03_Amazon_Fine_Food_Reviews_Analysis_KNN ass

January 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 [0]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")


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

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

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

        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle

        from tqdm import tqdm
        import os
```

```
In [0]: # using SQLite Table to read data.
        con = sqlite3.connect('drive/ai/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 """, con)

        # 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 (525814, 10)
```

```
Out[0]:    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 [0]: display = pd.read_sql_query("""
        SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
        FROM Reviews
        GROUP BY UserId
        HAVING COUNT(*)>1
        """, con)
```

```
In [0]: print(display.shape)
        display.head()
```

```
(80668, 7)
```

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

```
1  #oc-R11D9D7SHXIJB9  B005HG9ET0  Louis E. Emory "hoppy"  1342396800      5
2  #oc-R11DNU2NBKQ23Z  B007Y59HVM        Kim Cieszykowski  1348531200      1
3  #oc-R11O5J5ZVQE25C  B005HG9ET0           Penguin Chick  1346889600      5
4  #oc-R12KPBODL2B5ZD  B007OSBE1U   Christopher P. Presta  1348617600      1

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

```
In [0]: display[display['UserId']=='AZY10LLTJ71NX']
```

```
Out[0]:              UserId   ProductId                      ProfileName        Time  \
        80638  AZY10LLTJ71NX  B006P7E5ZI  undertheshrine "undertheshrine"  1334707200

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

```
In [0]: display['COUNT(*)'].sum()
```

```
Out[0]: 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 [0]: display= pd.read_sql_query("""
        SELECT *
        FROM Reviews
        WHERE Score != 3 AND UserId="AR5J8UI46CURR"
        ORDER BY ProductID
        """, con)
        display.head()
```

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

```
In [0]: #Deduplication of entries
        final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep=
        final.shape
```

```
Out[0]: (364173, 10)
```

```
In [0]: #Checking to see how much % of data still remains
        (final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

```
Out[0]: 69.25890143662969
```

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

        display.head()
```

```
Out[0]:       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 [0]: final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

```
In [0]: #Before starting the next phase of preprocessing lets see the number of entries left
        print(final.shape)

        #How many positive and negative reviews are present in our dataset?
        final['Score'].value_counts()

(364171, 10)


Out[0]: 1    307061
        0     57110
        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 [0]: # printing some random reviews
        sent_0 = final['Text'].values[0]
        print(sent_0)
        print("="*50)

        sent_1000 = final['Text'].values[1000]
        print(sent_1000)
        print("="*50)

        sent_1500 = final['Text'].values[1500]
        print(sent_1500)
        print("="*50)

        sent_4900 = final['Text'].values[4900]
        print(sent_4900)
        print("="*50)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're driving alo
==================================================
I was really looking forward to these pods based on the reviews.  Starbucks is good, but I pre
==================================================
Great ingredients although, chicken should have been 1st rather than chicken broth, the only t
==================================================
Can't do sugar.  Have tried scores of SF Syrups.  NONE of them can touch the excellence of thi
==================================================
```

```
In [0]: # https://codereview.stackexchange.com/questions/19663/http-url-validating
        i, j = 0 , 0
        for test in (final['Text'].values):
          i = i + 1
          if re.match('https?://(?:www)?(?:[\w-]{2,255}(?:\.\w{2,6}){1,2})(?:/[\w&%?#-]{1,300}
              print(test)
              print("indes = ",i)
              print("="*50)
              j = j + 1
              if j == 5:
                break;
```

```
http://www.amazon.com/gp/product/B0002XEI9O/ref=cm_cr_rev_prod_title<br /><br />So far, the Sp
indes =  18044
==================================================
http://www.amazon.com/gp/product/B000ER3EFC/ref=cm_cr_rev_prod_img<br /><br />I don't have a b
indes =  53187
==================================================
http://www.amazon.com/gp/product/B000MVGVY6/ref=cm_cr_rev_prod_img<br /><br />I have been in U
indes =  104802
==================================================
http://www.amazon.com/gp/product/B000UZP92Y/ref=cm_cr_rev_prod_title<br /><br />This product i
indes =  123863
==================================================
http://www.consumeraffairs.com/news04/2009/06/fda_evangers02.html<br /><br />This company has
indes =  130020
==================================================
```

```
In [0]: # printing some urls test reviews
        sent_18044 = final['Text'].values[18044 - 1]
        print(sent_18044)
        print("="*50)

        sent_53187 = final['Text'].values[53187 - 1]
        print(sent_53187)
        print("="*50)

        sent_104802 = final['Text'].values[104802 - 1]
        print(sent_104802)
        print("="*50)

        sent_123863 = final['Text'].values[123863 - 1]
        print(sent_123863)
        print("="*50)
```

```
http://www.amazon.com/gp/product/B0002XEI9O/ref=cm_cr_rev_prod_title<br /><br />So far, the Sp
==================================================
http://www.amazon.com/gp/product/B000ER3EFC/ref=cm_cr_rev_prod_img<br /><br />I don't have a b
==================================================
http://www.amazon.com/gp/product/B000MVGVY6/ref=cm_cr_rev_prod_img<br /><br />I have been in U
==================================================
http://www.amazon.com/gp/product/B000UZP92Y/ref=cm_cr_rev_prod_title<br /><br />This product i
==================================================
```

```
In [0]: # remove urls from text python: https://stackoverflow.com/a/40823105/4084039
        sent_18044 = re.sub(r"http\S+", "", sent_18044)
        sent_53187= re.sub(r"http\S+", "", sent_53187)
        sent_104802 = re.sub(r"http\S+", "", sent_104802)
        sent_123863 = re.sub(r"http\S+", "", sent_123863)

        print(sent_18044)
        print("="*40)
        print(sent_123863)
```

```
 /><br />So far, the Sprout Bag is good for growing various legume / bean - Sprouts. I am also
========================================
 /><br />This product is supposed to be the "Herbal Revive"  version but it does not exist in t
```

```
In [0]: # https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-
        from bs4 import BeautifulSoup

        soup = BeautifulSoup(sent_18044, 'lxml')
        text = soup.get_text()
        print(text)
        print("="*50)

        soup = BeautifulSoup(sent_53187, 'lxml')
        text = soup.get_text()
        print(text)
        print("="*50)

        soup = BeautifulSoup(sent_104802, 'lxml')
        text = soup.get_text()
        print(text)
        print("="*50)

        soup = BeautifulSoup(sent_123863, 'lxml')
        text = soup.get_text()
        print(text)
```

```
/>So far, the Sprout Bag is good for growing various legume / bean - Sprouts. I am also using t
==================================================
/>I don't have a baby, but I am on soft foods for a while after stomach surgery. I ordered some
==================================================
/>I have been in Utah over 25 years, at an altitude of about 4200 feet. My internist says that
==================================================
/>This product is supposed to be the "Herbal Revive"  version but it does not exist in the Amaz
```

```
In [0]: # 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 [0]: sent_18044 = decontracted(sent_18044)
        print(sent_18044)
        print("="*50)
        sent_53187 = decontracted(sent_53187)
        print(sent_53187)
        print("="*50)
        sent_123863 = decontracted(sent_123863)
        print(sent_123863)
        print("="*50)
```

```
 /><br />So far, the Sprout Bag is good for growing various legume / bean - Sprouts. I am also
==================================================
 /><br />I do not have a baby, but I am on soft foods for a while after stomach surgery. I orde
==================================================
 /><br />This product is supposed to be the "Herbal Revive"  version but it does not exist in t
==================================================
```

```
In [0]: # https://codereview.stackexchange.com/questions/19663/http-url-validating
        i, j = 0 , 0
        for test in (final['Text'].values):
          i = i + 1
          if re.match("\S*\d\S*",test):
              print(test)
              print("indes = ",i)
              print("="*50)
              j = j + 1
              if j == 5:
                break;
```

```
[[ASIN:B001AGXEAG Beetlejuice (20th Anniversary Deluxe Edition)]<br /><br />Beetlejuice, the Ti
indes =  391
==================================================
1st day, few stupid flies went in. 2nd day, it smell so so bad, had it relocated... 4th day, hu
indes =  752
==================================================
1st: my cats really don't eat this brand with much relish like they did when Wellness had the n
```

```
indes =  1699
==================================================
5 star.  Our vet recommended this product for our 8 year old male Golden Retriever.  He had so
indes =  2259
==================================================
24 packs for $19.94 comes to .83 per pack.  That is a bargain and does not even consider the s
indes =  2805
==================================================
```

```
In [0]: #remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
        sent = final['Text'].values[2805 - 1]
        print(sent)
```

```
24 packs for $19.94 comes to .83 per pack.  That is a bargain and does not even consider the s
```

```
In [0]: #remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
        sent = re.sub("\S*\d\S*", "", sent).strip()
        print(sent)
```

```
packs for  comes to  per pack.  That is a bargain and does not even consider the subscribe and
```

```
In [0]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
        sent_18044 = re.sub('[^A-Za-z0-9]+', ' ', sent_18044)
        print(sent_18044)
```

```
 br So far the Sprout Bag is good for growing various legume bean Sprouts I am also using the
```

```
In [0]: # 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', 'through
                    '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 [0]: # 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%|| 364171/364171 [02:38<00:00, 2298.24it/s]
```

```
In [0]: preprocessed_reviews[1500]
```

```
Out[0]: 'great ingredients although chicken rather chicken broth thing not think belongs canola
```

[3.2] Preprocessing Review Summary

```
In [0]: ## Similartly you can do preprocessing for review summary also.
        ## Similartly you can do preprocessing for review summary also.
        preprocessed_reviews_summary = []
        # 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 stopwo
            preprocessed_reviews_summary.append(sentance.strip())
```

```
100%|| 364171/364171 [01:46<00:00, 3419.59it/s]
```

```
In [0]: preprocessed_reviews_summary[1500]
```

```
Out[0]: 'would best canola oil left'
```

```
In [0]: # adding new columns ["CleanedText", "CleanedSummary"] to the data frame and save that
        final["CleanedText"] = preprocessed_reviews
        final["CleanedSummary"] = preprocessed_reviews_summary
        final.tail()
```

```
Out[0]:             Id   ProductId          UserId    ProfileName  \
        178145  193174  B009RSR8H0   A4P6AN2L435PV         romarc
        173675  188389  B009SF0TN6  A1L0GWGRK4BYPT  Bety Robinson
        204727  221795  B009SR40Q2  A32A6X5KCP7ARG        sicamar
        5259      5703  B009WSNWC4   AMP7K1084DH1T           ESTY
        302474  327601  B009WVB40S  A3ME78KVX31T21           K'la

                HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
        178145                     0                       0      1  1350432000
        173675                     0                       0      1  1350518400
        204727                     1                       1      1  1350604800
        5259                       0                       0      1  1351209600
        302474                     0                       0      1  1351123200

                                                  Summary  \
        178145                             LOVE!!  LOVE!!
        173675  Amazing!! Great sauce for everything!
        204727                              Awesome Taste
        5259                                    DELICIOUS
        302474                                     Tasty!

                                                             Text  \
        178145  LOVE, LOVE this sweetener!!  I use it in all m...
        173675  You have to try this sauce to believe it! It s...
        204727  I bought this Hazelnut Paste (Nocciola Spread)...
        5259    Purchased this product at a local store in NY ...
        302474  I purchased this to send to my son who's away ...

                                                      CleanedText  \
        178145  love love sweetener use baking unsweetened fla...
        173675  try sauce believe starts little sweet honey ta...
        204727  bought hazelnut paste nocciola spread local sh...
        5259    purchased product local store ny kids love qui...
        302474  purchased send son away college delivered righ...

                                CleanedSummary
        178145                       love love
        173675  amazing great sauce everything
        204727                   awesome taste
        5259                         delicious
        302474                           tasty
```

```
In [0]: # save the data frame as "preprocessed.pkl"
        final.to_pickle("drive/ai/preprocessed.pkl")
```

5 [4] Featurization

I am used to select 50k data points randaand sord them using time based splitting

```
In [0]: # Split the data into train , test and crossvalidation datasets
        # load "preprocessed.pkl" data frame
        df = pd.read_pickle("drive/ai/preprocessed.pkl")
        df.head(1)
```

```
Out[0]:             Id   ProductId         UserId      ProfileName  \
        138706  150524  0006641040  ACITT7DI6IDDL  shari zychinski

                HelpfulnessNumerator  HelpfulnessDenominator  Score       Time  \
        138706                     0                       0      1  939340800

                                  Summary  \
        138706  EVERY book is educational

                                                             Text  \
        138706  this witty little book makes my son laugh at l...

                                                      CleanedText  \
        138706  witty little book makes son laugh loud recite ...

                        CleanedSummary
        138706  every book educational
```

```
In [0]: df.shape
```

```
Out[0]: (364171, 12)
```

```
In [0]: # take 50k sample data randomly
        sample_data = df.sample(50000)
        sample_data.shape
```

```
Out[0]: (50000, 12)
```

```
In [0]: # sorted the data using time based
        sorted_data = sample_data.sort_values('Time', axis=0, inplace=False)
        sorted_data.shape
```

```
Out[0]: (50000, 12)
```

```
In [0]: sorted_data['Score'].value_counts()
```

```
Out[0]: 1    42277
        0     7723
        Name: Score, dtype: int64
```

```
In [0]: from sklearn.model_selection import train_test_split
```

```
In [0]: X = np.array(sorted_data['CleanedText'])
        y = np.array(sorted_data['Score'])
        print(X.shape)
        print(y.shape)
```

```
(50000,)
(50000,)
```

```
In [0]: # Simple cross validation
        # split the data sent into train and test
        train , test , train_y , test_y = train_test_split(X, y, test_size = 0.3, random_state=

        # split the train data set into cross validation train and cross validation test
        train, cv , train_y, cv_y = train_test_split(train, train_y, test_size=0.3, random_sta

        print("train data = ", train.shape)
        print("cros validation = ", cv.shape)
        print("test data = ", test.shape)
```

```
train data =  (24500,)
cros validation =  (10500,)
test data =  (15000,)
```

```
In [0]:
```

5.1 [4.1] BAG OF WORDS

```
In [0]: #BoW
        count_vect = CountVectorizer() #in scikit-learn
        count_vect.fit(train)
        print("some feature names ", count_vect.get_feature_names()[:10])
        print('='*50)

        final_counts_train = count_vect.fit_transform(train)
        final_counts_cv = count_vect.transform(cv)
        final_counts_test = count_vect.transform(test)
        print("============Train Data=========")
        print("the type of count vectorizer ",type(final_counts_train))
        print("the shape of out text BOW vectorizer ",final_counts_train.get_shape())
        print("the number of unique words ", final_counts_train.get_shape()[1])
        print("============Cross validation Data=========")
        print("the type of count vectorizer ",type(final_counts_cv))
        print("the shape of out text BOW vectorizer ",final_counts_cv.get_shape())
        print("the number of unique words ", final_counts_cv.get_shape()[1])
        print("============Test Data=========")
        print("the type of count vectorizer ",type(final_counts_test))
        print("the shape of out text BOW vectorizer ",final_counts_test.get_shape())
        print("the number of unique words ", final_counts_test.get_shape()[1])
```

```
some feature names  ['aa', 'aaa', 'aaaaaaarrrrrggghhh', 'aaah', 'aaahhhs', 'aabsolutely', 'aaf
==================================================
============Train Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (24500, 30806)
the number of unique words  30806
============Cross validation Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (10500, 30806)
the number of unique words  30806
============Test Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (15000, 30806)
the number of unique words  30806
```

```
In [0]: # the time of bagofwords is sparse matrix now convert to lower dimensions
        # Dimensionality reduction using truncated SVD
        from sklearn.decomposition import TruncatedSVD

        bagofwords_svd = TruncatedSVD(n_components= 500) #Desired dimensionality of output dat

        bow_train = bagofwords_svd.fit_transform(final_counts_train)
        print('Explained Variance Ratio is = %0.2f%%'% (bagofwords_svd.explained_variance_rati
        bow_cv = bagofwords_svd.fit_transform(final_counts_cv)
        bow_test = bagofwords_svd.fit_transform(final_counts_test)
        print("trian data shape = ", bow_train.shape)
        print("CV data shape = ", bow_cv.shape)
        print("test data shape = ", bow_test.shape)
```

```
Explained Variance Ratio is = 67.43%
trian data shape =  (24500, 500)
CV data shape =  (10500, 500)
test data shape =  (15000, 500)
```

```
In [0]: # save the datasets as numpy array
        bow_train = np.array(bow_train)
        bow_cv = np.array(bow_cv)
        bow_test = np.array(bow_test)
```

```
In [0]: np.save("drive/ai/bow_train.npy", bow_train)
        np.save("drive/ai/bow_train_y.npy", train_y)
        np.save("drive/ai/bow_cv.npy", bow_cv)
        np.save("drive/ai/bow_cv_y.npy", cv_y)
        np.save("drive/ai/bow_test.npy", bow_test)
        np.save("drive/ai/bow_test_y.npy", test_y)
```

```
In [0]: ## for kd_tree
```

5.2 for kd_tree

```
In [0]: # the time of bagofwords is sparse matrix now convert to lower dimensions
        # Dimensionality reduction using truncated SVD
        from sklearn.decomposition import TruncatedSVD

        bagofwords_svd = TruncatedSVD(n_components= 200) #Desired dimensionality of output dat

        bow_train = bagofwords_svd.fit_transform(final_counts_train)
        print('Explained Variance Ratio is = %0.2f%%'% (bagofwords_svd.explained_variance_ratio
        bow_cv = bagofwords_svd.fit_transform(final_counts_cv)
        bow_test = bagofwords_svd.fit_transform(final_counts_test)
        print("trian data shape = ", bow_train.shape)
        print("CV data shape = ", bow_cv.shape)
        print("test data shape = ", bow_test.shape)
```

```
Explained Variance Ratio is = 50.60%
trian data shape =  (24500, 200)
CV data shape =  (10500, 200)
test data shape =  (15000, 200)
```

```
In [0]: # save the datasets as numpy array
        bow_train = np.array(bow_train)
        bow_cv = np.array(bow_cv)
        bow_test = np.array(bow_test)
```

```
In [0]: np.save("drive/ai/kd_bow_train.npy", bow_train)
        np.save("drive/ai/kd_bow_train_y.npy", train_y)
        np.save("drive/ai/kd_bow_cv.npy", bow_cv)
        np.save("drive/ai/kd_bow_cv_y.npy", cv_y)
        np.save("drive/ai/kd_bow_test.npy", bow_test)
        np.save("drive/ai/kd_bow_test_y.npy", test_y)
```

5.3 [4.2] Bi-Grams and n-Grams.

```
In [0]: #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/modu

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

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

5.4 [4.3] TF-IDF

```
In [0]: tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
        tf_idf_vect.fit(train)
        print("some sample features(unique words in the corpus)",tf_idf_vect.get_feature_names
        print('='*50)
        print("================Train Data===========")
        final_tf_idf_train = tf_idf_vect.fit_transform(train)
        print("the type of count vectorizer ",type(final_tf_idf_train))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_train.get_shape())
        print("the number of unique words including both unigrams and bigrams ", final_tf_idf_
        print("================CV Data===========")
        final_tf_idf_cv = tf_idf_vect.transform(cv)
        print("the type of count vectorizer ",type(final_tf_idf_cv))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_cv.get_shape())
        print("the number of unique words including both unigrams and bigrams ", final_tf_idf_
        print("================Test Data===========")
        final_tf_idf_test = tf_idf_vect.transform(test)
        print("the type of count vectorizer ",type(final_tf_idf_test))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_test.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 buy', 'able eat', '
==================================================
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (24500, 14443)
the number of unique words including both unigrams and bigrams  14443
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (10500, 14443)
the number of unique words including both unigrams and bigrams  14443
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (15000, 14443)
the number of unique words including both unigrams and bigrams  14443
```

```
In [0]: # the time of bagofwords is sparse matrix now convert to lower dimensions
        # Dimensionality reduction using truncated SVD

        tfidf_svd = TruncatedSVD(n_components= 500) #Desired dimensionality of output data

        tfidf_train = tfidf_svd.fit_transform(final_tf_idf_train)
        print('Explained Variance Ratio is = %0.2f%%'% (tfidf_svd.explained_variance_ratio_.su
        tfidf_cv = bagofwords_svd.fit_transform(final_tf_idf_cv)
        tfidf_test = bagofwords_svd.fit_transform(final_tf_idf_test)
        print("trian data shape = ", tfidf_train.shape)
        print("CV data shape = ", tfidf_cv.shape)
        print("test data shape = ", tfidf_test.shape)
```

```
Explained Variance Ratio is = 34.12%
trian data shape =  (24500, 500)
CV data shape =  (10500, 500)
test data shape =  (15000, 500)
```

```
In [0]: # save the datasets as numpy array
        tfidf_train = np.array(tfidf_train)
        tfidf_cv = np.array(tfidf_cv)
        tfidf_test = np.array(tfidf_test)
```

```
In [0]: np.save("drive/ai/tfidf_train.npy", tfidf_train)
        np.save("drive/ai/tfidf_train_y.npy", train_y)
        np.save("drive/ai/tfidf_cv.npy", tfidf_cv)
        np.save("drive/ai/tfidf_cv_y.npy", cv_y)
        np.save("drive/ai/tfidf_test.npy", tfidf_test)
        np.save("drive/ai/tfidf_test_y.npy", test_y)
```

5.5 for kd_tree

```
In [0]: # the time of bagofwords is sparse matrix now convert to lower dimensions
        # Dimensionality reduction using truncated SVD

        tfidf_svd = TruncatedSVD(n_components= 200) #Desired dimensionality of output data

        tfidf_train = tfidf_svd.fit_transform(final_tf_idf_train)
        print('Explained Variance Ratio is = %0.2f%%'% (tfidf_svd.explained_variance_ratio_.su
        tfidf_cv = bagofwords_svd.fit_transform(final_tf_idf_cv)
        tfidf_test = bagofwords_svd.fit_transform(final_tf_idf_test)
        print("trian data shape = ", tfidf_train.shape)
        print("CV data shape = ", tfidf_cv.shape)
        print("test data shape = ", tfidf_test.shape)
```

```
Explained Variance Ratio is = 20.69%
trian data shape =  (24500, 200)
CV data shape =  (10500, 200)
test data shape =  (15000, 200)
```

```
In [0]: # save the datasets as numpy array
        tfidf_train = np.array(tfidf_train)
        tfidf_cv = np.array(tfidf_cv)
        tfidf_test = np.array(tfidf_test)
```

```
In [0]: np.save("drive/ai/kd_tfidf_train.npy", tfidf_train)
        np.save("drive/ai/kd_tfidf_train_y.npy", train_y)
        np.save("drive/ai/kd_tfidf_cv.npy", tfidf_cv)
        np.save("drive/ai/kd_tfidf_cv_y.npy", cv_y)
        np.save("drive/ai/kd_tfidf_test.npy", tfidf_test)
        np.save("drive/ai/kd_tfidf_test_y.npy", test_y)
```

5.6 [4.4] Word2Vec

```
In [0]: # Train your own Word2Vec model using your own text corpus
        ######## Train Set #########
        i=0
        list_of_train_sentance=[]
        for sentance in train:
            list_of_train_sentance.append(sentance.split())
        ######## CV Set ###########
        i=0
        list_of_cv_sentance=[]
        for sentance in cv:
            list_of_cv_sentance.append(sentance.split())
        ######## Test Set #########
        i=0
        list_of_test_sentance=[]
        for sentance in test:
            list_of_test_sentance.append(sentance.split())
        print("Length of Train = ", len(list_of_train_sentance))
        print("Length of CV = ", len(list_of_cv_sentance))
        print("Length of Test = ", len(list_of_test_sentance))
```

```
Length of Train =  24500
Length of CV =  10500
Length of Test =  15000
```

```
In [0]: # Using Google News Word2Vectors

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


        # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
        # you can comment this whole cell
        # or change these varible according to your need
        is_your_ram_gt_16g=False
        want_to_use_google_w2v = False
        want_to_train_w2v = True

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

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

```
[('snack', 0.9951335191726685), ('calorie', 0.9946465492248535), ('wonderful', 0.99460321664810
==================================================
[('varieties', 0.9994194507598877), ('become', 0.9992934465408325), ('popcorn', 0.999275088310
```

```
In [0]: w2v_model=Word2Vec(list_of_train_sentance,min_count=5,size=50, workers=4)
        print(w2v_model.wv.most_similar('great'))
        print('='*50)
        print(w2v_model.wv.most_similar('worst'))
```

```
[('awesome', 0.8108956813812256), ('excellent', 0.8053444623947144), ('wonderful', 0.803691029
==================================================
[('best', 0.7953071594238281), ('coolest', 0.7594555020332336), ('disgusting', 0.751032471656
```

```
In [0]: 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  9882
sample words  ['looked', 'everywhere', 'reviews', 'product', 'buying', 'could', 'not', 'find',
```

```
In [0]:
```

```
In [0]:
```

5.7 [4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

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

```
100%|| 24500/24500 [00:44<00:00, 551.45it/s]

24500
50
```

```
In [0]: ######## CV data ########
        # 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_cv_sentance): # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need to
            cnt_words =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                if word in w2v_words:
                    vec = w2v_model.wv[word]
                    sent_vec += vec
                    cnt_words += 1
            if cnt_words != 0:
                sent_vec /= cnt_words
            sent_vectors_cv.append(sent_vec)
        print(len(sent_vectors_cv))
        print(len(sent_vectors_cv[0]))
```

```
100%|| 10500/10500 [00:19<00:00, 536.26it/s]

10500
50
```

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

```
100%|| 15000/15000 [00:27<00:00, 551.77it/s]

15000
50
```

```
In [0]: # save the datasets as numpy array
        w2v_train = np.array(sent_vectors_train)
        w2v_cv = np.array(sent_vectors_cv)
        w2v_test = np.array(sent_vectors_test)
```

```
In [0]: np.save("drive/ai/w2v_train.npy", w2v_train)
        np.save("drive/ai/w2v_train_y.npy", train_y)
        np.save("drive/ai/w2v_cv.npy", w2v_cv)
        np.save("drive/ai/w2v_cv_y.npy", cv_y)
        np.save("drive/ai/w2v_test.npy", w2v_test)
        np.save("drive/ai/w2v_test_y.npy", test_y)
```

[4.4.1.2] TFIDF weighted W2v

```
In [0]: model = TfidfVectorizer()
        #tf_idf_matrix = model.fit_transform(train)

        print("================Train Data===========")
        final_tf_idf_train = model.fit_transform(train)
        print("the type of count vectorizer ",type(final_tf_idf_train))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_train.get_shape())
        print("the number of unique words including both unigrams and bigrams ", final_tf_idf_
        print("================CV Data===========")
        final_tf_idf_cv = model.transform(cv)
        print("the type of count vectorizer ",type(final_tf_idf_cv))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_cv.get_shape())
        print("the number of unique words including both unigrams and bigrams ", final_tf_idf_c
        print("================Test Data===========")
        final_tf_idf_test = model.transform(test)
        print("the type of count vectorizer ",type(final_tf_idf_test))
        print("the shape of out text TFIDF vectorizer ",final_tf_idf_test.get_shape())
        print("the number of unique words including both unigrams and bigrams ", final_tf_idf_

        # 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_)))
```

```
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (24500, 30961)
the number of unique words including both unigrams and bigrams  30961
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (10500, 30961)
the number of unique words including both unigrams and bigrams  30961
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (15000, 30961)
the number of unique words including both unigrams and bigrams  30961
```

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

        train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in t
        row=0;
        for sent in tqdm(list_of_train_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
            train_tfidf_sent_vectors.append(sent_vec)
            row += 1
```

```
100%|| 24500/24500 [08:09<00:00, 50.06it/s]
```

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

        cv_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this
        row=0;
        for sent in tqdm(list_of_cv_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
            cv_tfidf_sent_vectors.append(sent_vec)
            row += 1
```

```
100%|| 10500/10500 [03:33<00:00, 49.12it/s]
```

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

        test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in th
        row=0;
        for sent in tqdm(list_of_test_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
    test_tfidf_sent_vectors.append(sent_vec)
    row += 1
```

```
100%|| 15000/15000 [04:52<00:00, 51.23it/s]
```

```
In [0]: # save the datasets as numpy array
        tfidf_w2v_train = np.array(train_tfidf_sent_vectors)
        tfidf_w2v_cv = np.array(cv_tfidf_sent_vectors)
        tfidf_w2v_test = np.array(test_tfidf_sent_vectors)
```

```
In [0]: np.save("drive/ai/w2v_tfidf_train.npy", tfidf_w2v_train)
        np.save("drive/ai/w2v_tfidf_train_y.npy", train_y)
        np.save("drive/ai/w2v_tfidf_cv.npy", tfidf_w2v_cv)
        np.save("drive/ai/w2v_tfidf_cv_y.npy", cv_y)
        np.save("drive/ai/w2v_tfidf_test.npy", tfidf_w2v_test)
        np.save("drive/ai/w2v_tfidf_test_y.npy", test_y)
```

6 [5] Assignment 3: KNN

Apply Knn(brute force version) on these feature sets
SET 1:Review text, preprocessed one converted into vectors using (BOW)
SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)
SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)

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

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

```
</li>
<li><font color='red'>SET 6:</font>Review text, preprocessed one converted into vector
<pre>
    tf_idf_vect = TfidfVectorizer(min_df=10, max_features=500)
```

```
            tf_idf_vect.fit(preprocessed_reviews)
        </pre>
        </li>
        <li><font color='red'>SET 3:</font>Review text, preprocessed one converted into 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 [0]:

```
In [0]: from sklearn.neighbors import KNeighborsClassifier
        from sklearn.metrics import accuracy_score , f1_score , confusion_matrix
        from collections import Counter
        from sklearn.metrics import accuracy_score, roc_auc_score , roc_curve
        from sklearn.model_selection import train_test_split
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (BOW)
        bow_train = np.load("drive/ai/bow_train.npy")
        bow_train_y = np.load("drive/ai/bow_train_y.npy")
        bow_cv = np.load("drive/ai/bow_cv.npy")
        bow_cv_y = np.load("drive/ai/bow_cv_y.npy")
        bow_test = np.load("drive/ai/bow_test.npy")
        bow_test_y = np.load("drive/ai/bow_test_y.npy")
```

```
In [0]: print("Shape of Train = ", bow_train.shape)
        print("Shape of CV = ", bow_cv.shape)
        print("Shape of Test = ", bow_test.shape)
```

```
Shape of Train =  (24500, 500)
Shape of CV =  (10500, 500)
Shape of Test =  (15000, 500)
```

```
In [0]: bow_train_auc = []
        bow_cv_auc = []
        for i in range(1,10,2):
          knn = KNeighborsClassifier(n_neighbors=i)
          knn.fit(bow_train, bow_train_y)
          # train data
          y_prob_train = knn.predict_proba(bow_train)[:,1]
          y_pred = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(bow_train_y , y_prob_train)
          print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
          bow_train_auc.append(auc_roc_test)
          # CV
          y_prob_cv = knn.predict_proba(bow_cv)[:,1]
          y_pred = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(bow_cv_y , y_prob_cv)
          print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
          bow_cv_auc.append(auc_roc_cv)
```

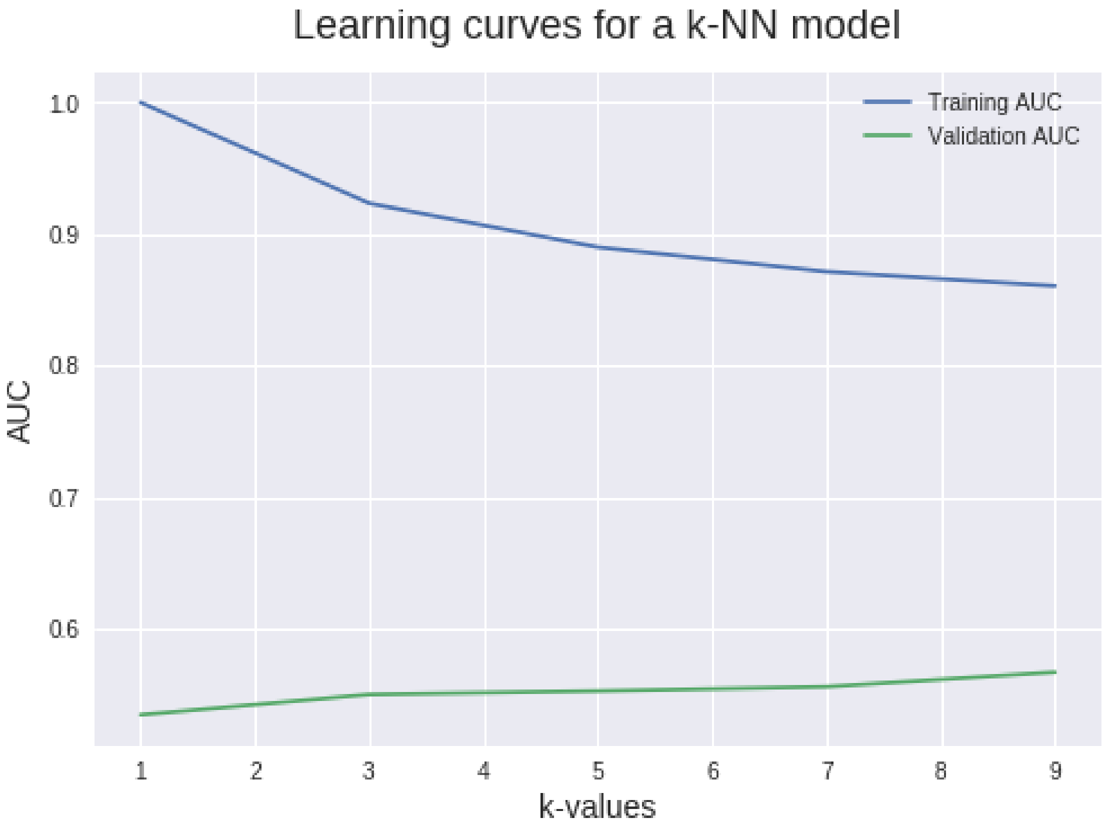
```
Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 53.47%
```

```
Train AUC for k = 3 is 92.31%

CV AUC for k = 3 is 55.03%

Train AUC for k = 5 is 88.99%

CV AUC for k = 5 is 55.29%

Train AUC for k = 7 is 87.13%

CV AUC for k = 7 is 55.61%

Train AUC for k = 9 is 86.04%

CV AUC for k = 9 is 56.72%
```

```
In [0]: k_values = [j for j in range(1,10,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        import matplotlib.pyplot as plt
        %matplotlib inline

        plt.style.use('seaborn')

        plt.plot(k_values, bow_train_auc, label = 'Training AUC')
        plt.plot(k_values, bow_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

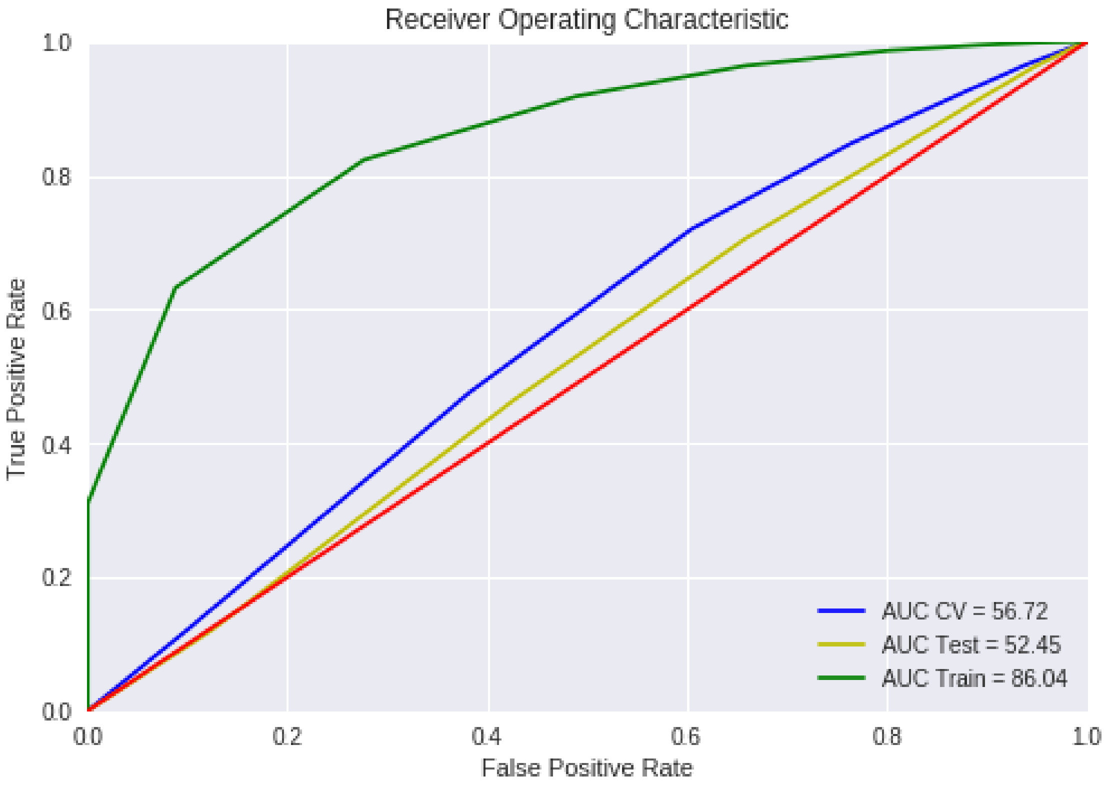
```
Out[0]: <matplotlib.legend.Legend at 0x7f2bd83f5748>
```



```
In [0]: knn = KNeighborsClassifier(n_neighbors=9)
        knn.fit(bow_train, bow_train_y)
        # train data
        y_prob_train = knn.predict_proba(bow_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(bow_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(bow_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(bow_cv)[:,1]
        fprc, tprc , throsholdc = roc_curve(bow_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(bow_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (9, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(bow_test)[:,1]
        fprts, tprts , throsholdts = roc_curve(bow_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(bow_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 9 is 86.04%

CV AUC for k = 9 is 56.72%

Test AUC for k = 9 is 52.45%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```

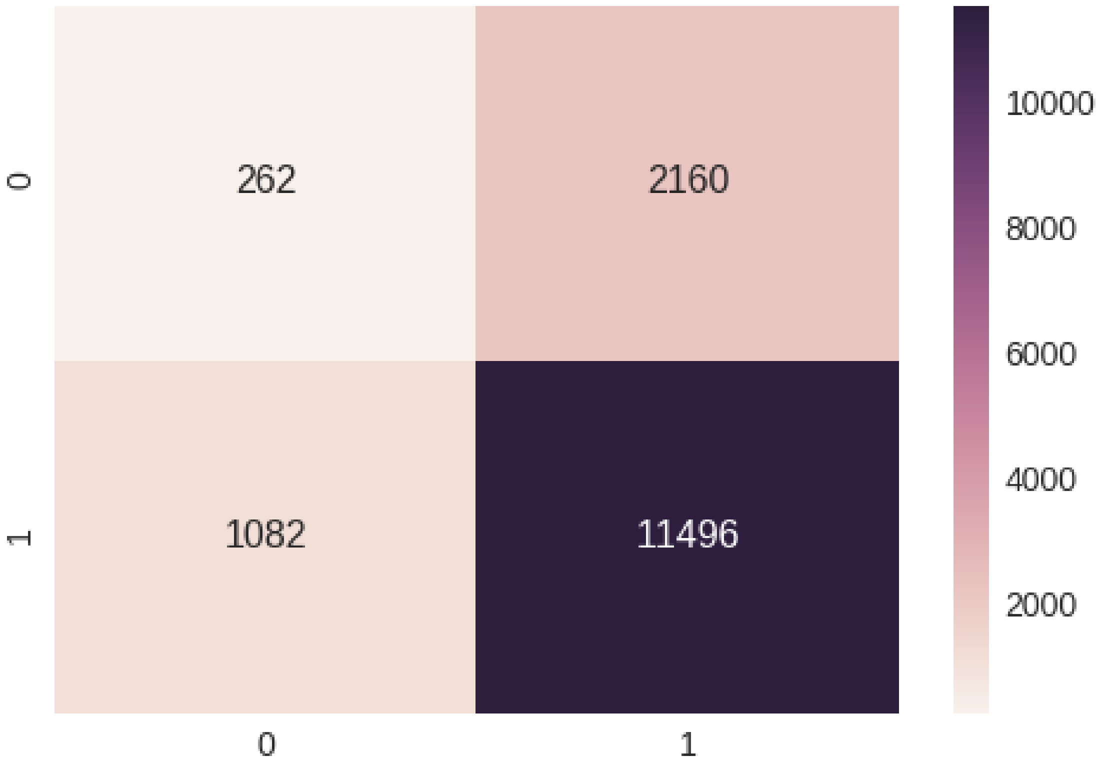


```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(bow_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.88
```

```
In [0]: df_cm = pd.DataFrame(confusion_matrix(bow_test_y, y_pred_test), range(2), range(2))
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2bd5b23198>
```



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

```
In [0]: # Please write all the code with proper documentation
        # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (BOW)
        tfidf_train = np.load("drive/ai/tfidf_train.npy")
        tfidf_train_y = np.load("drive/ai/tfidf_train_y.npy")
        tfidf_cv = np.load("drive/ai/tfidf_cv.npy")
        tfidf_cv_y = np.load("drive/ai/tfidf_cv_y.npy")
        tfidf_test = np.load("drive/ai/tfidf_test.npy")
        tfidf_test_y = np.load("drive/ai/tfidf_test_y.npy")
```

```
In [0]: print("Shape of Train = ", tfidf_train.shape)
        print("Shape of CV = ", tfidf_cv.shape)
        print("Shape of Test = ", tfidf_test.shape)
```

```
Shape of Train =  (24500, 500)
Shape of CV =  (10500, 500)
Shape of Test =  (15000, 500)
```

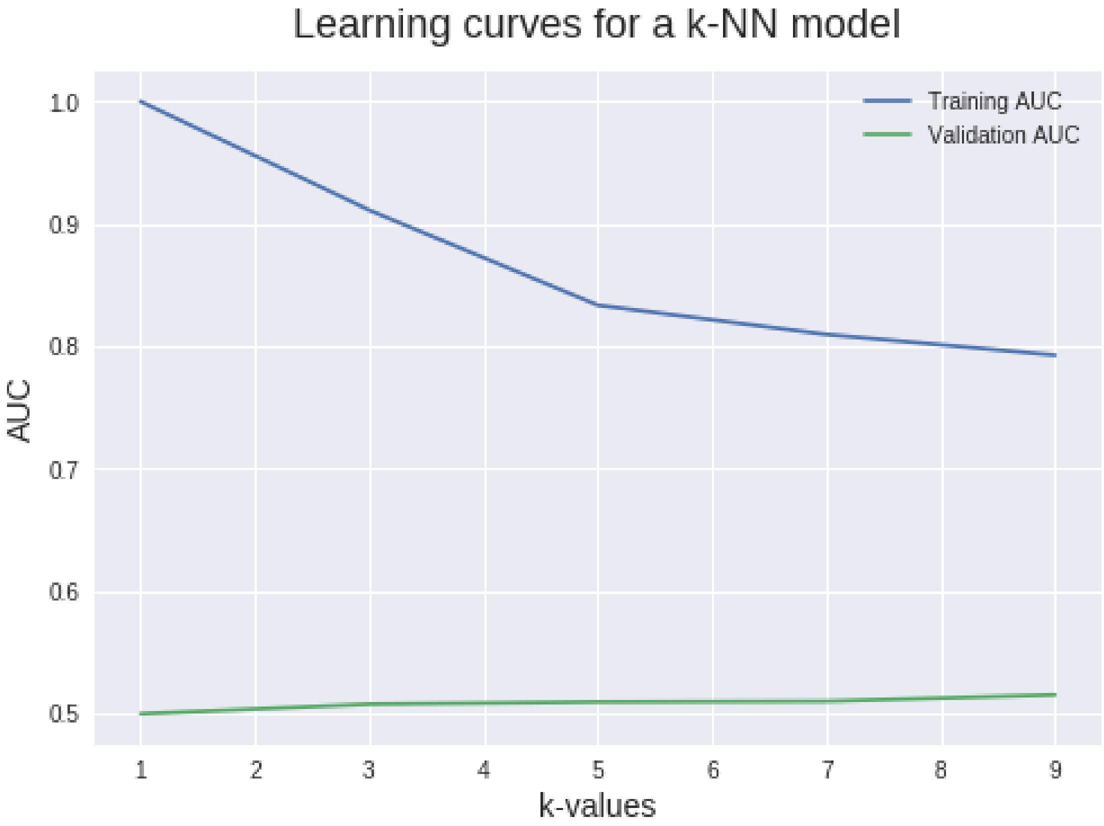
```
In [0]: tfidf_train_auc = []
        tfidf_cv_auc = []
        for i in range(1,10,2):
          knn = KNeighborsClassifier(n_neighbors=i)
          knn.fit(tfidf_train, tfidf_train_y)
          # train data
          y_prob_train = knn.predict_proba(tfidf_train)[:,1]
          y_pred = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(tfidf_train_y , y_prob_train)
          print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
          tfidf_train_auc.append(auc_roc_test)
          # CV
          y_prob_cv = knn.predict_proba(tfidf_cv)[:,1]
          y_pred = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(tfidf_cv_y , y_prob_cv)
          print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
          tfidf_cv_auc.append(auc_roc_cv)
          print("="*50)
```

```

Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 49.98%
==================================================

Train AUC for k = 3 is 91.10%

CV AUC for k = 3 is 50.77%
==================================================

Train AUC for k = 5 is 83.34%

CV AUC for k = 5 is 50.96%
==================================================

Train AUC for k = 7 is 80.95%

CV AUC for k = 7 is 51.01%
==================================================
Train AUC for k = 9 is 79.26%

CV AUC for k = 9 is 51.53%
==================================================
```

```
In [0]: k_values = [j for j in range(1,10,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        import matplotlib.pyplot as plt
        %matplotlib inline

        plt.style.use('seaborn')

        plt.plot(k_values, tfidf_train_auc, label = 'Training AUC')
        plt.plot(k_values, tfidf_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

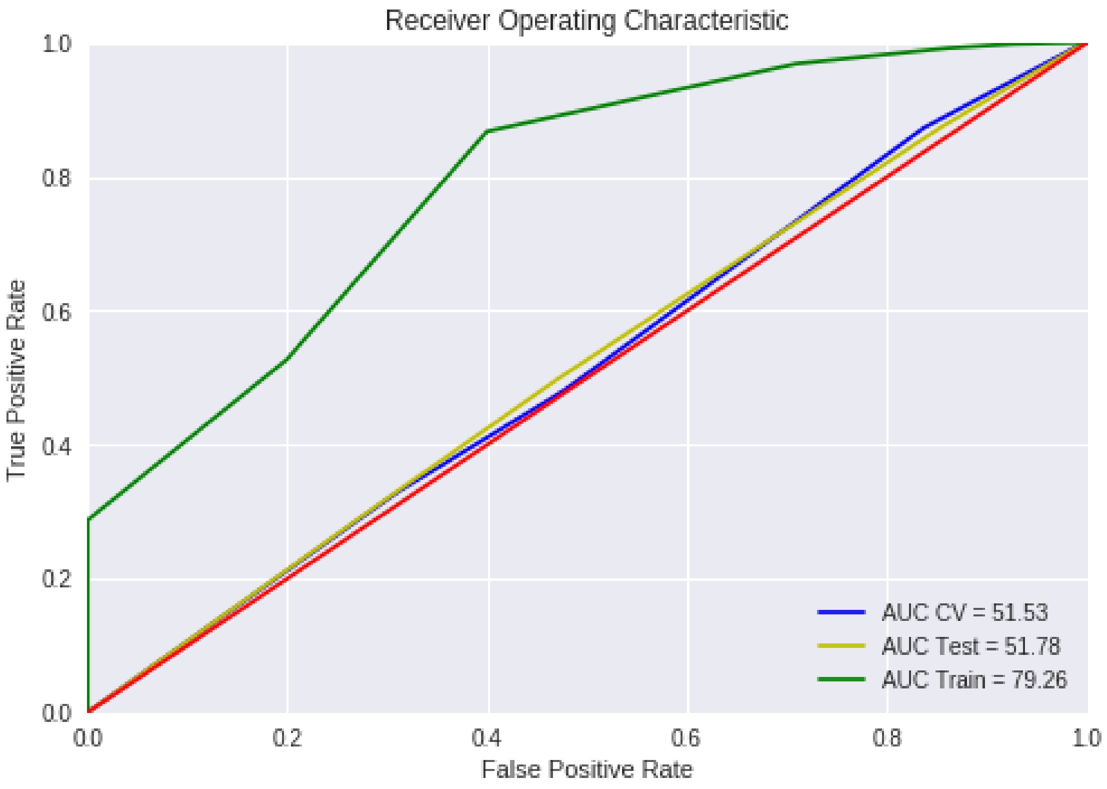
```
Out[0]: <matplotlib.legend.Legend at 0x7fcf996ce860>
```



```
In [0]: knn = KNeighborsClassifier(n_neighbors=9)
        knn.fit(tfidf_train, tfidf_train_y)
        # train data
        y_prob_train = knn.predict_proba(tfidf_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(tfidf_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(tfidf_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(tfidf_cv)[:,1]
        fprc, tprc , throsholdc = roc_curve(tfidf_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(tfidf_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (9, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(tfidf_test)[:,1]
        fprts, tprts , throsholdts = roc_curve(tfidf_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(tfidf_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
        print("="*50)
```

```

Train AUC for k = 9 is 79.26%

CV AUC for k = 97 is 51.53%

Test AUC for k = 97 is 51.78%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```

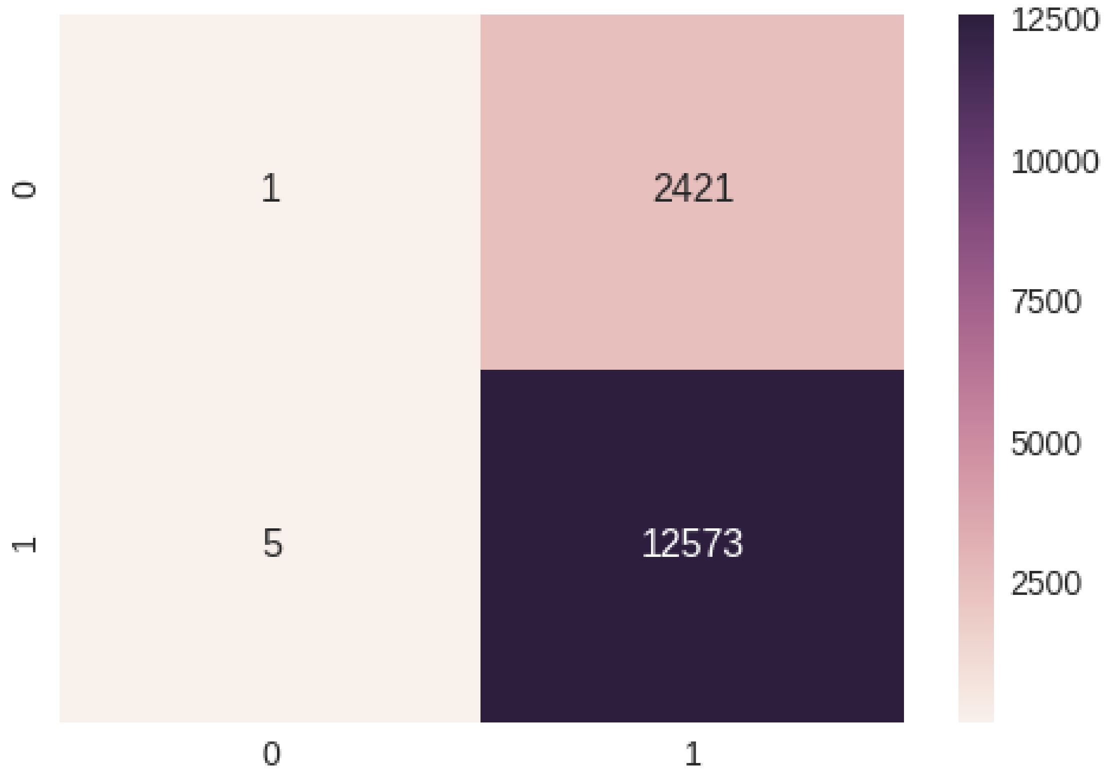


```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(tfidf_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.91
```

```
In [0]: df_cm = pd.DataFrame(confusion_matrix(tfidf_test_y, y_pred_test), range(2), range(2))
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7fcf96b31358>
```



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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (w2v)
        w2v_train = np.load("drive/ai/w2v_train.npy")
        w2v_train_y = np.load("drive/ai/w2v_train_y.npy")
        w2v_cv = np.load("drive/ai/w2v_cv.npy")
        w2v_cv_y = np.load("drive/ai/w2v_cv_y.npy")
        w2v_test = np.load("drive/ai/w2v_test.npy")
        w2v_test_y = np.load("drive/ai/w2v_test_y.npy")
```

```
In [0]: print("Shape of Train = ", w2v_train.shape)
        print("Shape of CV = ", w2v_cv.shape)
        print("Shape of Test = ", w2v_test.shape)
```

```
Shape of Train =  (24500, 50)
Shape of CV =  (10500, 50)
Shape of Test =  (15000, 50)
```

```
In [0]: w2v_train_auc = []
        w2v_cv_auc = []
        for i in range(1,40,2):
          knn = KNeighborsClassifier(n_neighbors=i)
          knn.fit(w2v_train, w2v_train_y)
          # train data
          y_prob_train = knn.predict_proba(w2v_train)[:,1]
          y_pred = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(w2v_train_y , y_prob_train)
          print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
          w2v_train_auc.append(auc_roc_test)
          # CV
          y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
          y_pred = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
          print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
          w2v_cv_auc.append(auc_roc_cv)
          print("="*50)
```

```

Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 66.50%
==================================================

Train AUC for k = 3 is 95.18%

CV AUC for k = 3 is 75.20%
==================================================

Train AUC for k = 5 is 93.10%

CV AUC for k = 5 is 79.20%
==================================================

Train AUC for k = 7 is 92.02%

CV AUC for k = 7 is 81.47%
==================================================

Train AUC for k = 9 is 91.48%

CV AUC for k = 9 is 82.27%
==================================================

Train AUC for k = 11 is 91.01%

CV AUC for k = 11 is 82.93%
```

```
==================================================

Train AUC for k = 13 is 90.63%

CV AUC for k = 13 is 83.80%
==================================================

Train AUC for k = 15 is 90.24%

CV AUC for k = 15 is 84.16%
==================================================

Train AUC for k = 17 is 89.95%

CV AUC for k = 17 is 84.47%
==================================================

Train AUC for k = 19 is 89.69%

CV AUC for k = 19 is 84.94%
==================================================

Train AUC for k = 21 is 89.50%

CV AUC for k = 21 is 85.12%
==================================================

Train AUC for k = 23 is 89.32%

CV AUC for k = 23 is 85.38%
==================================================

Train AUC for k = 25 is 89.12%

CV AUC for k = 25 is 85.49%
==================================================

Train AUC for k = 27 is 89.02%

CV AUC for k = 27 is 85.62%
==================================================

Train AUC for k = 29 is 88.97%

CV AUC for k = 29 is 85.66%
==================================================

Train AUC for k = 31 is 88.94%
```

```
CV AUC for k = 31 is 85.79%
==================================================

Train AUC for k = 33 is 88.93%

CV AUC for k = 33 is 85.81%
==================================================

Train AUC for k = 35 is 88.90%

CV AUC for k = 35 is 85.92%
==================================================

Train AUC for k = 37 is 88.80%

CV AUC for k = 37 is 86.11%
==================================================

Train AUC for k = 39 is 88.77%

CV AUC for k = 39 is 86.24%
==================================================
```

```
In [0]: for i in range(41,50,2):
            knn = KNeighborsClassifier(n_neighbors=i)
            knn.fit(w2v_train, w2v_train_y)
            # train data
            y_prob_train = knn.predict_proba(w2v_train)[:,1]
            y_pred = np.where(y_prob_train > 0.5, 1, 0)
            auc_roc_test = roc_auc_score(w2v_train_y , y_prob_train)
            print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
            w2v_train_auc.append(auc_roc_test)
            # CV
            y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
            y_pred = np.where(y_prob_cv > 0.5, 1, 0)
            auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
            print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
            w2v_cv_auc.append(auc_roc_cv)
            print("="*50)
```

```
Train AUC for k = 41 is 88.68%

CV AUC for k = 41 is 86.31%
==================================================
Train AUC for k = 43 is 88.57%

CV AUC for k = 43 is 86.35%
==================================================

Train AUC for k = 45 is 88.50%

CV AUC for k = 45 is 86.36%
==================================================

Train AUC for k = 47 is 88.44%

CV AUC for k = 47 is 86.45%
==================================================

Train AUC for k = 49 is 88.37%

CV AUC for k = 49 is 86.47%
==================================================
```

```
In [0]: for i in range(51,70,2):
            knn = KNeighborsClassifier(n_neighbors=i)
            knn.fit(w2v_train, w2v_train_y)
            # train data
            y_prob_train = knn.predict_proba(w2v_train)[:,1]
            y_pred = np.where(y_prob_train > 0.5, 1, 0)
            auc_roc_test = roc_auc_score(w2v_train_y , y_prob_train)
            print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
            w2v_train_auc.append(auc_roc_test)
            # CV
            y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
            y_pred = np.where(y_prob_cv > 0.5, 1, 0)
            auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
            print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
            w2v_cv_auc.append(auc_roc_cv)
            print("="*50)
```

```
Train AUC for k = 51 is 88.36%

CV AUC for k = 51 is 86.48%
==================================================

Train AUC for k = 53 is 88.32%

CV AUC for k = 53 is 86.48%
==================================================
Train AUC for k = 55 is 88.30%

CV AUC for k = 55 is 86.56%
==================================================

Train AUC for k = 57 is 88.17%

CV AUC for k = 57 is 86.56%
==================================================

Train AUC for k = 59 is 88.13%

CV AUC for k = 59 is 86.60%
==================================================

Train AUC for k = 61 is 88.11%

CV AUC for k = 61 is 86.59%
==================================================

Train AUC for k = 63 is 88.10%

CV AUC for k = 63 is 86.61%
==================================================

Train AUC for k = 65 is 88.04%

CV AUC for k = 65 is 86.59%
==================================================

Train AUC for k = 67 is 88.01%

CV AUC for k = 67 is 86.64%
==================================================

Train AUC for k = 69 is 87.97%

CV AUC for k = 69 is 86.68%
==================================================
```

```
In [0]: for i in range(71,100,2):
            knn = KNeighborsClassifier(n_neighbors=i)
            knn.fit(w2v_train, w2v_train_y)
            # train data
            y_prob_train = knn.predict_proba(w2v_train)[:,1]
            y_pred = np.where(y_prob_train > 0.5, 1, 0)
```

```
        auc_roc_test = roc_auc_score(w2v_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
        w2v_train_auc.append(auc_roc_test)
        # CV
        y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
        y_pred = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
        w2v_cv_auc.append(auc_roc_cv)
        print("="*50)
```

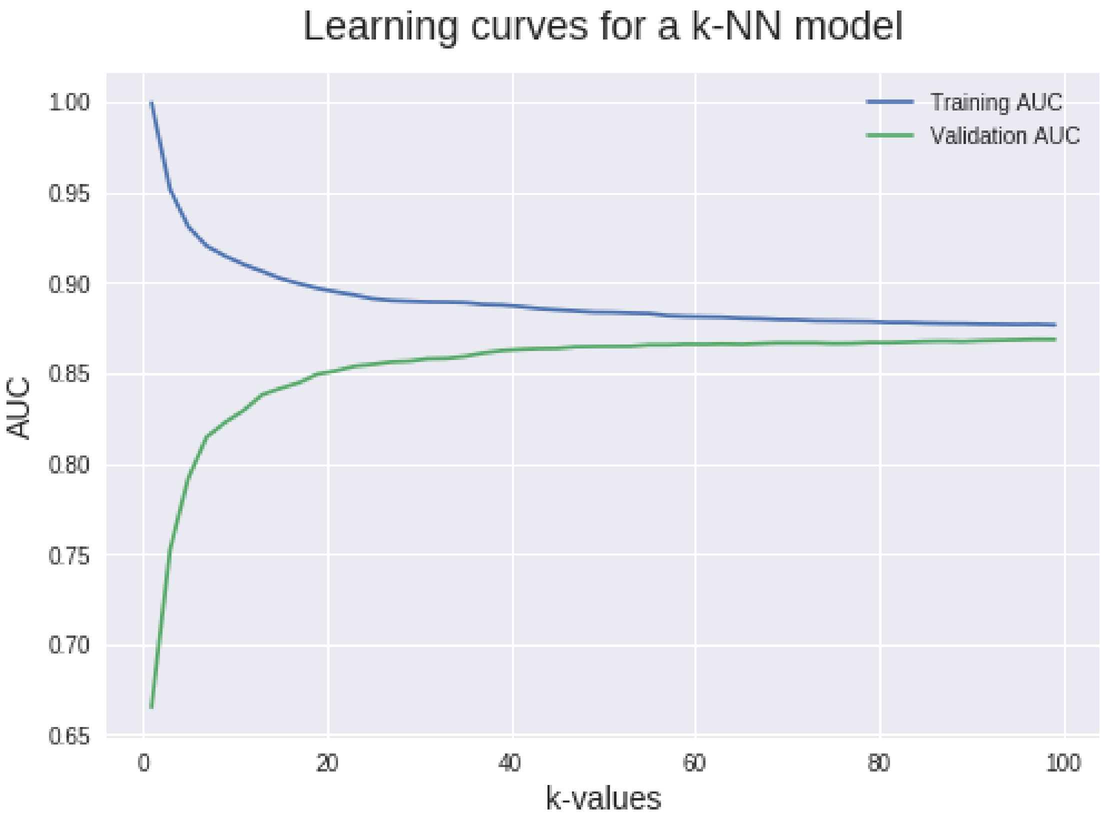
```
Train AUC for k = 71 is 87.95%

CV AUC for k = 71 is 86.67%
==================================================

Train AUC for k = 73 is 87.90%

CV AUC for k = 73 is 86.67%
==================================================

Train AUC for k = 75 is 87.89%

CV AUC for k = 75 is 86.63%
==================================================

Train AUC for k = 77 is 87.87%

CV AUC for k = 77 is 86.65%
==================================================

Train AUC for k = 79 is 87.85%

CV AUC for k = 79 is 86.70%
==================================================

Train AUC for k = 81 is 87.81%

CV AUC for k = 81 is 86.69%
==================================================

Train AUC for k = 83 is 87.81%

CV AUC for k = 83 is 86.72%
==================================================

Train AUC for k = 85 is 87.77%
```

```
CV AUC for k = 85 is 86.75%
==================================================

Train AUC for k = 87 is 87.75%

CV AUC for k = 87 is 86.77%
==================================================

Train AUC for k = 89 is 87.74%

CV AUC for k = 89 is 86.75%
==================================================

Train AUC for k = 91 is 87.72%

CV AUC for k = 91 is 86.80%
==================================================

Train AUC for k = 93 is 87.70%

CV AUC for k = 93 is 86.82%
==================================================

Train AUC for k = 95 is 87.69%

CV AUC for k = 95 is 86.84%
==================================================

Train AUC for k = 97 is 87.70%

CV AUC for k = 97 is 86.87%
==================================================

Train AUC for k = 99 is 87.67%

CV AUC for k = 99 is 86.86%
==================================================
```

```
In [0]: k_values = [j for j in range(1,100,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        import matplotlib.pyplot as plt
        %matplotlib inline

        plt.style.use('seaborn')
        plt.plot(k_values, w2v_train_auc, label = 'Training AUC')
        plt.plot(k_values, w2v_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

Out[0]: <matplotlib.legend.Legend at 0x7fa51d8cbba8>

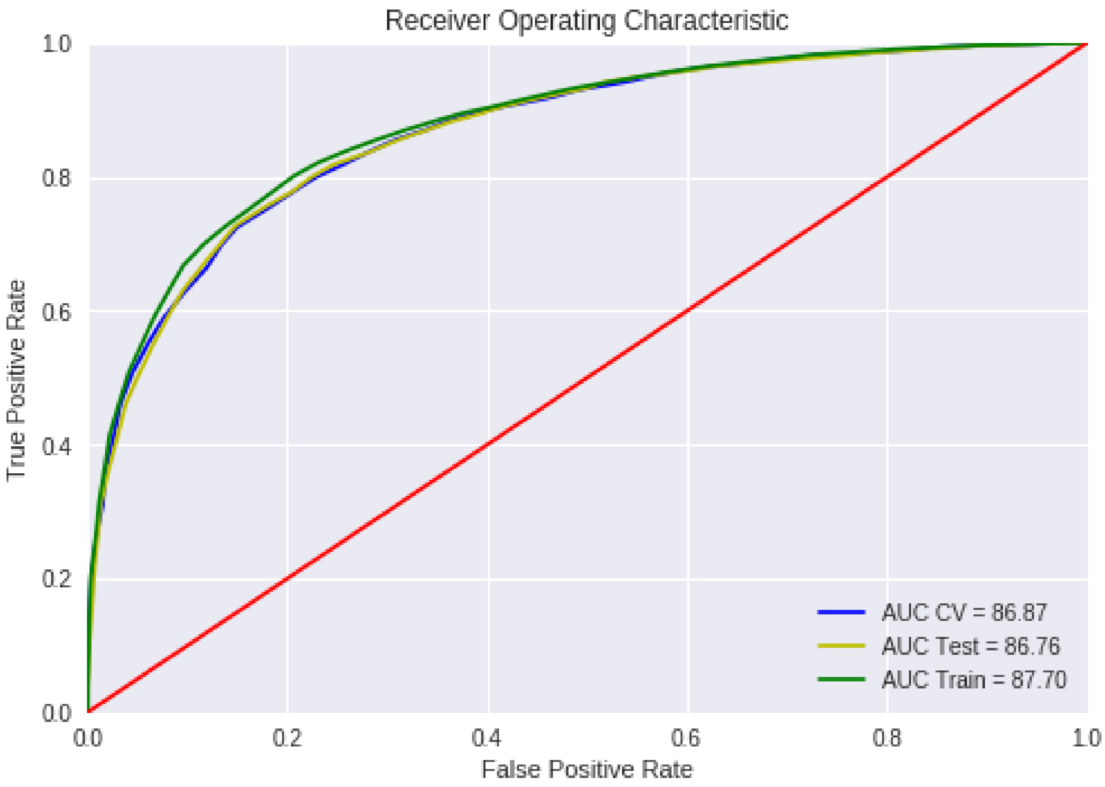


In [0]:
```
knn = KNeighborsClassifier(n_neighbors=97)
knn.fit(w2v_train, w2v_train_y)
# train data
y_prob_train = knn.predict_proba(w2v_train)[:,1]
fprt, tprt , throsholdt = roc_curve(w2v_train_y, y_prob_train)
y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
auc_roc_train = roc_auc_score(w2v_train_y , y_prob_train)
print('\nTrain AUC for k = %d is %0.2f%%' % (97, (auc_roc_test * float(100))))
# CV
y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
```

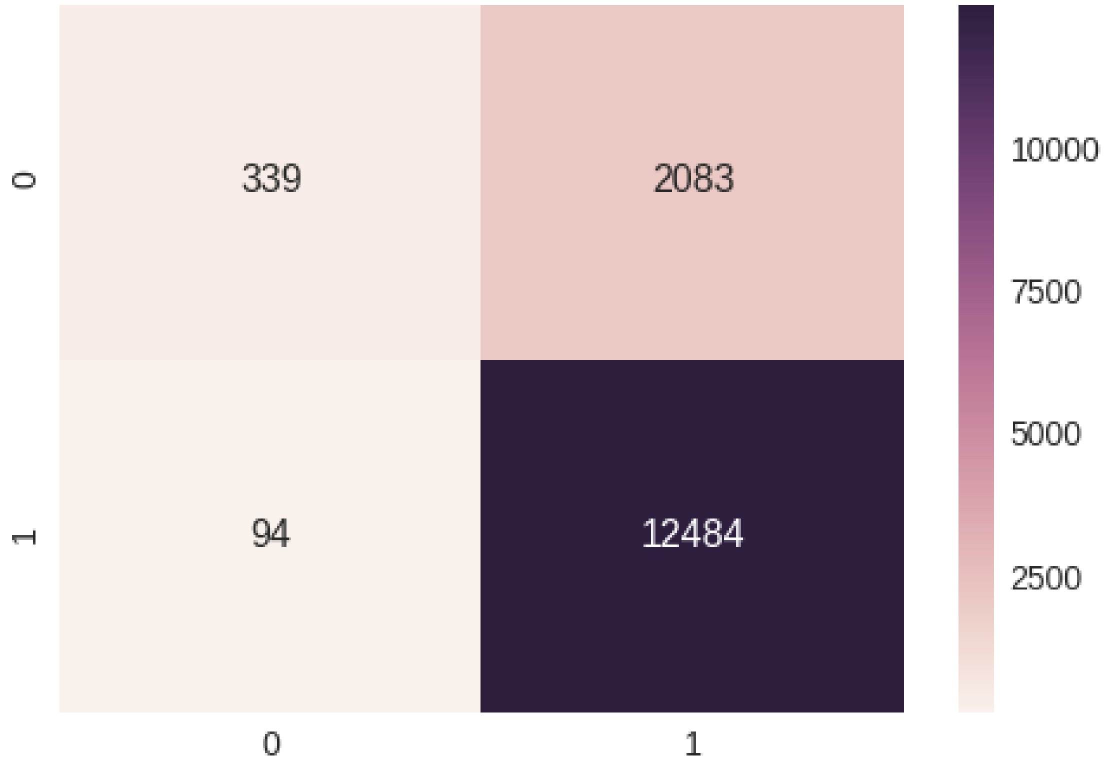
```
        fprc, tprc , thorsholdc = roc_curve(w2v_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (97, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(w2v_test)[:,1]
        fprts, tprts , thorsholdts = roc_curve(w2v_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(w2v_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (97, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 97 is 87.70%

CV AUC for k = 97 is 86.87%

Test AUC for k = 97 is 86.76%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```



```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(w2v_test_y, y_pred_test)))

F1-Score on test set: 0.92


In [0]: df_cm = pd.DataFrame(confusion_matrix(w2v_test_y, y_pred_test), range(2), range(2))
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa51d6676d8>
```



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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (w2v)
        tfidf_w2v_train = np.load("drive/ai/w2v_tfidf_train.npy")
        tfidf_w2v_train_y = np.load("drive/ai/w2v_tfidf_train_y.npy")
        tfidf_w2v_cv = np.load("drive/ai/w2v_tfidf_cv.npy")
        tfidf_w2v_cv_y = np.load("drive/ai/w2v_tfidf_cv_y.npy")
        tfidf_w2v_test = np.load("drive/ai/w2v_tfidf_test.npy")
        tfidf_w2v_test_y = np.load("drive/ai/w2v_tfidf_test_y.npy")
```

```
In [0]: print("Shape of Train = ", tfidf_w2v_train.shape)
        print("Shape of CV = ", tfidf_w2v_cv.shape)
        print("Shape of Test = ", tfidf_w2v_test.shape)
```

```
Shape of Train =  (24500, 50)
Shape of CV =  (10500, 50)
Shape of Test =  (15000, 50)
```

```
In [0]: tfidf_w2v_train_auc = []
        tfidf_w2v_cv_auc = []
```

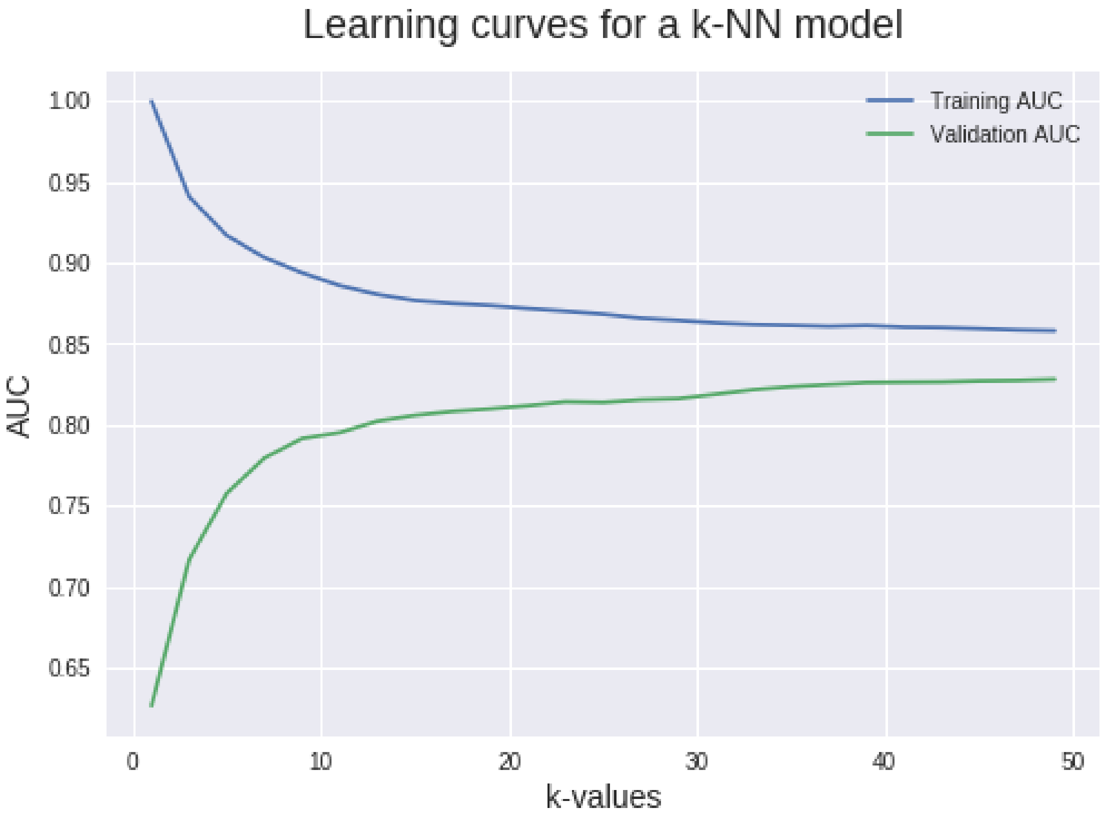
```
for i in range(1,50,2):
  knn = KNeighborsClassifier(n_neighbors=i)
  knn.fit(tfidf_w2v_train, tfidf_w2v_train_y)
  # train data
  y_prob_train = knn.predict_proba(tfidf_w2v_train)[:,1]
  y_pred = np.where(y_prob_train > 0.5, 1, 0)
  auc_roc_test = roc_auc_score(tfidf_w2v_train_y , y_prob_train)
  print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
  tfidf_w2v_train_auc.append(auc_roc_test)
  # CV
  y_prob_cv = knn.predict_proba(tfidf_w2v_cv)[:,1]
  y_pred = np.where(y_prob_cv > 0.5, 1, 0)
  auc_roc_cv = roc_auc_score(tfidf_w2v_cv_y , y_prob_cv)
  print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
  tfidf_w2v_cv_auc.append(auc_roc_cv)
  print("="*50)
```

```

Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 62.63%
==================================================

Train AUC for k = 3 is 94.05%

CV AUC for k = 3 is 71.66%
==================================================

Train AUC for k = 5 is 91.67%

CV AUC for k = 5 is 75.75%
==================================================

Train AUC for k = 7 is 90.30%

CV AUC for k = 7 is 77.93%
==================================================

Train AUC for k = 9 is 89.37%

CV AUC for k = 9 is 79.13%
==================================================

Train AUC for k = 11 is 88.58%

CV AUC for k = 11 is 79.50%
==================================================
Train AUC for k = 13 is 88.04%

CV AUC for k = 13 is 80.21%
==================================================

Train AUC for k = 15 is 87.66%

CV AUC for k = 15 is 80.56%
==================================================

Train AUC for k = 17 is 87.48%

CV AUC for k = 17 is 80.81%
==================================================

Train AUC for k = 19 is 87.35%

CV AUC for k = 19 is 80.97%
==================================================

Train AUC for k = 21 is 87.16%

CV AUC for k = 21 is 81.16%
==================================================

Train AUC for k = 23 is 87.00%

CV AUC for k = 23 is 81.40%
==================================================

Train AUC for k = 25 is 86.82%

CV AUC for k = 25 is 81.36%
==================================================

Train AUC for k = 27 is 86.57%

CV AUC for k = 27 is 81.53%
==================================================

Train AUC for k = 29 is 86.44%

CV AUC for k = 29 is 81.59%
==================================================

Train AUC for k = 31 is 86.28%

CV AUC for k = 31 is 81.87%
```

```
==================================================

Train AUC for k = 33 is 86.17%

CV AUC for k = 33 is 82.15%
==================================================

Train AUC for k = 35 is 86.13%

CV AUC for k = 35 is 82.34%
==================================================

Train AUC for k = 37 is 86.06%

CV AUC for k = 37 is 82.47%
==================================================

Train AUC for k = 39 is 86.12%

CV AUC for k = 39 is 82.59%
==================================================

Train AUC for k = 41 is 86.01%

CV AUC for k = 41 is 82.61%
==================================================

Train AUC for k = 43 is 85.98%

CV AUC for k = 43 is 82.63%
==================================================

Train AUC for k = 45 is 85.91%

CV AUC for k = 45 is 82.70%
==================================================

Train AUC for k = 47 is 85.83%

CV AUC for k = 47 is 82.72%
==================================================

Train AUC for k = 49 is 85.79%

CV AUC for k = 49 is 82.79%
==================================================
In [0]: k_values = [j for j in range(1,50,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        plt.style.use('seaborn')

        plt.plot(k_values, tfidf_w2v_train_auc, label = 'Training AUC')
        plt.plot(k_values, tfidf_w2v_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

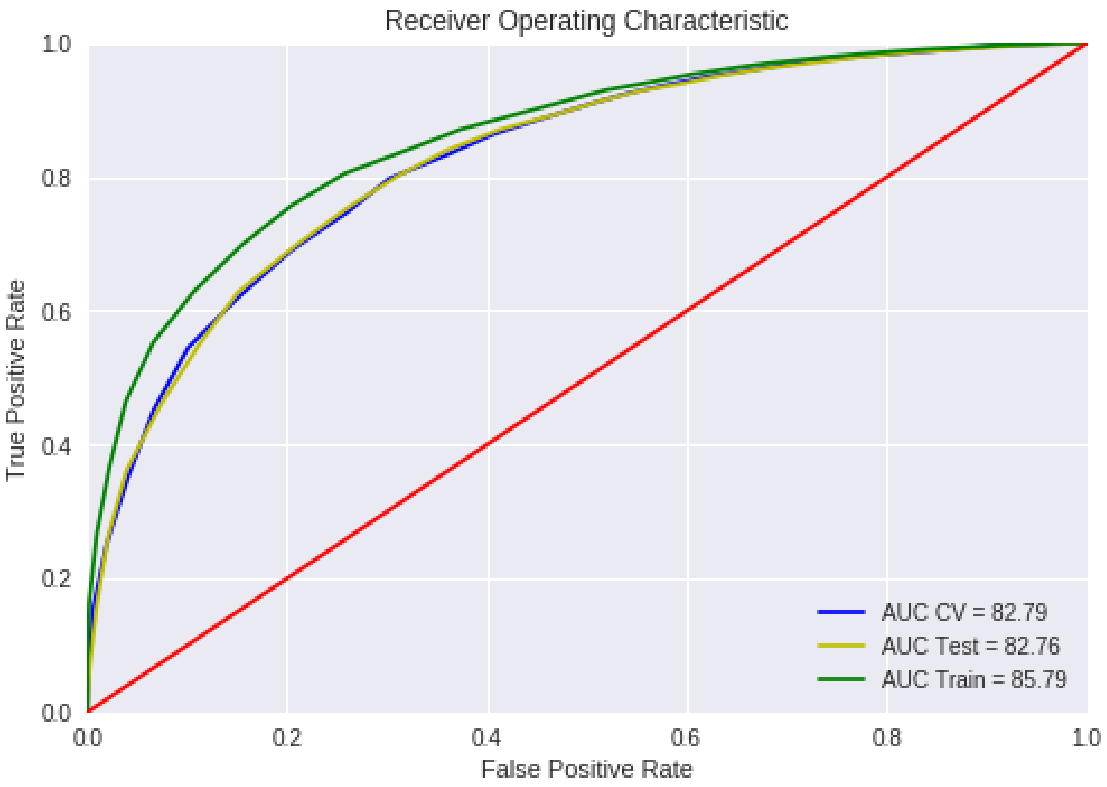
```
Out[0]: <matplotlib.legend.Legend at 0x7fa51d224b00>
```



```
In [0]: knn = KNeighborsClassifier(n_neighbors=49)
        knn.fit(tfidf_w2v_train, tfidf_w2v_train_y)
        # train data
        y_prob_train = knn.predict_proba(tfidf_w2v_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(tfidf_w2v_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(tfidf_w2v_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (49, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(tfidf_w2v_cv)[:,1]
        fprc, tprc , throsholdc = roc_curve(tfidf_w2v_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(tfidf_w2v_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (49, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(tfidf_w2v_test)[:,1]
        fprts, tprts , throsholdts = roc_curve(tfidf_w2v_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(tfidf_w2v_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (97, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 49 is 85.79%

CV AUC for k = 49 is 82.79%

Test AUC for k = 97 is 82.76%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```

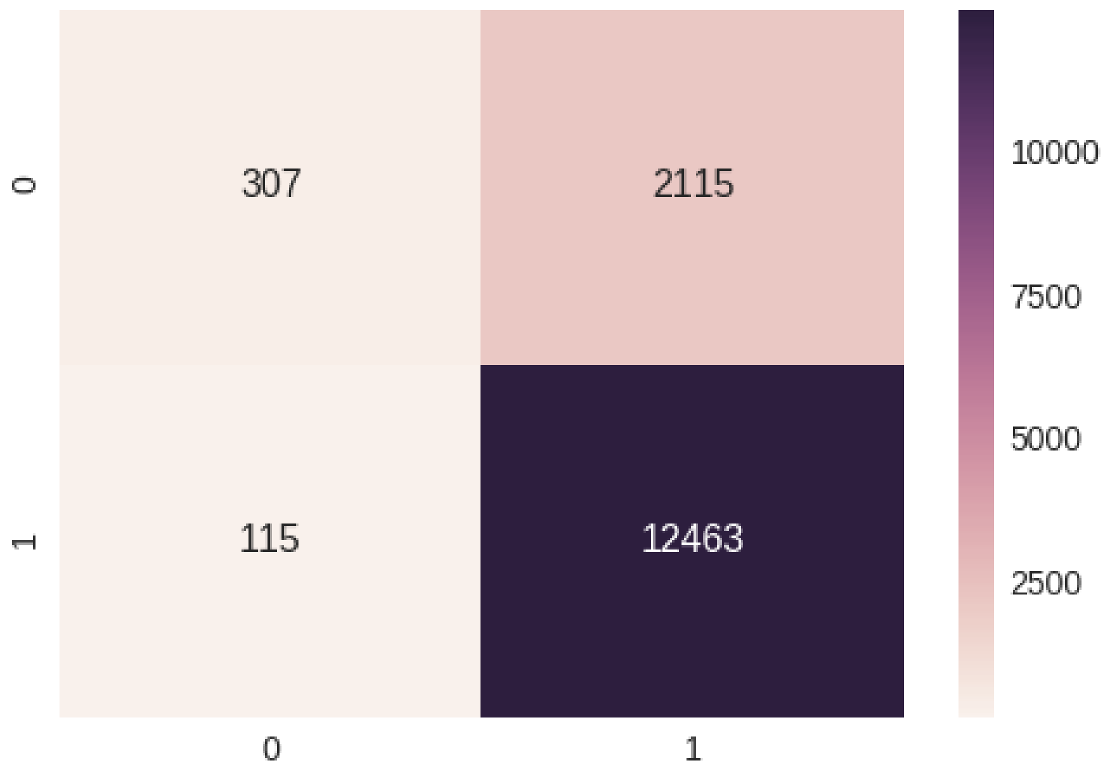


```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(tfidf_w2v_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.92
```

```
In [0]: df_cm = pd.DataFrame(confusion_matrix(tfidf_w2v_test_y, y_pred_test), range(2), range(
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa51d237898>
```



6.2 [5.2] Applying KNN kd-tree

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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (BOW)
        kd_bow_train = np.load("drive/ai/kd_bow_train.npy")
        kd_bow_train_y = np.load("drive/ai/kd_bow_train_y.npy")
        kd_bow_cv = np.load("drive/ai/kd_bow_cv.npy")
        kd_bow_cv_y = np.load("drive/ai/kd_bow_cv_y.npy")
        kd_bow_test = np.load("drive/ai/kd_bow_test.npy")
        kd_bow_test_y = np.load("drive/ai/kd_bow_test_y.npy")
```

```
In [0]: print("Shape of Train = ", kd_bow_train.shape)
        print("Shape of CV = ", kd_bow_cv.shape)
        print("Shape of Test = ", kd_bow_test.shape)
```

```
Shape of Train =  (24500, 200)
Shape of CV =  (10500, 200)
Shape of Test =  (15000, 200)
```

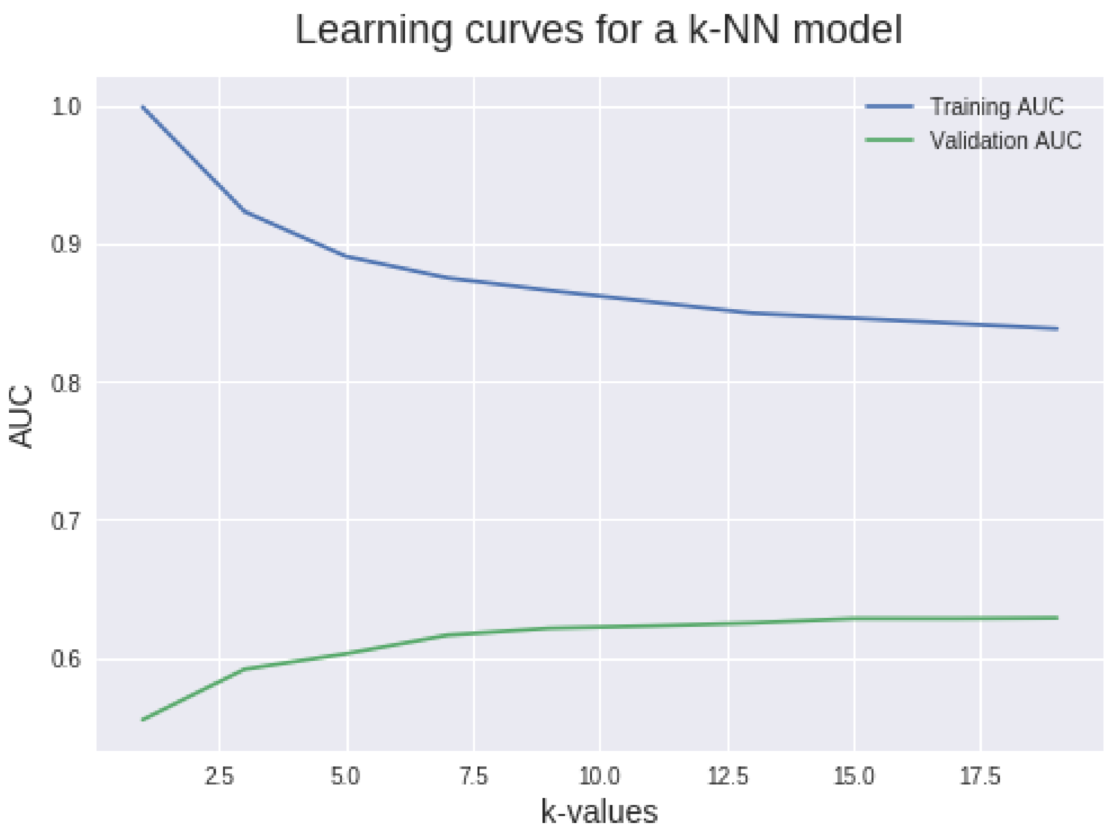
```
In [0]: bow_train_auc = []
        bow_cv_auc = []
        for i in range(1,20,2):
          knn = KNeighborsClassifier(n_neighbors=i, algorithm="kd_tree")
          knn.fit(kd_bow_train, kd_bow_train_y)
          # train data
          y_prob_train = knn.predict_proba(kd_bow_train)[:,1]
          y_pred = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(kd_bow_train_y , y_prob_train)
          print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
          bow_train_auc.append(auc_roc_test)
          # CV
          y_prob_cv = knn.predict_proba(kd_bow_cv)[:,1]
          y_pred = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(kd_bow_cv_y , y_prob_cv)
          print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
          bow_cv_auc.append(auc_roc_cv)
```

```
Train AUC for k = 1 is 99.89%

CV AUC for k = 1 is 55.49%

Train AUC for k = 3 is 92.33%

CV AUC for k = 3 is 59.16%

Train AUC for k = 5 is 89.09%

CV AUC for k = 5 is 60.28%

Train AUC for k = 7 is 87.52%

CV AUC for k = 7 is 61.62%

Train AUC for k = 9 is 86.61%

CV AUC for k = 9 is 62.11%

Train AUC for k = 11 is 85.79%

CV AUC for k = 11 is 62.28%

Train AUC for k = 13 is 84.96%
```

```
CV AUC for k = 13 is 62.50%

Train AUC for k = 15 is 84.59%

CV AUC for k = 15 is 62.82%

Train AUC for k = 17 is 84.22%

CV AUC for k = 17 is 62.82%

Train AUC for k = 19 is 83.84%

CV AUC for k = 19 is 62.86%
```

```
In [0]: k_values = [j for j in range(1,20,2)]
```

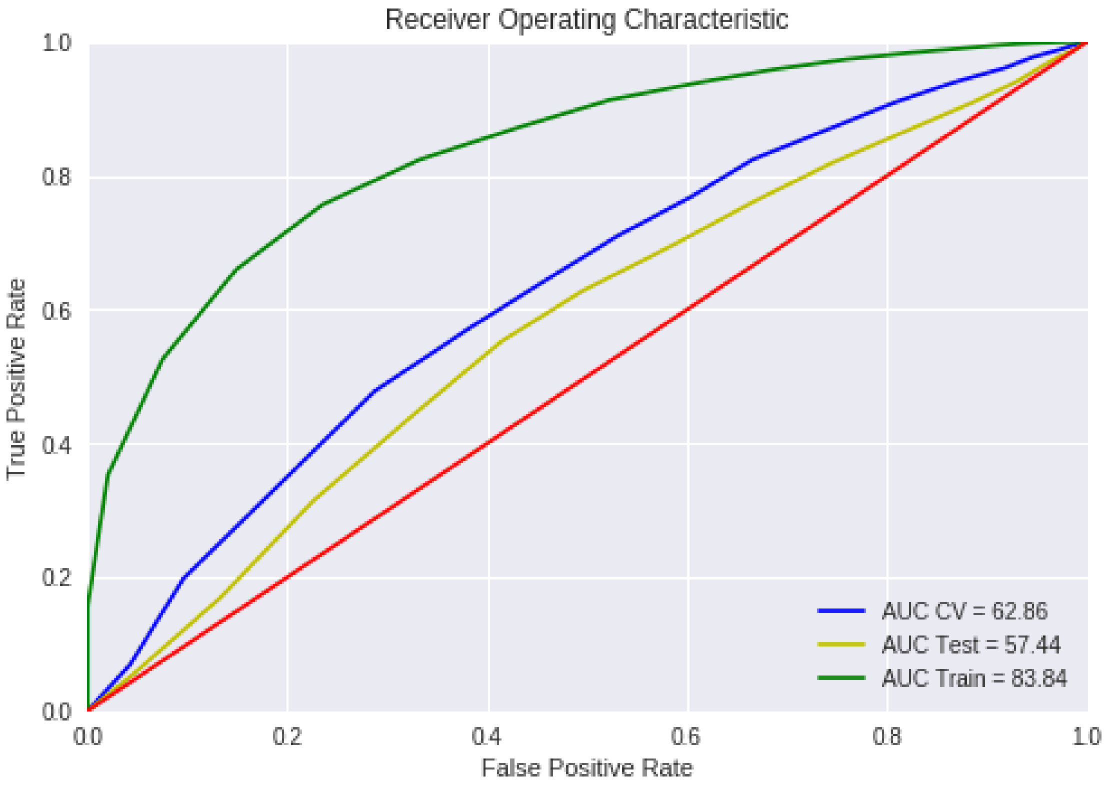
```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        import matplotlib.pyplot as plt
        %matplotlib inline

        plt.style.use('seaborn')

        plt.plot(k_values, bow_train_auc, label = 'Training AUC')
        plt.plot(k_values, bow_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()

Out[0]: <matplotlib.legend.Legend at 0x7f2bbb142860>
```



```
In [0]: knn = KNeighborsClassifier(n_neighbors=19 , algorithm="kd_tree")
        knn.fit(kd_bow_train, kd_bow_train_y)
        # train data
        y_prob_train = knn.predict_proba(kd_bow_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(kd_bow_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(kd_bow_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (19, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(kd_bow_cv)[:,1]
        fprc, tprc , throsholdc = roc_curve(kd_bow_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(kd_bow_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (19, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(kd_bow_test)[:,1]
        fprts, tprts , throsholdts = roc_curve(kd_bow_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(kd_bow_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (19, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 19 is 83.84%

CV AUC for k = 19 is 62.86%

Test AUC for k = 19 is 57.44%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```

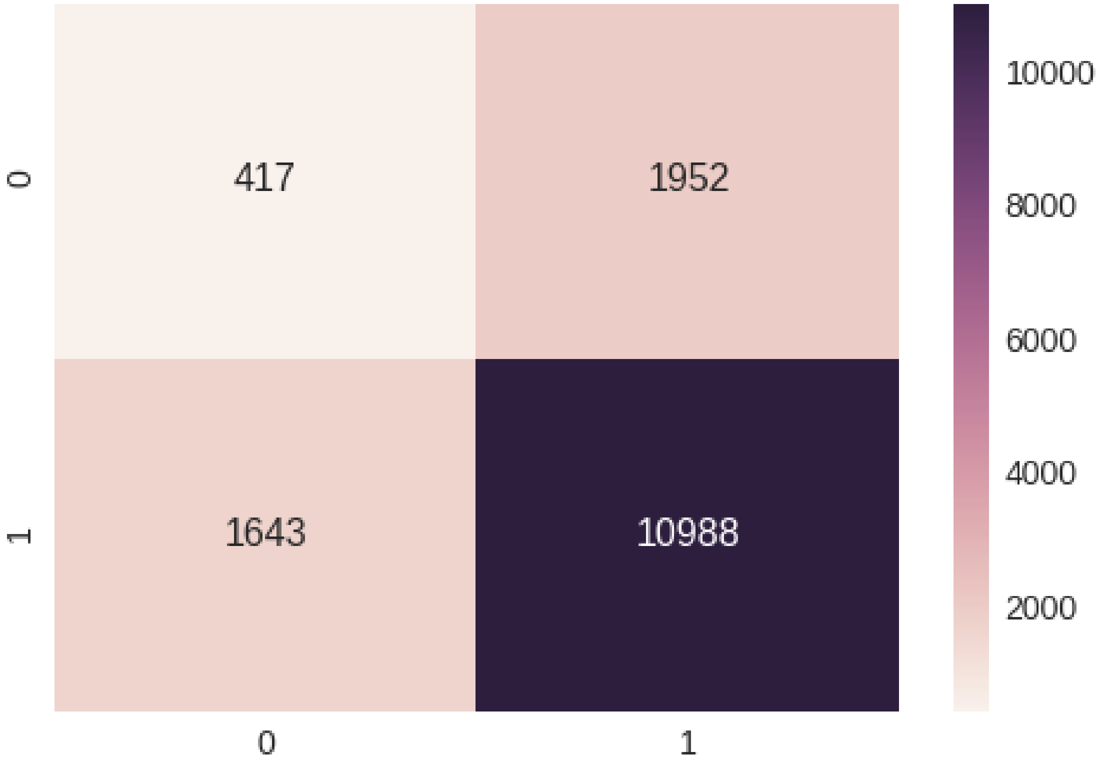


```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(kd_bow_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.86
```

```
In [0]: df_cm = pd.DataFrame(confusion_matrix(kd_bow_test_y, y_pred_test), range(2), range(2))
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2bbd522f98>
```



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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (BOW)
        kd_tfidf_train = np.load("drive/ai/kd_tfidf_train.npy")
        kd_tfidf_train_y = np.load("drive/ai/kd_tfidf_train_y.npy")
        kd_tfidf_cv = np.load("drive/ai/kd_tfidf_cv.npy")
        kd_tfidf_cv_y = np.load("drive/ai/kd_tfidf_cv_y.npy")
        kd_tfidf_test = np.load("drive/ai/kd_tfidf_test.npy")
        kd_tfidf_test_y = np.load("drive/ai/kd_tfidf_test_y.npy")
```

```
In [65]: print("Shape of Train = ", kd_tfidf_train.shape)
         print("Shape of CV = ", kd_tfidf_cv.shape)
         print("Shape of Test = ", kd_tfidf_test.shape)
```

```
Shape of Train =  (24500, 200)
Shape of CV =  (10500, 200)
Shape of Test =  (15000, 200)
```

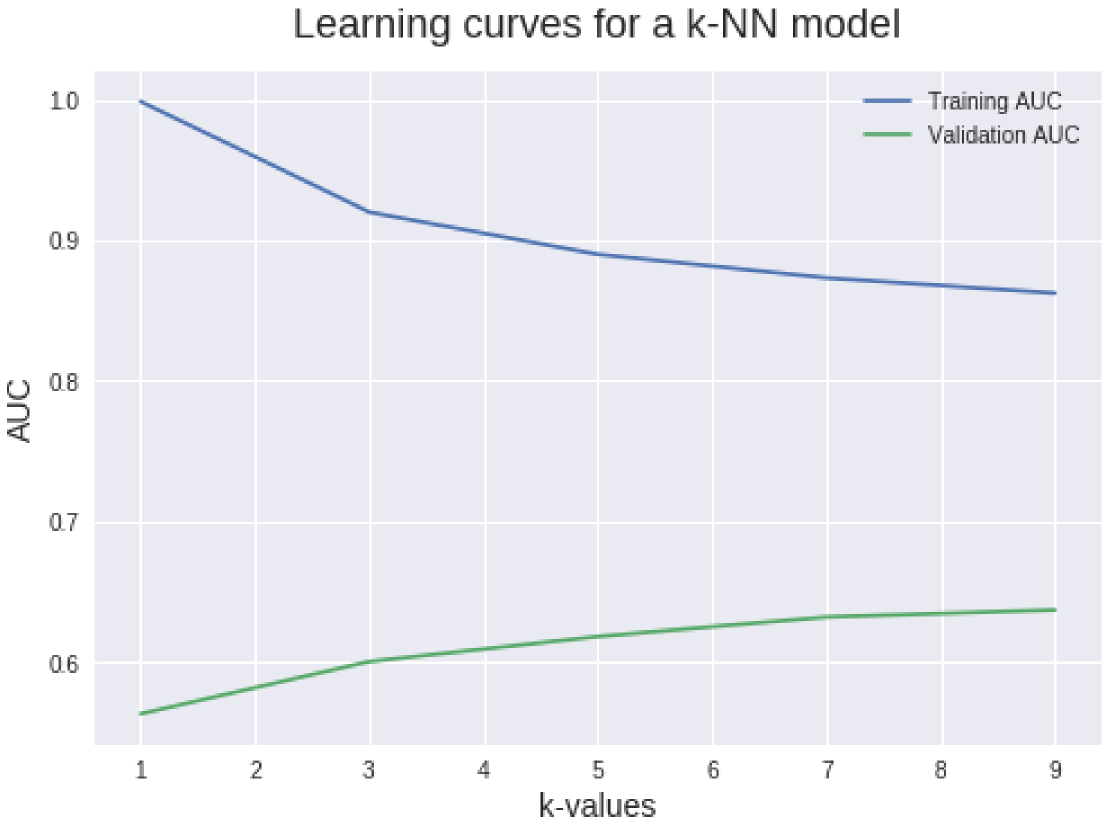
```
In [66]: tfidf_train_auc = []
         tfidf_cv_auc = []
         for i in range(1,10,2):
           knn = KNeighborsClassifier(n_neighbors=i, algorithm="kd_tree")
           knn.fit(kd_tfidf_train, kd_tfidf_train_y)
           # train data
           y_prob_train = knn.predict_proba(kd_tfidf_train)[:,1]
           y_pred = np.where(y_prob_train > 0.5, 1, 0)
           auc_roc_test = roc_auc_score(kd_tfidf_train_y , y_prob_train)
           print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
           tfidf_train_auc.append(auc_roc_test)
           # CV
           y_prob_cv = knn.predict_proba(kd_tfidf_cv)[:,1]
           y_pred = np.where(y_prob_cv > 0.5, 1, 0)
           auc_roc_cv = roc_auc_score(kd_tfidf_cv_y , y_prob_cv)
           print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
           tfidf_cv_auc.append(auc_roc_cv)
           print("="*50)
```

```

Train AUC for k = 1 is 99.89%

CV AUC for k = 1 is 56.31%
==================================================

Train AUC for k = 3 is 92.03%

CV AUC for k = 3 is 60.04%
==================================================

Train AUC for k = 5 is 89.02%

CV AUC for k = 5 is 61.82%
==================================================

Train AUC for k = 7 is 87.35%

CV AUC for k = 7 is 63.19%
==================================================
Train AUC for k = 9 is 86.26%

CV AUC for k = 9 is 63.70%
==================================================
```

```
In [0]: k_values = [j for j in range(1,10,2)]
```

```
In [68]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(k_values, tfidf_train_auc, label = 'Training AUC')
         plt.plot(k_values, tfidf_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('k-values', fontsize = 14)
         plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
         plt.legend()
```

```
Out[68]: <matplotlib.legend.Legend at 0x7f2bbc27f940>
```



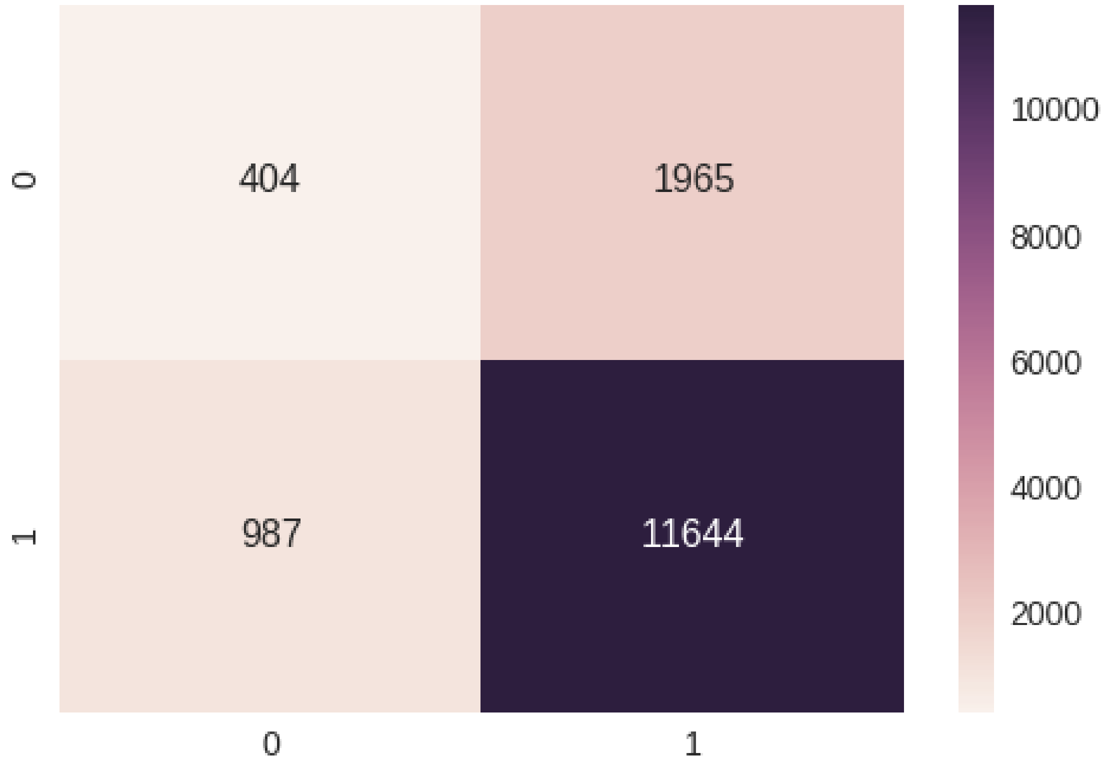
```
In [71]: knn = KNeighborsClassifier(n_neighbors=9, algorithm="kd_tree")
         knn.fit(kd_tfidf_train, kd_tfidf_train_y)
         # train data
         y_prob_train = knn.predict_proba(kd_tfidf_train)[:,1]
         fprt, tprt , throsholdt = roc_curve(kd_tfidf_train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(kd_tfidf_train_y , y_prob_train)
         print('\nTrain AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
         # CV
         y_prob_cv = knn.predict_proba(kd_tfidf_cv)[:,1]
         fprc, tprc , throsholdc = roc_curve(kd_tfidf_cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(kd_tfidf_cv_y , y_prob_cv)
         print('\nCV AUC for k = %d is %0.2f%%' % (9, (auc_roc_cv * float(100))))
         # Test
         y_prob_test = knn.predict_proba(kd_tfidf_test)[:,1]
         fprts, tprts , throsholdts = roc_curve(kd_tfidf_test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(kd_tfidf_test_y , y_prob_test)
         print('\nTest AUC for k = %d is %0.2f%%' % (9, (auc_roc_test * float(100))))
         print("="*50)
```

```

Train AUC for k = 9 is 86.26%

CV AUC for k = 9 is 63.70%

Test AUC for k = 9 is 60.71%
==================================================
```

```
In [73]: print("F1-Score on test set: %0.2f"%(f1_score(kd_tfidf_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.89
```

```
In [74]: df_cm = pd.DataFrame(confusion_matrix(kd_tfidf_test_y, y_pred_test), range(2), range(
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[74]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2bbd29a7f0>
```



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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (w2v)
        w2v_train = np.load("drive/ai/w2v_train.npy")
        w2v_train_y = np.load("drive/ai/w2v_train_y.npy")
        w2v_cv = np.load("drive/ai/w2v_cv.npy")
        w2v_cv_y = np.load("drive/ai/w2v_cv_y.npy")
        w2v_test = np.load("drive/ai/w2v_test.npy")
        w2v_test_y = np.load("drive/ai/w2v_test_y.npy")
```

```
In [0]: print("Shape of Train = ", w2v_train.shape)
        print("Shape of CV = ", w2v_cv.shape)
        print("Shape of Test = ", w2v_test.shape)
```

```
Shape of Train =  (24500, 50)
Shape of CV =  (10500, 50)
Shape of Test =  (15000, 50)
```

```
In [0]: w2v_train_auc = []
        w2v_cv_auc = []
```

```
for i in range(1,100,2):
  knn = KNeighborsClassifier(n_neighbors=i, algorithm="kd_tree")
  knn.fit(w2v_train, w2v_train_y)
  # train data
  y_prob_train = knn.predict_proba(w2v_train)[:,1]
  y_pred = np.where(y_prob_train > 0.5, 1, 0)
  auc_roc_test = roc_auc_score(w2v_train_y , y_prob_train)
  print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
  w2v_train_auc.append(auc_roc_test)
  # CV
  y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
  y_pred = np.where(y_prob_cv > 0.5, 1, 0)
  auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
  print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
  w2v_cv_auc.append(auc_roc_cv)
  print("="*50)
```

```

Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 66.50%
==================================================

Train AUC for k = 3 is 95.18%

CV AUC for k = 3 is 75.20%
==================================================

Train AUC for k = 5 is 93.10%

CV AUC for k = 5 is 79.20%
==================================================

Train AUC for k = 7 is 92.02%

CV AUC for k = 7 is 81.47%
==================================================

Train AUC for k = 9 is 91.48%

CV AUC for k = 9 is 82.27%
==================================================

Train AUC for k = 11 is 91.01%

CV AUC for k = 11 is 82.93%
==================================================
Train AUC for k = 13 is 90.63%

CV AUC for k = 13 is 83.80%
==================================================

Train AUC for k = 15 is 90.24%

CV AUC for k = 15 is 84.16%
==================================================

Train AUC for k = 17 is 89.95%

CV AUC for k = 17 is 84.47%
==================================================

Train AUC for k = 19 is 89.69%

CV AUC for k = 19 is 84.94%
==================================================

Train AUC for k = 21 is 89.50%

CV AUC for k = 21 is 85.12%
==================================================

Train AUC for k = 23 is 89.32%

CV AUC for k = 23 is 85.38%
==================================================

Train AUC for k = 25 is 89.12%

CV AUC for k = 25 is 85.49%
==================================================

Train AUC for k = 27 is 89.02%

CV AUC for k = 27 is 85.62%
==================================================

Train AUC for k = 29 is 88.97%

CV AUC for k = 29 is 85.66%
==================================================

Train AUC for k = 31 is 88.94%

CV AUC for k = 31 is 85.79%
```

```
==================================================

Train AUC for k = 33 is 88.93%

CV AUC for k = 33 is 85.81%
==================================================

Train AUC for k = 35 is 88.90%

CV AUC for k = 35 is 85.92%
==================================================

Train AUC for k = 37 is 88.80%

CV AUC for k = 37 is 86.11%
==================================================

Train AUC for k = 39 is 88.77%

CV AUC for k = 39 is 86.24%
==================================================

Train AUC for k = 41 is 88.68%

CV AUC for k = 41 is 86.31%
==================================================

Train AUC for k = 43 is 88.57%

CV AUC for k = 43 is 86.35%
==================================================

Train AUC for k = 45 is 88.50%

CV AUC for k = 45 is 86.36%
==================================================

Train AUC for k = 47 is 88.44%

CV AUC for k = 47 is 86.45%
==================================================

Train AUC for k = 49 is 88.37%

CV AUC for k = 49 is 86.47%
==================================================

Train AUC for k = 51 is 88.36%
```

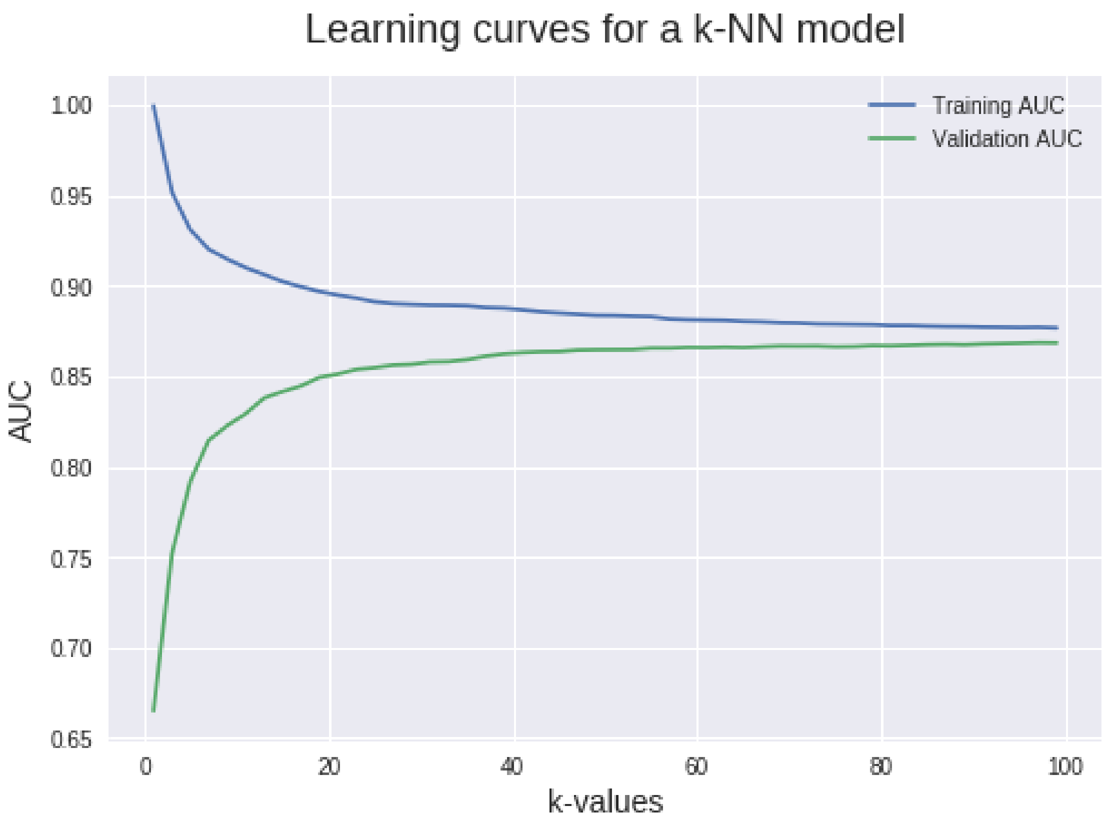
```
CV AUC for k = 51 is 86.48%
==================================================

Train AUC for k = 53 is 88.32%

CV AUC for k = 53 is 86.48%
==================================================

Train AUC for k = 55 is 88.30%

CV AUC for k = 55 is 86.56%
==================================================

Train AUC for k = 57 is 88.17%

CV AUC for k = 57 is 86.56%
==================================================

Train AUC for k = 59 is 88.13%

CV AUC for k = 59 is 86.60%
==================================================

Train AUC for k = 61 is 88.11%

CV AUC for k = 61 is 86.59%
==================================================

Train AUC for k = 63 is 88.10%

CV AUC for k = 63 is 86.61%
==================================================

Train AUC for k = 65 is 88.04%

CV AUC for k = 65 is 86.59%
==================================================

Train AUC for k = 67 is 88.01%

CV AUC for k = 67 is 86.64%
==================================================

Train AUC for k = 69 is 87.97%

CV AUC for k = 69 is 86.68%
==================================================
Train AUC for k = 71 is 87.95%

CV AUC for k = 71 is 86.67%
==================================================

Train AUC for k = 73 is 87.90%

CV AUC for k = 73 is 86.67%
==================================================

Train AUC for k = 75 is 87.89%

CV AUC for k = 75 is 86.63%
==================================================

Train AUC for k = 77 is 87.87%

CV AUC for k = 77 is 86.65%
==================================================

Train AUC for k = 79 is 87.85%

CV AUC for k = 79 is 86.70%
==================================================

Train AUC for k = 81 is 87.81%

CV AUC for k = 81 is 86.69%
==================================================

Train AUC for k = 83 is 87.81%

CV AUC for k = 83 is 86.72%
==================================================

Train AUC for k = 85 is 87.77%

CV AUC for k = 85 is 86.75%
==================================================

Train AUC for k = 87 is 87.75%

CV AUC for k = 87 is 86.77%
==================================================

Train AUC for k = 89 is 87.74%
```

```
CV AUC for k = 89 is 86.75%
==================================================

Train AUC for k = 91 is 87.72%

CV AUC for k = 91 is 86.80%
==================================================

Train AUC for k = 93 is 87.70%

CV AUC for k = 93 is 86.82%
==================================================

Train AUC for k = 95 is 87.69%

CV AUC for k = 95 is 86.84%
==================================================

Train AUC for k = 97 is 87.70%

CV AUC for k = 97 is 86.87%
==================================================

Train AUC for k = 99 is 87.67%

CV AUC for k = 99 is 86.86%
==================================================
```

```
In [0]: k_values = [j for j in range(1,100,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        import matplotlib.pyplot as plt
        %matplotlib inline

        plt.style.use('seaborn')

        plt.plot(k_values, w2v_train_auc, label = 'Training AUC')
        plt.plot(k_values, w2v_cv_auc, label = 'Validation AUC')

        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

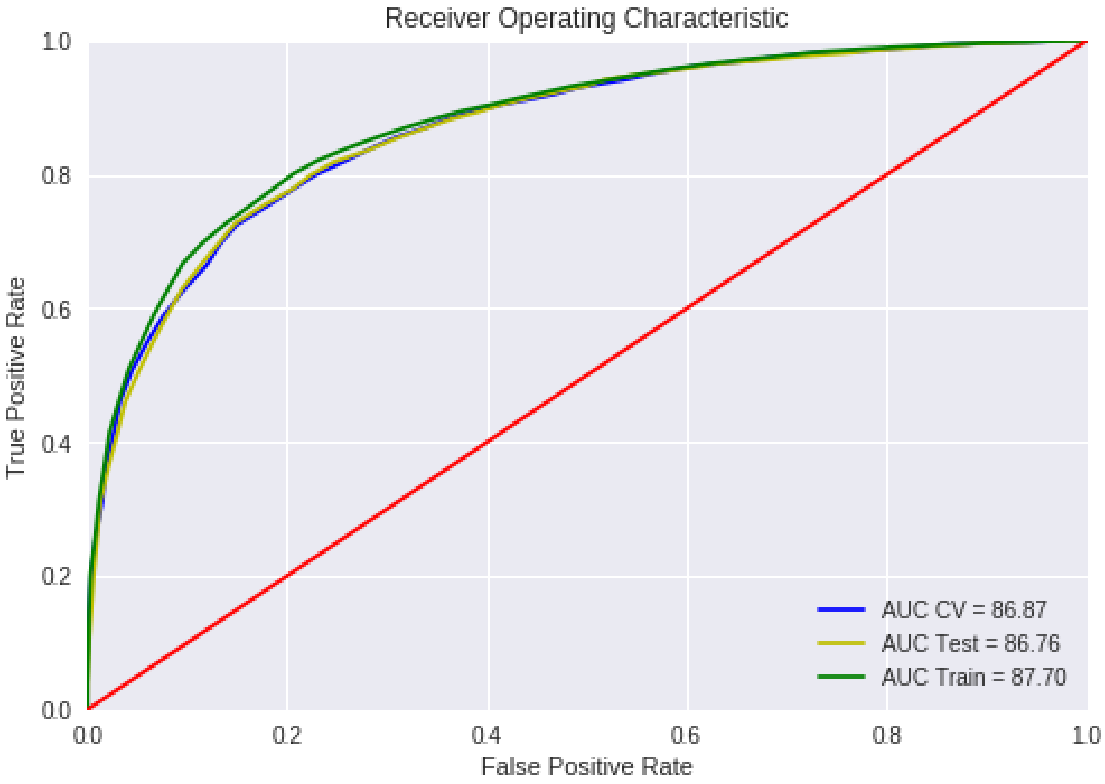
```
Out[0]: <matplotlib.legend.Legend at 0x7f2bd4776c50>
```



```
In [0]: knn = KNeighborsClassifier(n_neighbors=97, algorithm="kd_tree")
        knn.fit(w2v_train, w2v_train_y)
        # train data
        y_prob_train = knn.predict_proba(w2v_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(w2v_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(w2v_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (97, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(w2v_cv)[:,1]
        fprc, tprc , throsholdc = roc_curve(w2v_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(w2v_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (97, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(w2v_test)[:,1]
        fprts, tprts , throsholdts = roc_curve(w2v_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(w2v_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (97, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 97 is 87.67%

CV AUC for k = 97 is 86.87%

Test AUC for k = 97 is 86.76%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```

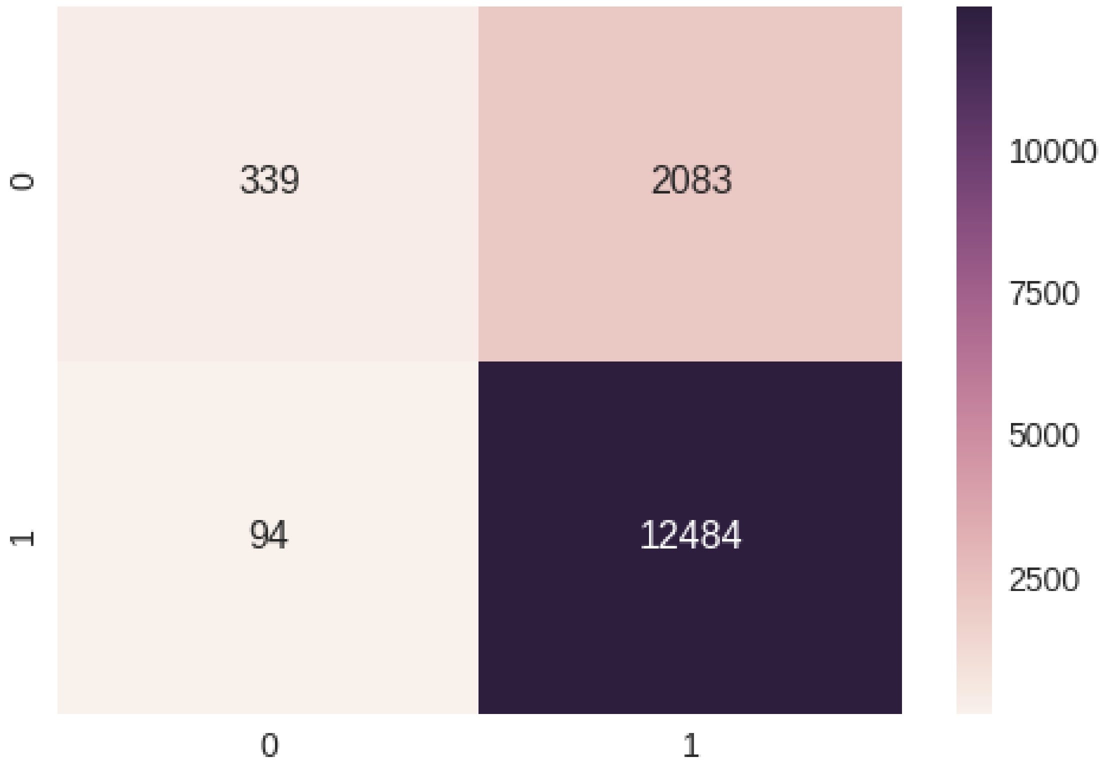


```
In [0]: print("F1-Score on test set: %0.2f"%(f1_score(w2v_test_y, y_pred_test)))
```

```
F1-Score on test set: 0.92
```

```
In [0]: df_cm = pd.DataFrame(confusion_matrix(w2v_test_y, y_pred_test), range(2), range(2))
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2bd4803908>
```



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

```
In [0]: # Please write all the code with proper documentation
```

```
In [0]: # Please write all the code with proper documentation
        # load Review text, preprocessed one converted into vectors using (w2v)
        tfidf_w2v_train = np.load("drive/ai/w2v_tfidf_train.npy")
        tfidf_w2v_train_y = np.load("drive/ai/w2v_tfidf_train_y.npy")
        tfidf_w2v_cv = np.load("drive/ai/w2v_tfidf_cv.npy")
        tfidf_w2v_cv_y = np.load("drive/ai/w2v_tfidf_cv_y.npy")
        tfidf_w2v_test = np.load("drive/ai/w2v_tfidf_test.npy")
        tfidf_w2v_test_y = np.load("drive/ai/w2v_tfidf_test_y.npy")
```

```
In [0]: print("Shape of Train = ", tfidf_w2v_train.shape)
        print("Shape of CV = ", tfidf_w2v_cv.shape)
        print("Shape of Test = ", tfidf_w2v_test.shape)
```

```
Shape of Train =  (24500, 50)
Shape of CV =  (10500, 50)
Shape of Test =  (15000, 50)
```

```
In [0]: tfidf_w2v_train_auc = []
        tfidf_w2v_cv_auc = []
        for i in range(1,100,2):
          knn = KNeighborsClassifier(n_neighbors=i)
          knn.fit(tfidf_w2v_train, tfidf_w2v_train_y)
          # train data
          y_prob_train = knn.predict_proba(tfidf_w2v_train)[:,1]
          y_pred = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(tfidf_w2v_train_y , y_prob_train)
          print('\nTrain AUC for k = %d is %0.2f%%' % (i, (auc_roc_test * float(100))))
          tfidf_w2v_train_auc.append(auc_roc_test)
          # CV
          y_prob_cv = knn.predict_proba(tfidf_w2v_cv)[:,1]
          y_pred = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(tfidf_w2v_cv_y , y_prob_cv)
          print('\nCV AUC for k = %d is %0.2f%%' % (i, (auc_roc_cv * float(100))))
          tfidf_w2v_cv_auc.append(auc_roc_cv)
          print("="*50)
```

```

Train AUC for k = 1 is 99.96%

CV AUC for k = 1 is 62.63%
==================================================

Train AUC for k = 3 is 94.05%

CV AUC for k = 3 is 71.66%
==================================================

Train AUC for k = 5 is 91.67%

CV AUC for k = 5 is 75.75%
==================================================

Train AUC for k = 7 is 90.30%

CV AUC for k = 7 is 77.93%
==================================================
Train AUC for k = 9 is 89.37%

CV AUC for k = 9 is 79.13%
==================================================

Train AUC for k = 11 is 88.58%

CV AUC for k = 11 is 79.50%
==================================================

Train AUC for k = 13 is 88.04%

CV AUC for k = 13 is 80.21%
==================================================

Train AUC for k = 15 is 87.66%

CV AUC for k = 15 is 80.56%
==================================================

Train AUC for k = 17 is 87.48%

CV AUC for k = 17 is 80.81%
==================================================

Train AUC for k = 19 is 87.35%

CV AUC for k = 19 is 80.97%
==================================================

Train AUC for k = 21 is 87.16%

CV AUC for k = 21 is 81.16%
==================================================

Train AUC for k = 23 is 87.00%

CV AUC for k = 23 is 81.40%
==================================================

Train AUC for k = 25 is 86.82%

CV AUC for k = 25 is 81.36%
==================================================

Train AUC for k = 27 is 86.57%
```

```
CV AUC for k = 27 is 81.53%
==================================================

Train AUC for k = 29 is 86.44%

CV AUC for k = 29 is 81.59%
==================================================

Train AUC for k = 31 is 86.28%

CV AUC for k = 31 is 81.87%
==================================================

Train AUC for k = 33 is 86.17%

CV AUC for k = 33 is 82.15%
==================================================

Train AUC for k = 35 is 86.13%

CV AUC for k = 35 is 82.34%
==================================================

Train AUC for k = 37 is 86.06%

CV AUC for k = 37 is 82.47%
==================================================

Train AUC for k = 39 is 86.12%

CV AUC for k = 39 is 82.59%
==================================================

Train AUC for k = 41 is 86.01%

CV AUC for k = 41 is 82.61%
==================================================

Train AUC for k = 43 is 85.98%

CV AUC for k = 43 is 82.63%
==================================================

Train AUC for k = 45 is 85.91%

CV AUC for k = 45 is 82.70%
==================================================
Train AUC for k = 47 is 85.83%

CV AUC for k = 47 is 82.72%
==================================================

Train AUC for k = 49 is 85.79%

CV AUC for k = 49 is 82.79%
==================================================

Train AUC for k = 51 is 85.75%

CV AUC for k = 51 is 82.83%
==================================================

Train AUC for k = 53 is 85.63%

CV AUC for k = 53 is 82.93%
==================================================

Train AUC for k = 55 is 85.58%

CV AUC for k = 55 is 82.96%
==================================================

Train AUC for k = 57 is 85.49%

CV AUC for k = 57 is 82.96%
==================================================

Train AUC for k = 59 is 85.46%

CV AUC for k = 59 is 82.91%
==================================================

Train AUC for k = 61 is 85.42%

CV AUC for k = 61 is 83.02%
==================================================

Train AUC for k = 63 is 85.42%

CV AUC for k = 63 is 83.11%
==================================================

Train AUC for k = 65 is 85.36%

CV AUC for k = 65 is 83.06%
```

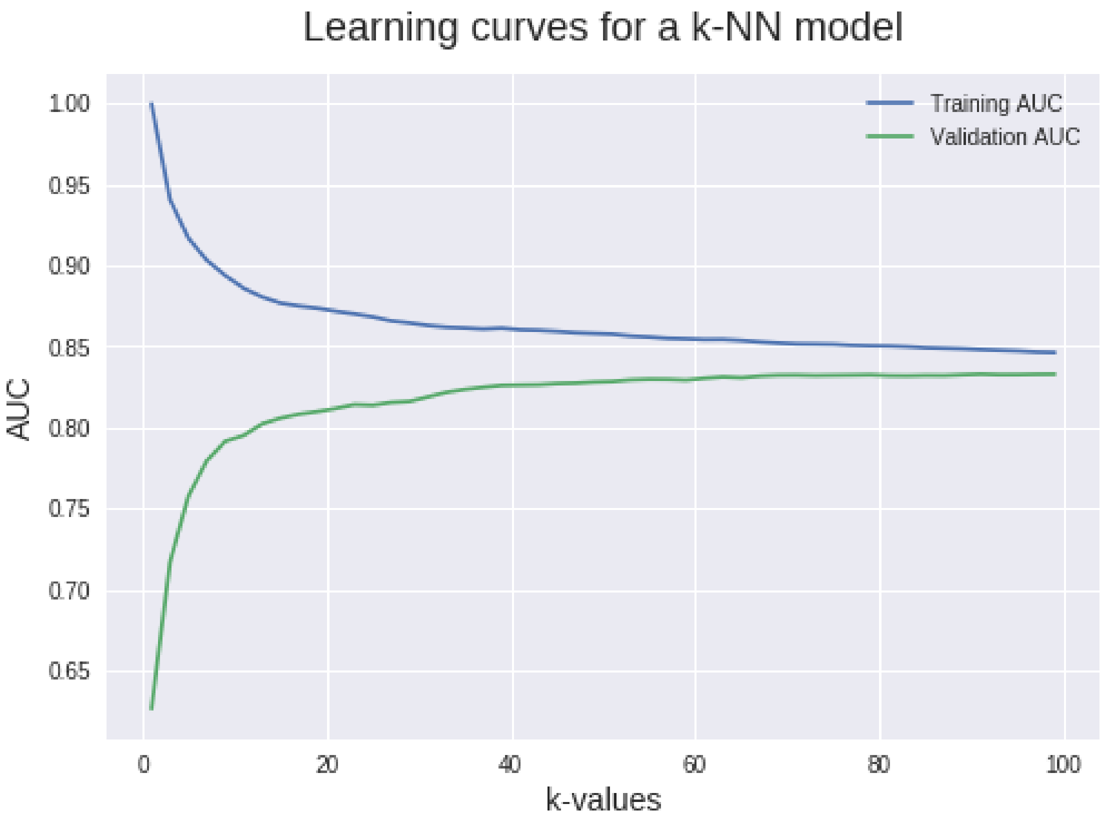
```
==================================================

Train AUC for k = 67 is 85.27%

CV AUC for k = 67 is 83.16%
==================================================

Train AUC for k = 69 is 85.20%

CV AUC for k = 69 is 83.21%
==================================================

Train AUC for k = 71 is 85.15%

CV AUC for k = 71 is 83.21%
==================================================

Train AUC for k = 73 is 85.14%

CV AUC for k = 73 is 83.19%
==================================================

Train AUC for k = 75 is 85.12%

CV AUC for k = 75 is 83.20%
==================================================

Train AUC for k = 77 is 85.06%

CV AUC for k = 77 is 83.21%
==================================================

Train AUC for k = 79 is 85.03%

CV AUC for k = 79 is 83.23%
==================================================

Train AUC for k = 81 is 85.02%

CV AUC for k = 81 is 83.18%
==================================================

Train AUC for k = 83 is 84.97%

CV AUC for k = 83 is 83.17%
==================================================

Train AUC for k = 85 is 84.90%
```

```
CV AUC for k = 85 is 83.20%
==================================================

Train AUC for k = 87 is 84.87%

CV AUC for k = 87 is 83.19%
==================================================

Train AUC for k = 89 is 84.84%

CV AUC for k = 89 is 83.23%
==================================================

Train AUC for k = 91 is 84.79%

CV AUC for k = 91 is 83.27%
==================================================

Train AUC for k = 93 is 84.75%

CV AUC for k = 93 is 83.24%
==================================================

Train AUC for k = 95 is 84.71%

CV AUC for k = 95 is 83.24%
==================================================

Train AUC for k = 97 is 84.64%

CV AUC for k = 97 is 83.26%
==================================================

Train AUC for k = 99 is 84.62%

CV AUC for k = 99 is 83.27%
==================================================
```

```
In [0]: k_values = [j for j in range(1,100,2)]
```

```
In [0]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

        plt.style.use('seaborn')

        plt.plot(k_values, tfidf_w2v_train_auc, label = 'Training AUC')
        plt.plot(k_values, tfidf_w2v_cv_auc, label = 'Validation AUC')
        plt.ylabel('AUC', fontsize = 14)
        plt.xlabel('k-values', fontsize = 14)
        plt.title('Learning curves for a k-NN model', fontsize = 18, y = 1.03)
        plt.legend()
```

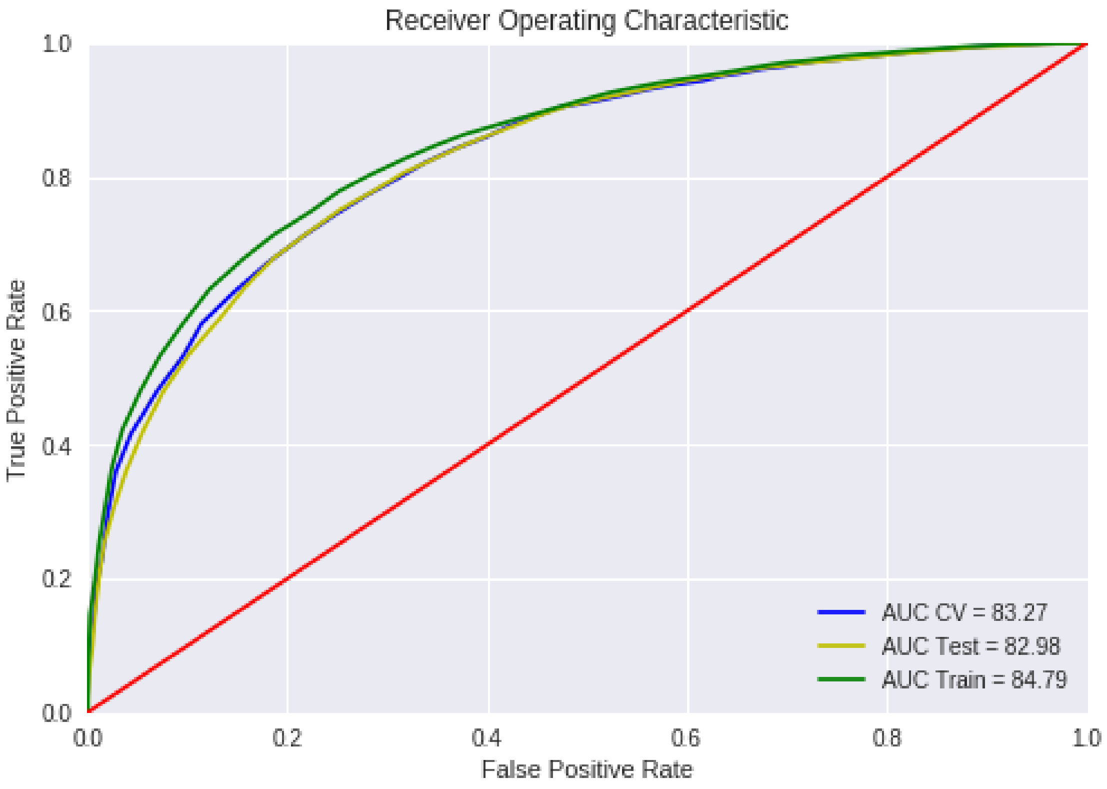
```
Out[0]: <matplotlib.legend.Legend at 0x7f2bd4757780>
```



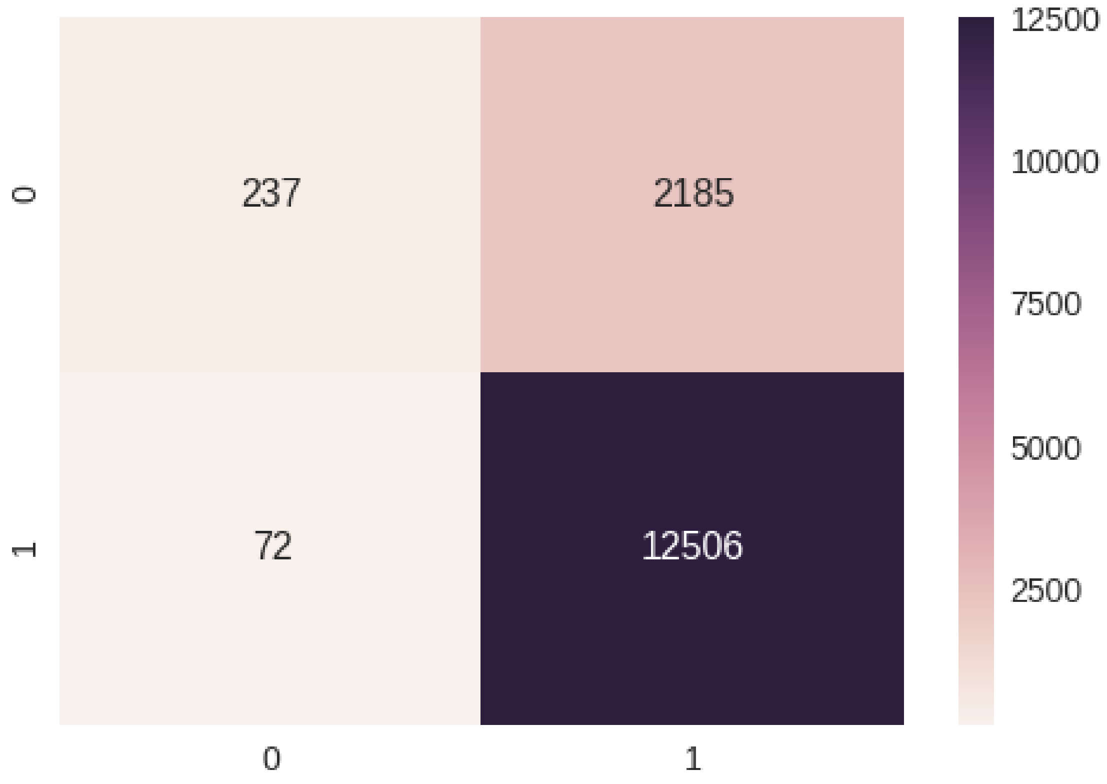
```
In [0]: knn = KNeighborsClassifier(n_neighbors=91, algorithm="kd_tree")
        knn.fit(tfidf_w2v_train, tfidf_w2v_train_y)
        # train data
        y_prob_train = knn.predict_proba(tfidf_w2v_train)[:,1]
        fprt, tprt , throsholdt = roc_curve(tfidf_w2v_train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(tfidf_w2v_train_y , y_prob_train)
        print('\nTrain AUC for k = %d is %0.2f%%' % (91, (auc_roc_test * float(100))))
        # CV
        y_prob_cv = knn.predict_proba(tfidf_w2v_cv)[:,1]
        fprc, tprc , thresholdc = roc_curve(tfidf_w2v_cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(tfidf_w2v_cv_y , y_prob_cv)
        print('\nCV AUC for k = %d is %0.2f%%' % (91, (auc_roc_cv * float(100))))
        # Test
        y_prob_test = knn.predict_proba(tfidf_w2v_test)[:,1]
        fprts, tprts , thrsholdts = roc_curve(tfidf_w2v_test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(tfidf_w2v_test_y , y_prob_test)
        print('\nTest AUC for k = %d is %0.2f%%' % (91, (auc_roc_test * float(100))))
        print("="*50)
```

```
Train AUC for k = 91 is 84.62%

CV AUC for k = 91 is 83.27%

Test AUC for k = 91 is 82.98%
==================================================
```

```
In [0]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

        import matplotlib.pyplot as plt
        plt.title('Receiver Operating Characteristic')
        plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
        plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
        plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
        plt.legend(loc = 'lower right')
        plt.plot([0, 1], [0, 1],'r')
        plt.xlim([0, 1])
        plt.ylim([0, 1])
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.show()
```



```
In [0]: df_cm = pd.DataFrame(confusion_matrix(tfidf_w2v_test_y, y_pred_test), range(2), range(
        sns.set(font_scale=1.4)
        sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[0]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2bd470ec18>
```



7 [6] Conclusions

```
In [0]: # Please compare all your models using Prettytable library
```

```
In [78]: from prettytable import PrettyTable

         x = PrettyTable(["Vectorizer", "Model", "Hyper parameter k", "AUC", "F1 Score"])

         x.add_row(["BOW","Brute", 9, 0.52, 0.88])
         x.add_row(["BOW","kd_tree", 19, 0.57, 0.86])
         x.add_row(["TFIDF", "Brute", 9, 0.51, 0.91])
         x.add_row(["TFIDF","kd_tree" , 9, 0.60, 0.89])
         x.add_row(["W2V", "Brute", 97, 0.86, 0.92])
         x.add_row(["W2V", "kd_tree", 97, 0.86, 0.92])
         x.add_row(["TFIDFW2V", "Brute", 47, 0.82, 0.92])
         x.add_row(["TFIDFW2V", "kd_tree", 91, 0.82, 0.92])

         print(x.get_string(title="k-NN Model"))
```

```
+------------+---------+-------------------+------+----------+
| Vectorizer |  Model  | Hyper parameter k | AUC  | F1 Score |
+------------+---------+-------------------+------+----------+
|    BOW     |  Brute  |         9         | 0.52 |   0.88   |
|    BOW     | kd_tree |         19        | 0.57 |   0.86   |
|   TFIDF    |  Brute  |         9         | 0.51 |   0.91   |
|   TFIDF    | kd_tree |         9         | 0.6  |   0.89   |
|    W2V     |  Brute  |         97        | 0.86 |   0.92   |
|    W2V     | kd_tree |         97        | 0.86 |   0.92   |
|  TFIDFW2V  |  Brute  |         47        | 0.82 |   0.92   |
|  TFIDFW2V  | kd_tree |         91        | 0.82 |   0.92   |
+------------+---------+-------------------+------+----------+
```

In [0]: