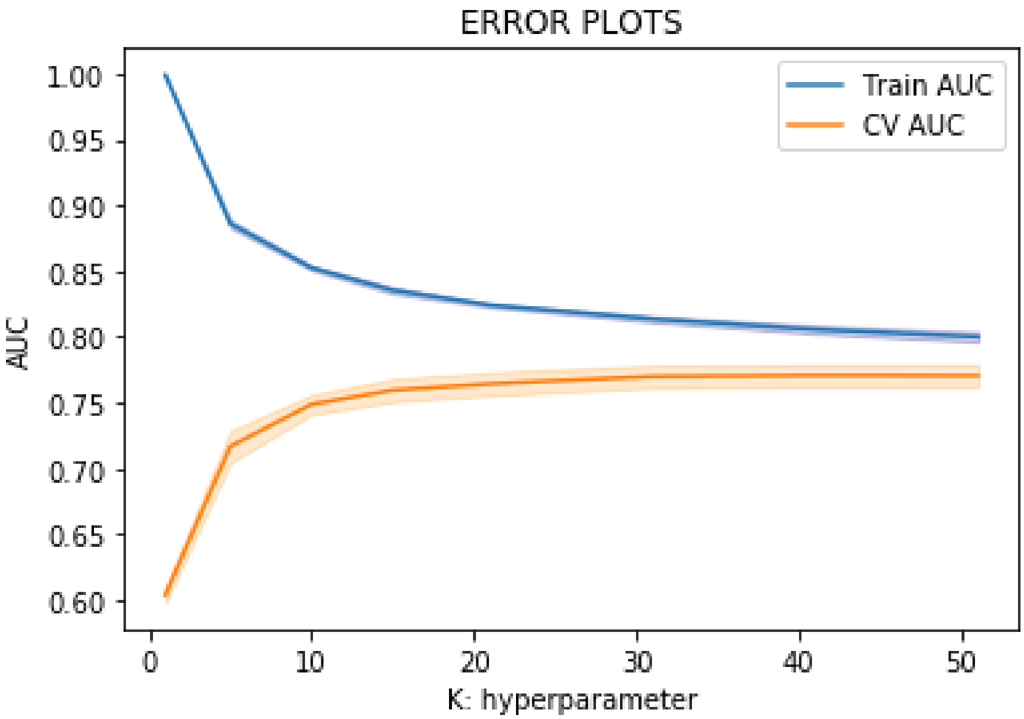


```
==============================================================================================
Train confusion matrix
[[ 1192  2457]
 [  429 18367]]
Test confusion matrix
[[  702  1957]
 [  390 13451]]
```

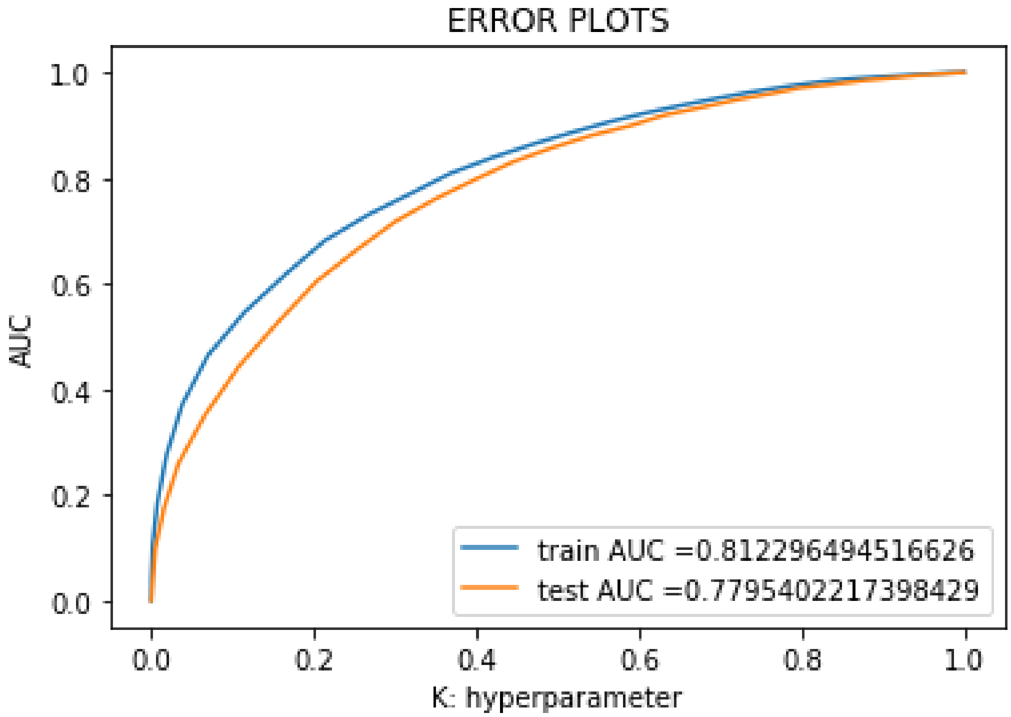
6.2 [5.2] Applying KNN kd-tree

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

```
In [56]: # Please write all the code with proper documentation
         from sklearn.decomposition import TruncatedSVD
         svd = TruncatedSVD(n_components=100)
         Xtrain_bow = svd.fit_transform(X_train_bow)
         Xtest_bow = svd.transform(X_test_bow)


         # Please write all the code with proper documentation
         # Importing libraries
         from sklearn.model_selection import GridSearchCV

         neigh = KNeighborsClassifier(algorithm='kd_tree')
         parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
         clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
         clf.fit(Xtrain_bow, y_train)

         train_auc= clf.cv_results_['mean_train_score']
         train_auc_std= clf.cv_results_['std_train_score']
         cv_auc = clf.cv_results_['mean_test_score']
         cv_auc_std= clf.cv_results_['std_test_score']

         plt.plot(K, train_auc, label='Train AUC')
         # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
         plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.

         plt.plot(K, cv_auc, label='CV AUC')
         # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
         plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dar
         plt.legend()
         plt.xlabel("K: hyperparameter")
         plt.ylabel("AUC")
         plt.title("ERROR PLOTS")
         plt.show()
```



```
In [226]: best_k=41

In [227]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(Xtrain_bow, y_train)

          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(Xtrain_bow
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(Xtest_bow)[:,

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(Xtrain_bow)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(Xtest_bow)))



          # Variables for table
          bow_kdTree_K = best_k
          bow_kdTree_train = train_auc
          bow_kdTree_test = cv_auc
```

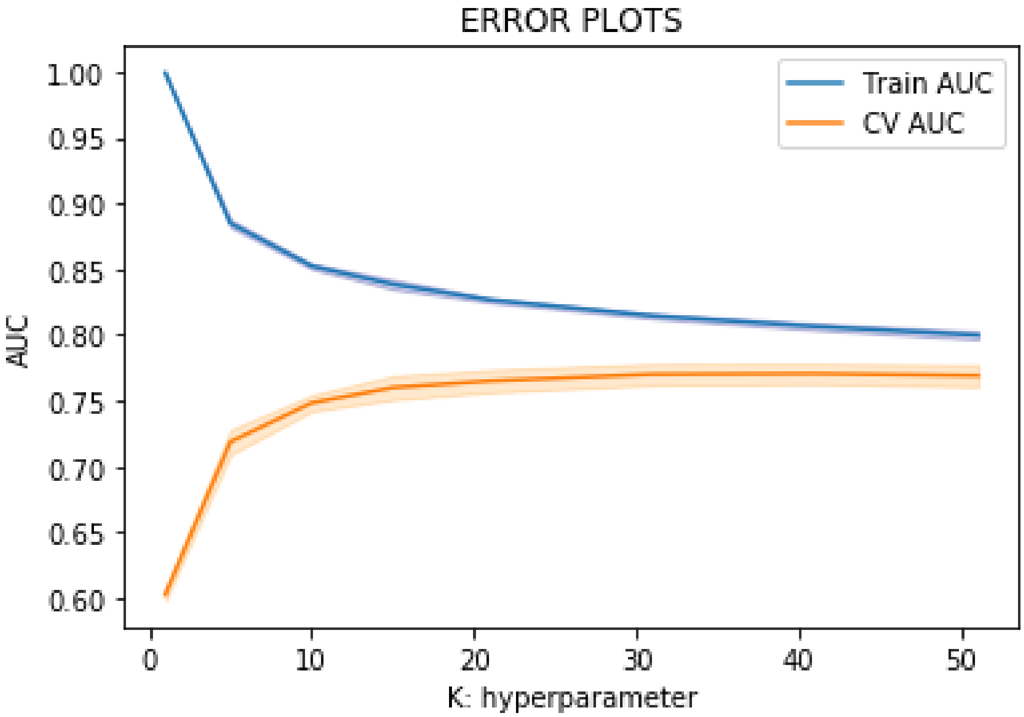


```
==============================================================================================
Train confusion matrix
[[  793  2856]
 [  487 18309]]
Test confusion matrix
[[  532  2127]
 [  393 13448]]
```

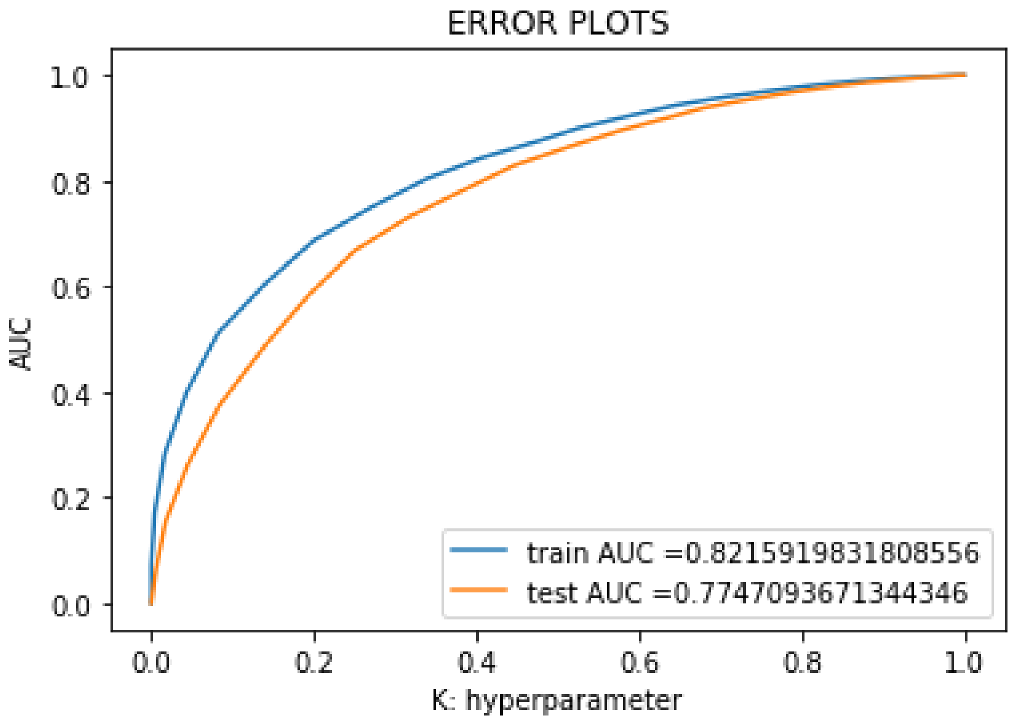
6.2.2 [5.2.2] Applying KNN kd-tree on TFIDF, SET 6

```
In [60]: # Please write all the code with proper documentation
         svd = TruncatedSVD(n_components=100)
         Xtrain_tfidf = svd.fit_transform(X_train_bow)
```

```
Xtest_tfidf = svd.transform(X_test_bow)

# Please write all the code with proper documentation
# Importing libraries
from sklearn.model_selection import GridSearchCV


neigh = KNeighborsClassifier(algorithm='kd_tree')
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(Xtrain_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(K, train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dark
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



```
In [228]: best_k=31

In [229]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(Xtrain_tfidf, y_train)



          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(Xtrain_tfi
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(Xtest_tfidf)[

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(Xtrain_tfidf)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(Xtest_tfidf)))


          # Variables for table
          tfidf_kdTree_K = best_k
          tfidf_kdTree_train = train_auc
          tfidf_kdTree_test = cv_auc
```

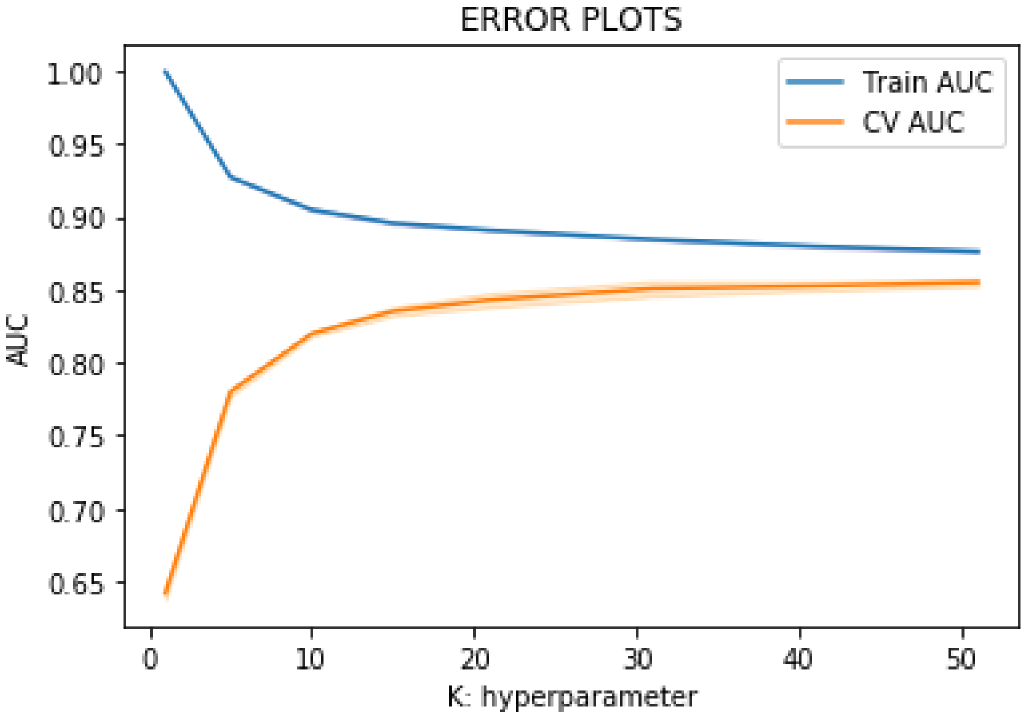


```
===============================================================================================
Train confusion matrix
[[  850  2799]
 [  537 18259]]
Test confusion matrix
[[  567  2092]
 [  450 13391]]
```

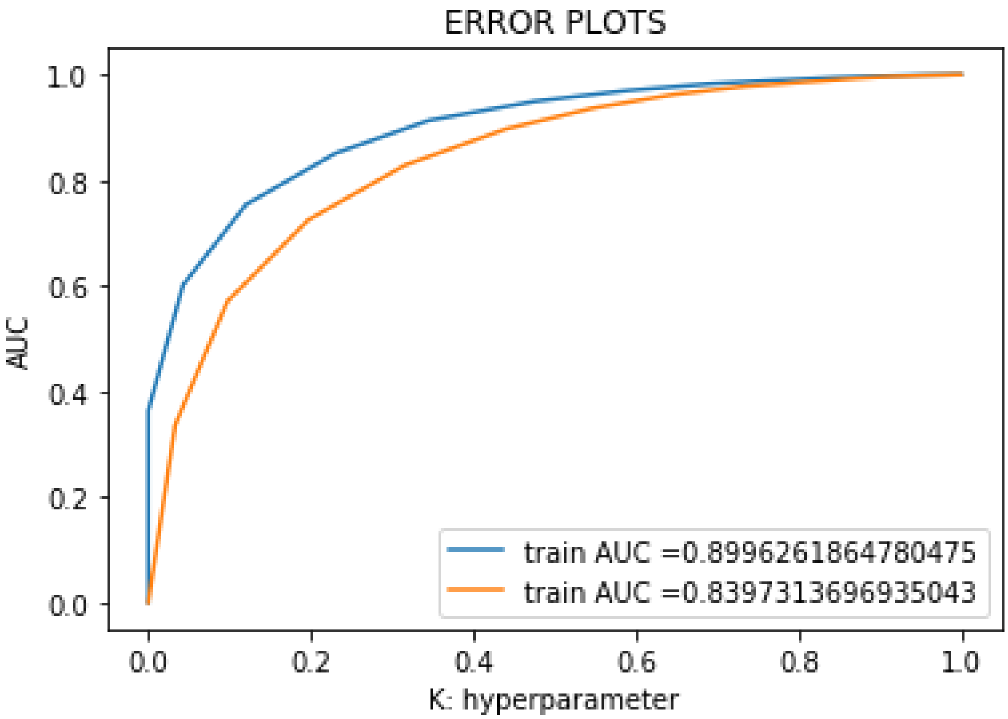
6.2.3 [5.2.3] Applying KNN kd-tree on AVG W2V, SET 7

```
In [63]: from sklearn.model_selection import GridSearchCV
```

```
neigh = KNeighborsClassifier(algorithm='kd_tree')
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(train_vectors, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(K, train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dar
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



```
In [230]: best_k=15
In [231]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(train_vectors, y_train)

          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(train_vecto
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(test_vectors)

          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="train AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(train_vectors)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(test_vectors)))



          # Variables for table
          Avg_Word2Vec_kdTree_K = best_k
          Avg_Word2Vec_kdTree_train = train_auc
          Avg_Word2Vec_kdTree_test = cv_auc
```

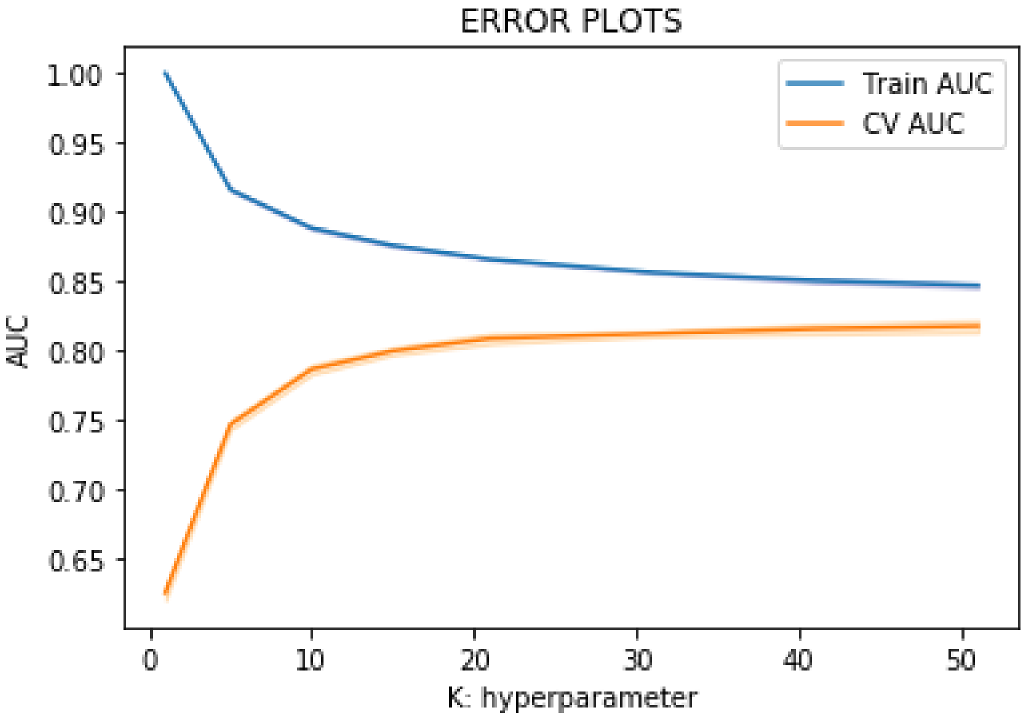


```
============================================================================================
Train confusion matrix
[[ 1135  2514]
 [  333 18463]]
Test confusion matrix
[[  706  1953]
 [  304 13537]]
```

6.2.4 [5.2.4] Applying KNN kd-tree on TFIDF W2V, SET 8

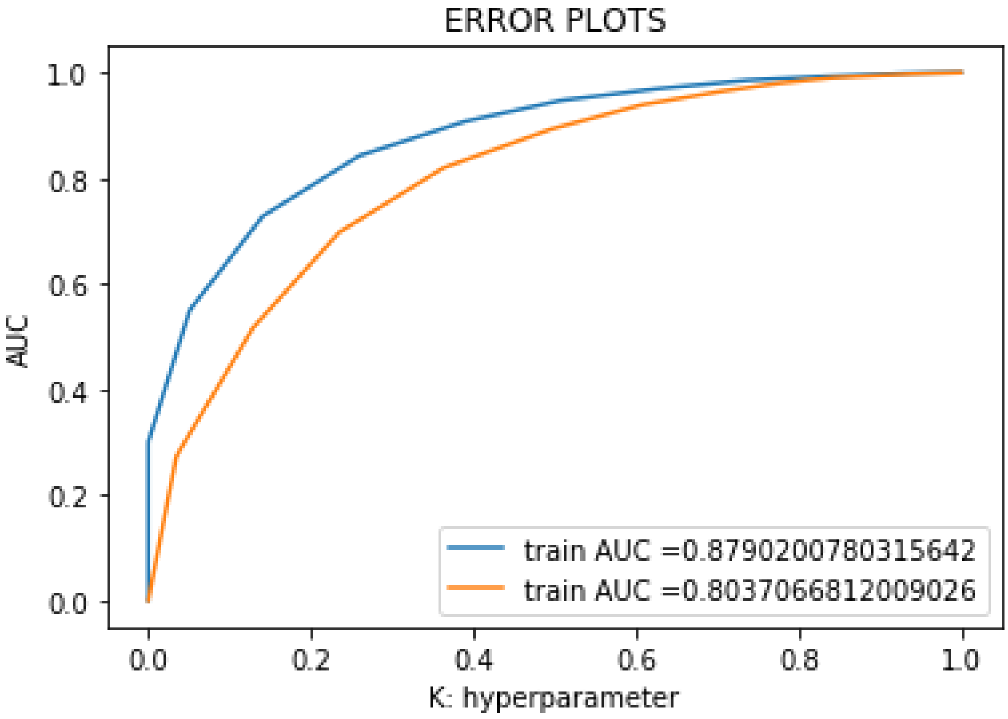
In [67]:
```
neigh = KNeighborsClassifier(algorithm='kd_tree')
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(tfidf_train_vectors, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(K, train_auc, label='Train AUC')
```

```
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(K,cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='dar
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```



```
In [232]: best_k=15
```

```
In [233]: neigh = KNeighborsClassifier(n_neighbors=best_k)
          neigh.fit(tfidf_train_vectors, y_train)

          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs


          train_fpr, train_tpr, thresholds = roc_curve(y_train, neigh.predict_proba(tfidf_trai
          test_fpr, test_tpr, thresholds = roc_curve(y_test, neigh.predict_proba(tfidf_test_ve
          plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="train AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("ERROR PLOTS")
          plt.show()

          print("="*100)

          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, neigh.predict(tfidf_train_vectors)))
          print("Test confusion matrix")
          print(confusion_matrix(y_test, neigh.predict(tfidf_test_vectors)))

          # Variables for table
          TFIDF_Word2Vec_kdTree_K = best_k
          TFIDF_Word2Vec_kdTree_train = train_auc
          TFIDF_Word2Vec_kdTree_test = cv_auc
```



```
==============================================================================================
Train confusion matrix
```

```
[[  962  2687]
 [  276 18520]]
Test confusion matrix
[[  588  2071]
 [  269 13572]]
```

7 [6] Conclusions

```
In [235]: from prettytable import PrettyTable

          # Initializing prettytable

          ptable = PrettyTable()

          names = ["brute for BoW", "kdTree for BoW", "brute for TFIDF", "kdTree' for TFIDF", "
                  "brute for TFIDF-Word2Vec", "kdTree' for TFIDF-Word2Vec"]

          k = ([bow_brute_K , bow_kdTree_K , tfidf_brute_K , tfidf_kdTree_K , Avg_Word2Vec_bru
                      TFIDF_Word2Vec_brute_K , TFIDF_Word2Vec_kdTree_K ])

          train = ([bow_brute_train, bow_kdTree_train, tfidf_brute_train, tfidf_kdTree_train, \
                       Avg_Word2Vec_brute_train, Avg_Word2Vec_kdTree_train, TFIDF_Word2Vec_bru
                       TFIDF_Word2Vec_kdTree_train])

          test = ([bow_brute_test, bow_kdTree_test , tfidf_brute_test , tfidf_kdTree_test , \
                      Avg_word2Vec_brute_test, Avg_Word2Vec_kdTree_test , TFIDF_word2Vec_brute_
                      TFIDF_Word2Vec_kdTree_test ])

          ptable.add_column("MODEL",names)
          ptable.add_column("K: hyperparameter",k)
          ptable.add_column("Train",train)
          ptable.add_column("Test",test)

          # Printing the Table
          print(ptable)
```

```
+----------------------------+-------------------+--------------------------------------------
|           MODEL            | K: hyperparameter |                              Train
+----------------------------+-------------------+--------------------------------------------
|       brute for BoW        |         10        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                      0.78554394 0.78689953]
|       kdTree for BoW       |         41        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                      0.78554394 0.78689953]
|      brute for TFIDF       |         50        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                      0.78554394 0.78689953]
|     kdTree' for TFIDF      |         31        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                       0.78554394 0.78689953]
|   brute for Avg-Word2Vec   |         15        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                       0.78554394 0.78689953]
|  kdTree for Avg-Word2Vec   |         15        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                       0.78554394 0.78689953]
|  brute for TFIDF-Word2Vec  |         14        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                       0.78554394 0.78689953]
| kdTree' for TFIDF-Word2Vec |         15        | [0.99904082 0.87564734 0.83360146 0.81453208
|                            |                   |                       0.78554394 0.78689953]
+----------------------------+-------------------+---------------------------------------------
```

In [ ]: