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```
In [1]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")
        import sqlite3
        import pandas as pd
        import numpy as np
        import nltk
        import string
        import matplotlib.pyplot as plt
        import seaborn as sns
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer
        import re
        # Tutorial about Python regular expressions: https://pymotw.com/2/re/
        import string
        from nltk.corpus import stopwords
        from nltk.stem import PorterStemmer
        from nltk.stem.wordnet import WordNetLemmatizer
        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle
        from tqdm import tqdm
        import os
        from plotly import plotly
        import plotly.offline as offline
        import plotly.graph_objs as go
        offline.init_notebook_mode()
        from collections import Counter
        from sklearn.metrics import accuracy_score
```

```
C:\Users\Arvind\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected Window
```

```
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

1 1.1 Reading Data

```
In [2]: project_data = pd.read_csv('train_data.csv', nrows=50000)
        resource_data = pd.read_csv('resources.csv')
```

```
In [3]: print("Number of data points in train data", project_data.shape)
        print('-'*50)
        print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (50000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

```
In [4]: cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.col
        #sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084
        project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
        project_data.drop('project_submitted_datetime', axis=1, inplace=True)
        project_data.sort_values(by=['Date'], inplace=True)
        # how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
        project_data = project_data[cols]
        project_data.head(2)
```

```
Out[4]:        Unnamed: 0       id                        teacher_id teacher_prefix  \
        473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs.
        41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs.

              school_state                 Date project_grade_category  \
        473             GA  2016-04-27 00:53:00          Grades PreK-2
        41558           WA  2016-04-27 01:05:25             Grades 3-5

              project_subject_categories project_subject_subcategories  \
        473             Applied Learning             Early Development
        41558        Literacy & Language                      Literacy

                                        project_title  \
        473    Flexible Seating for Flexible Learning
        41558  Going Deep: The Art of Inner Thinking!

                                                 project_essay_1  \
473    I recently read an article about giving studen...
41558  My students crave challenge, they eat obstacle...

                                          project_essay_2  \
473    I teach at a low-income (Title 1) school. Ever...
41558  We are an urban, public k-5 elementary school...

                                          project_essay_3  \
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...

                                          project_essay_4  \
473    Benjamin Franklin once said, \"Tell me and I f...
41558  These remarkable gifts will provide students w...

                                 project_resource_summary  \
473    My students need flexible seating in the class...
41558  My students need copies of the New York Times ...

       teacher_number_of_previously_posted_projects  project_is_approved
473                                               2                    1
41558                                             2                    1
```

```
In [5]: print("Number of data points in train data", resource_data.shape)
        print(resource_data.columns.values)
        resource_data.head(2)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
```

```
Out[5]:         id                                        description  quantity  \
        0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
        1  p069063        Bouncy Bands for Desks (Blue support pipes)         3

            price
        0  149.00
        1   14.95
```

```
In [6]: project_grade_category = []
        for i in range(len(project_data)):
            a = project_data["project_grade_category"][i].replace(" ", "_")
            project_grade_category.append(a)
```

```
In [7]: project_grade_category[0:5]
```

```
Out[7]: ['Grades_PreK-2', 'Grades_6-8', 'Grades_6-8', 'Grades_PreK-2', 'Grades_PreK-2']
```

```
In [8]: project_data.drop(['project_grade_category'], axis=1, inplace=True)
In [9]: project_data["project_grade_category"] = project_grade_category
```

```
In [10]: project_data.head(5)
```

```
Out[10]:        Unnamed: 0       id                        teacher_id teacher_prefix  \
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs.
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs.
         29891      146723  p099708  c0a28c79fe8ad5810da49de47b3fb491           Mrs.
         23374       72317  p087808  598621c141cda5fb184ee7e8ccdd3fcc            Ms.
         49228       57854  p099430  4000cfe0c8b2df75a218347c1765e283            Ms.

               school_state                Date        project_subject_categories  \
         473             GA 2016-04-27 00:53:00                  Applied Learning
         41558           WA 2016-04-27 01:05:25               Literacy & Language
         29891           CA 2016-04-27 01:10:09  Math & Science, History & Civics
         23374           CA 2016-04-27 02:04:15               Literacy & Language
         49228           IL 2016-04-27 07:19:44               Literacy & Language

               project_subject_subcategories                             project_title  \
         473               Early Development    Flexible Seating for Flexible Learning
         41558                      Literacy    Going Deep: The Art of Inner Thinking!
         29891  Mathematics, Social Sciences        Breakout Box to Ignite Engagement!
         23374                 ESL, Literacy                         iPad for Learners
         49228                      Literacy  A flexible classroom for flexible minds!

                                                  project_essay_1  \
         473    I recently read an article about giving studen...
         41558  My students crave challenge, they eat obstacle...
         29891  It's the end of the school year. Routines have...
         23374  Never has society so rapidly changed. Technolo...
         49228  My students yearn for a classroom environment ...

                                                  project_essay_2  \
         473    I teach at a low-income (Title 1) school. Ever...
         41558  We are an urban, public k-5 elementary school...
         29891  My students desire challenges, movement, and c...
         23374  Our Language Arts and Social Justice Magnet Sc...
         49228  I have the privilege of teaching an incredible...

                                                  project_essay_3  \
         473    We need a classroom rug that we can use as a c...
         41558  With the new common core standards that have b...
         29891  I will design different clues using specific c...
         23374  \"Is it my turn, Ms. K? When am I going to be ...
         49228  Ideally, I would love to delve right into \"fl...

                                                  project_essay_4  \
         473    Benjamin Franklin once said, \"Tell me and I f...
```

```
41558  These remarkable gifts will provide students w...
29891  Donations to this project will immediately imp...
23374  By donating to this project, you will give my ...
49228  This project will be so beneficial for my stud...

                             project_resource_summary  \
473    My students need flexible seating in the class...
41558  My students need copies of the New York Times ...
29891  My students need items from a \"Breakout Box\"...
23374                        My students need 1 ipad mini.
49228  My students need 5 Hokki Stools and an easel o...

       teacher_number_of_previously_posted_projects  project_is_approved  \
473                                               2                    1
41558                                             2                    1
29891                                             6                    1
23374                                           127                    1
49228                                             1                    1

      project_grade_category
473            Grades_PreK-2
41558             Grades_6-8
29891             Grades_6-8
23374          Grades_PreK-2
49228          Grades_PreK-2
```

2 1.2 preprocessing of project_subject_categories

In [11]:

```
categories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-st
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-py
cat_list = []
for i in categories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warm
        if 'The' in j.split(): # this will split each of the catogory based on space
            j=j.replace('The','') # if we have the words "The" we are going to replac
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing s
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

project_data['clean_categories'] = cat_list
```

```
project_data.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

In [12]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-st
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-py

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warm
        if 'The' in j.split(): # this will split each of the catogory based on space
            j=j.replace('The','') # if we have the words "The" we are going to replac
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing s
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())
```

In [13]:
```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
```

In [14]:
```
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())
    sub_cat_dict = dict(my_counter)
    sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [15]:
```
title_word_count = []
```

In [16]:
```
for a in project_data["project_title"] :
    b = len(a.split())
    title_word_count.append(b)
```

In [17]:
```
project_data["title_word_count"] = title_word_count
```

In [18]:
```
project_data.head(5)
```

Out[18]:
```
      Unnamed: 0       id                        teacher_id teacher_prefix  \
473       100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs.
```

```
41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5          Mrs.
29891      146723  p099708  c0a28c79fe8ad5810da49de47b3fb491          Mrs.
23374       72317  p087808  598621c141cda5fb184ee7e8ccdd3fcc           Ms.
49228       57854  p099430  4000cfe0c8b2df75a218347c1765e283           Ms.

      school_state                Date  \
473             GA 2016-04-27 00:53:00
41558           WA 2016-04-27 01:05:25
29891           CA 2016-04-27 01:10:09
23374           CA 2016-04-27 02:04:15
49228           IL 2016-04-27 07:19:44

                                  project_title  \
473      Flexible Seating for Flexible Learning
41558    Going Deep: The Art of Inner Thinking!
29891        Breakout Box to Ignite Engagement!
23374                         iPad for Learners
49228  A flexible classroom for flexible minds!

                                         project_essay_1  \
473    I recently read an article about giving studen...
41558  My students crave challenge, they eat obstacle...
29891  It's the end of the school year. Routines have...
23374  Never has society so rapidly changed. Technolo...
49228  My students yearn for a classroom environment ...

                                         project_essay_2  \
473    I teach at a low-income (Title 1) school. Ever...
41558  We are an urban, public k-5 elementary school...
29891  My students desire challenges, movement, and c...
23374  Our Language Arts and Social Justice Magnet Sc...
49228  I have the privilege of teaching an incredible...

                                         project_essay_3  \
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...
29891  I will design different clues using specific c...
23374  \"Is it my turn, Ms. K? When am I going to be ...
49228  Ideally, I would love to delve right into \"fl...

                                         project_essay_4  \
473    Benjamin Franklin once said, \"Tell me and I f...
41558  These remarkable gifts will provide students w...
29891  Donations to this project will immediately imp...
23374  By donating to this project, you will give my ...
49228  This project will be so beneficial for my stud...

                                project_resource_summary  \
473    My students need flexible seating in the class...
41558  My students need copies of the New York Times ...
29891  My students need items from a \"Breakout Box\"...
23374                      My students need 1 ipad mini.
49228  My students need 5 Hokki Stools and an easel o...

       teacher_number_of_previously_posted_projects  project_is_approved  \
473                                               2                    1
41558                                             2                    1
29891                                             6                    1
23374                                           127                    1
49228                                             1                    1

      project_grade_category             clean_categories  \
473            Grades_PreK-2              AppliedLearning
41558             Grades_6-8            Literacy_Language
29891             Grades_6-8  Math_Science History_Civics
23374          Grades_PreK-2            Literacy_Language
49228          Grades_PreK-2            Literacy_Language

              clean_subcategories  title_word_count
473              EarlyDevelopment                 5
41558                    Literacy                 7
29891  Mathematics SocialSciences                 5
23374                ESL Literacy                 3
49228                    Literacy                 6
```

```
In [19]: len(project_data["project_title"][2].split())
```

```
Out[19]: 7
```

```
In [20]: # merge two column text dataframe:
         project_data["essay"] = project_data["project_essay_1"].map(str) +\
         project_data["project_essay_2"].map(str) + \
         project_data["project_essay_3"].map(str) + \
         project_data["project_essay_4"].map(str)
```

3 1.6 Introducing new feature “Number of Words in Essay”

```
In [21]: essay_word_count = []
```

```
In [22]: for ess in project_data["essay"] :
             c = len(ess.split())
             essay_word_count.append(c)
```

```
In [23]: project_data["essay_word_count"] = essay_word_count
```

```
In [24]: project_data.head(5)
```

```
Out[24]:        Unnamed: 0       id                        teacher_id teacher_prefix  \
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           Mrs.   
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           Mrs.   
         29891      146723  p099708  c0a28c79fe8ad5810da49de47b3fb491           Mrs.   
         23374       72317  p087808  598621c141cda5fb184ee7e8ccdd3fcc            Ms.   
         49228       57854  p099430  4000cfe0c8b2df75a218347c1765e283            Ms.   

               school_state                Date  \
         473             GA 2016-04-27 00:53:00   
         41558           WA 2016-04-27 01:05:25   
         29891           CA 2016-04-27 01:10:09   
         23374           CA 2016-04-27 02:04:15   
         49228           IL 2016-04-27 07:19:44   

                                           project_title  \
         473      Flexible Seating for Flexible Learning   
         41558    Going Deep: The Art of Inner Thinking!   
         29891        Breakout Box to Ignite Engagement!   
         23374                         iPad for Learners   
         49228  A flexible classroom for flexible minds!   

                                                  project_essay_1  \
         473    I recently read an article about giving studen...   
         41558  My students crave challenge, they eat obstacle...   
         29891  It's the end of the school year. Routines have...   
         23374  Never has society so rapidly changed. Technolo...   
         49228  My students yearn for a classroom environment ...   

                                                  project_essay_2  \
         473    I teach at a low-income (Title 1) school. Ever...   
         41558  We are an urban, public k-5 elementary school...    
         29891  My students desire challenges, movement, and c...   
         23374  Our Language Arts and Social Justice Magnet Sc...   
         49228  I have the privilege of teaching an incredible...   

                                                  project_essay_3  \
         473    We need a classroom rug that we can use as a c...   
         41558  With the new common core standards that have b...   
         29891  I will design different clues using specific c...   
         23374  \"Is it my turn, Ms. K? When am I going to be ...   
         49228  Ideally, I would love to delve right into \"fl...   

                                                  project_essay_4  \
         473    Benjamin Franklin once said, \"Tell me and I f...   
         41558  These remarkable gifts will provide students w...   
         29891  Donations to this project will immediately imp...   
         23374  By donating to this project, you will give my ...   
         49228  This project will be so beneficial for my stud...   
```

```
                                project_resource_summary  \
473    My students need flexible seating in the class...
41558  My students need copies of the New York Times ...
29891  My students need items from a \"Breakout Box\"...
23374                      My students need 1 ipad mini.
49228  My students need 5 Hokki Stools and an easel o...

       teacher_number_of_previously_posted_projects  project_is_approved  \
473                                               2                    1
41558                                             2                    1
29891                                             6                    1
23374                                           127                    1
49228                                             1                    1

      project_grade_category             clean_categories  \
473            Grades_PreK-2              AppliedLearning
41558             Grades_6-8            Literacy_Language
29891             Grades_6-8  Math_Science History_Civics
23374          Grades_PreK-2            Literacy_Language
49228          Grades_PreK-2            Literacy_Language

              clean_subcategories  title_word_count  \
473              EarlyDevelopment                 5
41558                    Literacy                 7
29891  Mathematics SocialSciences                 5
23374                ESL Literacy                 3
49228                    Literacy                 6

                                                   essay  essay_word_count
473    I recently read an article about giving studen...               225
41558  My students crave challenge, they eat obstacle...               184
29891  It's the end of the school year. Routines have...               285
23374  Never has society so rapidly changed. Technolo...               317
49228  My students yearn for a classroom environment ...               275
```

4 1.4 Test - Train Split

```
In [25]: # train test split
         from sklearn.model_selection import train_test_split
         X_train, X_test, y_train, y_test = train_test_split(project_data,
         project_data['project_is_approved'], test_size=0.33, stratify = project_data['project_
         X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stra
```

```
In [26]: X_train.drop(['project_is_approved'], axis=1, inplace=True)
         X_test.drop(['project_is_approved'], axis=1, inplace=True)
         X_cv.drop(['project_is_approved'], axis=1, inplace=True)
```

5 1.5 Text preprocessing

```
In [27]: # printing some random reviews
         print(X_train['essay'].values[0])
         print("="*50)
         print(X_train['essay'].values[500])
         print("="*50)
         print(X_train['essay'].values[1000])
         print("="*50)
         print(X_train['essay'].values[10000])
         print("="*50)
         print(X_train['essay'].values[20000])
         print("="*50)
```

```
I teach a dynamic group of fabulous kindergarten students in an extremely diverse school in Bro
==================================================
My students walk into our classroom every day full of life, ready to learn, and excited for wha
==================================================
My students are 29 of the most enthusiastic 2nd graders I've ever had!  They come bounding in e
==================================================
The great thing about 8th grade Health class is that all of my students can be successful! Beca
==================================================
I have the most creative students, they love to learn. Many of my students come form low income
==================================================
```

```
In [28]: # https://stackoverflow.com/a/47091490/4084039
         import re
         def decontracted(phrase):
             phrase = re.sub(r"won't", "will not", phrase)
             phrase = re.sub(r"can\'t", "can not", phrase)
             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 [29]: sent = decontracted(X_train['essay'].values[20000])
         print(sent)
         print("="*50)
```

```
I have the most creative students, they love to learn. Many of my students come form low income
==================================================
In [30]: # \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-
         sent = sent.replace('\\r', ' ')
         sent = sent.replace('\\"', ' ')
         sent = sent.replace('\\n', ' ')
         print(sent)
```

```
I have the most creative students, they love to learn. Many of my students come form low income
```

```
In [31]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
         print(sent)
```

```
I have the most creative students they love to learn Many of my students come form low income
```

```
In [32]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you'
         \
         "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
         'himself', \
         'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them
         'their',\
         'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
         'these', 'those', \
         'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having
         'do', 'does', \
         'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until',
         'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during'
         'before', 'after',\
         'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under
         , 'again', 'further',\
         'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both',
         'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very',
         's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd',
         , 'm', 'o', 're', \
         've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn',
         "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
         "mightn't", 'mustn',\
         "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
         "wasn't", 'weren', "weren't", \
         'won', "won't", 'wouldn', "wouldn't"]
```

6 1.5.1 Preprocessed Train data (Text)

```
In [33]: from tqdm import tqdm
         preprocessed_essays_train = []
         # tqdm is for printing the status bar
         for sentence in tqdm(X_train['essay'].values):
             sent = decontracted(sentence)
             sent = sent.replace('\\r', ' ')
             sent = sent.replace('\\"', ' ')
             sent = sent.replace('\\n', ' ')
             sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
             sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
             preprocessed_essays_train.append(sent.lower().strip())
```

```
100%|| 22445/22445 [00:14<00:00, 1512.69it/s]
```

```
In [34]: # after preprocesing
         preprocessed_essays_train[1000]
```

```
Out[34]: 'students 29 enthusiastic 2nd graders ever come bounding ever day ready take new chal
```

7 1.5.2 Preprocessed Test data (Text)

```
In [35]: preprocessed_essays_test = []
         # tqdm is for printing the status bar
         for sentence in tqdm(X_test['essay'].values):
             sent = decontracted(sentence)
             sent = sent.replace('\\r', ' ')
             sent = sent.replace('\\"', ' ')
             sent = sent.replace('\\n', ' ')
             sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
             sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
             preprocessed_essays_test.append(sent.lower().strip())
```

```
100%|| 16500/16500 [00:10<00:00, 1561.09it/s]
```

```
In [36]: # after preprocesing
         preprocessed_essays_test[1000]
```

```
Out[36]: 'students energetic students city chicago come different neighborhoods backgrounds co
```

8 1.5.3 Preprocessed Cross Validation data (Text)

```
In [37]: preprocessed_essays_cv = []
         # tqdm is for printing the status bar
         for sentence in tqdm(X_cv['essay'].values):
             sent = decontracted(sentence)
             sent = sent.replace('\\r', ' ')
             sent = sent.replace('\\"', ' ')
             sent = sent.replace('\\n', ' ')
```

```
            sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
            sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
            preprocessed_essays_cv.append(sent.lower().strip())
```

```
100%|| 11055/11055 [00:07<00:00, 1544.63it/s]
```

```
In [38]: # after preprocesing
         preprocessed_essays_cv[1000]
```

```
Out[38]: 'students 4 5 year many social economic backgrounds cultures early childhood years cr
```

9 1.6 Preprocessing of Project_title

```
In [39]: # printing some random titles.
         print(project_data['project_title'].values[0])
         print("="*50)
         print(project_data['project_title'].values[150])
         print("="*50)
         print(project_data['project_title'].values[1000])
         print("="*50)
         print(project_data['project_title'].values[20000])
         print("="*50)
```

```
Flexible Seating for Flexible Learning
==================================================
Elmo for Math Instruction
==================================================
Comfy Carpet for Creative Learning
==================================================
Wiggle, Waggle, Wobble: Hocus Focus!
==================================================
```

```
In [40]: preprocessed_titles_train = []
         for titles in tqdm(X_train["project_title"]):
             title = decontracted(titles)
             title = title.replace('\\r', ' ')
             title = title.replace('\\"', ' ')
             title = title.replace('\\n', ' ')
             title = re.sub('[^A-Za-z0-9]+', ' ', title)
             title = ' '.join(f for f in title.split() if f not in stopwords)
             preprocessed_titles_train.append(title.lower().strip())
```

```
100%|| 22445/22445 [00:00<00:00, 28775.69it/s]
```

```
In [41]: preprocessed_titles_train[1000]
```

```
Out[41]: 'help us wiggle on our wobble seats'
```

10 1.6.2 Preprocessing of Project Title for Test data

```
In [42]: preprocessed_titles_test = []
         for titles in tqdm(X_test["project_title"]):

             title = decontracted(titles)
             title = title.replace('\\r', ' ')
             title = title.replace('\\"', ' ')
             title = title.replace('\\n', ' ')
             title = re.sub('[^A-Za-z0-9]+', ' ', title)
             title = ' '.join(f for f in title.split() if f not in stopwords)
             preprocessed_titles_test.append(title.lower().strip())
```

```
100%|| 16500/16500 [00:00<00:00, 31728.53it/s]
```

```
In [43]: preprocessed_titles_test[1000]
```

```
Out[43]: 'charging towards stem'
```

11 1.6.3 Preprocessing of Project Title for Cross Validation data

```
In [44]: preprocessed_titles_cv = []
         for titles in tqdm(X_cv["project_title"]):
             title = decontracted(titles)
             title = title.replace('\\r', ' ')
             title = title.replace('\\"', ' ')
             title = title.replace('\\n', ' ')
             title = re.sub('[^A-Za-z0-9]+', ' ', title)
             title = ' '.join(f for f in title.split() if f not in stopwords)
             preprocessed_titles_cv.append(title.lower().strip())
```

```
100%|| 11055/11055 [00:00<00:00, 29716.45it/s]
```

```
In [45]: preprocessed_titles_cv[1000]
```

```
Out[45]: 'creating environment enhance my students learning'
```

12 1.5 Preparing data for models

```
In [46]: project_data.columns
```

```
Out[46]: Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
                'Date', 'project_title', 'project_essay_1', 'project_essay_2',
                'project_essay_3', 'project_essay_4', 'project_resource_summary',
                'teacher_number_of_previously_posted_projects', 'project_is_approved',
                'project_grade_category', 'clean_categories', 'clean_subcategories',
                'title_word_count', 'essay', 'essay_word_count'],
               dtype='object')
```

we are going to consider - school_state : categorical data - clean_categories : categorical data - clean_subcategories : categorical data - project_grade_category : categorical data - teacher_prefix : categorical data - project_title : text data - text : text data - project_resource_summary: text data (optinal) - quantity : numerical (optinal) - teacher_number_of_previously_posted_projects : numerical - price : numerical

13 1.5.1 Vectorizing Categorical data

14 One Hot Encode - Clean Categories of Projects

```
In [47]: # we use count vectorizer to convert the values into one

         from sklearn.feature_extraction.text import CountVectorizer

         vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False
         vectorizer.fit(X_train['clean_categories'].values)

         categories_one_hot_train = vectorizer.transform(X_train['clean_categories'].values)
         categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)
         categories_one_hot_cv = vectorizer.transform(X_cv['clean_categories'].values)

         print(vectorizer.get_feature_names())

         print("Shape of matrix of Train data after one hot encoding ",categories_one_hot_trai
         print("Shape of matrix of Test data after one hot encoding ",categories_one_hot_test.s
         print("Shape of matrix of CV data after one hot encoding ",categories_one_hot_cv.shape
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', 'I
Shape of matrix of Train data after one hot encoding  (22445, 9)
Shape of matrix of Test data after one hot encoding  (16500, 9)
Shape of matrix of CV data after one hot encoding  (11055, 9)
```

15 One Hot Encode - Clean Sub-Categories of Projects

```
In [48]: vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=Fa
         True)
         vectorizer.fit(X_train['clean_subcategories'].values)
         sub_categories_one_hot_train = vectorizer.transform(X_train['clean_subcategories'].val
         sub_categories_one_hot_test = vectorizer.transform(X_test['clean_subcategories'].value
         sub_categories_one_hot_cv = vectorizer.transform(X_cv['clean_subcategories'].values)
         print(vectorizer.get_feature_names())
         print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_hot_t
         print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_hot_te
         print("Shape of matrix of Cross Validation data after one hot encoding ",sub_categorie
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
Shape of matrix of Train data after one hot encoding  (22445, 30)
Shape of matrix of Test data after one hot encoding  (16500, 30)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 30)
```

16 One Hot Encode - School States

```
In [49]: my_counter = Counter()
         for state in project_data['school_state'].values:
             my_counter.update(state.split())
```

```
In [50]: school_state_cat_dict = dict(my_counter)
         sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lambda
```

```
In [51]: ## we use count vectorizer to convert the values into one hot encoded features

         vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lo
         vectorizer.fit(X_train['school_state'].values)

         school_state_categories_one_hot_train = vectorizer.transform(X_train['school_state'].
         school_state_categories_one_hot_test = vectorizer.transform(X_test['school_state'].va
         school_state_categories_one_hot_cv = vectorizer.transform(X_cv['school_state'].values

         print(vectorizer.get_feature_names())

         print("Shape of matrix of Train data after one hot encoding ",school_state_categories
         print("Shape of matrix of Test data after one hot encoding ",school_state_categories_
         print("Shape of matrix of Cross Validation data after one hot encoding ",school_state
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'SD', 'NE', 'AK', 'DE', 'WV', 'ME', 'NM', 'HI', 'DC', 'KS
Shape of matrix of Train data after one hot encoding  (22445, 51)
Shape of matrix of Test data after one hot encoding  (16500, 51)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 51)
```

17 One Hot Encode - Project Grade Category

```
In [52]: my_counter = Counter()
         for project_grade in project_data['project_grade_category'].values:
             my_counter.update(project_grade.split())
```

```
In [53]: project_grade_cat_dict = dict(my_counter)
         sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.items(), key=lambd
```

```
In [54]: ## we use count vectorizer to convert the values into one hot encoded features

         vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys()), l
         vectorizer.fit(X_train['project_grade_category'].values)
```

```
        project_grade_categories_one_hot_train = vectorizer.transform(X_train['project_grade_c
        project_grade_categories_one_hot_test = vectorizer.transform(X_test['project_grade_cat
        project_grade_categories_one_hot_cv = vectorizer.transform(X_cv['project_grade_catego

        print(vectorizer.get_feature_names())

        print("Shape of matrix of Train data after one hot encoding ",project_grade_categories
        print("Shape of matrix of Test data after one hot encoding ",project_grade_categories_
        print("Shape of matrix of Cross Validation data after one hot encoding ",project_grade
```

```
['Grades_9-12', 'Grades_6-8', 'Grades_3-5', 'Grades_PreK-2']
Shape of matrix of Train data after one hot encoding  (22445, 4)
Shape of matrix of Test data after one hot encoding  (16500, 4)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 4)
```

```
In [55]: project_data["teacher_prefix"].fillna(" ", inplace = True)
```

18 One Hot Encode - Teacher Prefix

```
In [56]: my_counter = Counter()
         for teacher_prefix in project_data['teacher_prefix'].values:
             teacher_prefix = str(teacher_prefix)
             my_counter.update(teacher_prefix.split())
```

```
In [57]: teacher_prefix_cat_dict = dict(my_counter)
         sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.items(), key=lamb
```

```
In [58]: ## we use count vectorizer to convert the values into one hot encoded features
         ## Unlike the previous Categories this category returns a
         ## ValueError: np.nan is an invalid document, expected byte or unicode string.
         ## The link below explains h0w to tackle such discrepancies.
         ## https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-value

         vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), l
         vectorizer.fit(X_train['teacher_prefix'].values.astype("U"))

         teacher_prefix_categories_one_hot_train = vectorizer.transform(X_train['teacher_prefi
         teacher_prefix_categories_one_hot_test = vectorizer.transform(X_test['teacher_prefix']
         teacher_prefix_categories_one_hot_cv = vectorizer.transform(X_cv['teacher_prefix'].val

         print(vectorizer.get_feature_names())

         print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_trai
         print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_tes
         print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_cv.s
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of matrix after one hot encoding  (22445, 5)
Shape of matrix after one hot encoding  (16500, 5)
Shape of matrix after one hot encoding  (11055, 5)
```

19 1.11 Vectorizing Text data

20 A) Bag of Words (BOW)

21 Bag of words - Train Data - Essays

```
In [59]: # We are considering only the words which appeared in at least 10 documents(rows or p

         vectorizer = CountVectorizer(min_df=10)
         vectorizer.fit(preprocessed_essays_train)

         text_bow_train = vectorizer.transform(preprocessed_essays_train)

         print("Shape of matrix after one hot encoding ",text_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 8827)
```

22 Bag of words - Test Data - Essays

```
In [60]: text_bow_test = vectorizer.transform(preprocessed_essays_test)
         print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8827)
```

23 Bag of words - Cross Validation Data - Essays

```
In [61]: text_bow_cv = vectorizer.transform(preprocessed_essays_cv)
         print("Shape of matrix after one hot encoding ",text_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8827)
```

24 Bag of words - Train Data - Titles

```
In [62]: vectorizer.fit(preprocessed_titles_train)
         title_bow_train = vectorizer.transform(preprocessed_titles_train)
         print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1241)
```

25 Bag of words - Test Data - Titles

```
In [63]: title_bow_test = vectorizer.transform(preprocessed_titles_test)
         print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1241)
```

26 Bag of words - Cross Validation Data - Titles

```
In [64]: title_bow_cv = vectorizer.transform(preprocessed_titles_cv)
         print("Shape of matrix after one hot encoding ",title_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 1241)
```

27 B) TFIDF vectorizer

TFIDF - Train Data - Essays

```
In [65]: from sklearn.feature_extraction.text import TfidfVectorizer

         vectorizer = TfidfVectorizer(min_df=10)
         vectorizer.fit(preprocessed_essays_train)

         text_tfidf_train = vectorizer.transform(preprocessed_essays_train)
         print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 8827)
```

28 TFIDF - Test Data - Essays

```
In [66]: text_tfidf_test = vectorizer.transform(preprocessed_essays_test)
         print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8827)
```

29 TFIDF - Cross Validation Data - Essays

```
In [67]: text_tfidf_cv = vectorizer.transform(preprocessed_essays_cv)
         print("Shape of matrix after one hot encoding ",text_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8827)
```

30 TFIDF - Train Data - Titles

```
In [68]: vectorizer = TfidfVectorizer(min_df=10)

         vectorizer.fit(preprocessed_titles_train)
         title_tfidf_train = vectorizer.transform(preprocessed_titles_train)
         print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1241)
```

31 TFIDF - Test Data - Titles

```
In [69]: title_tfidf_test = vectorizer.transform(preprocessed_titles_test)
         print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1241)
```

32 TFIDF - Cross Validation Data - Titles

```
In [70]: title_tfidf_cv = vectorizer.transform(preprocessed_titles_cv)
         print("Shape of matrix after one hot encoding ",title_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 1241)
```

33 C) Using Pretrained Models: Avg W2V

```
In [71]: with open('glove_vectors', 'rb') as f:
             model = pickle.load(f)
             glove_words =  set(model.keys())
```

```
In [72]: words_train_essays = []

         for i in preprocessed_essays_train :
             words_train_essays.extend(i.split(' '))
```

```
In [73]: ## Find the total number of words in the Train data of Essays.

         print("all the words in the corpus", len(words_train_essays))
```

```
all the words in the corpus 3091831
```

```
In [74]: ## Find the unique words in this set of words

         words_train_essay = set(words_train_essays)
         print("the unique words in the corpus", len(words_train_essay))
```

```
the unique words in the corpus 30365
```

```
In [75]: # Find the words present in both Glove Vectors as well as our corpus.

         inter_words = set(model.keys()).intersection(words_train_essay)

         print("The number of words that are present in both glove vectors and our corpus are 
         is nearly {}% ".format(len(inter_words), np.round((float(len(inter_words))/len(words_
```

```
The number of words that are present in both glove vectors and our corpus are 18804 which is ne
```

```
In [76]: words_corpus_train_essay = {}

         words_glove = set(model.keys())

         for i in words_train_essay:
             if i in words_glove:
                 words_corpus_train_essay[i] = model[i]

         print("word 2 vec length", len(words_corpus_train_essay))
```

```
word 2 vec length 18804
```

```
In [77]: # stronging variables into pickle files python: http://www.jessicayung.com/how-to-use

         import pickle
         with open('glove_vectors', 'wb') as f:
             pickle.dump(words_corpus_train_essay, f)
```

```
In [78]: # stronging variables into pickle files python: http://www.jessicayung.com/how-to-use
         # make sure you have the glove_vectors file
         with open('glove_vectors', 'rb') as f:
             model = pickle.load(f)
             glove_words =  set(model.keys())
```

34 Train - Essays

```
In [79]: # average Word2Vec
         # compute average word2vec for each review.

         avg_w2v_vectors_train = [];

         for sentence in tqdm(preprocessed_essays_train): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
```

```
            for word in sentence.split(): # for each word in a review/sentence
                if word in glove_words:
                    vector += model[word]
                    cnt_words += 1
            if cnt_words != 0:
                vector /= cnt_words
            avg_w2v_vectors_train.append(vector)

        print(len(avg_w2v_vectors_train))
        print(len(avg_w2v_vectors_train[0]))
```

```
100%|| 22445/22445 [00:08<00:00, 2683.39it/s]


22445
300
```

35 Test - Essays

```
In [80]: # average Word2Vec
         # compute average word2vec for each review.

         avg_w2v_vectors_test = [];

         for sentence in tqdm(preprocessed_essays_test): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_test.append(vector)

         print(len(avg_w2v_vectors_test))
         print(len(avg_w2v_vectors_test[0]))
```

```
100%|| 16500/16500 [00:06<00:00, 2637.31it/s]


16500
300
```

36 Cross-Validation - Essays

```
In [81]: # average Word2Vec
         # compute average word2vec for each review.

         avg_w2v_vectors_cv = [];

         for sentence in tqdm(preprocessed_essays_cv): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_cv.append(vector)

         print(len(avg_w2v_vectors_cv))
         print(len(avg_w2v_vectors_cv[0]))
```

```
100%|| 11055/11055 [00:03<00:00, 2796.71it/s]


11055
300
```

37 Train - Titles

```
In [82]: # Similarly you can vectorize for title also

         avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored i
         for sentence in tqdm(preprocessed_titles_train): # for each title
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_titles_train.append(vector)

         print(len(avg_w2v_vectors_titles_train))
         print(len(avg_w2v_vectors_titles_train[0]))
```

```
100%|| 22445/22445 [00:00<00:00, 38963.81it/s]
```

```
22445
300
```

38 Test - Titles

```
In [83]: # Similarly you can vectorize for title also

         avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(preprocessed_titles_test): # for each title
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_titles_test.append(vector)

         print(len(avg_w2v_vectors_titles_test))
         print(len(avg_w2v_vectors_titles_test[0]))
```

```
100%|| 16500/16500 [00:00<00:00, 49699.01it/s]


16500
300
```

39 Cross-Validation - Titles

```
In [84]: # Similarly you can vectorize for title also

         avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in t
         for sentence in tqdm(preprocessed_titles_cv): # for each title
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_titles_cv.append(vector)

         print(len(avg_w2v_vectors_titles_cv))
         print(len(avg_w2v_vectors_titles_cv[0]))
```

```
100%|| 11055/11055 [00:00<00:00, 40052.82it/s]


11055
300
```

40 D) Using Pretrained Models: TFIDF weighted W2V

41 Train - Essays

```
In [85]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         tfidf_model = TfidfVectorizer()
         tfidf_model.fit(preprocessed_essays_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
         tfidf_words = set(tfidf_model.get_feature_names())
```

```
In [86]: # average Word2Vec
         # compute average word2vec for each review.
         tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in thi
         for sentence in tqdm(preprocessed_essays_train): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_train.append(vector)

         print(len(tfidf_w2v_vectors_train))
         print(len(tfidf_w2v_vectors_train[0]))
```

```
100%|| 22445/22445 [00:55<00:00, 402.02it/s]


22445
300
```

42 Test - Essays

```
In [87]: # compute average word2vec for each review.
```

```
         tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this
         for sentence in tqdm(preprocessed_essays_test): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_test.append(vector)

         print(len(tfidf_w2v_vectors_test))
         print(len(tfidf_w2v_vectors_test[0]))
```

```
100%|| 16500/16500 [00:40<00:00, 452.18it/s]


16500
300
```

43 Cross-Validation - Essays

```
In [88]: # compute average word2vec for each review.

         tfidf_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this l
         for sentence in tqdm(preprocessed_essays_cv): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_cv.append(vector)

         print(len(tfidf_w2v_vectors_cv))
         print(len(tfidf_w2v_vectors_cv[0]))
```

```
100%|| 11055/11055 [00:24<00:00, 448.89it/s]
```

```
11055
300
```

44 Train - Titles

```
In [89]: tfidf_model = TfidfVectorizer()
         tfidf_model.fit(preprocessed_titles_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
         tfidf_words = set(tfidf_model.get_feature_names())
```

```
In [90]: # compute average word2vec for each review.

         tfidf_w2v_vectors_titles_train = [];

         for sentence in tqdm(preprocessed_titles_train): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_titles_train.append(vector)

         print(len(tfidf_w2v_vectors_titles_train))
         print(len(tfidf_w2v_vectors_titles_train[0]))
```

```
100%|| 22445/22445 [00:00<00:00, 26343.83it/s]


22445
300
```

45 Test - Titles

```
In [91]: # compute average word2vec for each review.

         tfidf_w2v_vectors_titles_test = [];

         for sentence in tqdm(preprocessed_titles_test): # for each review/sentence
```

```
            vector = np.zeros(300) # as word vectors are of zero length
            tf_idf_weight =0; # num of words with a valid vector in the sentence/review
            for word in sentence.split(): # for each word in a review/sentence
                if (word in glove_words) and (word in tfidf_words):
                    vec = model[word] # getting the vector for each word
                    # here we are multiplying idf value(dictionary[word]) and the tf value((s
                    tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
                    vector += (vec * tf_idf) # calculating tfidf weighted w2v
                    tf_idf_weight += tf_idf
            if tf_idf_weight != 0:
                vector /= tf_idf_weight
            tfidf_w2v_vectors_titles_test.append(vector)

        print(len(tfidf_w2v_vectors_titles_test))
        print(len(tfidf_w2v_vectors_titles_test[0]))
```

```
100%|| 16500/16500 [00:00<00:00, 26785.75it/s]


16500
300
```

46 Cross-Validation - Titles

```
In [92]: # compute average word2vec for each review.

         tfidf_w2v_vectors_titles_cv = [];

         for sentence in tqdm(preprocessed_titles_cv): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             tf_idf_weight =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if (word in glove_words) and (word in tfidf_words):
                     vec = model[word] # getting the vector for each word
                     # here we are multiplying idf value(dictionary[word]) and the tf value((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_titles_cv.append(vector)

         print(len(tfidf_w2v_vectors_titles_cv))
         print(len(tfidf_w2v_vectors_titles_cv[0]))
```

```
100%|| 11055/11055 [00:00<00:00, 22108.02it/s]
```

```
11055
300
```

47 1.12 Vectorizing Numerical features

48 A) Price

```
In [93]: # https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-
         price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_
         price_data.head(2)

Out[93]:         id   price  quantity
         0  p000001  459.56         7
         1  p000002  515.89        21

In [94]: # join two dataframes in python:
         X_train = pd.merge(X_train, price_data, on='id', how='left')
         X_test = pd.merge(X_test, price_data, on='id', how='left')
         X_cv = pd.merge(X_cv, price_data, on='id', how='left')

In [95]: from sklearn.preprocessing import Normalizer

         normalizer = Normalizer()

         # normalizer.fit(X_train['price'].values)
         # this will rise an error Expected 2D array, got 1D array instead:
         # array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
         # Reshape your data either using
         # array.reshape(-1, 1) if your data has a single feature
         # array.reshape(1, -1)  if it contains a single sample.

         normalizer.fit(X_train['price'].values.reshape(-1,1))

         price_train = normalizer.transform(X_train['price'].values.reshape(-1,1))
         price_cv = normalizer.transform(X_cv['price'].values.reshape(-1,1))
         price_test = normalizer.transform(X_test['price'].values.reshape(-1,1))

         print("After vectorizations")
         print(price_train.shape, y_train.shape)
         print(price_cv.shape, y_cv.shape)
         print(price_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
```

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

49 B) Quantity

```
In [96]: normalizer = Normalizer()

         # normalizer.fit(X_train['price'].values)
         # this will rise an error Expected 2D array, got 1D array instead:
         # array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
         # Reshape your data either using
         # array.reshape(-1, 1) if your data has a single feature
         # array.reshape(1, -1)  if it contains a single sample.

         normalizer.fit(X_train['quantity'].values.reshape(-1,1))

         quantity_train = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
         quantity_cv = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
         quantity_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

         print("After vectorizations")
         print(quantity_train.shape, y_train.shape)
         print(quantity_cv.shape, y_cv.shape)
         print(quantity_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
===============================================================================================
```

50 C) Number of Projects previously proposed by Teacher

```
In [97]: normalizer = Normalizer()

         # normalizer.fit(X_train['price'].values)
         # this will rise an error Expected 2D array, got 1D array instead:
         # array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
         # Reshape your data either using
         # array.reshape(-1, 1) if your data has a single feature
         # array.reshape(1, -1)  if it contains a single sample.

         normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape

         prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_poste
         prev_projects_cv = normalizer.transform(X_cv['teacher_number_of_previously_posted_pro
         prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_

         print("After vectorizations")
         print(prev_projects_train.shape, y_train.shape)
         print(prev_projects_cv.shape, y_cv.shape)
         print(prev_projects_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
===============================================================================================
```

51 D) Title word Count

```
In [98]: normalizer = Normalizer()

         normalizer.fit(X_train['title_word_count'].values.reshape(-1,1))

         title_word_count_train = normalizer.transform(X_train['title_word_count'].values.resha
         title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1
         title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshap

         print("After vectorizations")
         print(title_word_count_train.shape, y_train.shape)
         print(title_word_count_cv.shape, y_cv.shape)
         print(title_word_count_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
===============================================================================================
```

52 E) Essay word Count

```
In [99]: normalizer = Normalizer()

         normalizer.fit(X_train['essay_word_count'].values.reshape(-1,1))

         essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.resha
         essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1
         essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape

         print("After vectorizations")
         print(essay_word_count_train.shape, y_train.shape)
         print(essay_word_count_cv.shape, y_cv.shape)
         print(essay_word_count_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
===============================================================================================
```

53 Assignment : Apply KNN

54 K Nearest Neighbor

55 Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

```
In [100]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
          X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, school_state_catego
```

```
In [101]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_cr.shape, y_cv.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix
(22445, 10172) (22445,)
(11055, 10172) (11055,)
(16500, 10172) (16500,)
===============================================================================================
```

56 A) Find the best hyper parameter which results in the maximum AUC value

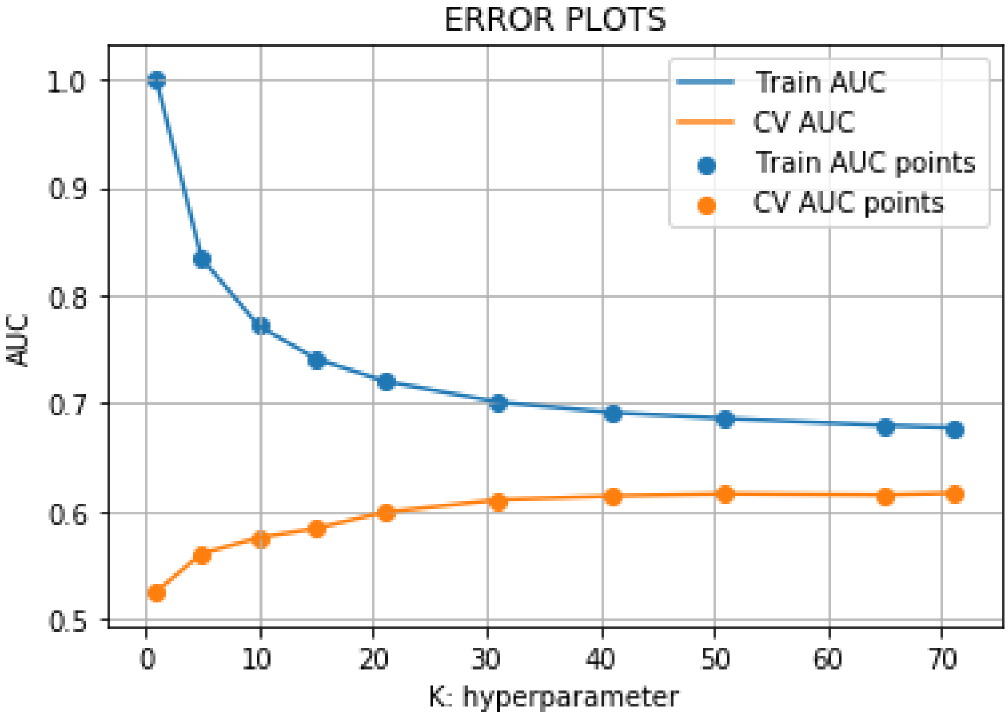
```
In [104]: def batch_predict(clf, data):
              # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
```

```
        # not the predicted outputs

        y_data_pred = []
        tr_loop = data.shape[0] - data.shape[0]%1000
        # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000
        # in this for loop we will iterate unti the last 1000 multiplier
        for i in range(0, tr_loop, 1000):
            y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
        # we will be predicting for the last data points
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

        return y_data_pred
```

In [105]:
```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence
decisions (as returned by decision_function on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater lab

"""

train_auc = []
cv_auc = []
a = []
b = []

K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cr)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    a.append(y_train_pred)
```

```
            b.append(y_cv_pred)
        plt.plot(K, train_auc, label='Train AUC')
        plt.plot(K, cv_auc, label='CV AUC')

        plt.scatter(K, train_auc, label='Train AUC points')
        plt.scatter(K, cv_auc, label='CV AUC points')

        plt.legend()
        plt.xlabel("K: hyperparameter")
        plt.ylabel("AUC")
        plt.title("ERROR PLOTS")
        plt.grid()
        plt.show()
```

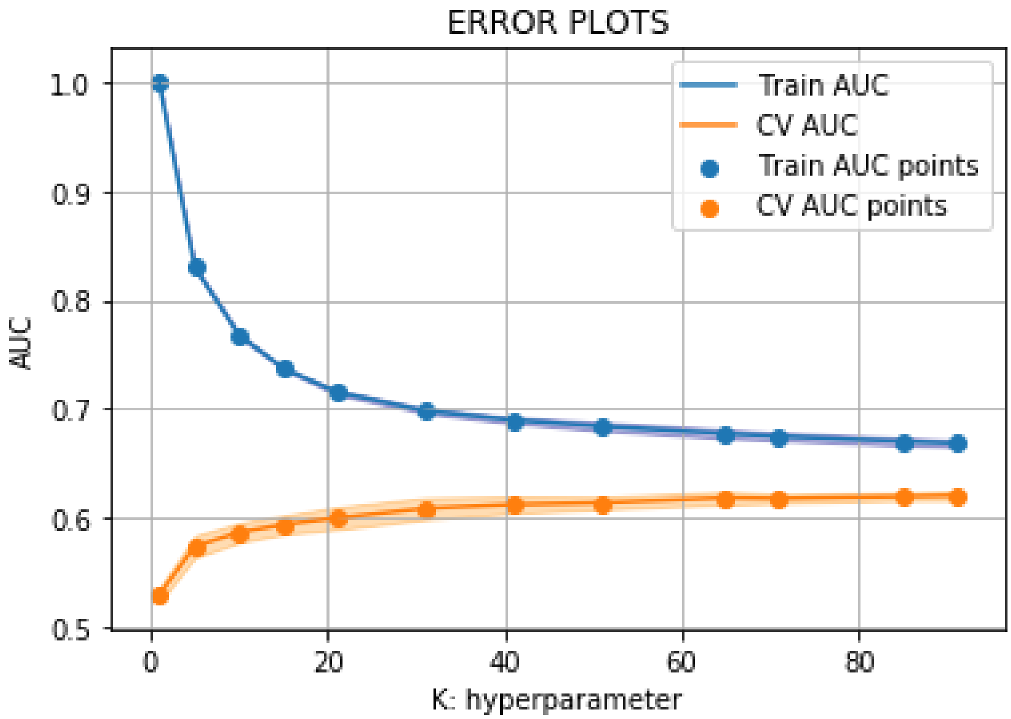
```
100%|| 10/10 [13:16<00:00, 82.34s/it]
```



57 B) Gridsearch-cv

```
In [108]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSear
          from sklearn.model_selection import GridSearchCV

          neigh = KNeighborsClassifier()
```

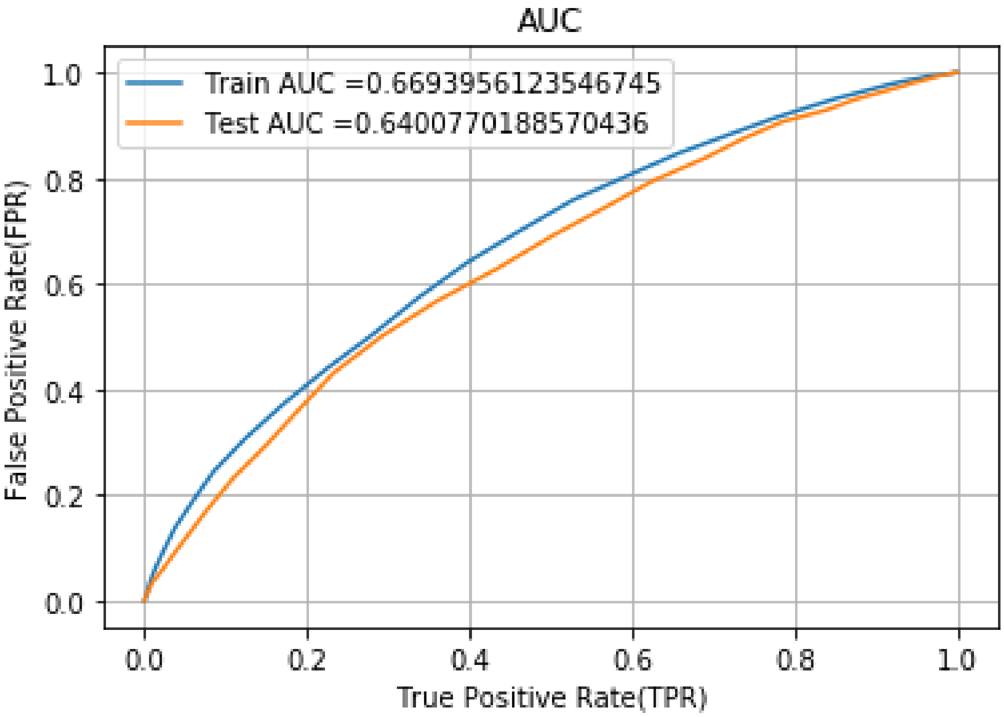
```
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]}

clf = GridSearchCV(neigh, parameters, cv= 5, scoring='roc_auc')

clf.fit(X_tr, y_train)

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

plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_

plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



```
In [131]: best_k_3 = 91
```

58 C) Train model using the best hyper-parameter value

```
In [132]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s

          neigh = KNeighborsClassifier(n_neighbors=best_k_3)
          neigh.fit(X_tr, y_train)
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          y_train_pred = batch_predict(neigh, X_tr)
          y_test_pred = batch_predict(neigh, X_te)

          train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
          test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

          plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("True Positive Rate(TPR)")
          plt.ylabel("False Positive Rate(FPR)")
          plt.title("AUC")
          plt.grid()
          plt.show()
```



59 D) Confusion Matrix

60 Train Data

```
In [114]: def predict(proba, threshould, fpr, tpr):

              t = threshould[np.argmax(fpr*(1-tpr))]

              # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

              print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.r
              predictions = []
              for i in proba:
                  if i>=t:
                      predictions.append(1)
                  else:
                      predictions.append(0)
              return predictions
```

```
In [134]: print("="*100)
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

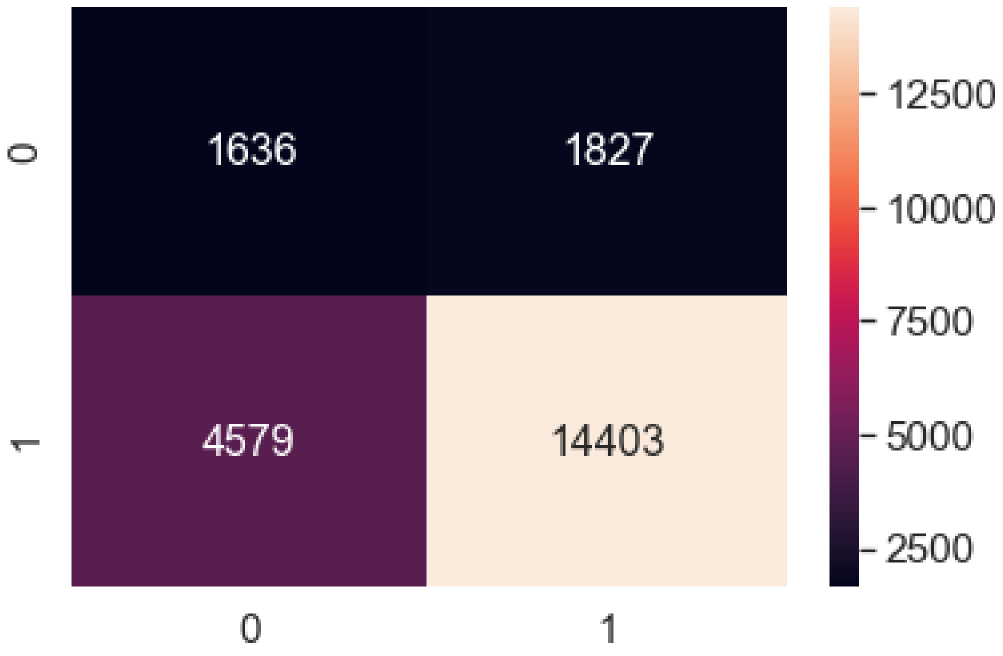
```
==========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24923949554921135 for threshold 0.769
[[ 1636  1827]
 [ 4579 14403]]
```

```
In [135]: conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.24923949554921135 for threshold 0.769
```

```
In [136]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_2, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[136]: <matplotlib.axes._subplots.AxesSubplot at 0x25976f06518>
```



61 Test Data

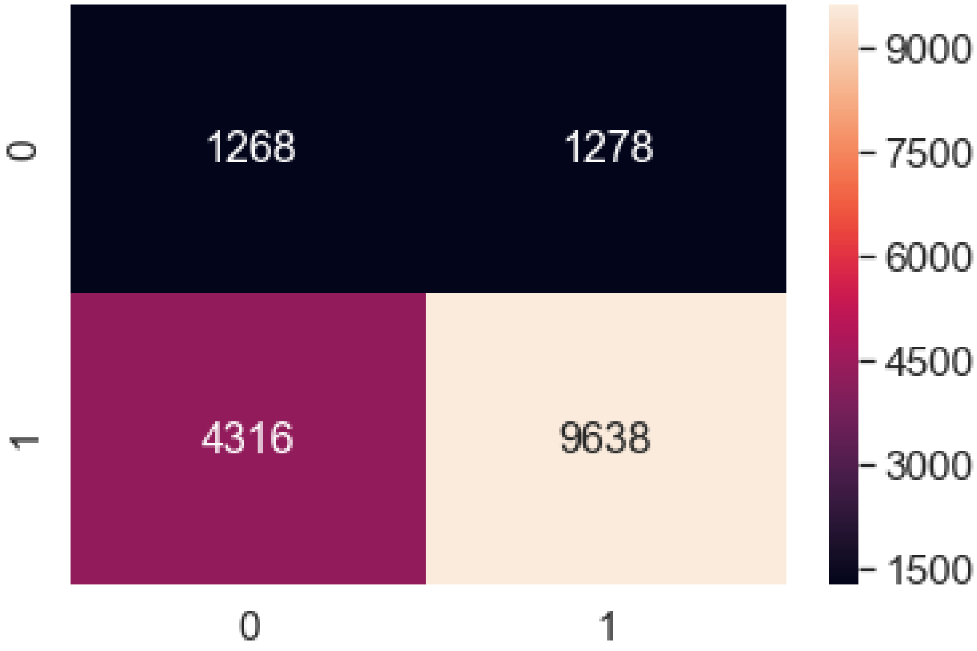
```
In [137]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999614323470917 for threshold 0.78
[[1268 1278]
 [4316 9638]]
```

```
In [138]: conf_matr_df_test = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thi
```

```
the maximum value of tpr*(1-fpr) 0.24999614323470917 for threshold 0.78
```

```
In [139]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[139]: <matplotlib.axes._subplots.AxesSubplot at 0x25976dbea20>
```



62 Set 2 : categorical, numerical features + project_title(TFIDF) + preprocessed_essay (TFIDF)

```
In [140]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
          X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, school_state_catego
In [141]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_cr.shape, y_cv.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

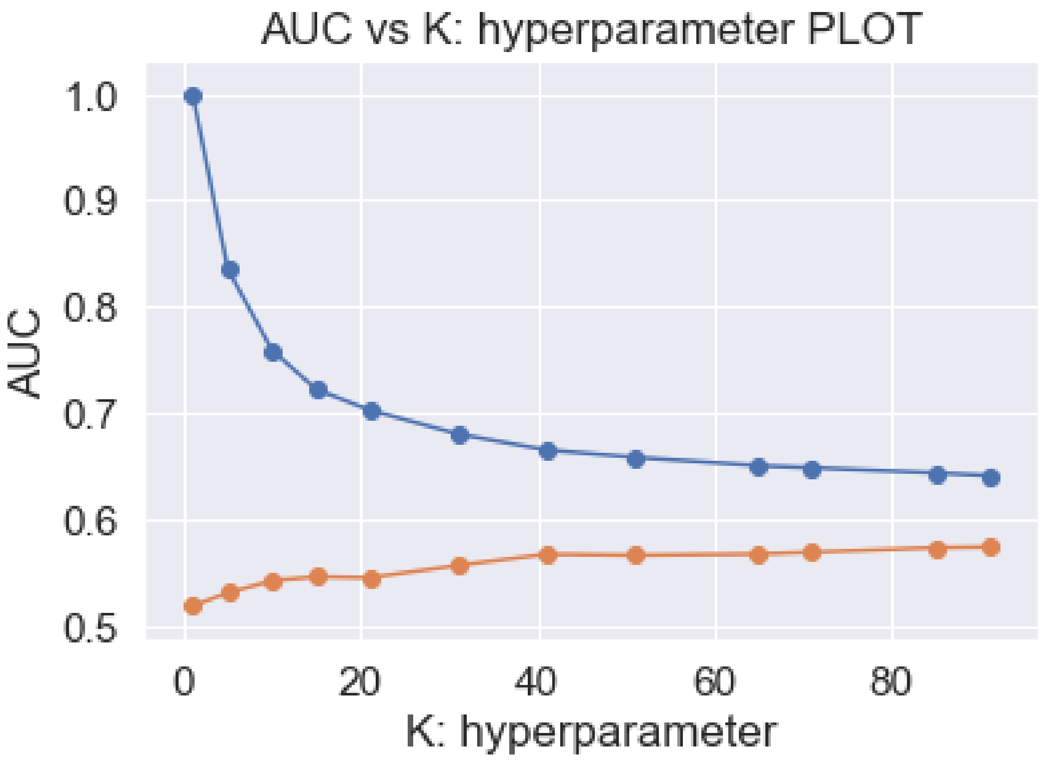
```
Final Data matrix
(22445, 10164) (22445,)
(11055, 10164) (11055,)
(16500, 10164) (16500,)
==============================================================================================
```

63 A) Find the best hyper parameter which results in the maximum AUC value

```
In [142]: train_auc = []
          cv_auc = []
          K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]
          for i in tqdm(K):
              neigh = KNeighborsClassifier(n_neighbors=i)
              neigh.fit(X_tr, y_train)

              y_train_pred = batch_predict(neigh, X_tr)
              y_cv_pred = batch_predict(neigh, X_cr)

              # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
              # not the predicted outputs
              train_auc.append(roc_auc_score(y_train,y_train_pred))
              cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

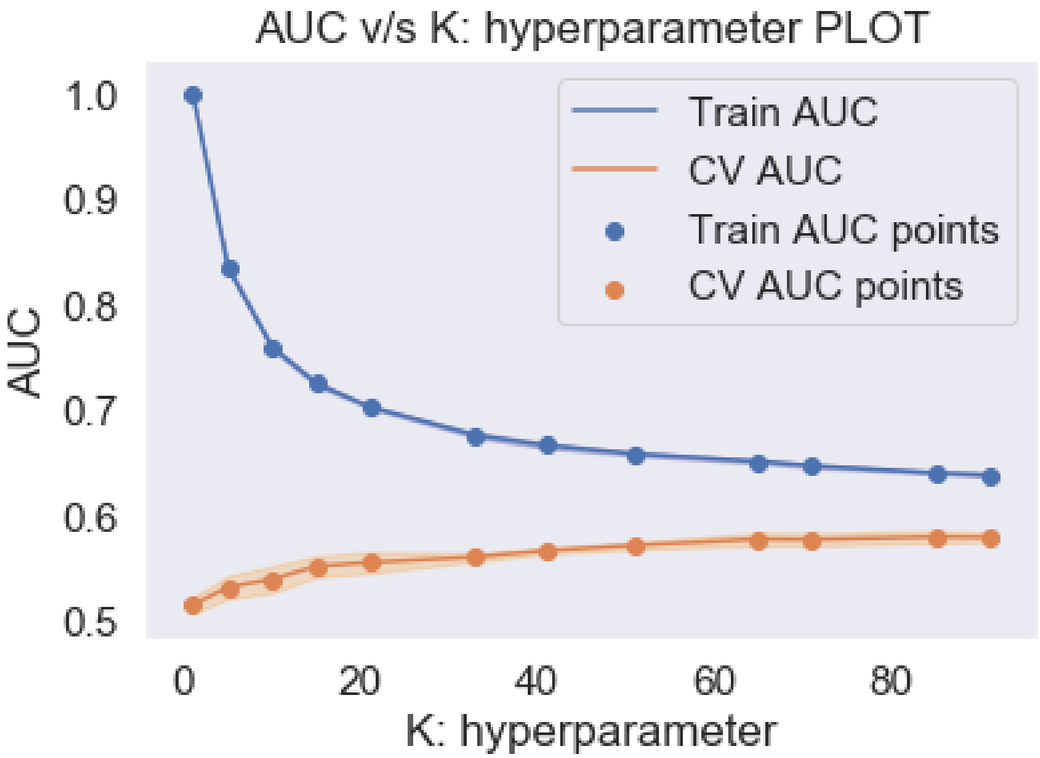
```
100%|| 12/12 [18:43<00:00, 80.58s/it]
```

```
In [144]: plt.plot(K, train_auc, label='Train AUC')
          plt.plot(K, cv_auc, label='CV AUC')

          plt.scatter(K, train_auc, label='Train AUC points')
          plt.scatter(K, cv_auc, label='CV AUC points')

          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC vs K: hyperparameter PLOT")
          plt.show()
```



64 B) Gridsearch-cv

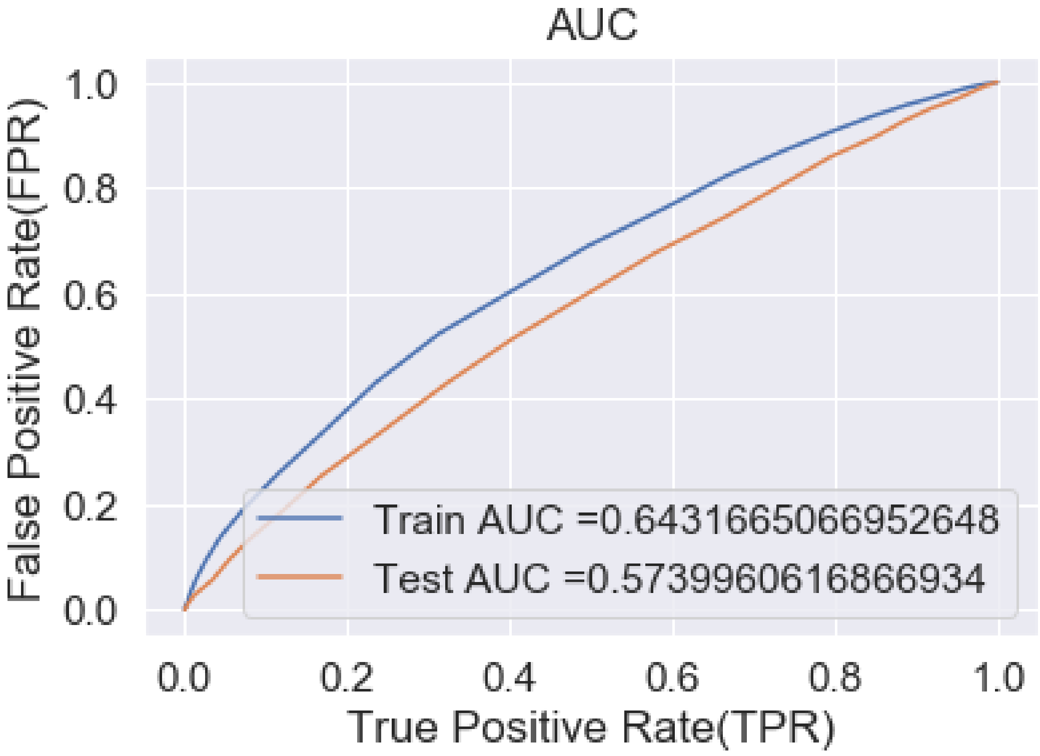
```
In [145]: neigh = KNeighborsClassifier()
          parameters = {'n_neighbors':[1, 5, 10, 15, 21, 33, 41, 51, 65, 71, 85, 91]}
          clf = GridSearchCV(neigh, parameters, cv=5, scoring='roc_auc')
          clf.fit(X_tr, y_train)

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

          plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
          plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc

          plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
          plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_

          plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
          plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')
          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC v/s K: hyperparameter PLOT")
          plt.grid()
          plt.show()
```



```
In [146]: best_k_2 = 85
```

65 C) Train model using the best hyper-parameter value

```
In [147]: neigh = KNeighborsClassifier(n_neighbors=best_k_2)
          neigh.fit(X_tr, y_train)
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          y_train_pred = batch_predict(neigh, X_tr)
          y_test_pred = batch_predict(neigh, X_te)

          train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
          test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

          plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("True Positive Rate(TPR)")
          plt.ylabel("False Positive Rate(FPR)")
          plt.title("AUC")
          plt.show()
```



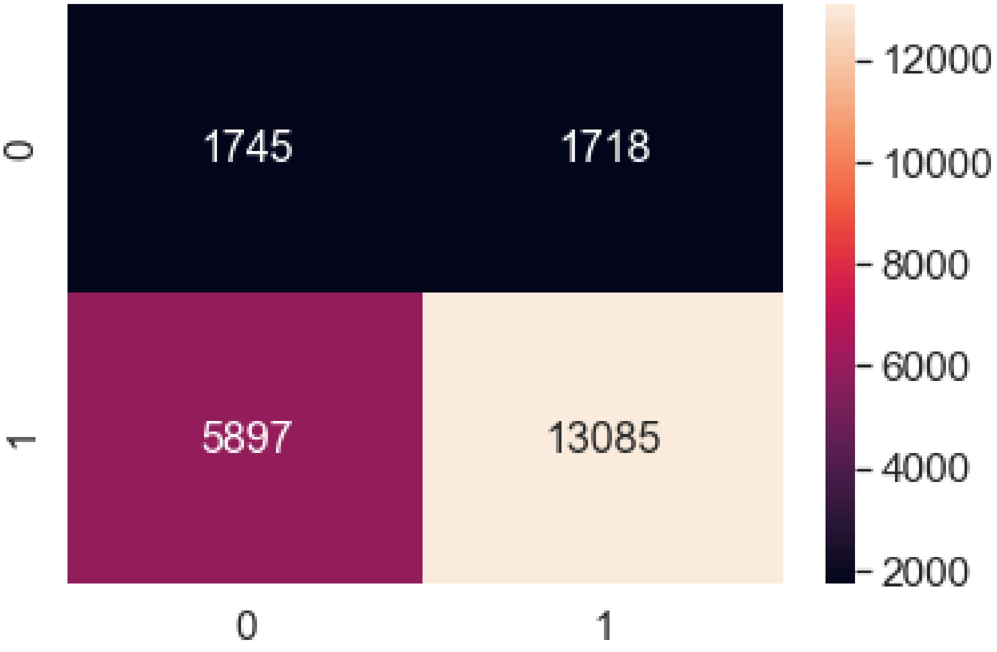
66 D) Confusion Matrix

```
In [148]: print("="*100)
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

```
==============================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24998480283587005 for threshold 0.835
[[ 1745  1718]
 [ 5897 13085]]
```

```
In [149]: conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t

the maximum value of tpr*(1-fpr) 0.24998480283587005 for threshold 0.835
```

```
In [150]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[150]: <matplotlib.axes._subplots.AxesSubplot at 0x25976f0c080>
```



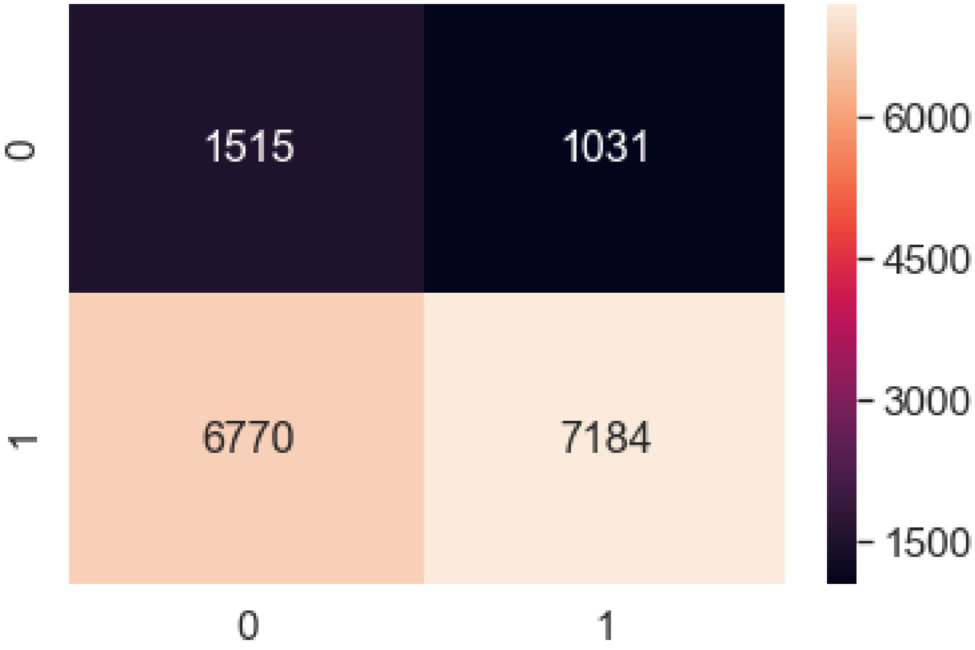
67 Test Data

```
In [151]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr

====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24998133325599237 for threshold 0.859
[[1515 1031]
 [6770 7184]]
```

```
In [152]: conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_t
the maximum value of tpr*(1-fpr) 0.24998133325599237 for threshold 0.859
```

```
In [153]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[153]: <matplotlib.axes._subplots.AxesSubplot at 0x25976dfc518>
```



68 Set 3 : categorical, numerical features + project_title(AVG W2V) + preprocessed_essay (AVG W2V)

```
In [154]: from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_ca
          X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, school_state_catego
```

```
In [155]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_cr.shape, y_cv.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

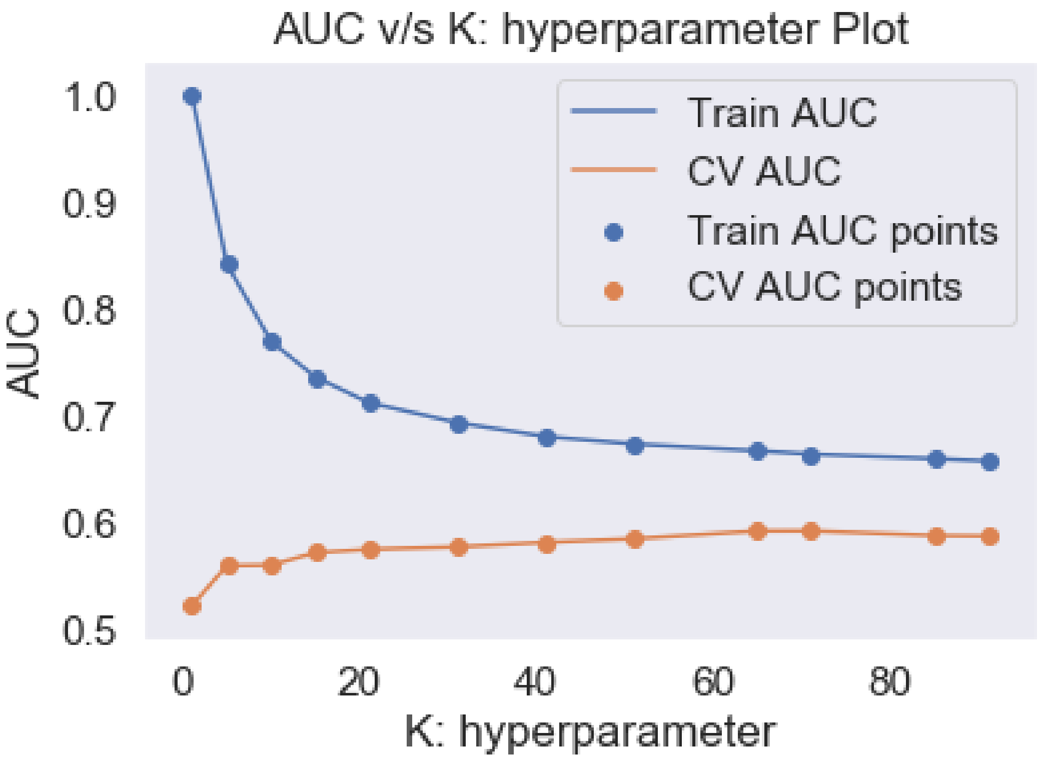
```
Final Data matrix
(22445, 704) (22445,)
```

```
(11055, 704) (11055,)
(16500, 704) (16500,)
===========================================================================================
```

69 A) Find the best hyper parameter which results in the maximum AUC value

```
In [156]: train_auc = []
          cv_auc = []

          K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

          for i in tqdm(K):
              neigh = KNeighborsClassifier(n_neighbors=i)
              neigh.fit(X_tr, y_train)

              y_train_pred = batch_predict(neigh, X_tr)
              y_cv_pred = batch_predict(neigh, X_cr)

              # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
              # not the predicted outputs
              train_auc.append(roc_auc_score(y_train,y_train_pred))
              cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

          plt.scatter(K, train_auc, label='Train AUC points')
          plt.scatter(K, cv_auc, label='CV AUC points')

          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC v/s K: hyperparameter Plot")
          plt.grid()
          plt.show()
```

```
100%|| 12/12 [3:28:43<00:00, 1044.29s/it]
```



70 B) Gridsearch-cv

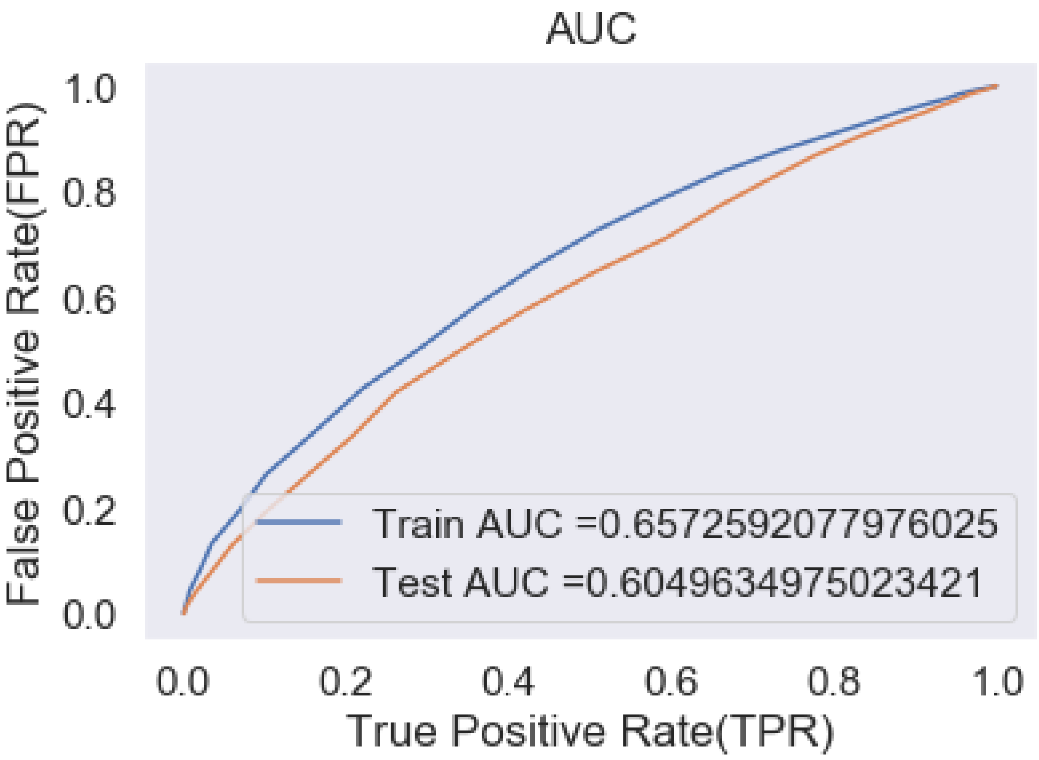
In [ ]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearch

neigh = KNeighborsClassifier()
parameters = {'n_neighbors':[1, 5, 10, 15, 21, 33, 41, 51, 65, 71, 85, 91]}
clf = GridSearchCV(neigh, parameters, cv=5, scoring='roc_auc')
clf.fit(X_tr, y_train)

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

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

plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_s
plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot - using GridSearchcv")
plt.show()
```

```
In [ ]: best_k_3 = 91
```

71 C) Train model using the best hyper-parameter value

```
In [158]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s

          neigh = KNeighborsClassifier(n_neighbors=best_k_3)
          neigh.fit(X_tr, y_train)
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          y_train_pred = batch_predict(neigh, X_tr)
          y_test_pred = batch_predict(neigh, X_te)

          train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
          test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

          plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("True Positive Rate(TPR)")
          plt.ylabel("False Positive Rate(FPR)")
          plt.title("AUC")
          plt.grid()
          plt.show()
```



72 D) Confusion Matrix

```
In [159]: print("="*100)
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

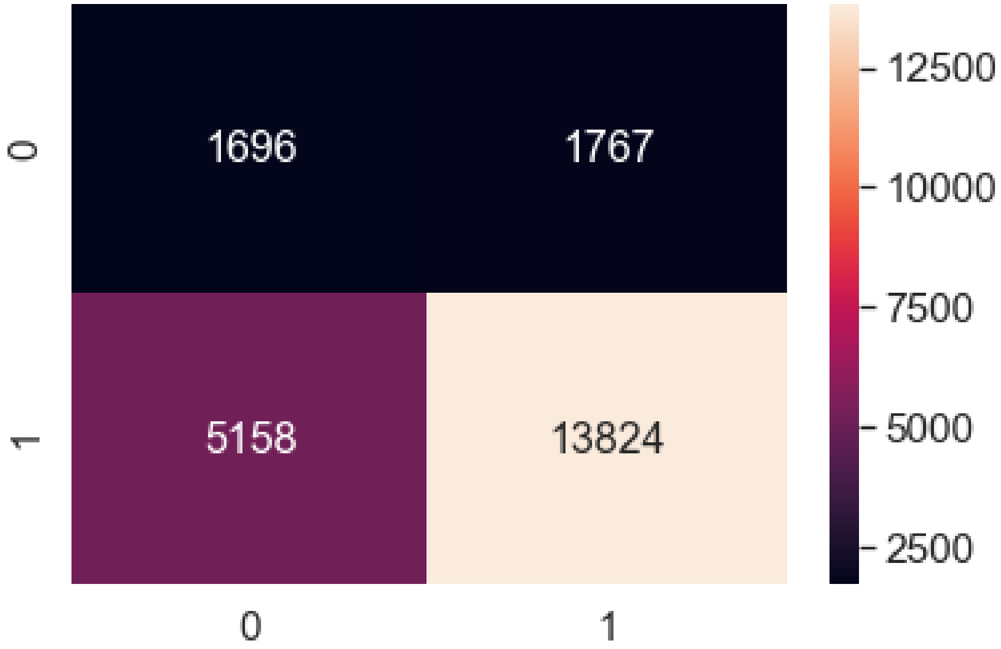
```
=========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.249894912339672 for threshold 0.835
[[ 1696  1767]
 [ 5158 13824]]
```

```
In [160]: conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.249894912339672 for threshold 0.835
```

```
In [161]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_2, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[161]: <matplotlib.axes._subplots.AxesSubplot at 0x2594ef279b0>
```



73 Test Data

```
In [162]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
```

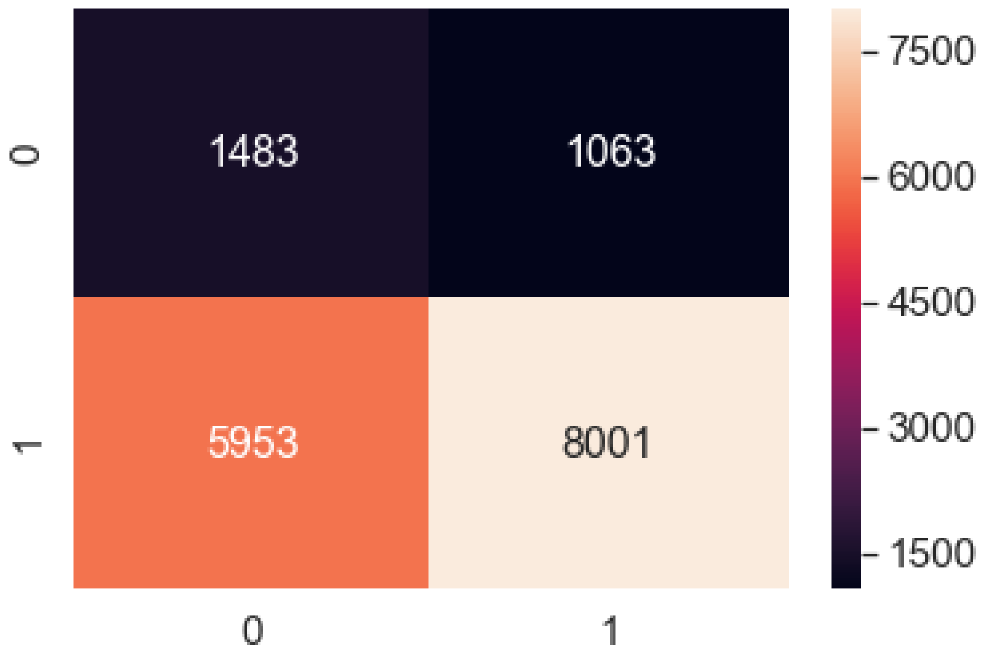
```
===================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24995541579323788 for threshold 0.857
[[1483 1063]
 [5953 8001]]
```

```
In [163]: conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_
```

```
the maximum value of tpr*(1-fpr) 0.24995541579323788 for threshold 0.857
```

```
In [164]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_2, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[164]: <matplotlib.axes._subplots.AxesSubplot at 0x25900084e80>
```



74 Set 4 : categorical, numerical features + project_title(TFIDF W2V) + preprocessed_essay (TFIDF W2V)

```
In [165]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
          X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, school_state_categor
```

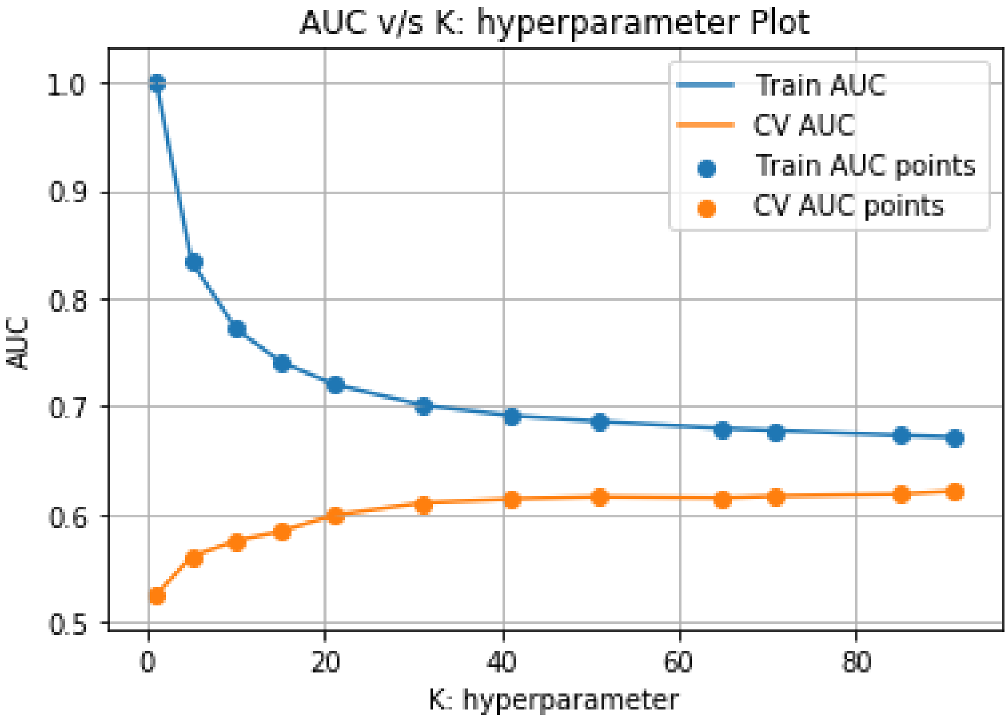
```
In [166]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_cr.shape, y_cv.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix
(22445, 704) (22445,)
(11055, 704) (11055,)
(16500, 704) (16500,)
================================================================================================
```

75 A) Find the best hyper parameter which results in the maximum AUC value

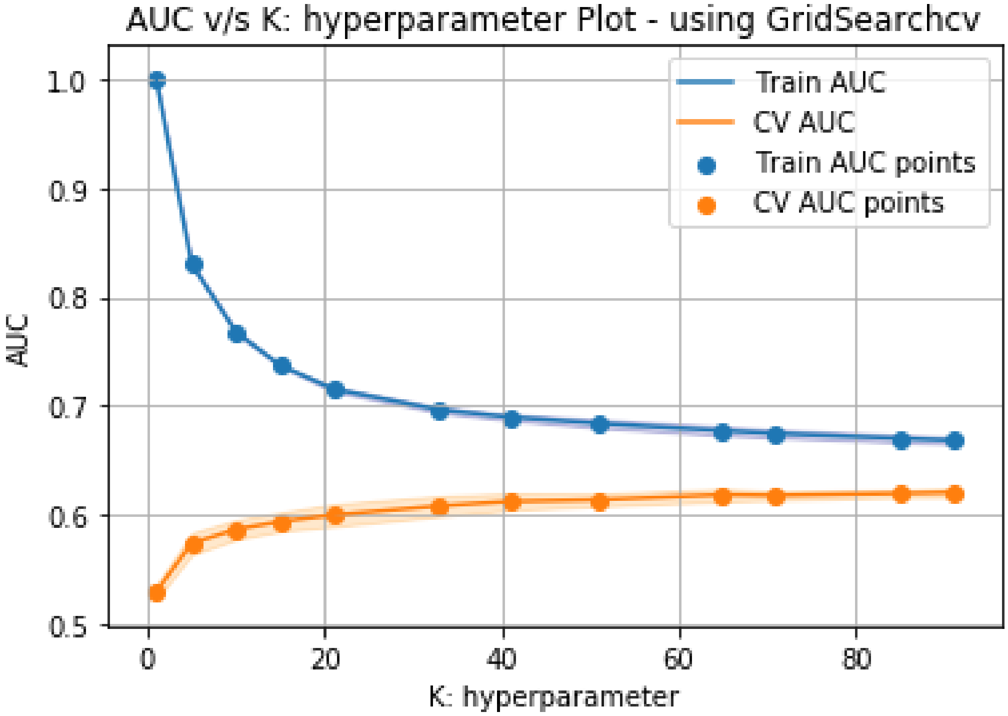
```
In [106]: train_auc = []
          cv_auc = []

          K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

          for i in tqdm(K):
              neigh = KNeighborsClassifier(n_neighbors=i)
              neigh.fit(X_tr, y_train)

              y_train_pred = batch_predict(neigh, X_tr)
              y_cv_pred = batch_predict(neigh, X_cr)

              # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
              # not the predicted outputs
              train_auc.append(roc_auc_score(y_train,y_train_pred))
              cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

          plt.scatter(K, train_auc, label='Train AUC points')
          plt.scatter(K, cv_auc, label='CV AUC points')

          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC v/s K: hyperparameter Plot")
          plt.grid()
          plt.show()
```

```
100%|| 12/12 [15:28<00:00, 77.98s/it]
```



76 B) Gridsearch-cv

```
In [109]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSear

          neigh = KNeighborsClassifier()
          parameters = {'n_neighbors':[1, 5, 10, 15, 21, 33, 41, 51, 65, 71, 85, 91]}
          clf = GridSearchCV(neigh, parameters, cv=5, scoring='roc_auc')
          clf.fit(X_tr, y_train)

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

          plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
          plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc

          plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
          plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc

          plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
          plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')


          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC v/s K: hyperparameter Plot - using GridSearchcv")
          plt.grid()
          plt.show()
```

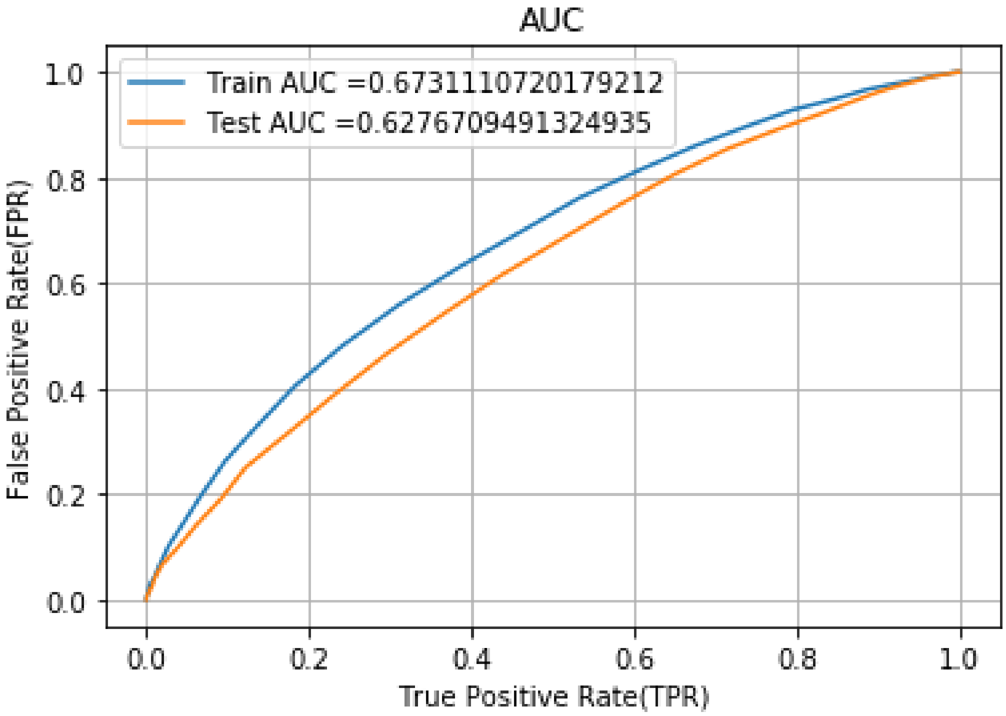


```
In [111]: best_k_4 = 85
```

77 C) Train model using the best hyper-parameter value

```
In [112]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s

          neigh = KNeighborsClassifier(n_neighbors=best_k_4)
          neigh.fit(X_tr, y_train)
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          y_train_pred = batch_predict(neigh, X_tr)
          y_test_pred = batch_predict(neigh, X_te)
```

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



78 D) Confusion Matrix

79 Train Data

```
In [115]: print("="*100)
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

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

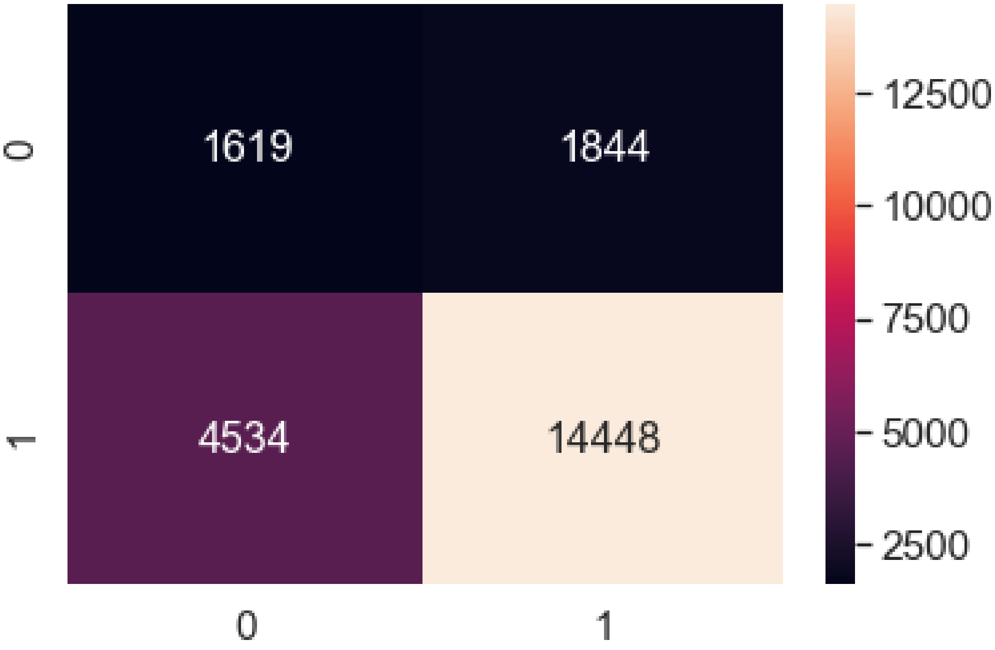
```
the maximum value of tpr*(1-fpr) 0.24894464137986413 for threshold 0.776
[[ 1619  1844]
 [ 4534 14448]]
```

```
In [116]: conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.24894464137986413 for threshold 0.776
```

```
In [117]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[117]: <matplotlib.axes._subplots.AxesSubplot at 0x17b07f827f0>
```



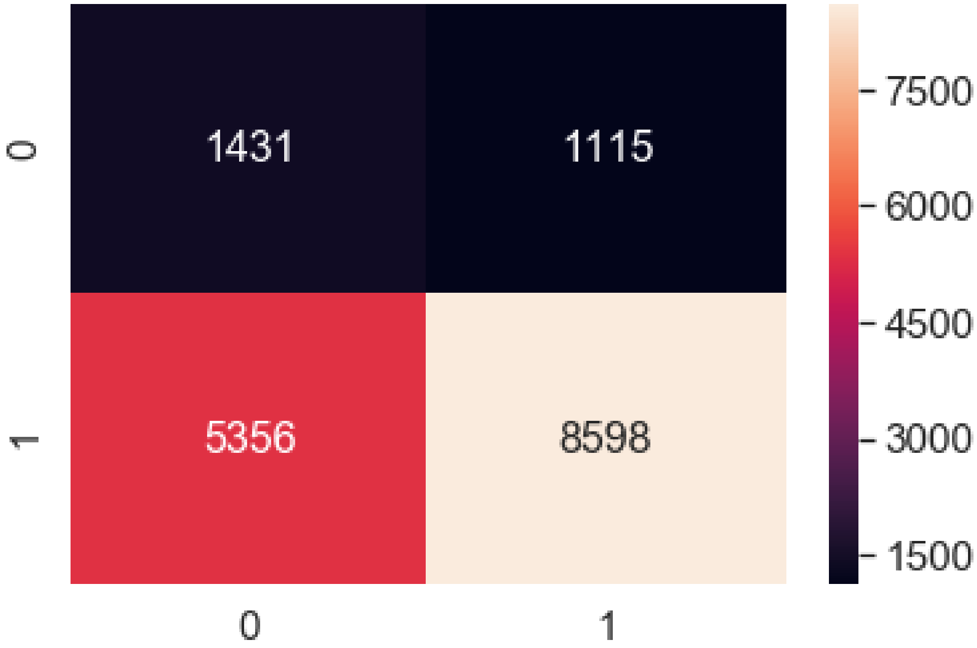
80 Test Data

```
In [118]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
```

```
========================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24975316702138622 for threshold 0.8
[[1431 1115]
 [5356 8598]]
```

```
In [119]: conf_matr_df_test_3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_t

the maximum value of tpr*(1-fpr) 0.24975316702138622 for threshold 0.8
```

```
In [120]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_3, annot=True,annot_kws={"size": 16}, fmt='g')

Out[120]: <matplotlib.axes._subplots.AxesSubplot at 0x17b07f56cc0>
```



81 2.5 Feature selection with SelectKBest

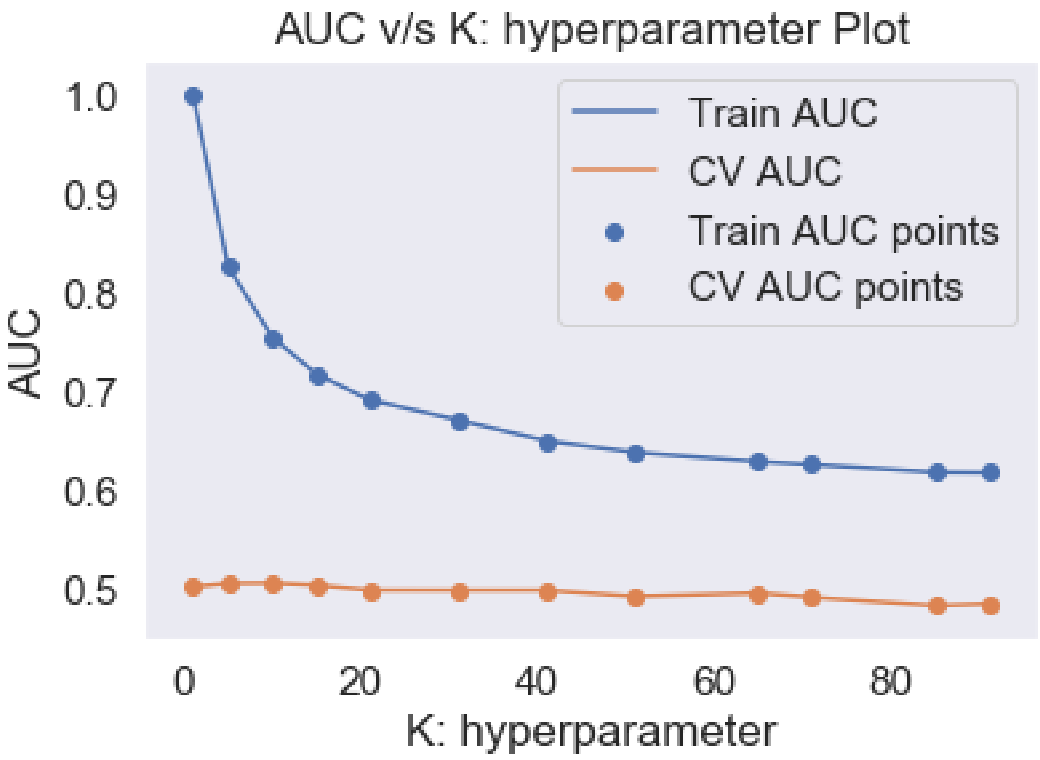
```
In [121]: X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
          X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv, school_state_catego

In [122]: from sklearn.feature_selection import SelectKBest, chi2

          X_tr_new = SelectKBest(chi2, k=2000).fit_transform(X_tr, y_train)
          X_te_new = SelectKBest(chi2, k=2000).fit_transform(X_te, y_test)
          X_cr_new = SelectKBest(chi2, k=2000).fit_transform(X_cr, y_cv)

In [123]: print("Final Data matrix")
          print(X_tr_new.shape, y_train.shape)
          print(X_cr_new.shape, y_cv.shape)
          print(X_te_new.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix
(22445, 2000) (22445,)
(11055, 2000) (11055,)
(16500, 2000) (16500,)
==============================================================================================
```

82 A) Find the best hyper parameter which results in the maximum AUC value

```
In [124]: train_auc = []
          cv_auc = []

          K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

          for i in tqdm(K):
              neigh = KNeighborsClassifier(n_neighbors=i)
              neigh.fit(X_tr_new, y_train)

              y_train_pred = batch_predict(neigh, X_tr_new)
              y_cv_pred = batch_predict(neigh, X_cr_new)

              # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimat
              # not the predicted outputs
              train_auc.append(roc_auc_score(y_train,y_train_pred))
              cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

          plt.scatter(K, train_auc, label='Train AUC points')
          plt.scatter(K, cv_auc, label='CV AUC points')

          plt.legend()
          plt.xlabel("K: hyperparameter")
          plt.ylabel("AUC")
          plt.title("AUC v/s K: hyperparameter Plot")
          plt.grid()
          plt.show()
```

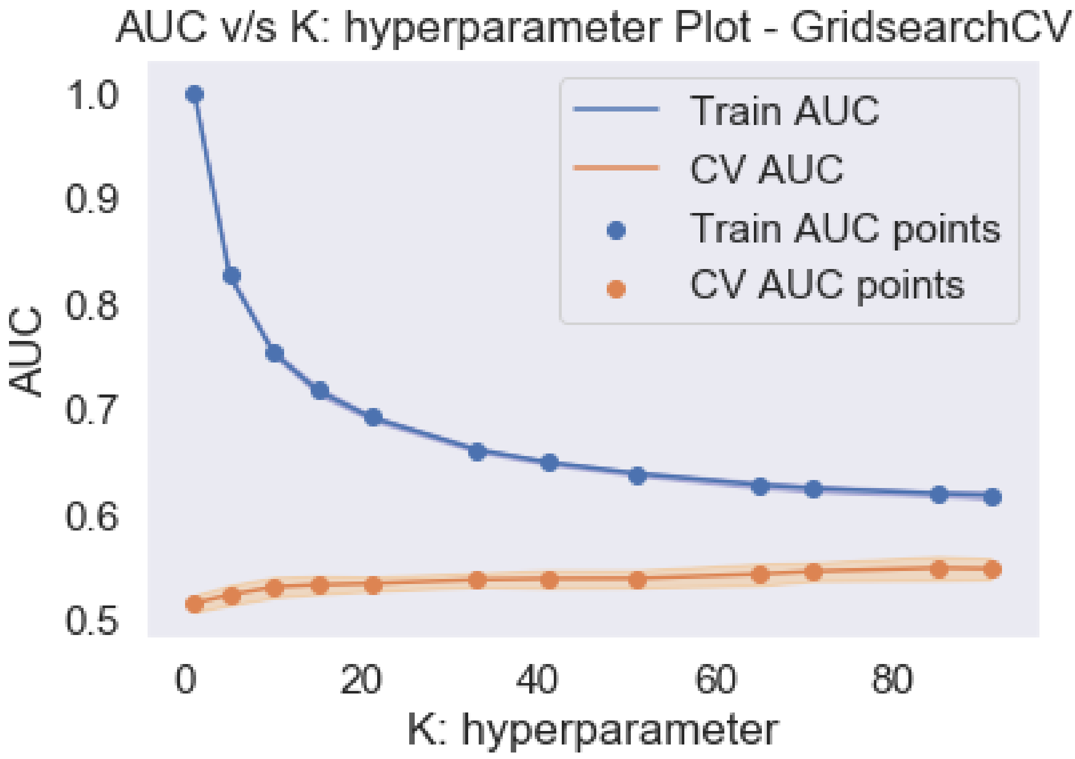
```
100%|| 12/12 [08:47<00:00, 45.13s/it]
```



83 B) Gridsearch-cv

```
In [125]: # https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSear

          neigh = KNeighborsClassifier()

          parameters = {'n_neighbors':[1, 5, 10, 15, 21, 33, 41, 51, 65, 71, 85, 91]}

          clf = GridSearchCV(neigh, parameters, cv=5, scoring='roc_auc')
          clf.fit(X_tr_new, y_train)

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

          plt.plot(parameters['n_neighbors'], train_auc, label='Train AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
          plt.gca().fill_between(parameters['n_neighbors'],train_auc - train_auc_std,train_auc

          plt.plot(parameters['n_neighbors'], cv_auc, label='CV AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

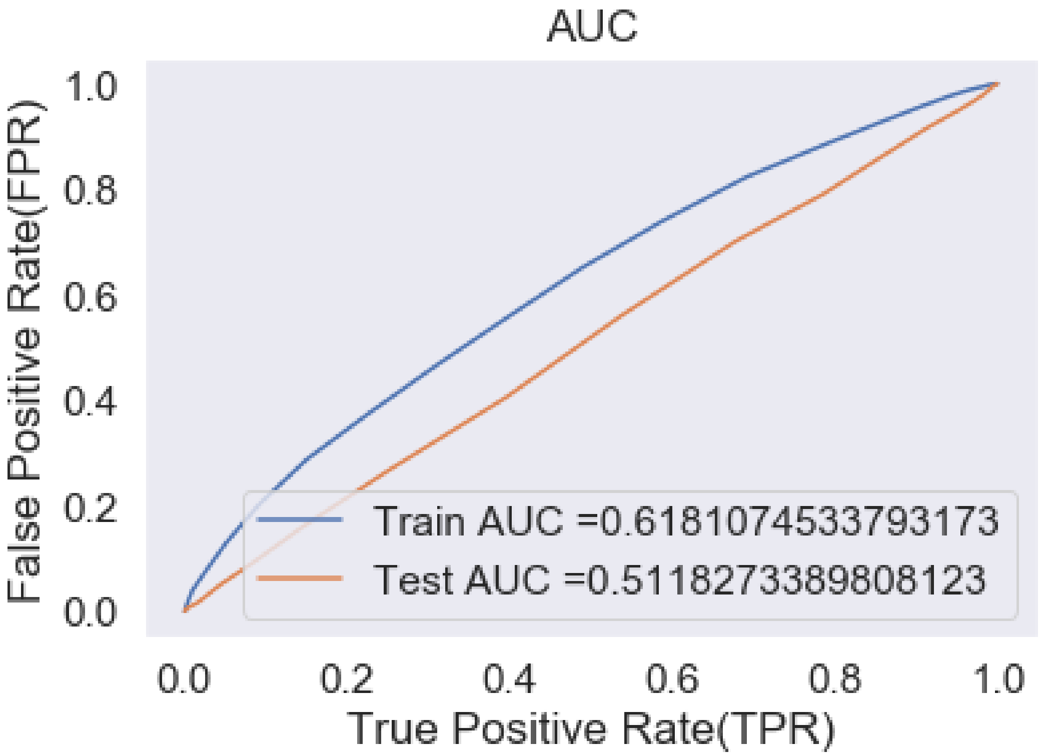
```
plt.gca().fill_between(parameters['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_

plt.scatter(parameters['n_neighbors'], train_auc, label='Train AUC points')
plt.scatter(parameters['n_neighbors'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot - GridsearchCV")
plt.grid()
plt.show()
```



```
In [126]: best_k_5 = 85
```

84 C) Train model using the best hyper-parameter value

```
In [127]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sk

          neigh = KNeighborsClassifier(n_neighbors=best_k_5)
          neigh.fit(X_tr_new, y_train)
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates o
          # not the predicted outputs

          y_train_pred = batch_predict(neigh, X_tr_new)
          y_test_pred = batch_predict(neigh, X_te_new)

          train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
          test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

          plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
          plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
          plt.legend()
          plt.xlabel("True Positive Rate(TPR)")
          plt.ylabel("False Positive Rate(FPR)")
          plt.title("AUC")
          plt.grid()
          plt.show()
```



85 D) Confusion Matrix

86 Train Data

```
In [128]: print("="*100)
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

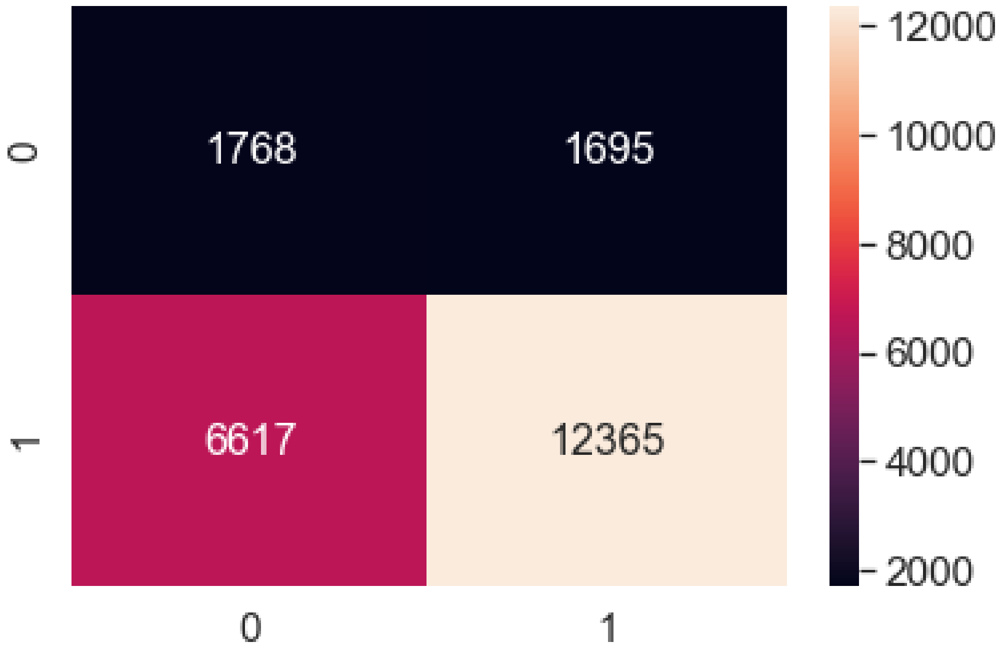
```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2498889085217441 for threshold 0.835
[[ 1768  1695]
 [ 6617 12365]]
```

```
In [129]: conf_matr_df_train_4 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.2498889085217441 for threshold 0.835
```

```
In [130]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[130]: <matplotlib.axes._subplots.AxesSubplot at 0x17b33f494e0>
```



87 Test Data

```
In [131]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
```

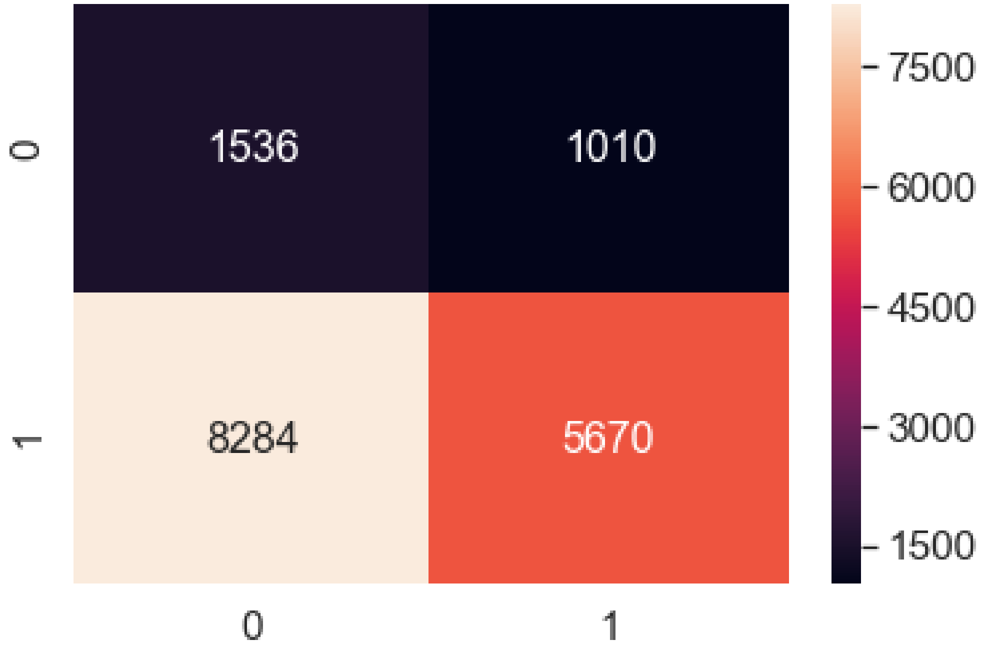
```
===============================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24857824204318466 for threshold 0.824
[[1536 1010]
 [8284 5670]]
```

```
In [132]: conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_
```

```
the maximum value of tpr*(1-fpr) 0.24857824204318466 for threshold 0.824
```

```
In [133]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[133]: <matplotlib.axes._subplots.AxesSubplot at 0x17b337e57f0>
```



88 3. Conclusions

```
In [134]: # Compare all your models using Prettytable library
          # http://zetcode.com/python/prettytable/

          from prettytable import PrettyTable

          #If you get a ModuleNotFoundError error , install prettytable using: pip3 install pr

          x = PrettyTable()
          x.field_names = ["Vectorizer", "Model", "Hyper Parameter", "AUC"]

          x.add_row(["BOW", "Brute", 91, 0.63])
          x.add_row(["TFIDF", "Brute", 85, 0.57])
          x.add_row(["AVG W2V", "Brute", 91, 0.6])
          x.add_row(["TFIDF W2V", "Brute", 85, 0.55])
          x.add_row(["TFIDF", "Top 2000", 85, 0.51])

          print(x)
```

```
+------------+----------+-----------------+------+
| Vectorizer |  Model   | Hyper Parameter | AUC  |
+------------+----------+-----------------+------+
|    BOW     |  Brute   |        91       | 0.63 |
|   TFIDF    |  Brute   |        85       | 0.57 |
|  AVG W2V   |  Brute   |        91       | 0.6  |
| TFIDF W2V  |  Brute   |        85       | 0.55 |
|   TFIDF    | Top 2000 |        85       | 0.51 |
+------------+----------+-----------------+------+
```