Assignment03 - Amazon Fine Food Reviews Analysis_KNN

April 17, 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 [77]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

from prettytable import PrettyTable
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 scikitplot import *

from tqdm import tqdm
import os
```

In [78]:
```
# using SQLite Table to read data.

data_path = '/home/monodeepdas112/Datasets/amazon-fine-food-reviews/database.sqlite'
con = sqlite3.connect(data_path)

# 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 poin
```

```
# 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
# for tsne assignment you can take 5k data points

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 50

# Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negati
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 (5000, 10)
```

Out[78]:

	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 [79]:
```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [80]:
```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[80]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

In [81]:
```
display[display['UserId']=='AZY10LLTJ71NX']
```

Out[81]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	5	I was recommended to try green tea extract to ...	5

In [82]:
```
display['COUNT(*)'].sum()
```

Out[82]: 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 [83]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND UserId="AR5J8UI46CURR"
ORDER BY ProductID
""", con)
display.head()
```

Out[83]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	Text
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOACKER QUADRATINI VANILLA WAFER COOKIES, 8.82-O...	DELICIOUS WAFER COOKIES. I ORDER THESE FOR MYSE...
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOACKER QUADRATINI VANILLA WAFER COOKIES, 8.82-O...	DELICIOUS WAFER COOKIES. I ORDER THESE FOR MYSE...
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOACKER QUADRATINI VANILLA WAFER COOKIES, 8.82-O...	DELICIOUS WAFER COOKIES. I ORDER THESE FOR MYSE...
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOACKER QUADRATINI VANILLA WAFER COOKIES, 8.82-O...	DELICIOUS WAFER COOKIES. I ORDER THESE FOR MYSE...
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOACKER QUADRATINI VANILLA WAFER COOKIES, 8.82-O...	DELICIOUS WAFER COOKIES. I ORDER THESE FOR MYSE...

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

In [85]: #Deduplication of entries
         final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep=
         final.shape

Out[85]: (4986, 10)

In [86]: #Checking to see how much % of data still remains
         (final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100

Out[86]: 99.72
```

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 [87]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND Id=44737 OR Id=64422
ORDER BY ProductID
""", con)

display.head()
```

Out[87]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	Text
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	1	5	1224892800	Bought This for My Son at College	My son loves spaghetti so I didn't hesitate or...
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	2	4	1212883200	Pure cocoa taste with crunchy almonds inside	It was almost a 'love at first bite' - the per...

In [88]:
```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [89]:
```
#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()
```

```
(4986, 10)
```

Out[89]:
```
1    4178
0     808
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 [90]: # 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)
```

```
Why is this $[...] when the same product is available for $[...] here?<br />http://www.amazon.
==================================================
I recently tried this flavor/brand and was surprised at how delicious these chips are.  The bes
==================================================
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the otl
==================================================
love to order my coffee on amazon.  easy and shows up quickly.<br />This k cup is great coffee
==================================================
```

```
In [91]: # 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)
```

```
Why is this $[...] when the same product is available for $[...] here?<br /> /><br />The Victo
```

In [92]:
```
# 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)
```

```
Why is this $[...] when the same product is available for $[...] here? />The Victor M380 and M5
==================================================
I recently tried this flavor/brand and was surprised at how delicious these chips are.  The bes
==================================================
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the otl
==================================================
love to order my coffee on amazon.  easy and shows up quickly.This k cup is great coffee.  dca
```

In [93]:
```
# 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 [94]: sent_1500 = decontracted(sent_1500)
         print(sent_1500)
         print("="*50)
```

```
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the otl
==================================================
```

```
In [95]: #remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
         sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
         print(sent_0)
```

```
Why is this $[...] when the same product is available for $[...] here?<br /> /><br />The Victor
```

```
In [96]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
         print(sent_1500)
```

```
Wow So far two two star reviews One obviously had no idea what they were ordering the other wa
```

```
In [97]: # 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', "t
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'h
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'throug
                     'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'o
                     'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'an
                     'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too
                     's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'n
                     '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 [98]: # Combining all the above stundents
         from tqdm import tqdm
         preprocessed_reviews = []
         # tqdm is for printing the status bar
         for sentance in tqdm(final['Text'].values):
```

```
            sentance = re.sub(r"http\S+", "", sentance)
            sentance = BeautifulSoup(sentance, 'lxml').get_text()
            sentance = decontracted(sentance)
            sentance = re.sub("\S*\d\S*", "", sentance).strip()
            sentance = re.sub('[^A-Za-z]+', ' ', sentance)
            # https://gist.github.com/sebleier/554280
            sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwo
            preprocessed_reviews.append(sentance.strip())
```

```
100%|| 4986/4986 [00:02<00:00, 2450.25it/s]
```

```
In [99]: preprocessed_reviews[1500]
```

```
Out[99]: 'wow far two two star reviews one obviously no idea ordering wants crispy cookies hey
```

[3.2] Preprocessing Review Summary

```
In [100]: ## Similartly you can do preprocessing for review summary also.
          # Combining all the above stundents
          from tqdm import tqdm
          preprocessed_review_summarys = []
          # tqdm is for printing the status bar
          for sentance in tqdm(final['Summary'].values):
              sentance = re.sub(r"http\S+", "", sentance)
              sentance = BeautifulSoup(sentance, 'lxml').get_text()
              sentance = decontracted(sentance)
              sentance = re.sub("\S*\d\S*", "", sentance).strip()
              sentance = re.sub('[^A-Za-z]+', ' ', sentance)
              # https://gist.github.com/sebleier/554280
              sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopw
              preprocessed_review_summarys.append(sentance.strip())
```

```
100%|| 4986/4986 [00:01<00:00, 3996.26it/s]
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

```
In [101]: #BoW
          count_vect = CountVectorizer() #in scikit-learn
          count_vect.fit(preprocessed_reviews)
          print("some feature names ", count_vect.get_feature_names()[:10])
          print('='*50)

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

```
some feature names  ['aa', 'aahhhs', 'aback', 'abandon', 'abates', 'abbott', 'abby', 'abdominal
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (4986, 12997)
the number of unique words  12997
```

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

```
In [102]: #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/mo

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

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (4986, 3144)
the number of unique words including both unigrams and bigrams  3144
```

5.3 [4.3] TF-IDF

```
In [103]: tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
          tf_idf_vect.fit(preprocessed_reviews)
          print("some sample features(unique words in the corpus)",tf_idf_vect.get_feature_name
          print('='*50)

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

```
some sample features(unique words in the corpus) ['ability', 'able', 'able find', 'able get',
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4986, 3144)
the number of unique words including both unigrams and bigrams  3144
```

5.4 [4.4] Word2Vec

In [104]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance=[]
for sentance in preprocessed_reviews:
    list_of_sentance.append(sentance.split())
```

In [105]:
```
# Using Google News Word2Vectors

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


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

is_your_ram_gt_16g=False
want_to_use_google_w2v = False
want_to_train_w2v = True

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

elif want_to_use_google_w2v and is_your_ram_gt_16g:
    if os.path.isfile('GoogleNews-vectors-negative300.bin'):
        w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.
        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,
```

```
[('alternative', 0.9937111139297485), ('tasty', 0.9935559034347534), ('healthy', 0.993433713911
==================================================
[('oh', 0.9994993805885315), ('must', 0.9994907379150391), ('easily', 0.9994389414787292), ('pe
```

In [106]:
```
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  3817
sample words  ['product', 'available', 'course', 'total', 'pretty', 'stinky', 'right', 'nearby
```

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

[4.4.1.1] Avg W2v

```
In [107]: # average Word2Vec
          # compute average word2vec for each review.
          sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
          for sent in tqdm(list_of_sentance): # for each review/sentence
              sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need
              cnt_words =0; # num of words with a valid vector in the sentence/review
              for word in sent: # for each word in a review/sentence
                  if word in w2v_words:
                      vec = w2v_model.wv[word]
                      sent_vec += vec
                      cnt_words += 1
              if cnt_words != 0:
                  sent_vec /= cnt_words
              sent_vectors.append(sent_vec)
          print(len(sent_vectors))
          print(len(sent_vectors[0]))
```

```
100%|| 4986/4986 [00:06<00:00, 799.63it/s]

4986
50
```

[4.4.1.2] TFIDF weighted W2v

```
In [108]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
          model = TfidfVectorizer()
          tf_idf_matrix = model.fit_transform(preprocessed_reviews)
          # we are converting a dictionary with word as a key, and the idf as a value
          dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [109]: # 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 = tfid
```

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

```
100%|| 4986/4986 [00:36<00:00, 136.68it/s]
```

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 vectors
        <li><font color='red'>SET 2:</font>Review text, preprocessed one converted into vectors
        <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 mat
    <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 for
    <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

```
In [110]: #Getting the necessary imports and function definations
          from sklearn.neighbors import KNeighborsClassifier
          from sklearn.model_selection import KFold
```

```
from sklearn.model_selection import train_test_split
import scikitplot as skplt
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve, auc
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import confusion_matrix
import pprint
from sklearn.pipeline import Pipeline
import os.path
import pickle
```

6.1.1 [5.0.0] Splitting up the Dataset into D_train and D_test

```
In [111]: Dx_train, Dx_test, Dy_train, Dy_test = train_test_split(preprocessed_reviews, final[
```

6.1.2 [5.0.1] Defining some functions to increase code reusability and readability

```
In [112]: '''Creating Custom Vectorizers for TFIDF - W2Vec and Avg - W2Vec'''
          class Tfidf_W2Vec_Vectorizer(object):
              def __init__(self):
                  self.tfidf = TfidfVectorizer(max_features=50)
                  self.word2vec = None
                  self.dictionary = None
                  self.tfidf_feat = None
                  self.w2vec_words = None

              def fit(self, X, y):
                  #Initializing the TFIDF Vectorizer
                  self.tfidf.fit_transform(X)

                  #Initializing the Word2Vec Model
                  list_of_sentences=[]
                  for sentence in X:
                      list_of_sentences.append(sentence.split())
                  self.word2vec=Word2Vec(list_of_sentences, min_count=5, size=50, workers=4)

                  # we are converting a dictionary with word as a key, and the idf as a value
                  self.dictionary = dict(zip(self.tfidf.get_feature_names(), list(self.tfidf.id
                  self.w2vec_words = list(self.word2vec.wv.vocab)
                  self.tfidf_feat = self.tfidf.get_feature_names()
                  return self

              def transform(self, X):
                  return np.array([
                          np.mean([self.word2vec[w] * self.dictionary[word]*(X.cout(word)/len(X
                                   for w in words if w in self.word2vec and w in self.tfidf_fea
                                  [np.zeros(50)], axis=0)
```

```
                    for words in X
                ])

        class Avg_W2Vec_Vectorizer(object):
            def __init__(self):
                self.word2vec = None

            def fit(self, X, y):
                list_of_sentences=[]
                for sentence in X:
                    list_of_sentences.append(sentence.split())
                self.word2vec = Word2Vec(list_of_sentences, min_count=5, size=50, workers=4)
                return self

            def transform(self, X):
                return np.array([
                    np.mean([self.word2vec[w] for w in words if w in self.word2vec]
                            or [np.zeros(50)], axis=0)
                    for words in X
                ])
```

In [113]:
```
        '''Creation of Pipeline'''
        def create_KNN_pipeline(vectorizer):
            steps = []
            if(vectorizer=='BOW'):
                steps.append(('Bow_Vect', CountVectorizer(ngram_range=(1,2), min_df=10, max_
            if(vectorizer=='TFIDF'):
                steps.append(('TFIDF_Vect', TfidfVectorizer(ngram_range=(1,2), min_df=10, ma
            if(vectorizer=='TFIDF-W2Vec'):
                steps.append(('TFIDF-W2Vec', Tfidf_W2Vec_Vectorizer()))
            if(vectorizer=='Avg-W2Vec'):
                steps.append(('Avg-W2Vec', Avg_W2Vec_Vectorizer()))

            #Appending the KNN Classifier at the end of vectorization
            steps.append(('knn', KNeighborsClassifier()))
            return Pipeline(steps)
```

In [114]:
```
        '''This function takes input the X, Y data and algorithm to use and
        model path (just to avoiding retraining an already trained model)
        Performs GridSearchCV and returns the best parameters and cv_results_
        data formatted as a pandas DataFrame'''
        def perform_grid_search_cv(X, Y, algorithm, vectorizer, model_path):
            if(os.path.exists(model_path)):
                #if present simply load the model
                with open(model_path, 'rb') as input_file:
                    clf = pickle.load(input_file)
            else:
                #if model not present then initialize --> perform cross validation --> save
```

```
            parameters_grid = {
                'knn__weights' : ['uniform', 'distance'],
                'knn__algorithm' : [algorithm],
                'knn__n_neighbors' : [i for i in range(1, 201, 2)]
                }

            pipe = create_KNN_pipeline(vectorizer)
            clf = GridSearchCV(pipe,
                               param_grid=parameters_grid,
                               scoring='roc_auc',
                               verbose=1,
                               error_score='raise',
                               cv = 10,
                               iid=False,
                               pre_dispatch='4*n_jobs',
                               return_train_score=True, n_jobs=-1)
            #Start to fit the model to get the best hyperparameters
            clf.fit(X, Y)

            #Save the model to the supplied model path
            with open(model_path, 'wb') as output_file:
                pickle.dump(clf, output_file)

        #Displaying the best parameters and best score acheived
        print('\n\nMaximum Area under ROC Curve with best params as : {0} \nwith the max

        #Converting the cv_results to a pandas DataFrame
        cresults = pd.DataFrame(clf.cv_results_)
        cresults = pd.DataFrame(cresults.loc[:,['param_knn__n_neighbors',
                                                'param_knn__weights',
                                                'rank_test_score',
                                                'mean_train_score',
                                                'mean_test_score',
                                                'std_train_score',
                                                'std_test_score',]])
        return cresults, clf.best_params_, clf.best_score_

    def analyse_results(df):
        #Sorting the dataframe as per 1-> best test scores then followed -> number of ne
        cresults = df
        cresults = cresults.sort_values(by=['rank_test_score', 'param_knn__n_neighbors']

        #seperating the dataframe by the weighing method to maintain uniformity of compa
        uniform_weighted = cresults[cresults['param_knn__weights']=='uniform']
        distance_weighted = cresults[cresults['param_knn__weights']=='distance']

        #plotting the uniform weighted measure K-NN results
        test_auc = uniform_weighted.mean_test_score
```

```
    test_auc_std = uniform_weighted.std_test_score
    plt.plot(uniform_weighted.param_knn__n_neighbors.tolist(),
             test_auc, label='Validation AUC')
    plt.gca().fill_between(uniform_weighted.param_knn__n_neighbors.tolist(),
                           test_auc-test_auc_std, test_auc + test_auc_std, alpha=0.2,

    train_auc = uniform_weighted.mean_train_score
    train_auc_std = uniform_weighted.std_train_score
    plt.plot(uniform_weighted.param_knn__n_neighbors.tolist(),
             train_auc, label='Train AUC')
    plt.gca().fill_between(uniform_weighted.param_knn__n_neighbors.tolist(),
                           train_auc-train_auc_std, train_auc + train_auc_std, alpha=
    plt.xlabel('n-neighbors')
    plt.ylabel('Area Under ROC Curve')
    plt.title('Area Under ROC Curve for K-NN with "uniform" distance metrics')
    plt.legend(loc='best')
    plt.show()



    #plotting the inverse-distance weighted measure K-NN results
    test_auc = distance_weighted.mean_test_score
    test_auc_std = distance_weighted.std_test_score
    plt.plot(distance_weighted.param_knn__n_neighbors.tolist(),
             test_auc, label='Validation AUC')
    plt.gca().fill_between(distance_weighted.param_knn__n_neighbors.tolist(),
                           test_auc-test_auc_std, test_auc + test_auc_std, alpha=0.2,

    train_auc = distance_weighted.mean_train_score
    train_auc_std = distance_weighted.std_train_score
    plt.plot(distance_weighted.param_knn__n_neighbors.tolist(),
             distance_weighted.mean_train_score.tolist(), label='Train AUC')
    plt.gca().fill_between(distance_weighted.param_knn__n_neighbors.tolist(),
                           train_auc-train_auc_std, train_auc + train_auc_std, alpha=
    plt.xlabel('n-neighbors')
    plt.ylabel('Area Under ROC Curve')
    plt.title('Area Under ROC Curve for K-NN with "inverse-distance" distance metrics
    plt.legend(loc='best')
    plt.show()


def retrain_with_best_hyperparameters(X, Y, best_params_):
    #Initializing the model with the selected best parameters from GridSearchCV
    knn = KNeighborsClassifier(algorithm = best_params_['knn__algorithm'],
                               n_neighbors = best_params_['knn__n_neighbors'],
                               weights = best_params_['knn__weights'],
                               n_jobs=-1)
```

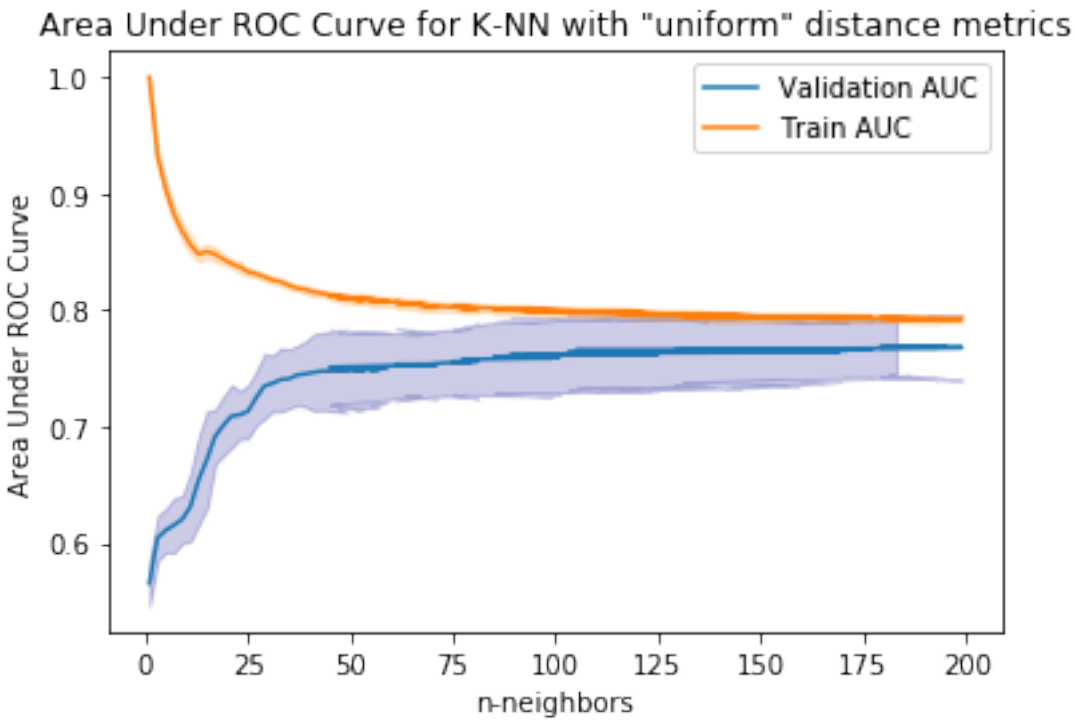
```
        #Training the model
        knn.fit(X, Y)
        return knn

    def plot_confusion_matrix(model, data, labels, dataset):
        pred = model.predict(data)
        conf_mat = confusion_matrix(labels, pred)

        ax = plt.axes()
        ax.set_title('Confusion Matrix : {0}'.format(dataset))
        sns.heatmap(conf_mat, annot=True, fmt="d",cmap="YlGnBu", ax = ax)
        plt.show()


    def plot_AUC_ROC(knn, Dx_train, Dy_train, Dx_test, Dy_test):

        #predicting probability of Dx_test, Dx_train
        test_score = knn.predict_proba(Dx_test)
        train_score = knn.predict_proba(Dx_train)

        #Finding out the ROC_AUC_SCORE
        train_roc_auc_score = roc_auc_score(Dy_train, train_score[:, 1])
        print('Area Under the Curve for Train : ', train_roc_auc_score)
        test_roc_auc_score = roc_auc_score(Dy_test, test_score[:, 1])
        print('Area Under the Curve for Test : ', test_roc_auc_score)

        #Plotting with matplotlib.pyplot
        #ROC Curve for D-train
        train_fpr, train_tpr, thresholds = roc_curve(Dy_train, train_score[:, 1])
        plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))

        # #ROC Curve for D-test
        test_fpr, test_tpr, thresholds = roc_curve(Dy_test, test_score[:, 1])
        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("Area Under ROC Curve")
        plt.show()

    prettytable_data = []
```

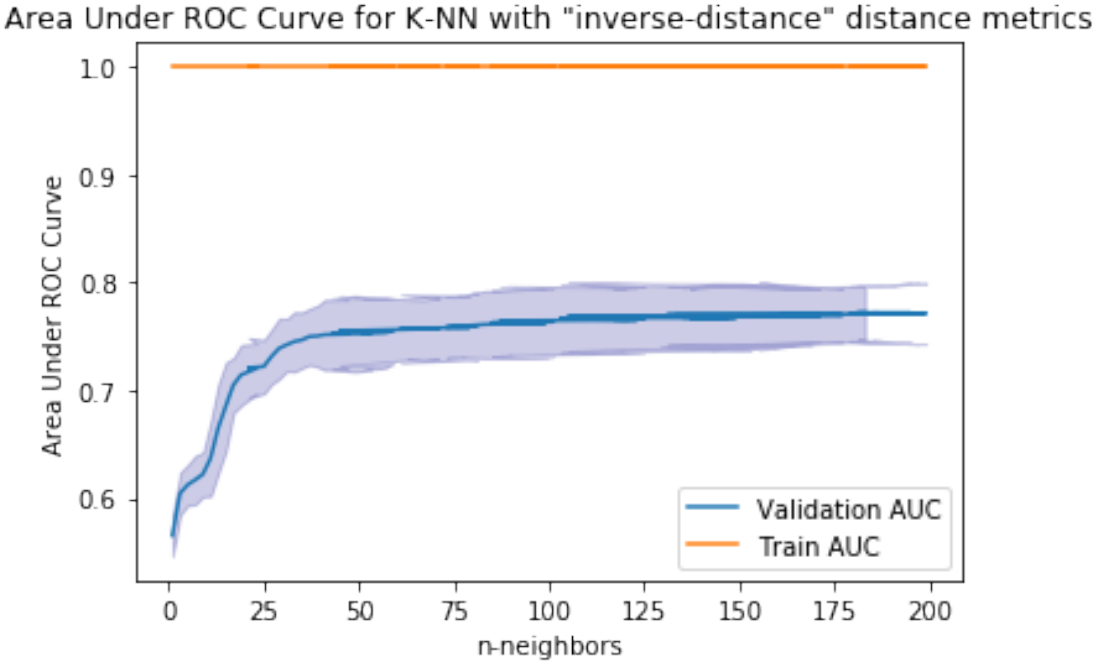
6.1.3 [5.1.1] Applying KNN brute force on BOW, SET 1

In [115]:
```
# Please write all the code with proper documentation
path = 'saved_models/grid_search_cv_bow.pkl'
```

```
cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                    Y=Dy_train,
                                                                    algorithm='brute',
                                                                    vectorizer='BOW',
                                                                    model_path=path)

#PrettyTable Data Collection
prettytable_data.append(['BOW', best_hyperparameters['knn__algorithm'], best_hyperpa

#Analysing the results
analyse_results(df=cresults)

#Retrain with the best foud hyperparameters
##Initializing Vectorizer
vectorizer = CountVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
x_train = vectorizer.fit_transform(Dx_train)
x_test = vectorizer.transform(Dx_test)
#fitting the model
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hyp

#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)
```

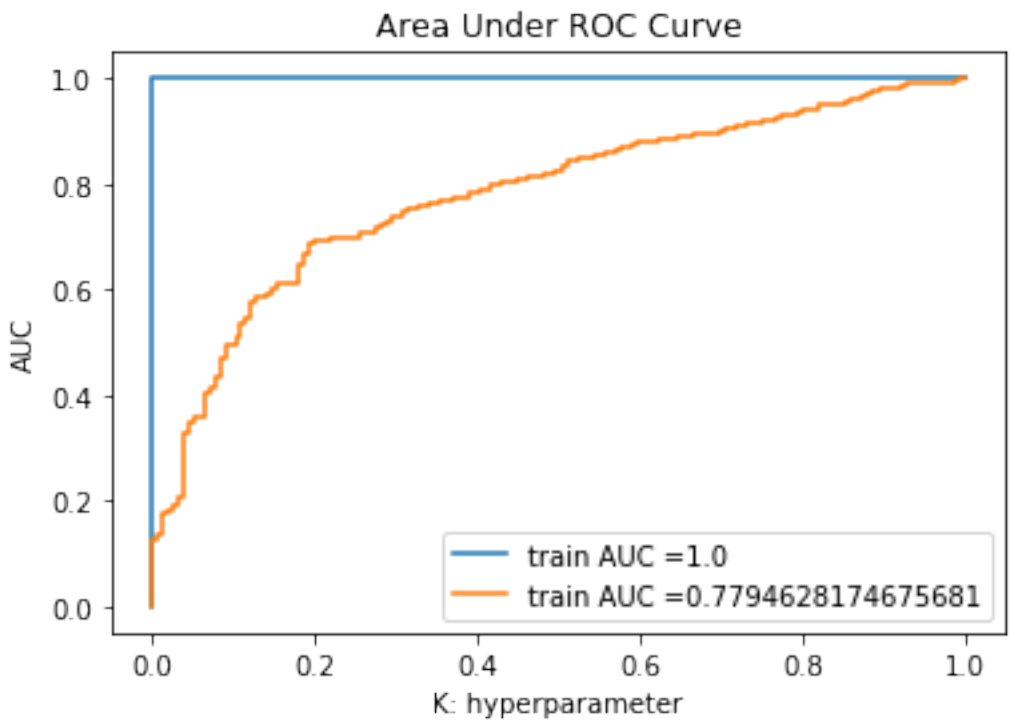
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'brute', 'knn__n_neighbo
with the max area of 0.7724075411201159
```



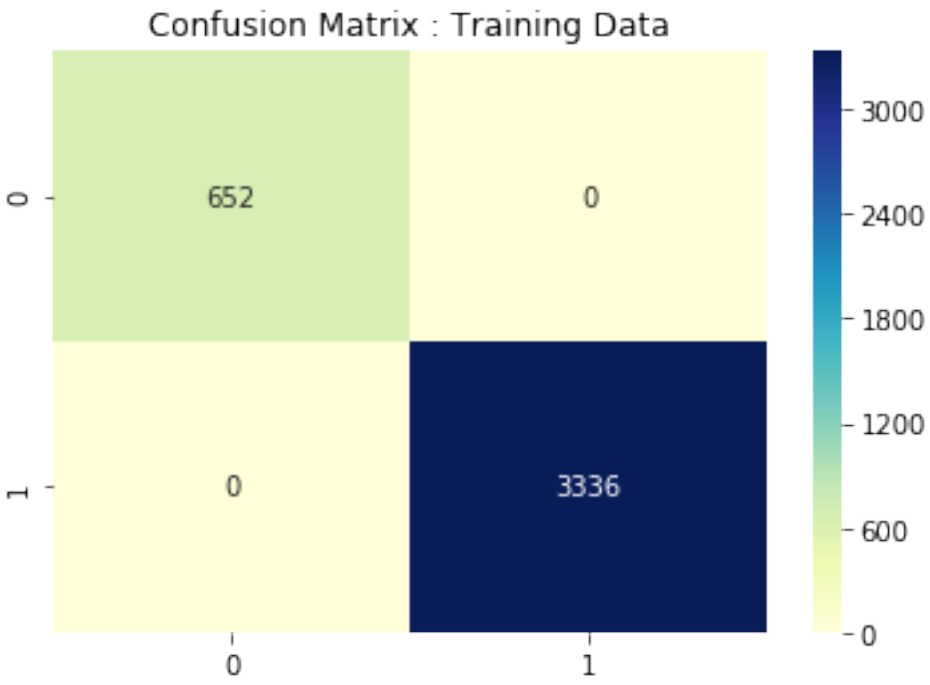


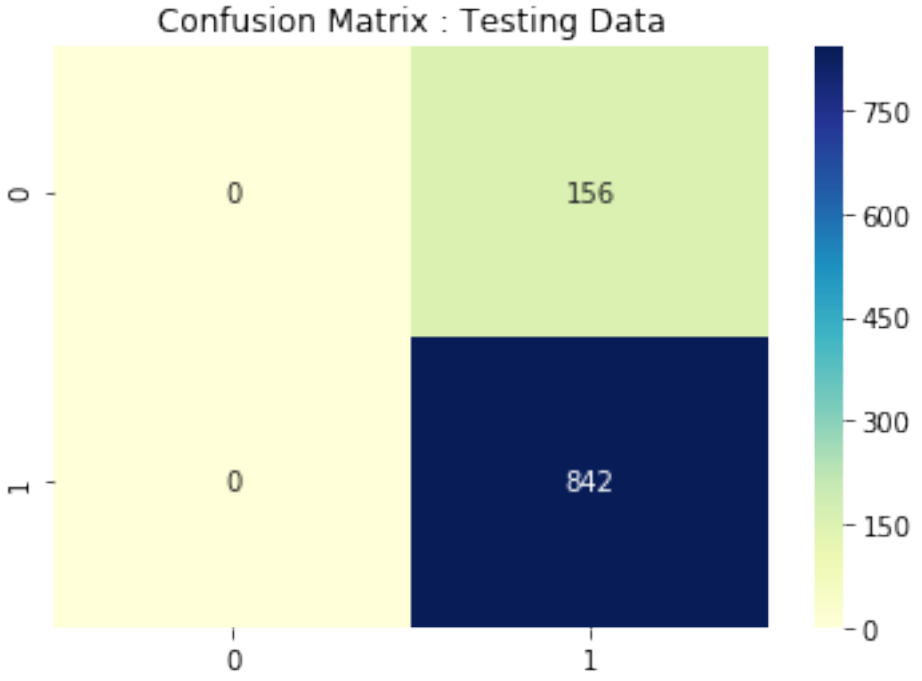

```
Area Under the Curve for Train :  1.0
```

```
Area Under the Curve for Test :  0.7794628174675681
```



In [116]:
```
#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')

#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

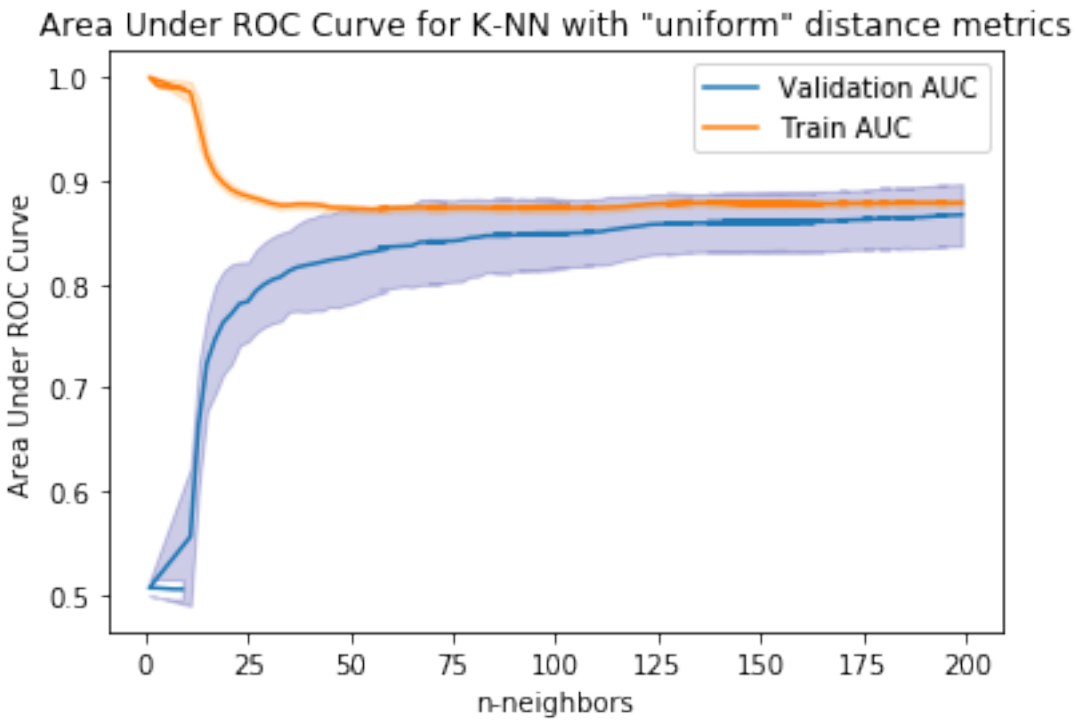

Confusion Matrix : Training Data
652
0
0
3336
0
1
0
1
3000
2400
1800
1200
600
0

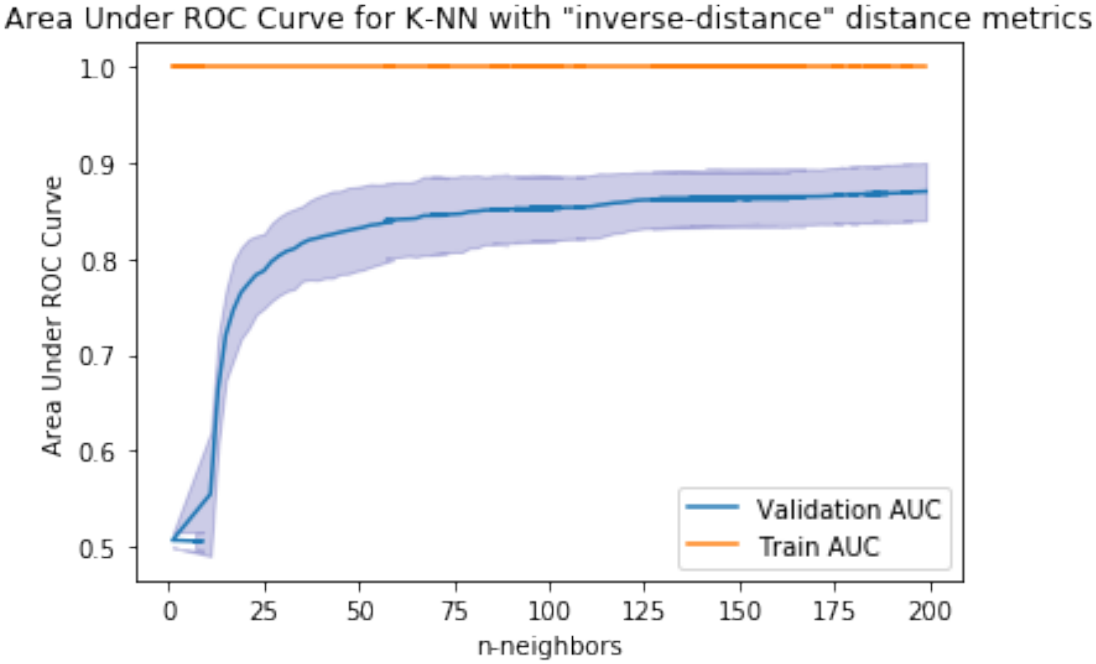

Confusion Matrix : Testing Data
0
156
0
842
0
1
0
1
750
600
450
300
150
0

6.2 [5.1.2] Applying KNN brute force on TFIDF, SET 2

In [117]:
```
# Please write all the code with proper documentation
path = 'saved_models/grid_search_cv_tfidf.pkl'


cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                    Y=Dy_train,
                                                                    algorithm='brute',
                                                                    vectorizer='TFIDF',
                                                                    model_path=path)

#PrettyTable Data Collection
prettytable_data.append(['TFIDF', best_hyperparameters['knn__algorithm'], best_hyperp

#analysing the dataframe
analyse_results(cresults)

#Retrain with the best foud hyperparameters
##Initializing Vectorizer
vectorizer = TfidfVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
x_train = vectorizer.fit_transform(Dx_train)
x_test = vectorizer.transform(Dx_test)
#fitting the model
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype

#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

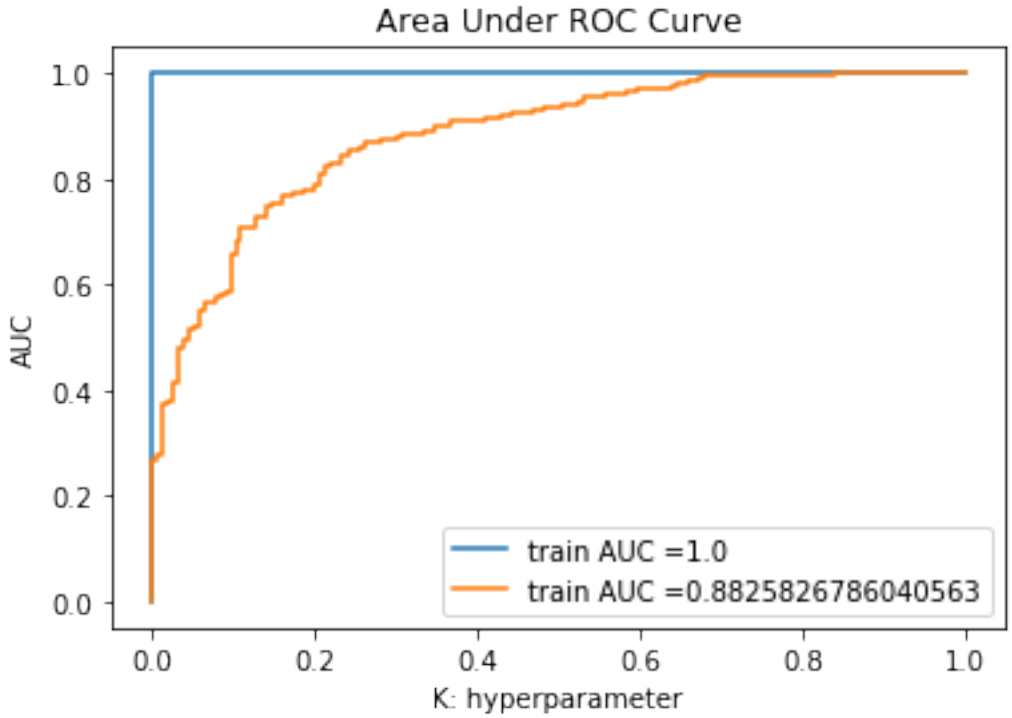
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'brute', 'knn__n_neighbo
with the max area of 0.8702931577781877
```

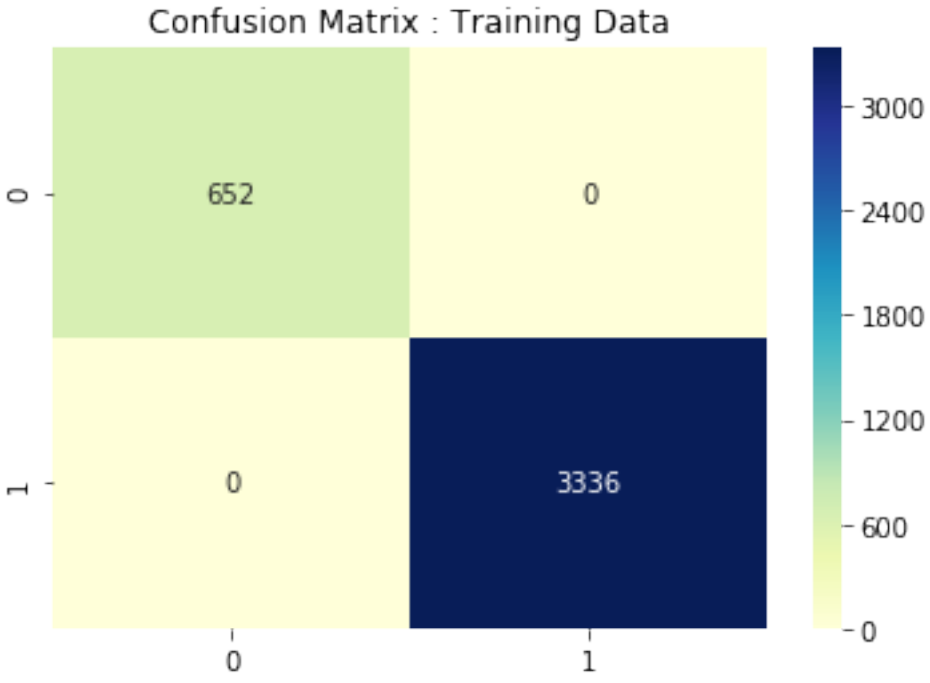


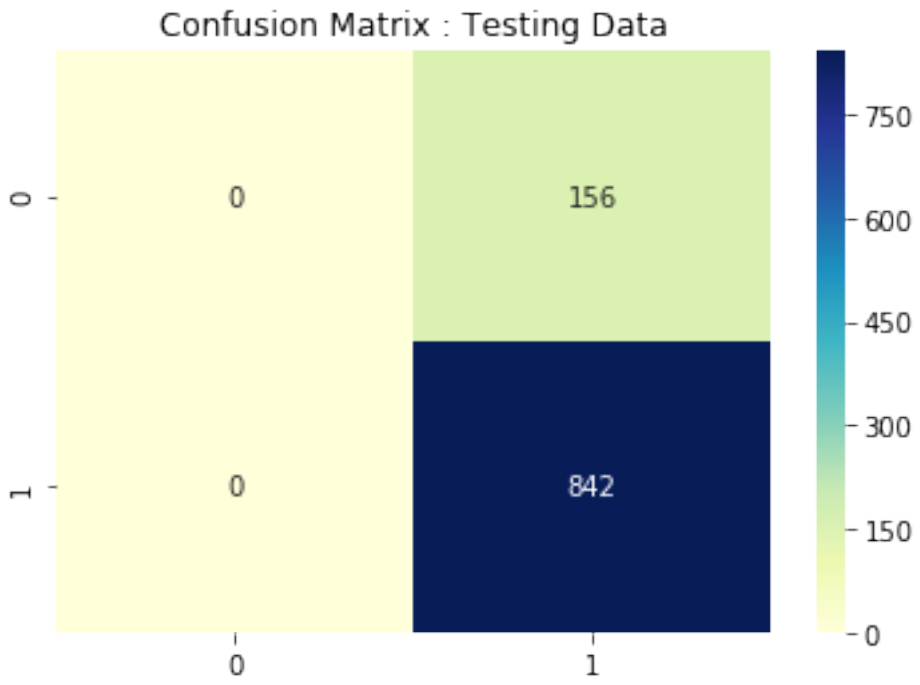



```
Area Under the Curve for Train :  1.0
```

```
Area Under the Curve for Test :  0.8825826786040563
```





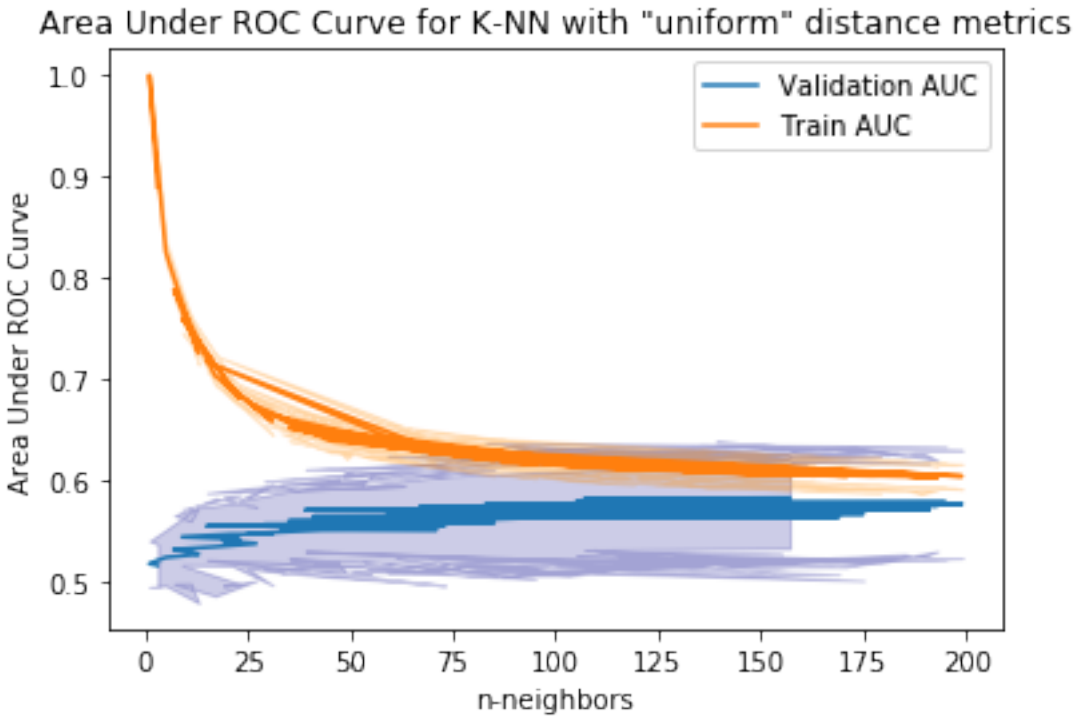


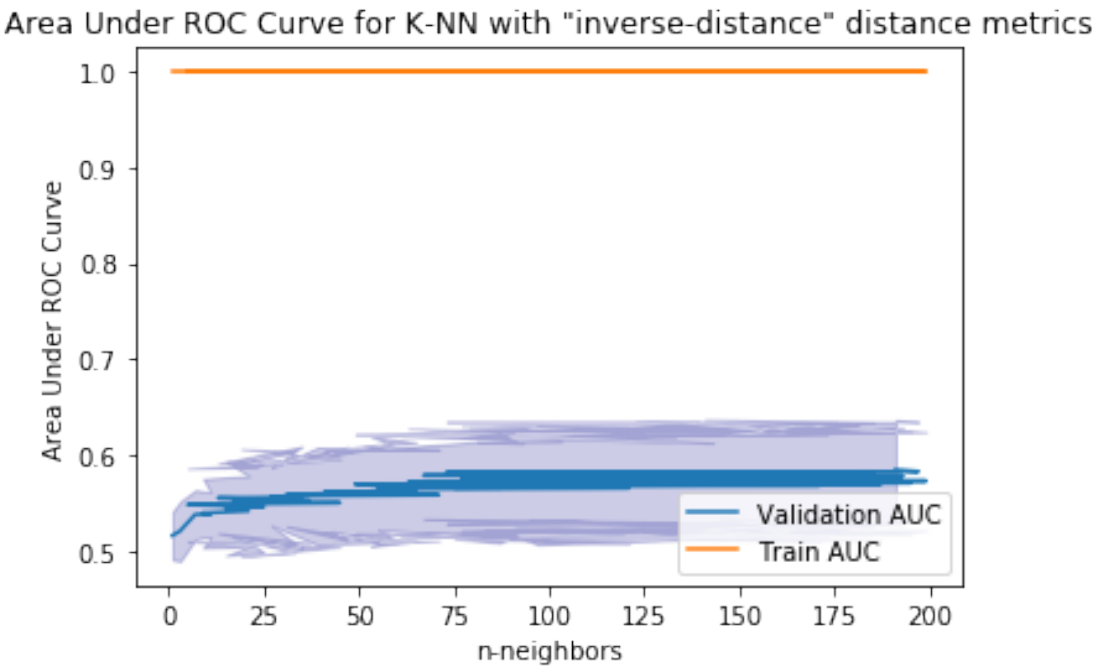
[5.1.3] Applying KNN brute force on AVG W2V, SET 3

```
In [118]: # Please write all the code with proper documentation
          path = 'saved_models/grid_search_cv_avg_w2v.pkl'
          cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                              Y=Dy_train,
                                                                              algorithm='brute',
                                                                              vectorizer='Avg-W2Vec',
                                                                              model_path=path)

          #PrettyTable Data Collection
          prettytable_data.append(['Avg-W2Vec', best_hyperparameters['knn__algorithm'], best_hy
          #analysing the dataframe
          analyse_results(cresults)

          #Retrain with the best foud hyperparameters
          ##Initializing Vectorizer
          vectorizer = Avg_W2Vec_Vectorizer()
          vectorizer.fit(Dx_train, Dy_train)
          x_train = vectorizer.transform(Dx_train)
          x_test = vectorizer.transform(Dx_test)
          #fitting the model
          knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype

          #Plot Area Under ROC Curve
```

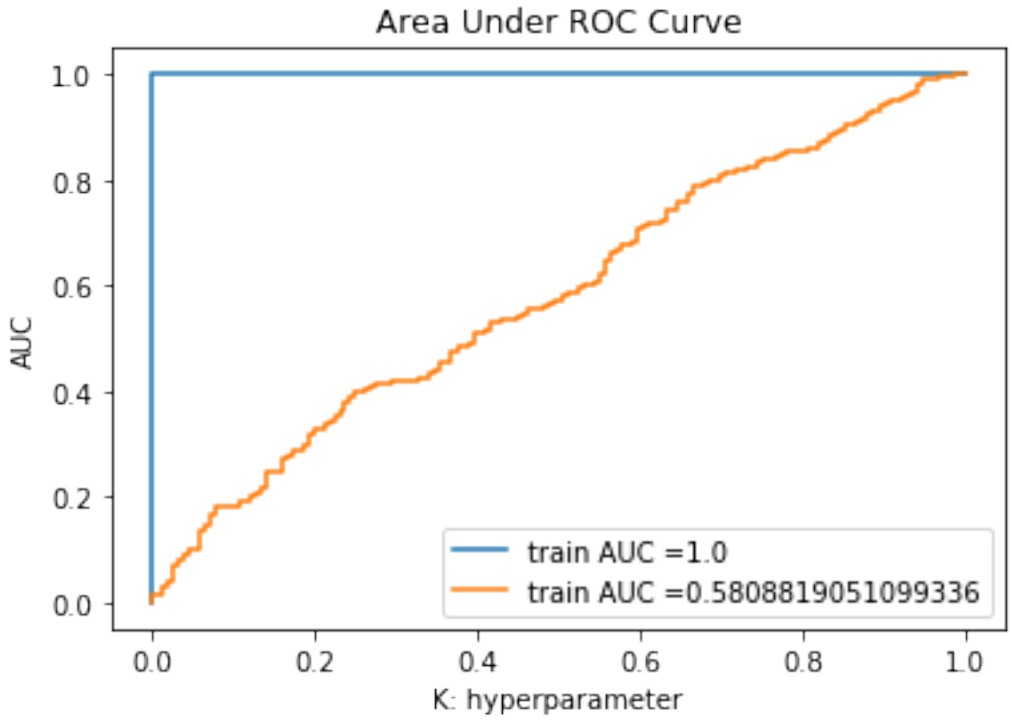
```
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

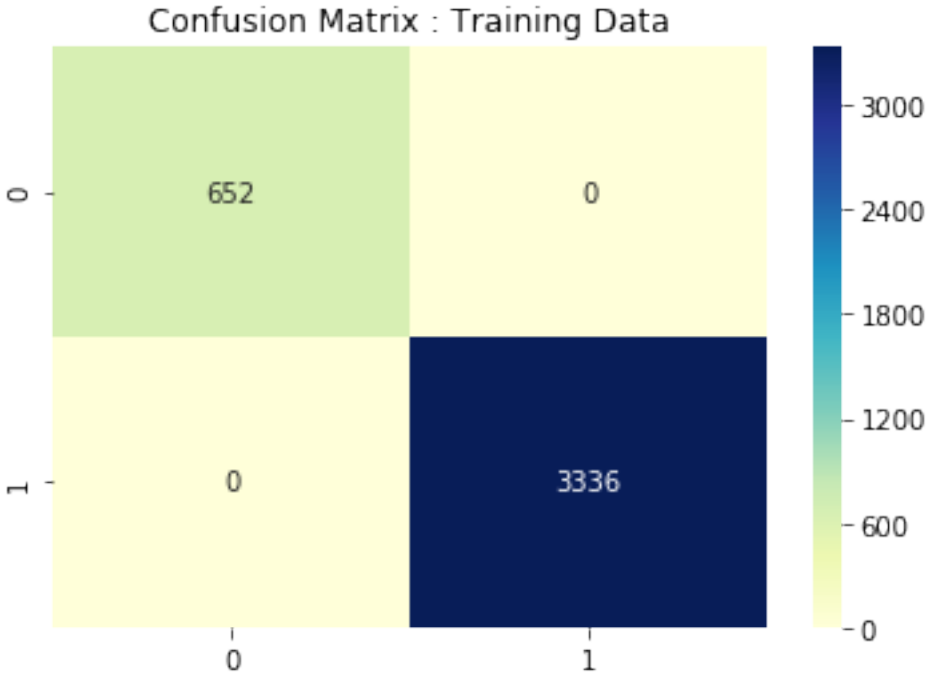
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'brute', 'knn__n_neighbo
with the max area of 0.5844119289927674
```

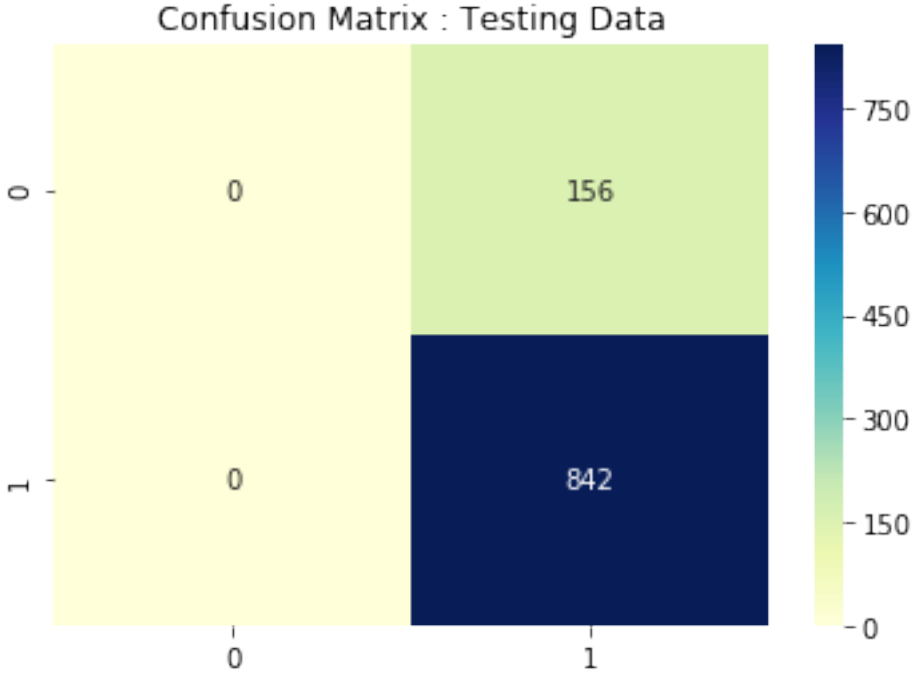





```
Area Under the Curve for Train :  1.0
Area Under the Curve for Test :  0.5808819051099336
```



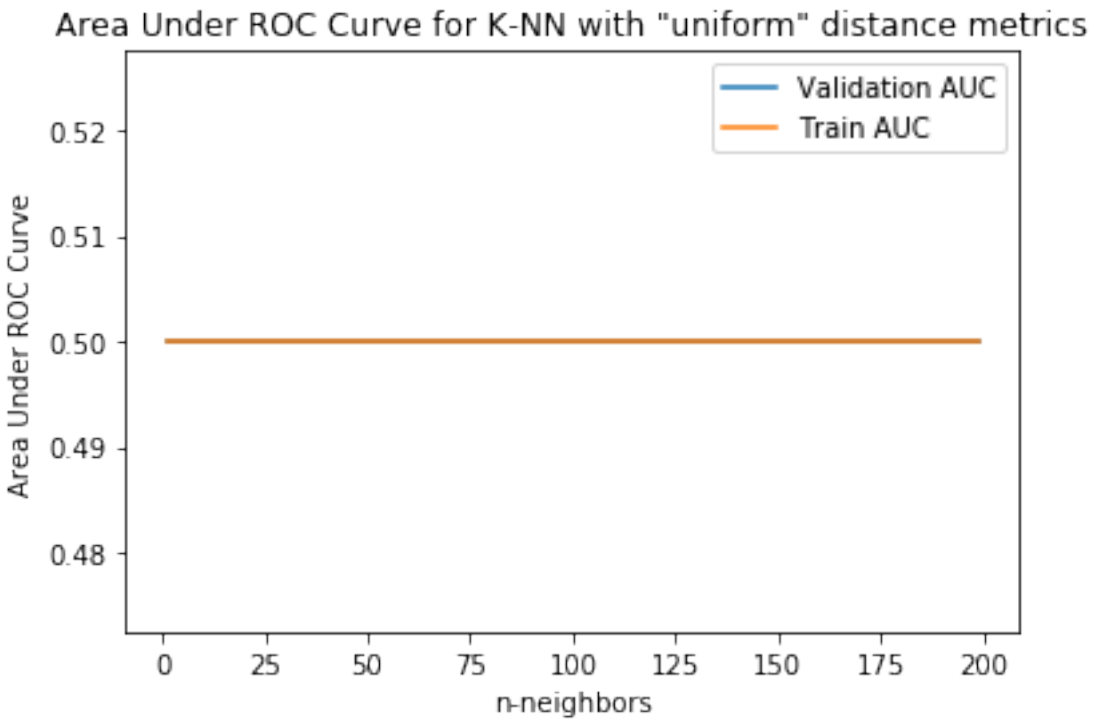

Confusion Matrix : Training Data
652
0
0
3336
0
1
0
1
3000
2400
1800
1200
600
0

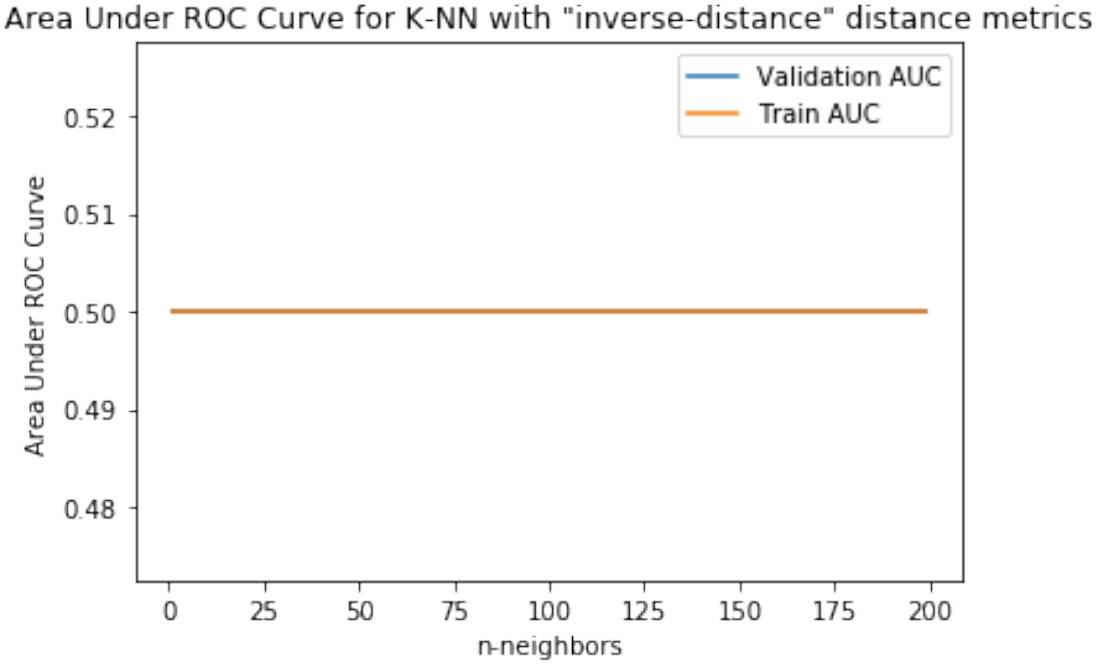

Confusion Matrix : Testing Data
0
156
0
842
0
1
0
1
750
600
450
300
150
0

6.2.1 [5.1.4] Applying KNN brute force on TFIDF W2V, SET 4

In [119]:
```
# Please write all the code with proper documentation
path = 'saved_models/grid_search_cv_tf_idf_w2v.pkl'
cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                    Y=Dy_train,
                                                                    algorithm='brute',
                                                                    vectorizer='TFIDF-W2Vec',
                                                                    model_path=path)

#PrettyTable Data Collection
prettytable_data.append(['TFIDF-W2Vec', best_hyperparameters['knn__algorithm'], best

#analysing the dataframe
analyse_results(cresults)

#Retrain with the best foud hyperparameters
##Initializing Vectorizer
vectorizer = Tfidf_W2Vec_Vectorizer()
vectorizer.fit(Dx_train, Dy_train)
x_train = vectorizer.transform(Dx_train)
x_test = vectorizer.transform(Dx_test)
#fitting the model
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype

#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

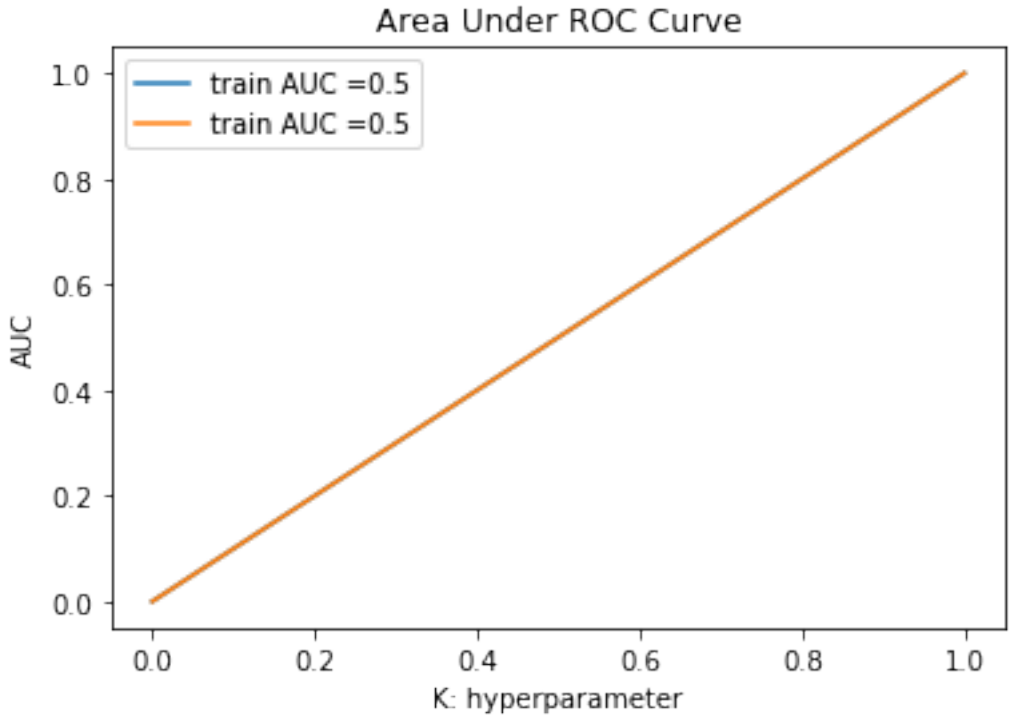
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'brute', 'knn__n_neighbo
with the max area of 0.5
```

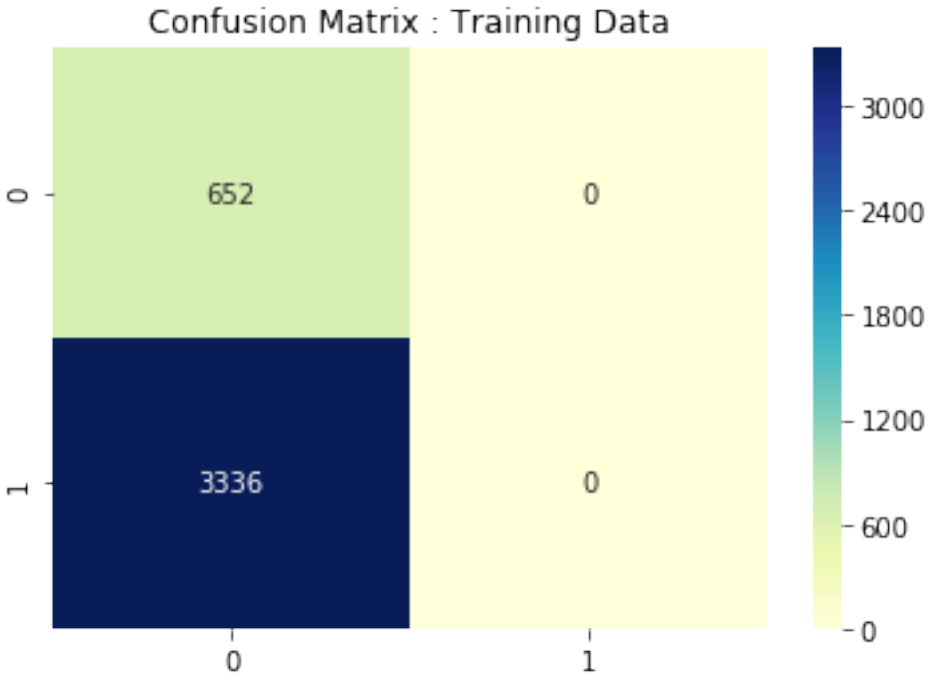


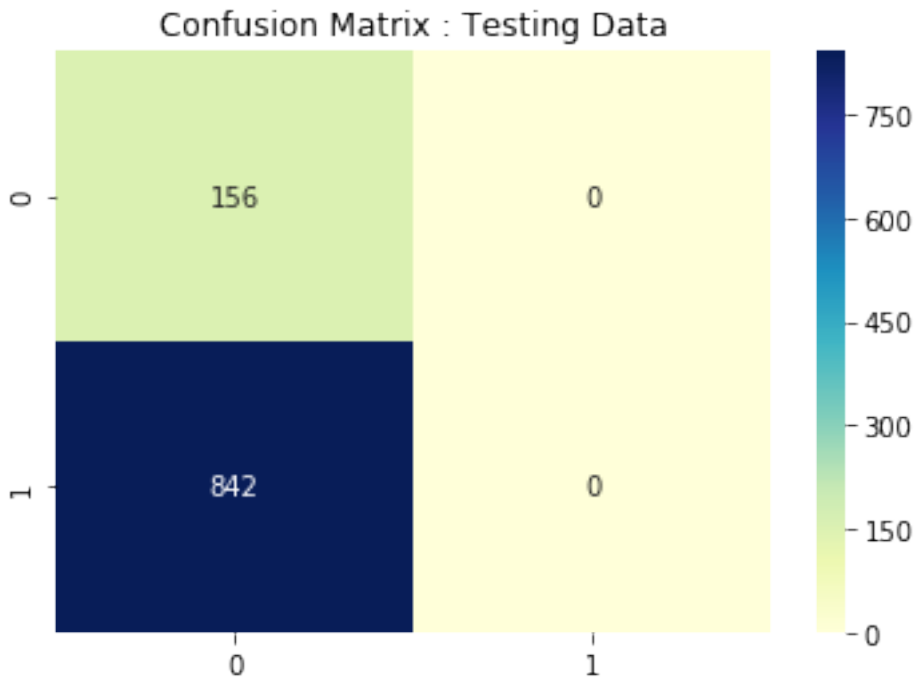



```
Area Under the Curve for Train :  0.5
```

```
Area Under the Curve for Test :  0.5
```







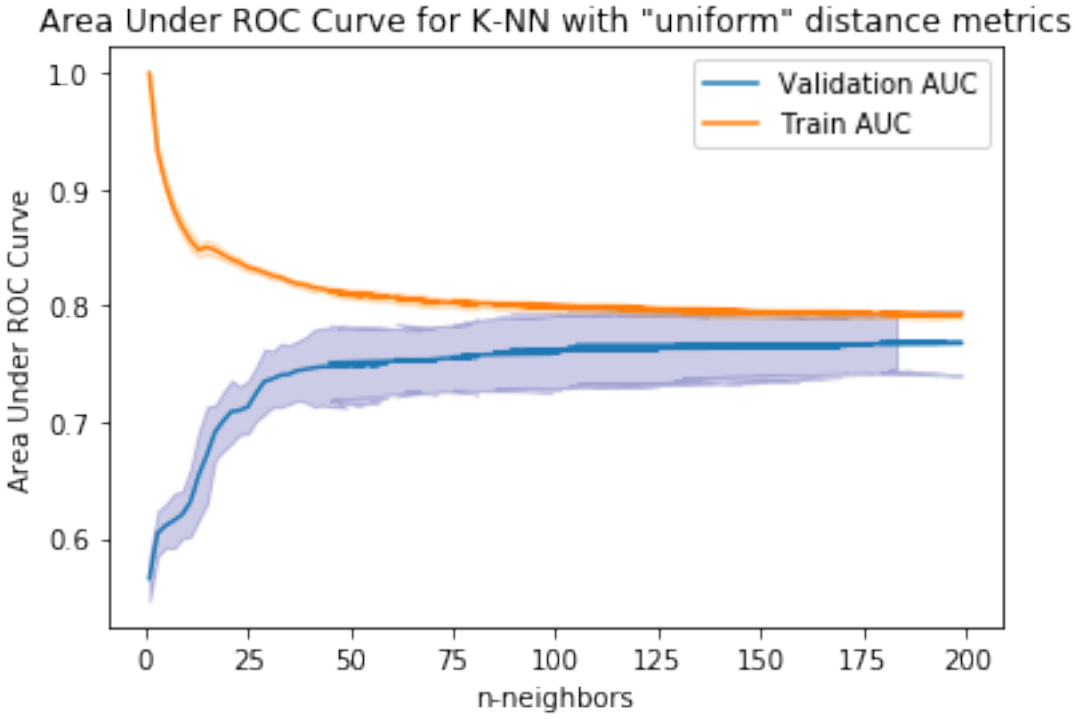
6.3 [5.2] Applying KNN kd-tree

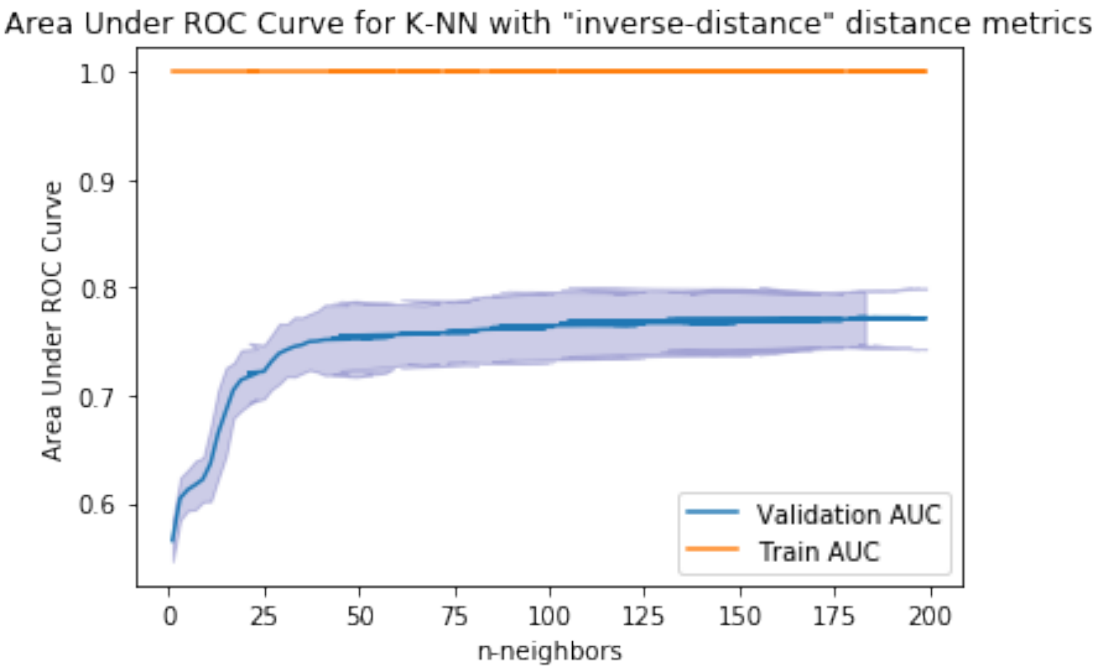
6.3.1 [5.2.1] Applying KNN kd-tree on BOW, SET 5

In [120]:
```
# Please write all the code with proper documentation
path = 'saved_models/grid_search_cv_bow_kd.pkl'
cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                    Y=Dy_train,
                                                                    algorithm='kd_tree',
                                                                    vectorizer='BOW',
                                                                    model_path=path)
#PrettyTable Data Collection
prettytable_data.append(['BOW-kd', best_hyperparameters['knn__algorithm'], best_hype

#Analysing the results
analyse_results(df=cresults)

#Retrain with the best foud hyperparameters
##Initializing Vectorizer
vectorizer = CountVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
x_train = vectorizer.fit_transform(Dx_train)
x_test = vectorizer.transform(Dx_test)
#fitting the model
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hyp
```

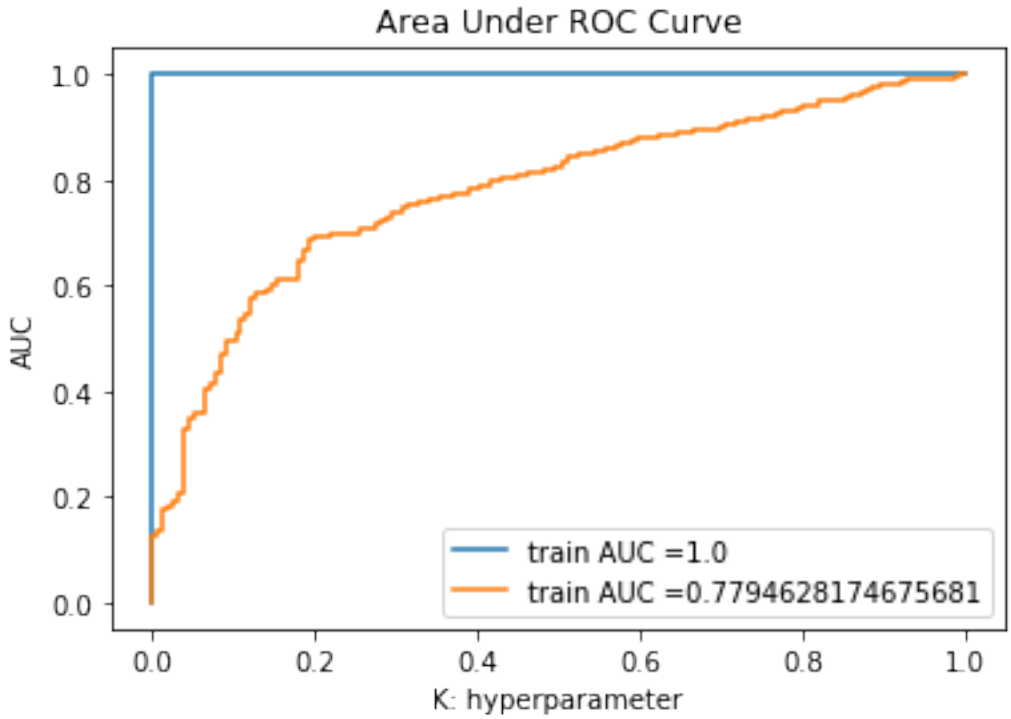
```
#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

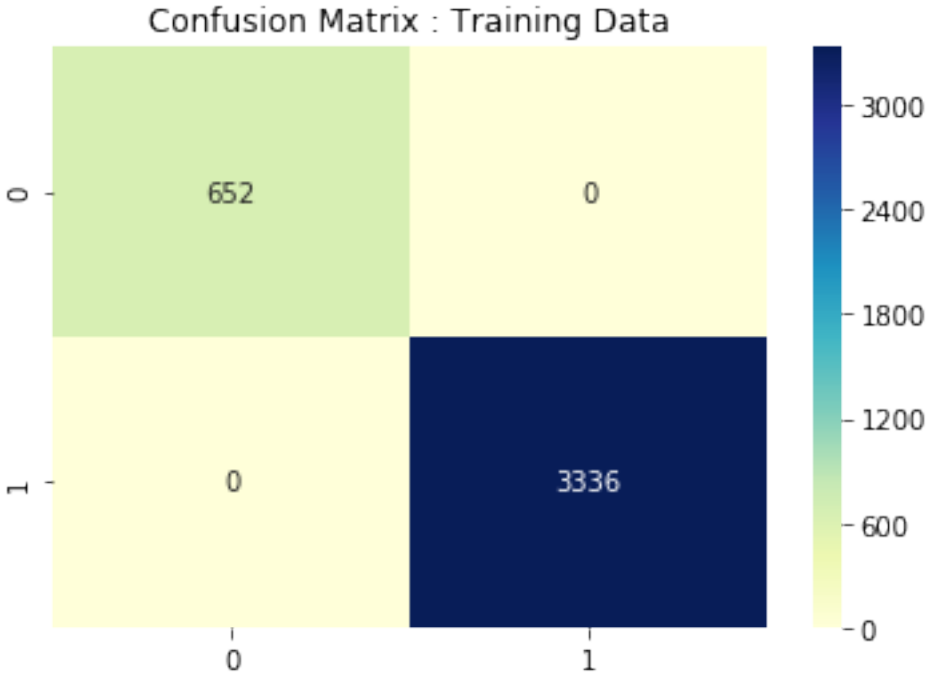
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'kd_tree', 'knn__n_neighb
with the max area of 0.7724075411201159
```

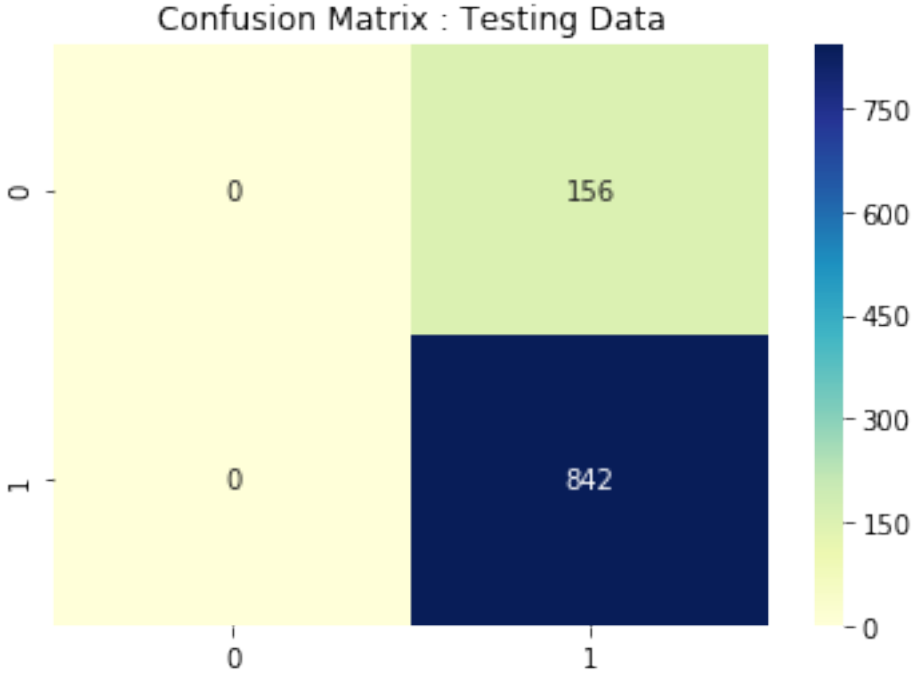





```
Area Under the Curve for Train :  1.0
Area Under the Curve for Test :  0.7794628174675681
```



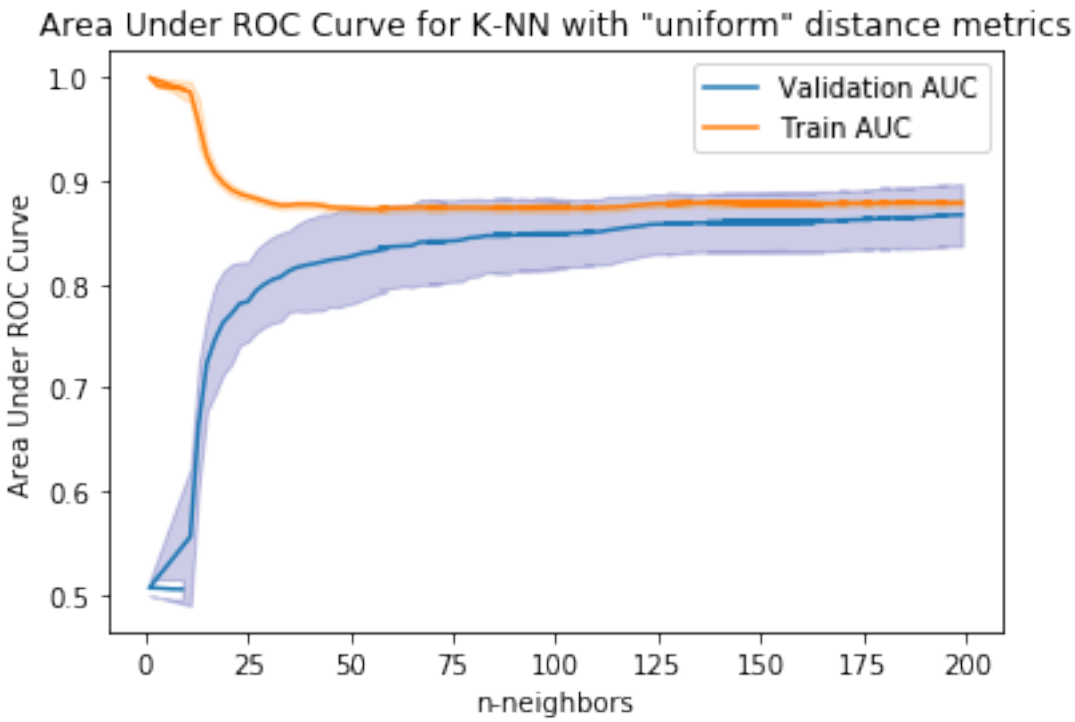

Confusion Matrix : Training Data
652
0
0
3336
0
1
0
1
3000
2400
1800
1200
600
0

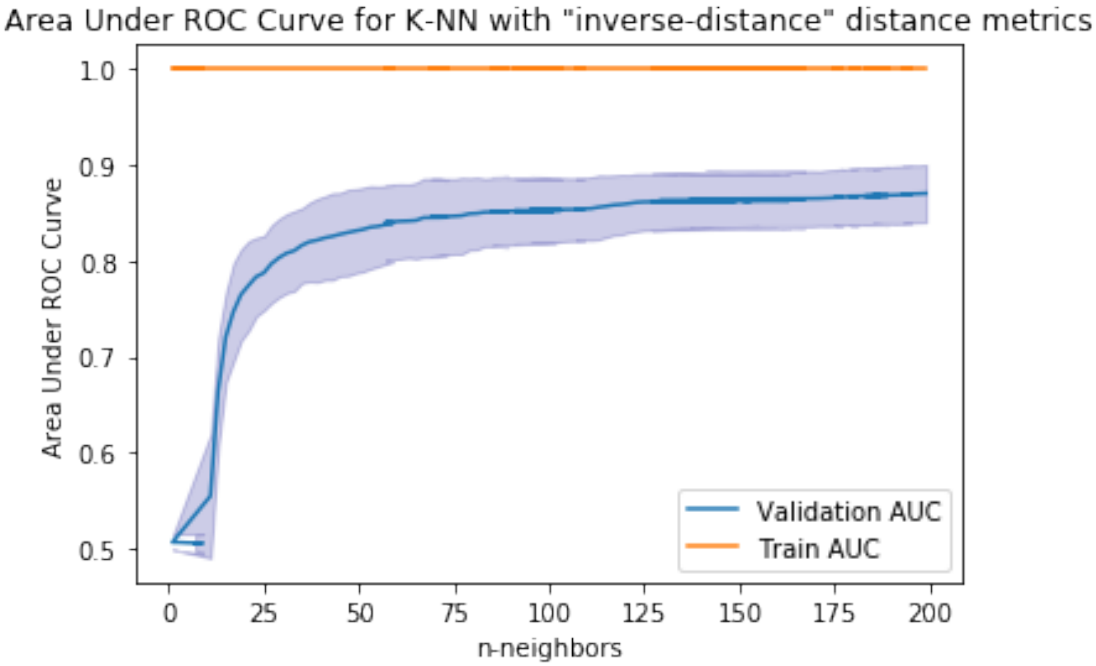

Confusion Matrix : Testing Data
0
156
0
842
0
1
0
1
750
600
450
300
150
0

6.3.2 [5.2.2] Applying KNN kd-tree on TFIDF, SET 6

```
In [121]: # Please write all the code with proper documentation
          path = 'saved_models/grid_search_cv_tfidf_kd.pkl'
          cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                              Y=Dy_train,
                                                                              algorithm='kd_tree',
                                                                              vectorizer='TFIDF',
                                                                              model_path=path)


          #PrettyTable Data Collection
          prettytable_data.append(['TF-IDF-kd', best_hyperparameters['knn__algorithm'], best_hy

          #analysing the dataframe
          analyse_results(cresults)

          #Retrain with the best foud hyperparameters
          ##Initializing Vectorizer
          vectorizer = TfidfVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
          x_train = vectorizer.fit_transform(Dx_train)
          x_test = vectorizer.transform(Dx_test)
          #fitting the model
          knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype


          #Plot Area Under ROC Curve
          plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

          #Plotting confusion matrix x_train
          plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
          #Plotting confusion matrix x_test
          plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

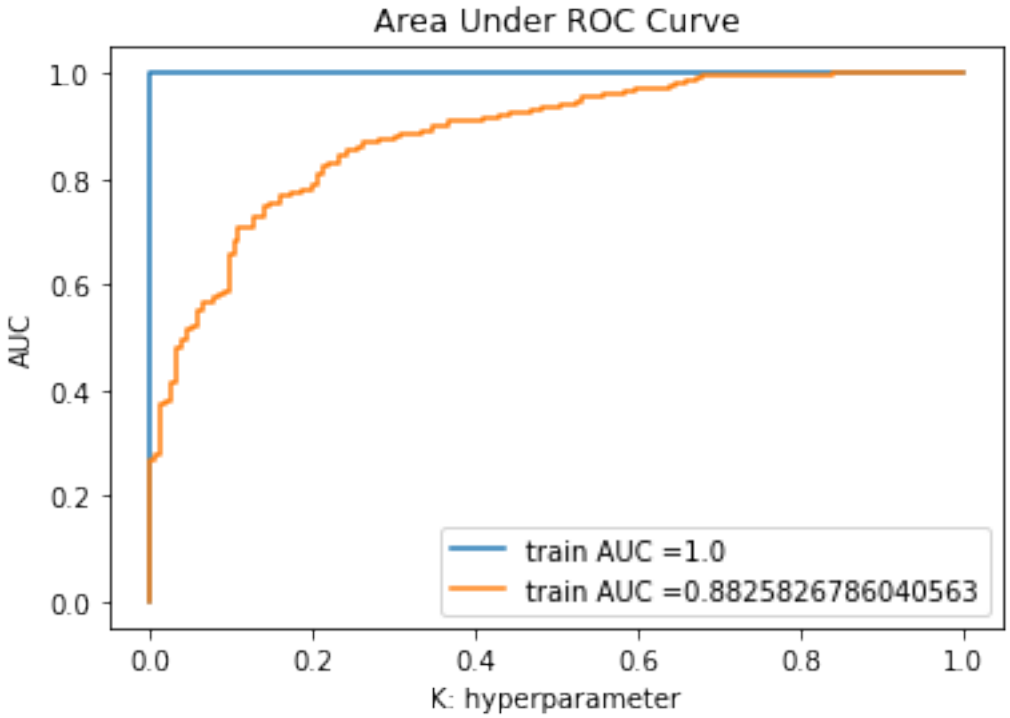
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'kd_tree', 'knn__n_neighb
with the max area of 0.8702931577781877
```

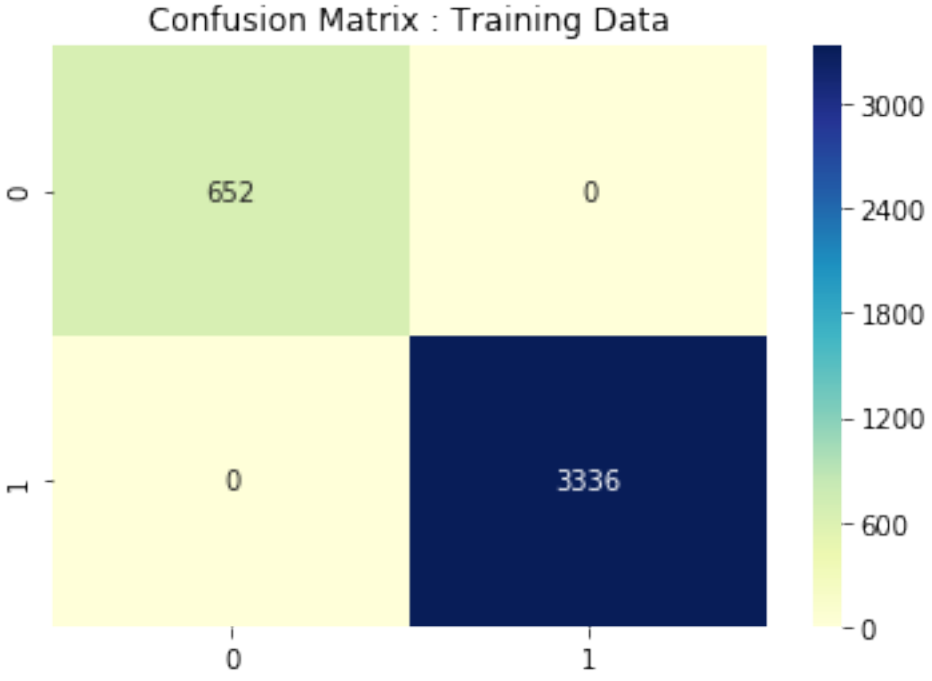


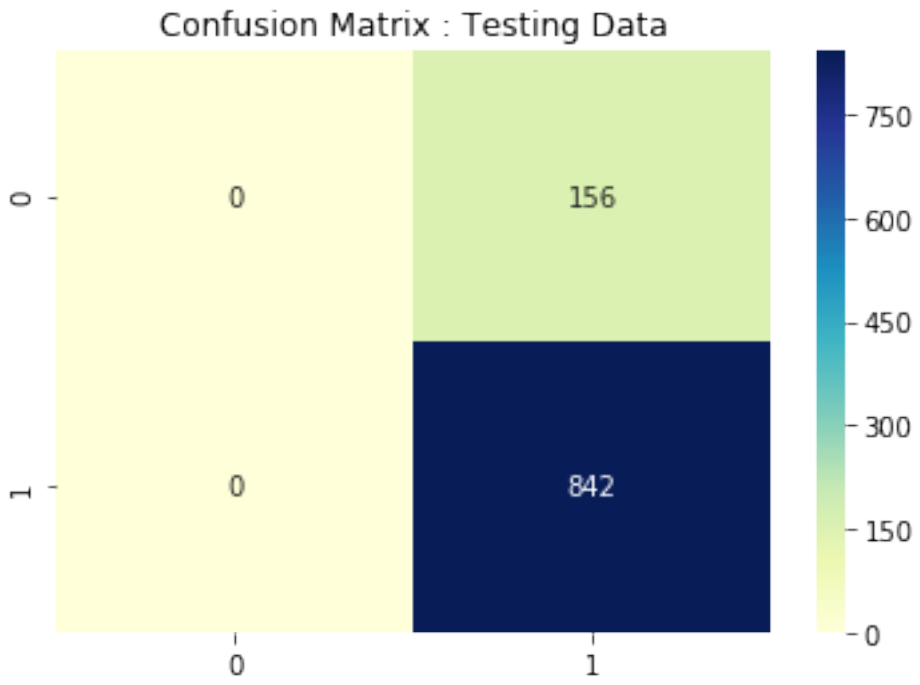



```
Area Under the Curve for Train :  1.0
```

```
Area Under the Curve for Test :  0.8825826786040563
```





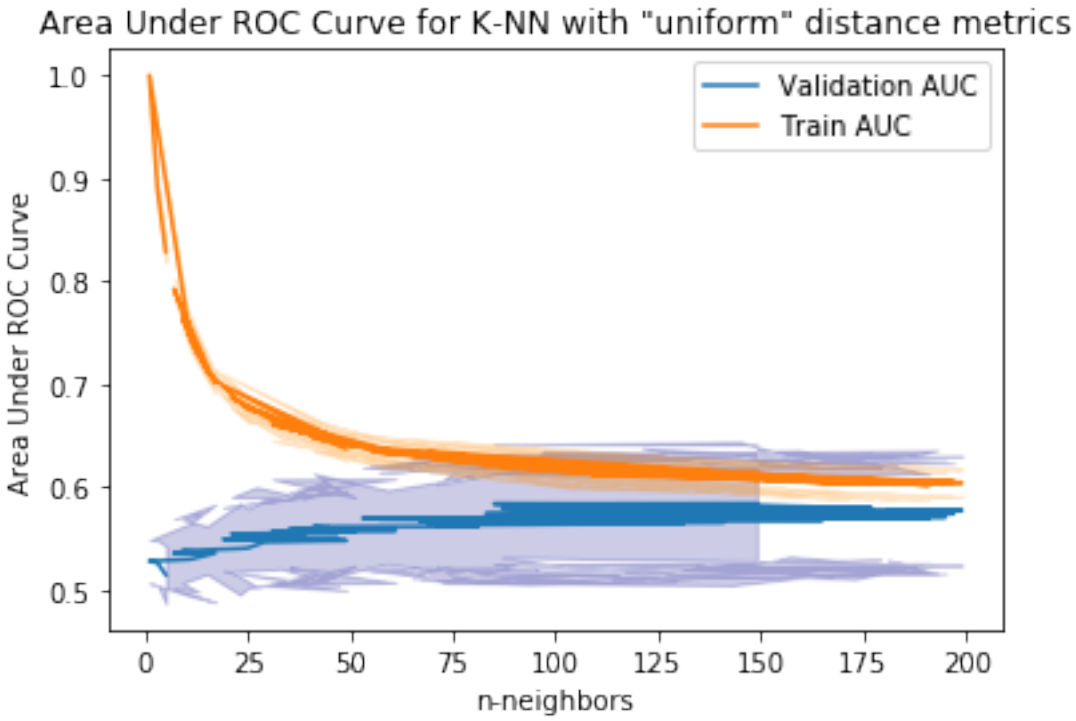


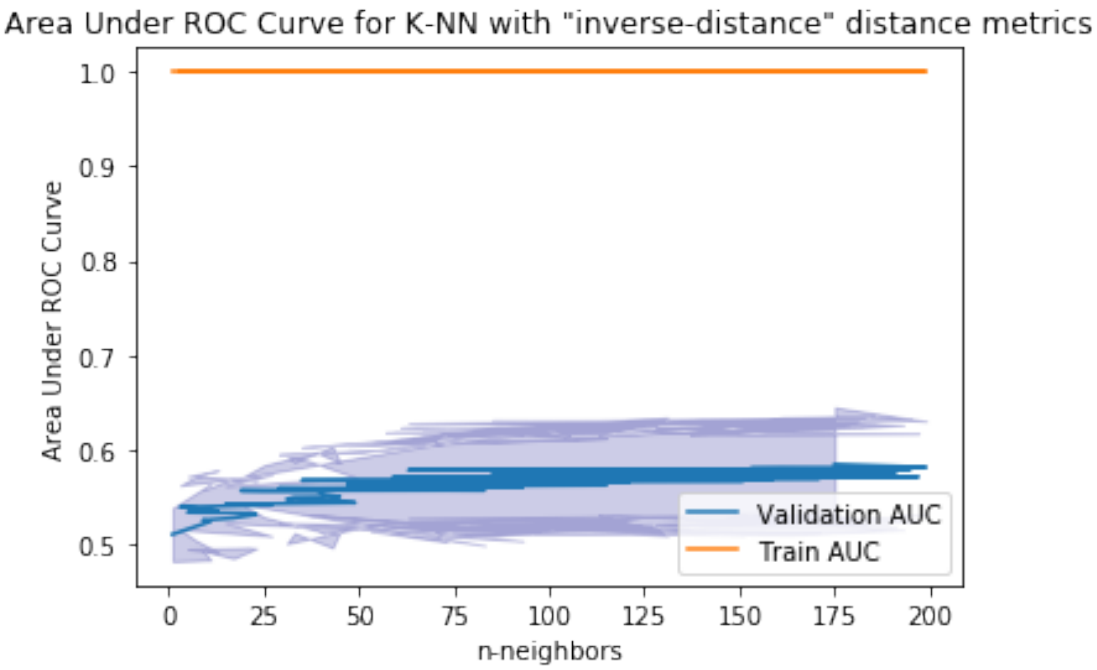
6.3.3 [5.2.3] Applying KNN kd-tree on AVG W2V, SET 3

```
In [122]: # Please write all the code with proper documentation
          path = 'saved_models/grid_search_cv_avg_w2v_kd.pkl'

          cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                              Y=Dy_train,
                                                                              algorithm='kd_tree',
                                                                              vectorizer='Avg-W2Vec',
                                                                              model_path=path)

          #PrettyTable Data Collection
          prettytable_data.append(['Avg-W2Vec-kd', best_hyperparameters['knn__algorithm'], best

          #analysing the dataframe
          analyse_results(cresults)


          #Retrain with the best foud hyperparameters
          ##Initializing Vectorizer
          vectorizer = Avg_W2Vec_Vectorizer()
          vectorizer.fit(Dx_train, Dy_train)
          x_train = vectorizer.transform(Dx_train)
          x_test = vectorizer.transform(Dx_test)
          #fitting the model
```

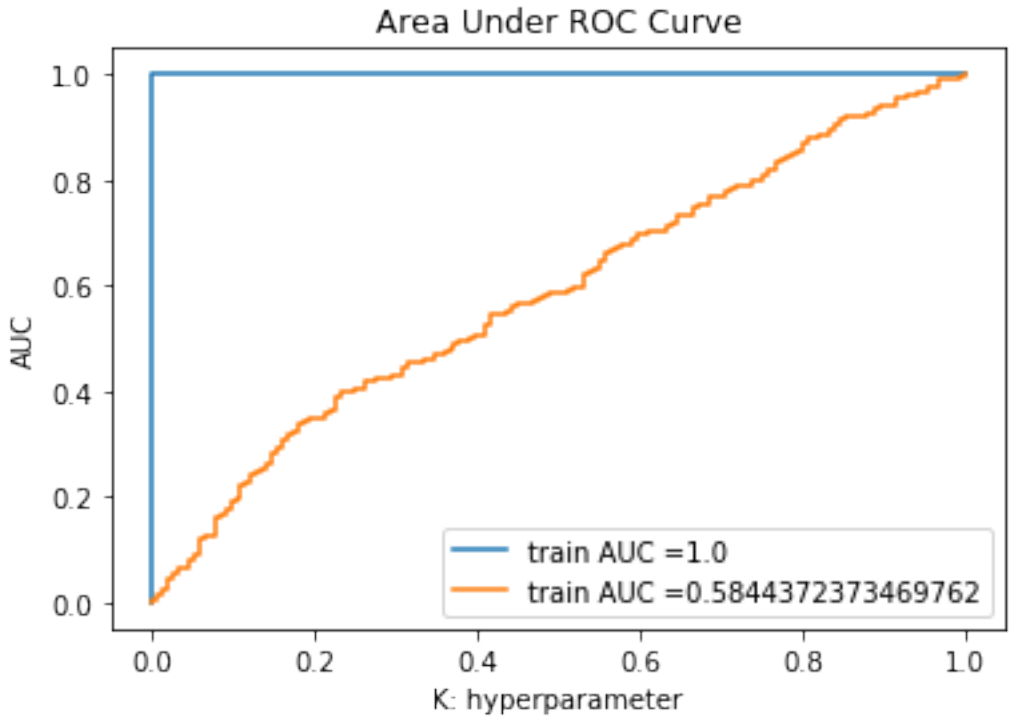
```
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype

#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

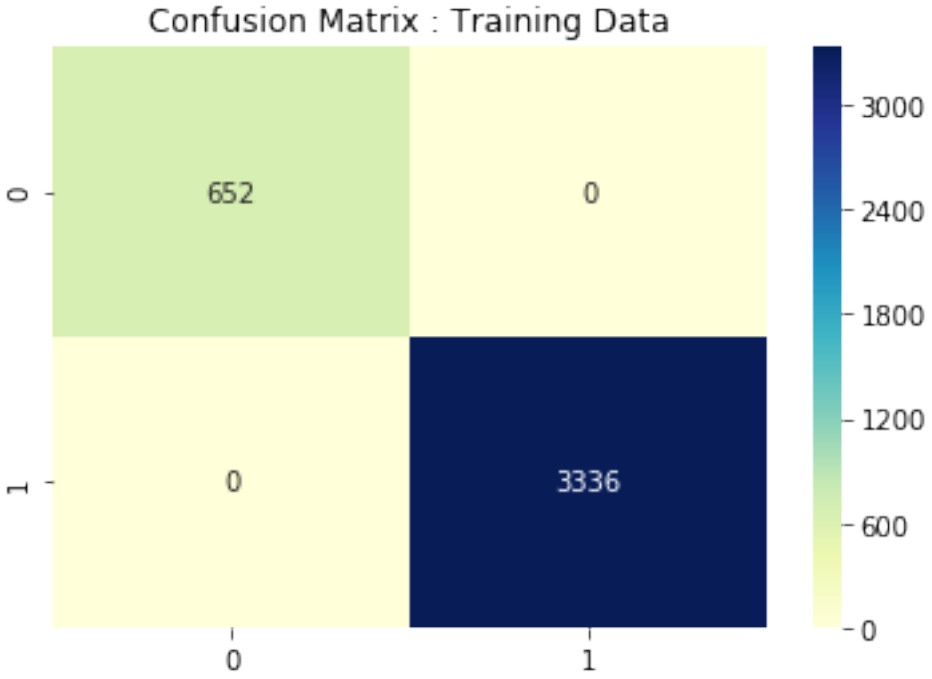
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'kd_tree', 'knn__n_neighb
with the max area of 0.5843349739756926
```

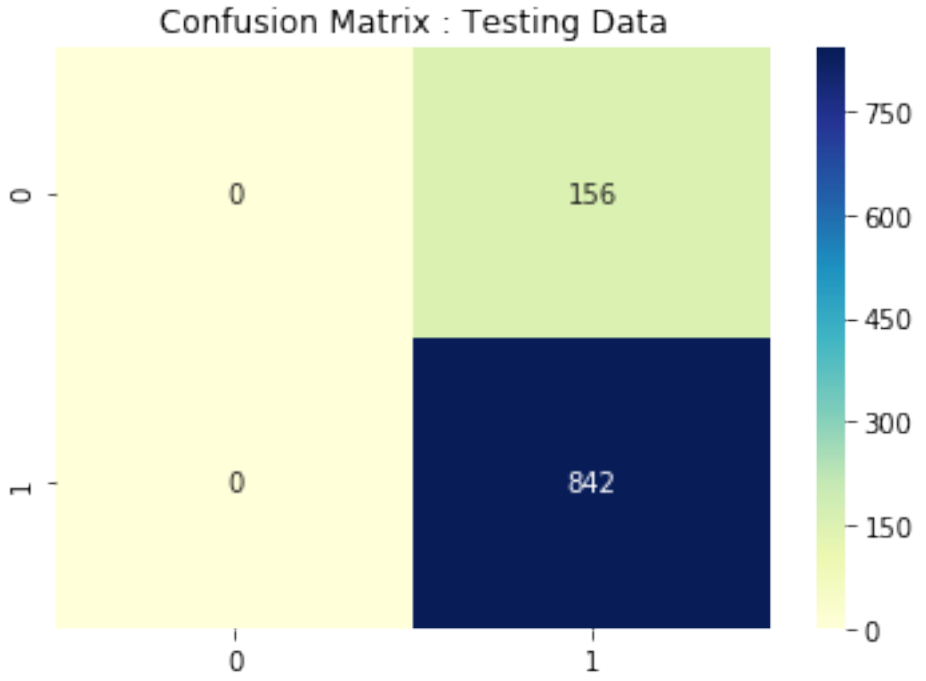





```
Area Under the Curve for Train :  1.0
Area Under the Curve for Test :  0.5844372373469762
```



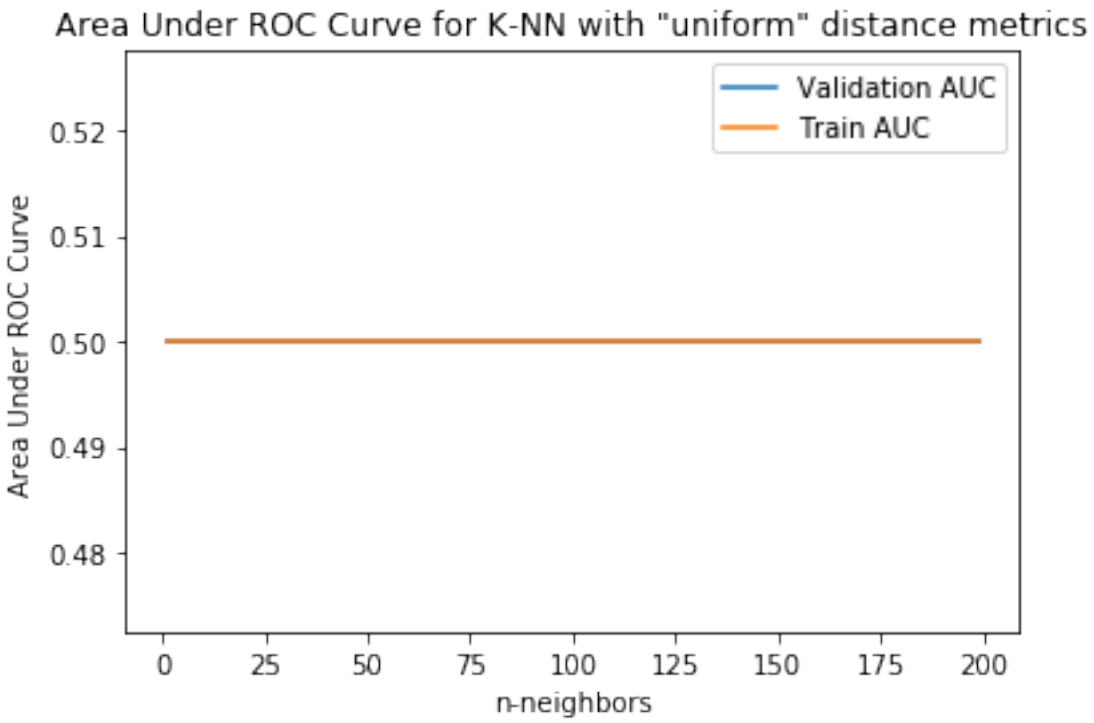

Confusion Matrix : Training Data
652
0
0
3336
0
1
0
1
3000
2400
1800
1200
600
0

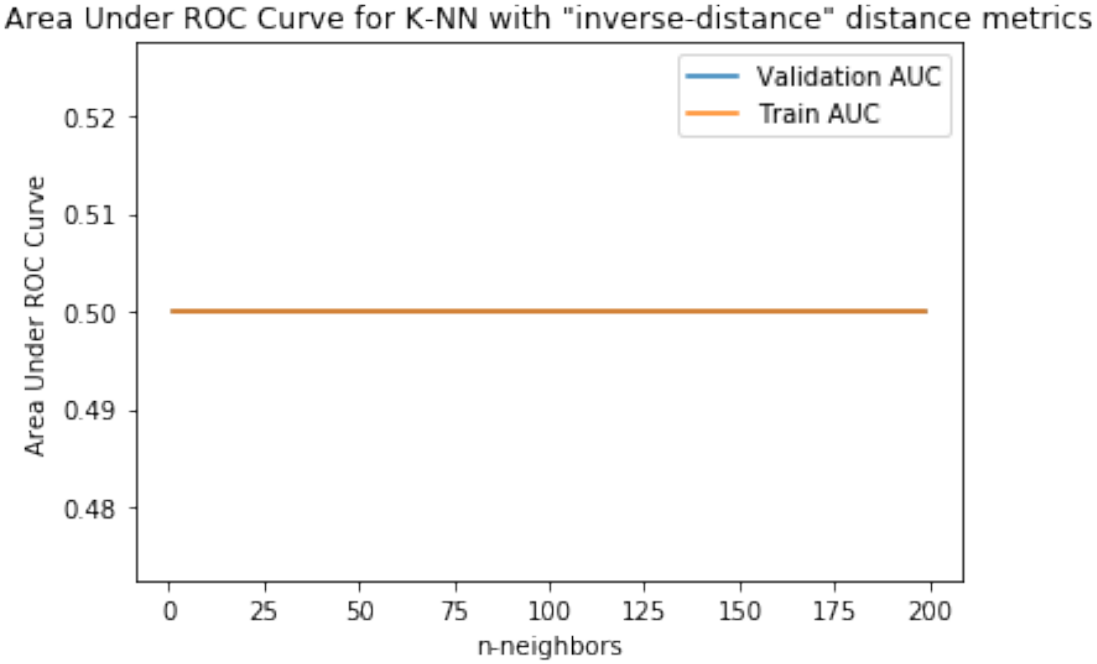

Confusion Matrix : Testing Data
0
156
0
842
0
1
0
1
750
600
450
300
150
0

6.3.4 [5.2.4] Applying KNN kd-tree on TFIDF W2V, SET 4

In [123]:
```
# Please write all the code with proper documentation
path = 'saved_models/grid_search_cv_tf_idf_w2v_kd.pkl'
cresults, best_hyperparameters, best_score = perform_grid_search_cv(X=Dx_train,
                                                                    Y=Dy_train,
                                                                    algorithm='kd_tree',
                                                                    vectorizer='TFIDF-W2Vec',
                                                                    model_path=path)


#PrettyTable Data Collection
prettytable_data.append(['TFIDF-W2Vec-kd', best_hyperparameters['knn__algorithm'], be

#analysing the dataframe
analyse_results(cresults)


#Retrain with the best foud hyperparameters
##Initializing Vectorizer
vectorizer = Tfidf_W2Vec_Vectorizer()
vectorizer.fit(Dx_train, Dy_train)
x_train = vectorizer.transform(Dx_train)
x_test = vectorizer.transform(Dx_test)
#fitting the model
knn = retrain_with_best_hyperparameters(X=x_train, Y=Dy_train, best_params_=best_hype

#Plot Area Under ROC Curve
plot_AUC_ROC(knn, x_train, Dy_train, x_test, Dy_test)

#Plotting confusion matrix x_train
plot_confusion_matrix(knn, x_train, Dy_train, 'Training Data')
#Plotting confusion matrix x_test
plot_confusion_matrix(knn, x_test, Dy_test, 'Testing Data')
```

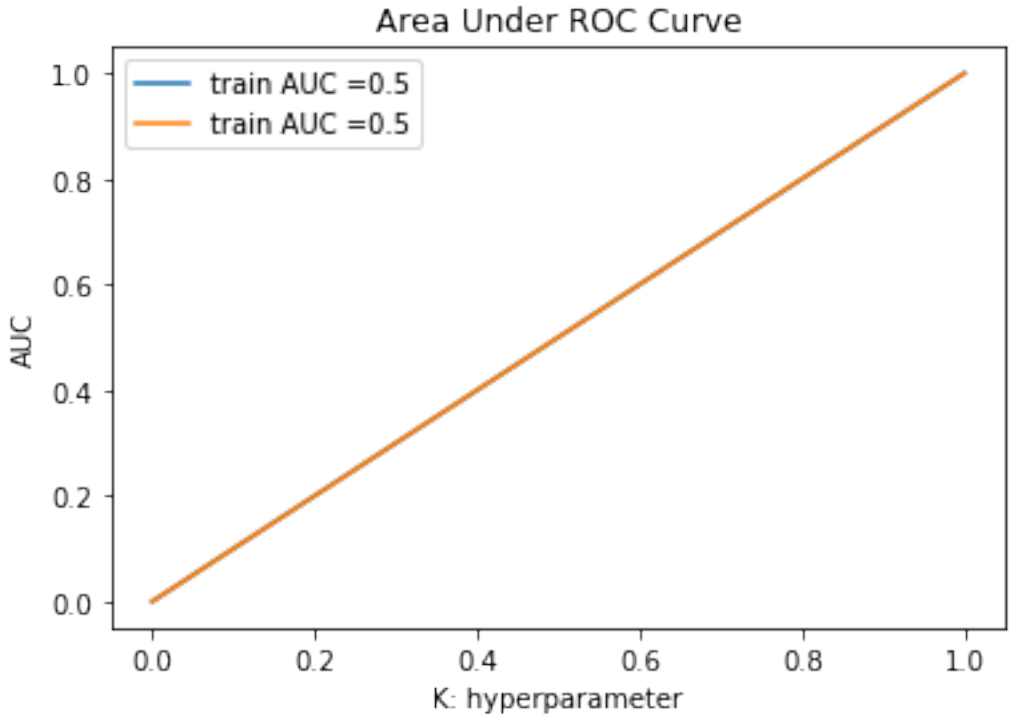
```
Maximum Area under ROC Curve with best params as : {'knn__algorithm': 'kd_tree', 'knn__n_neighb
with the max area of 0.5
```

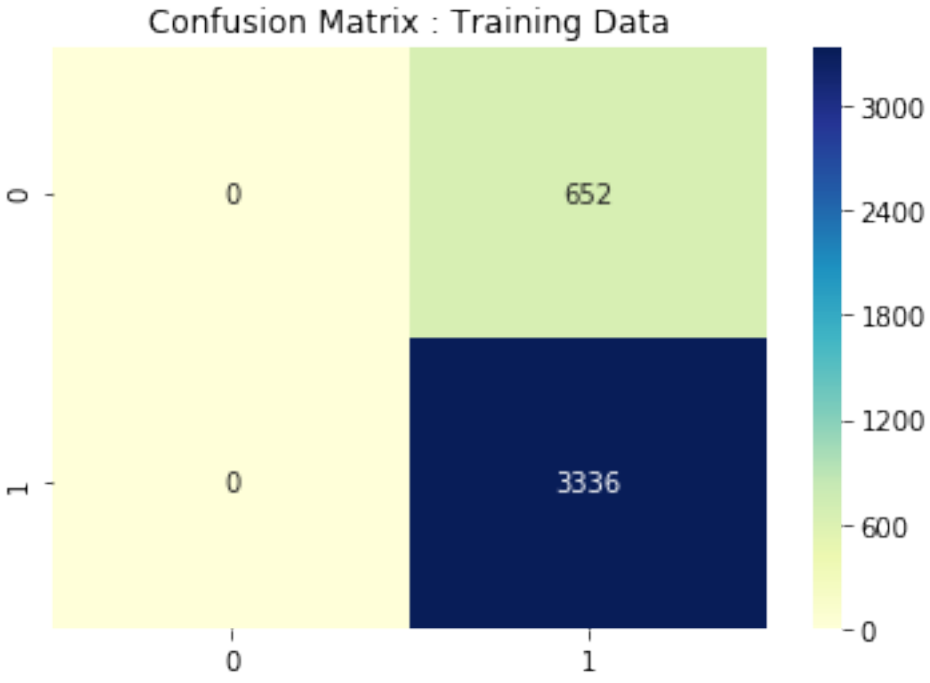


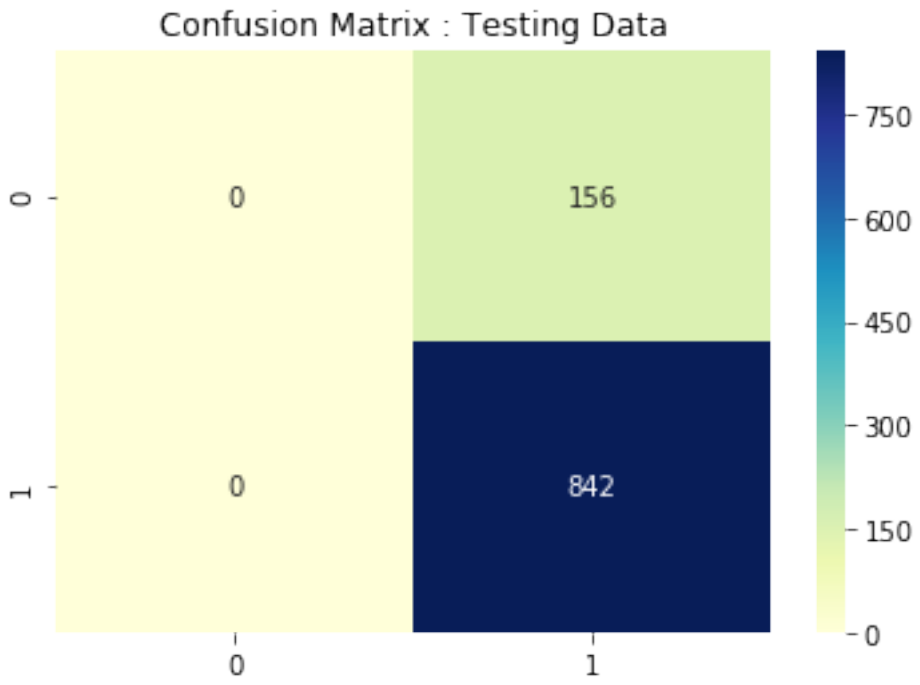



```
Area Under the Curve for Train :  0.5
```

```
Area Under the Curve for Test :  0.5
```







7 [6] Conclusions

In [124]: *# Please compare all your models using Prettytable library*

In [125]:
```
x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyper parameter", "AUC"]
[x.add_row(i) for i in prettytable_data]
print(x)
```

```
+----------------+---------+-----------------+--------------------+
|   Vectorizer   |  Model  | Hyper parameter |        AUC         |
+----------------+---------+-----------------+--------------------+
|      BOW       |  brute  |       183       | 0.7724075411201159 |
|     TFIDF      |  brute  |       199       | 0.8702931577781877 |
|   Avg-W2Vec    |  brute  |       191       | 0.5844119289927674 |
|  TFIDF-W2Vec   |  brute  |        1        |        0.5         |
|     BOW-kd     | kd_tree |       183       | 0.7724075411201159 |
|   TF-IDF-kd    | kd_tree |       199       | 0.8702931577781877 |
|  Avg-W2Vec-kd  | kd_tree |       175       | 0.5843349739756926 |
| TFIDF-W2Vec-kd | kd_tree |        1        |        0.5         |
+----------------+---------+-----------------+--------------------+
```

7.1 TF-IDF Vectorizer seem to perform the best with the max AUC score of 0.87