DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	De
`project_id`	A unique identifier for the proposed project. **Example:**
`project_title`	Title of the project. **E** • `Art Will Make You` • `First Gr`
`project_grade_category`	Grade level of students for which the project is targeted. One of the enumerate • `Grades` • `Gra` • `Gra` • `Grad`
`project_subject_categories`	One or more (comma-separated) subject categories for the projec following enumerated list • `Applied L` • `Care &` • `Health &` • `History &` • `Literacy & L` • `Math &` • `Music & T` • `Specia` • **Ex** • `Music & T` • `Literacy & Language, Math &`
`school_state`	State where school is located (Two-letter U.S. p (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Posta **Exam**
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for th **Ex** • `L` • `Literature & Writing, Social S`
`project_resource_summary`	An explanation of the resources needed for the project. **E** • `My students need hands on literacy materials to sensory`
`project_essay_1`	First applicat
`project_essay_2`	Second applicat
`project_essay_3`	Third applicat
`project_essay_4`	Fourth applicat
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `201 12:43`
`teacher_id`	A unique identifier for the teacher of the proposed project. `bdf8baa8fedef6bfeec7ae4ff`

Feature	De
teacher_prefix	Teacher's title. One of the following enumerate • • • • • •
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the sam **Exa**

[*] See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
id	A `project_id` value from the `train.csv` file. **Example:** `p036502`
description	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
quantity	Quantity of the resource required. **Example:** `3`
price	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
project_is_approved	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os

from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv')
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 (109248, 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]:

```
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[4]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

In [ ]:

```
```

1.1 Sorted by time

In [5]:

```
#https://stats.stackexchange.com/questions/341312/train-test-split-with-time-and-person
-indexed-data
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.col
umns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/40840
39
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[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT

In [ ]:

```

```

1.2 Adding resource data in dataframe

In [6]:

```
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[6]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

In [7]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [8]:

```
project_data.head(2)
```

Out[8]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	D
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	20 04 00:27
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	20 04 00:3

In [9]:

```
project_data = project_data.sample(n=50000)
#project_data=project_data.tail(1000)
project_data.shape
```

Out[9]:

```
(50000, 19)
```

In [10]:

```
project_data.shape
```

Out[10]:

```
(50000, 19)
```

1.2 preprocessing of `project_subject_categories`

In [11]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in 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", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        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]))
```

1.3 preprocessing of `project_subject_subcategories`

In [12]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

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

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", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace
 it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"M
ath & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
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 [13]:

```
project_data.columns
```

Out[13]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories'],
      dtype='object')
```

In [ ]:

```

```

1.3 Text preprocessing

In [14]:

```
# 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)
```

In [15]:

```
project_data.head(2)
```

Out[15]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
32796	5963	p093927	c748eba2b70edb7dbfce5a75edbea070	Mrs.	ME
54625	136624	p225948	5acca0b3cd6b00680b5bd920c92b63b6	Mr.	AZ

In [16]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [17]:

```
'''# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)'''
```

Out[17]:

```
'# printing some random reviews\nprint(project_data[\'essay\'].values[0])
\nprint("="*50)\nprint(project_data[\'essay\'].values[150])\nprint("="*50)
\nprint(project_data[\'essay\'].values[1000])\nprint("="*50)\nprint(projec
t_data[\'essay\'].values[20000])\nprint("="*50)\nprint(project_data[\'essa
y\'].values[99999])\nprint("="*50)'
```

In [18]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [19]:

```
'''sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)'''
```

Out[19]:

```
'sent = decontracted(project_data[\'essay\'].values[20000])\nprint(sent)\n
print("="*50)'
```

In [20]:

```
'''# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks
-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)'''
```

Out[20]:

```
'# \r \n \t remove from string python: http://texthandler.com/info/remove-
line-breaks-python/\nsent = sent.replace(\'\\r\', \' \')\nsent = sent.repl
ace(\'\\"\', \' \')\nsent = sent.replace(\'\\n\', \' \')\nprint(sent)'
```

In [21]:

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

Out[21]:

```
"#remove spacial character: https://stackoverflow.com/a/5843547/4084039\ns
ent = re.sub('[^A-Za-z0-9]+', ' ', sent)\nprint(sent)"
```

In [22]:

```
# 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'r
e", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him',
'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 't
hey', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "th
at'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'ha
d', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as'
, 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through'
, 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'ov
er', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'an
y', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too'
, 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'no
w', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't",
'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'migh
tn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'w
asn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

1.3.1Preprocess of Preprocessing of essay

In [23]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████| 50000/50000 [00:29<00:00, 1712.05
it/s]
```

In [24]:

```
# after preprocesing
#preprocessed_essays[10:]
```

In [25]:

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

1.3.2Preprocessing of `project_title`

In [26]:

```
# similarly you can preprocess the titles also
```

In [27]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_project_title = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_project_title.append(sent.lower().strip())
```

```
100%|██████████| 50000/50000 [00:01<00:00, 37762.19
it/s]
```

In [28]:

```
# after preprocesing
#preprocessed_project_title[1000]
```

In [29]:

```
#https://stackoverflow.com/questions/26666919/add-column-in-dataframe-from-list/3849072
7
project_data['preprocessed_project_title'] = preprocessed_project_title
project_data.drop(['project_title'], axis=1, inplace=True)
```

In [30]:

```
project_data.head(2)
```

Out[30]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
32796	5963	p093927	c748eba2b70edb7dbfce5a75edbea070	Mrs.	ME
54625	136624	p225948	5acca0b3cd6b00680b5bd920c92b63b6	Mr.	AZ

In [31]:

```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 50000 entries, 32796 to 85985
Data columns (total 20 columns):
Unnamed: 0                                      50000 non-null int64
id                                              50000 non-null object
teacher_id                                      50000 non-null object
teacher_prefix                                  49998 non-null object
school_state                                    50000 non-null object
Date                                            50000 non-null datetime64
[ns]
project_grade_category                          50000 non-null object
project_essay_1                                 50000 non-null object
project_essay_2                                 50000 non-null object
project_essay_3                                 1771 non-null object
project_essay_4                                 1771 non-null object
project_resource_summary                        50000 non-null object
teacher_number_of_previously_posted_projects    50000 non-null int64
project_is_approved                             50000 non-null int64
price                                           50000 non-null float64
quantity                                        50000 non-null int64
clean_categories                                50000 non-null object
clean_subcategories                             50000 non-null object
preprocessed_essays                             50000 non-null object
preprocessed_project_title                      50000 non-null object
dtypes: datetime64[ns](1), float64(1), int64(4), object(14)
memory usage: 8.0+ MB
```

1.5 Preparing data for models

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/ (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/)

1.5.3 Vectorizing Numerical features

merge all above variable

1.5.2 Vectorizing Text data

Assignment 3: Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning to find best K**

    - Find the best hyper parameter which results in the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
    - Find the best hyper paramter using k-fold cross validation (or) simple cross validation data
    - Use gridsearch-cv or randomsearch-cv or write your own for loops to do this task

3. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
    - Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
    - Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points

4. **[Task-2]**

    - Select top 2000 features from feature Set 2 using `SelectKBest` (https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html) and then apply KNN on top of these features

    -
      ```
      from sklearn.datasets import load_digits
      from sklearn.feature_selection import SelectKBest, chi2
      X, y = load_digits(return_X_y=True)
      X.shape
      X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
      X_new.shape
      ========
      output:
      (1797, 64)
      (1797, 20)
      ```
    - Repeat the steps 2 and 3 on the data matrix after feature selection

5. **Conclusion**

    - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link (http://zetcode.com/python/prettytable/)

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this [link. (https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)](https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

2. K Nearest Neighbor

2.1 Splitting data into Train and cross validation(or test): Stratified Sampling

In [32]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import model_selection
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score

from collections import Counter
from sklearn.metrics import accuracy_score

from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_validate
```

In [33]:

```
y=project_data['project_is_approved']
y.shape
```

Out[33]:

```
(50000,)
```

In [34]:

```
#replace NAN to space https ://stackoverflow.com/questions/49259305/raise-valueerrornp-nan-is-an-invalid-document-expected-byte-or?rq=1
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(' ')
```

In [35]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_s
plit.html

#split the data into train and test fo bag of words

x_t,x_test,y_t,y_test=model_selection.train_test_split(project_data,y,test_size=0.3,ran
dom_state=0)
#split train into cross val train and cross val test
x_train,x_cv,y_train,y_cv=model_selection.train_test_split(x_t,y_t,test_size=0.3,random
_state=0)
```

spliting train_data into train and cross validation in ratio of 7/3

In [36]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.2 Make Data Model Ready: encoding numerical, categorical features

2.2.1 encoding categorical features</font>

In [37]:

```
x_train.head(2)
```

Out[37]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
15510	155339	p229269	e645a2ae052066fcacaa32ada8c5dae0	Ms.	NY
84214	91601	p176451	04060a066047c4a8f816d019e02a0fb3	Mrs.	MA

In [38]:

```
#one hot encoding for clean_categories
#_________________________
# 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,
binary=True)
x_train_categories_one_hot = vectorizer.fit_transform(x_train['clean_categories'].value
s)
x_cv_categories_one_hot = vectorizer.fit_transform(x_cv['clean_categories'].values)
x_test_categories_one_hot = vectorizer.fit_transform(x_test['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",x_train_categories_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_cv_categories_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_test_categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearnin
g', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (24500, 9)
Shape of matrix after one hot encodig  (10500, 9)
Shape of matrix after one hot encodig  (15000, 9)
```

In [39]:

```
#one hot encoding for clean_subcategories
#_________________________
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=Fal
se, binary=True)
x_train_subcategories_one_hot = vectorizer.fit_transform(x_train['clean_subcategories']
.values)
x_cv_subcategories_one_hot = vectorizer.fit_transform(x_cv['clean_subcategories'].value
s)
x_test_subcategories_one_hot = vectorizer.fit_transform(x_test['clean_subcategories'].v
alues)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",x_train_subcategories_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_cv_subcategories_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_test_subcategories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvemen
t', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'Nutrition
Education', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts',
'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Musi
c', 'History_Geography', 'EarlyDevelopment', 'Health_LifeScience', 'ESL',
'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'A
ppliedSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Lit
eracy']
Shape of matrix after one hot encodig  (24500, 30)
Shape of matrix after one hot encodig  (10500, 30)
Shape of matrix after one hot encodig  (15000, 30)
```

In [40]:

```
#one hot encoding for school_state


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

school_state_cat_dict = dict(my_counter)
sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lambda kv
: kv[1]))

#_________________________
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lowe
rcase=False, binary=True)
x_train_school_state_one_hot = vectorizer.fit_transform(x_train['school_state'].values)
x_cv_school_state_one_hot = vectorizer.fit_transform(x_cv['school_state'].values)
x_test_school_state_one_hot = vectorizer.fit_transform(x_test['school_state'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",x_train_school_state_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_cv_school_state_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_test_school_state_one_hot.shape)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NE', 'DE', 'NH', 'SD', 'AK', 'WV', 'HI',
'DC', 'ME', 'NM', 'KS', 'IA', 'ID', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'N
V', 'MD', 'CT', 'TN', 'UT', 'WI', 'AL', 'VA', 'AZ', 'OK', 'NJ', 'MA', 'W
A', 'LA', 'MO', 'OH', 'IN', 'MI', 'PA', 'SC', 'GA', 'IL', 'NC', 'FL', 'N
Y', 'TX', 'CA']
Shape of matrix after one hot encodig  (24500, 51)
Shape of matrix after one hot encodig  (10500, 51)
Shape of matrix after one hot encodig  (15000, 51)
```

In [41]:

```
#one hot encoding for project_grade_category

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


project_grade_cat_dict = dict(my_counter)
sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.items(), key=lambda kv: kv[1]))
#_________________________
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys()), lowercase=False, binary=True)
x_train_grade_category_one_hot = vectorizer.fit_transform(x_train['project_grade_category'].values)
x_cv_grade_category_one_hot = vectorizer.fit_transform(x_cv['project_grade_category'].values)
x_test_grade_category_one_hot = vectorizer.fit_transform(x_test['project_grade_category'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",x_train_grade_category_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_cv_grade_category_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_test_grade_category_one_hot.shape)
```

```
['9-12', '6-8', '3-5', 'PreK-2', 'Grades']
Shape of matrix after one hot encodig  (24500, 5)
Shape of matrix after one hot encodig  (10500, 5)
Shape of matrix after one hot encodig  (15000, 5)
```

```
In [42]:
```

```
#one hot encoding for prefix_category

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

teacher_prefix_cat_dict = dict(my_counter)
sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.items(), key=lambd
a kv: kv[1]))



#_________________________
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lo
wercase=False, binary=True)
x_train_prefix_one_hot = vectorizer.fit_transform(x_train['teacher_prefix'].values)
x_cv_prefix_one_hot = vectorizer.fit_transform(x_cv['teacher_prefix'].values)
x_test_prefix_one_hot = vectorizer.fit_transform(x_test['teacher_prefix'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",x_train_prefix_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_cv_prefix_one_hot.shape)
print("Shape of matrix after one hot encodig ",x_test_prefix_one_hot.shape)
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of matrix after one hot encodig  (24500, 5)
Shape of matrix after one hot encodig  (10500, 5)
Shape of matrix after one hot encodig  (15000, 5)
```

```
In [43]:
```

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.2.2 encoding numerical features</font>

In [44]:

```
x_train.head(2)
```

Out[44]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
15510	155339	p229269	e645a2ae052066fcacaa32ada8c5dae0	Ms.	NY
84214	91601	p176451	04060a066047c4a8f816d019e02a0fb3	Mrs.	MA

In [45]:

```
#price standardization of x_train data
#---------------------------------------
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ...
 399.    287.73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(x_train['price'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
x_train_price_standardized = price_scalar.transform(x_train['price'].values.reshape(-1, 1))
```

```
Mean : 299.3812893877551, Standard deviation : 376.00806703910007
```

In [46]:

```
#price standardization of x_cv data
#---------------------------------------
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.pr
eprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ...
 399.   287.73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(x_cv['price'].values.reshape(-1,1)) # finding the mean and standard de
viation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var
_[0])}")

# Now standardize the data with above maen and variance.
x_cv_price_standardized = price_scalar.transform(x_cv['price'].values.reshape(-1, 1))
```

In [47]:

```
#price standardization of x_test data
#---------------------------------------
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.pr
eprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ...
 399.   287.73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(x_test['price'].values.reshape(-1,1)) # finding the mean and standard
 deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var
_[0])}")

# Now standardize the data with above maen and variance.
x_test_price_standardized = price_scalar.transform(x_test['price'].values.reshape(-1, 1
))
```

2.2.3 merge numerical and categorical data</font>

In [48]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
x_train_ohe = hstack((x_train_categories_one_hot, x_train_subcategories_one_hot, x_train_school_state_one_hot, x_train_grade_category_one_hot, x_train_prefix_one_hot, x_train_price_standardized))
x_cv_ohe = hstack((x_cv_categories_one_hot, x_cv_subcategories_one_hot, x_cv_school_state_one_hot, x_cv_grade_category_one_hot, x_cv_prefix_one_hot, x_cv_price_standardized))
x_test_ohe = hstack((x_test_categories_one_hot, x_test_subcategories_one_hot, x_test_school_state_one_hot, x_test_grade_category_one_hot, x_test_prefix_one_hot, x_test_price_standardized))

print(x_train_ohe.shape)
print(x_cv_ohe.shape)
print(x_test_ohe.shape)
```

```
(24500, 101)
(10500, 101)
(15000, 101)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

2.4 Appling KNN on different kind of featurization as mentioned in the instructions

In [49]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4.1 Applying KNN brute force on BOW, SET 1

vectorize the essay and title data, SET 1

In [50]:

```
#you can vectorize the essay
#______________________________
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10, ngram_range=(1,4), max_features=5000)
vectorizer.fit(x_train['preprocessed_essays'].values)# fit has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_bow_essays = vectorizer.transform(x_train['preprocessed_essays'].values)
x_cv_bow_essays = vectorizer.transform(x_cv['preprocessed_essays'].values)
x_test_bow_essays = vectorizer.transform(x_test['preprocessed_essays'].values)

print("Shape of matrix after one hot encodig ",x_train_bow_essays.shape, y_train.shape)
print("Shape of matrix after one hot encodig ",x_cv_bow_essays.shape)
print("Shape of matrix after one hot encodig ",x_test_bow_essays.shape)
```

```
Shape of matrix after one hot encodig  (24500, 5000) (24500,)
Shape of matrix after one hot encodig  (10500, 5000)
Shape of matrix after one hot encodig  (15000, 5000)
```

In [51]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html
#you can vectorize the title
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10, ngram_range=(1,4), max_features=5000)
vectorizer.fit(x_train['preprocessed_project_title'].values)# fit has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_bow_title = vectorizer.transform(x_train['preprocessed_project_title'].values)
x_cv_bow_title = vectorizer.transform(x_cv['preprocessed_project_title'].values)
x_test_bow_title = vectorizer.transform(x_test['preprocessed_project_title'].values)

print("Shape of matrix after one hot encodig ",x_train_bow_title.shape)
print("Shape of matrix after one hot encodig ",x_cv_bow_title.shape)
print("Shape of matrix after one hot encodig ",x_test_bow_title.shape)
```

```
Shape of matrix after one hot encodig  (24500, 2152)
Shape of matrix after one hot encodig  (10500, 2152)
Shape of matrix after one hot encodig  (15000, 2152)
```

In [52]:

```
x_train.columns
```

Out[52]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_essay_1', 'project_essay
_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title'],
      dtype='object')
```

In [53]:

```
# Please write all the code with proper documentation
```

merge dataset, SET 1

In [54]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#https://stackoverflow.com/questions/30163830/accessing-elements-in-coo-matrix
from scipy.sparse import hstack
from scipy.sparse import coo_matrix
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_bow = hstack((x_train_ohe, x_train_bow_essays, x_train_bow_title)).tocsr()
x_cv_bow = hstack((x_cv_ohe, x_cv_bow_essays, x_cv_bow_title)).tocsr()
x_test_bow = hstack((x_test_ohe, x_test_bow_essays, x_test_bow_title)).tocsr()

print(x_train_bow.shape, y_train.shape)
print(x_cv_bow.shape)
print(x_test_bow.shape)
```

```
(24500, 7253) (24500,)
(10500, 7253)
(15000, 7253)
```

In [55]:

```
type(x_train_bow)
```

Out[55]:

```
scipy.sparse.csr.csr_matrix
```

Hyperparameter tuning by AUC plot for cv and train dataset, SET 1

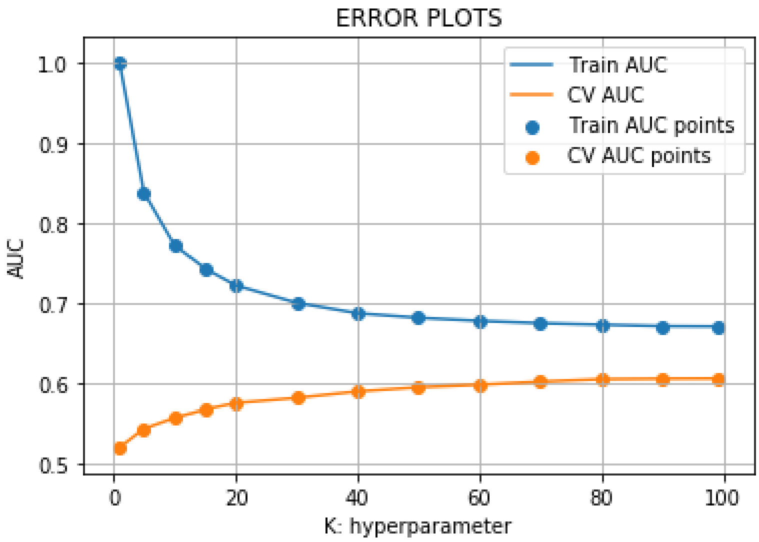
In [56]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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 tr_loop will be 49041 - 49041%1000 =
 49000
    # 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
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [57]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
from scipy.sparse import coo_matrix
"""
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 va
lues, or non-thresholded measure of
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 label.

"""


train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    neigh.fit(x_train_bow, y_train)


    y_train_pred = batch_predict(neigh, x_train_bow)
    y_cv_pred = batch_predict(neigh, x_cv_bow)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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("ERROR PLOTS")
plt.grid()
plt.show()
```

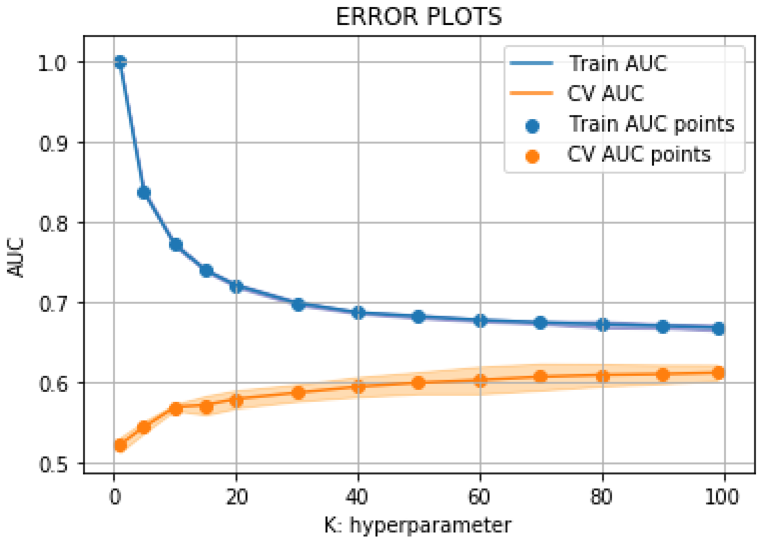
```
100%|██████████████████████████████████████████| 13/13 [12:43<00:00, 59.40
s/it]
```



PARAMETER TUNING USING GRID SEARCH

In [58]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchC
V.html
from sklearn.model_selection import GridSearchCV

neigh = KNeighborsClassifier()

grid_val = {'n_neighbors':[1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]}

clf = GridSearchCV(neigh, grid_val, cv= 5, scoring='roc_auc')
clf.fit(x_train_bow, y_train)

results_grid_bow = pd.DataFrame.from_dict(clf.cv_results_).sort_values(['param_n_neighb
ors'])


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(grid_val['n_neighbors'], train_auc, label='Train AUC')
# code reference: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(grid_val['n_neighbors'],train_auc - train_auc_std,train_auc + tr
ain_auc_std,alpha=0.3,color='darkblue')

plt.plot(grid_val['n_neighbors'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(grid_val['n_neighbors'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,
alpha=0.3,color='darkorange')

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

results_grid_bow.head()
```



Out[58]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_n_neighbors	p
0	0.054803	0.004020	7.968456	0.006957	1	{'n_neig
1	0.054803	0.001166	8.658895	0.094484	5	{'n_neig
2	0.051603	0.000800	8.655695	0.099362	10	{'n_neig
3	0.050403	0.001855	8.633894	0.088956	15	{'n_neig
4	0.048403	0.001356	8.659695	0.064865	20	{'n_neig

5 rows × 21 columns

In [ ]:

PARAMETER TUNING USING Random search

In [ ]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV

neigh = KNeighborsClassifier(n_jobs=-1)
parameters = {'n_neighbors':sp_randint(40, 100)}
clf = RandomizedSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
clf.fit(x_train_bow, y_train)

results_rand_bow = pd.DataFrame.from_dict(clf.cv_results_).sort_values(['param_n_neighbors'])


train_auc= results['mean_train_score']
train_auc_std= results['std_train_score']
cv_auc = results['mean_test_score']
cv_auc_std= results['std_test_score']
K =  results['param_n_neighbors']

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

plt.plot(K, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
# plt.gca().fill_between(K, cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='darkorange')

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("Hyper parameter Vs AUC plot")
plt.grid()
plt.show()

results_rand_bow.head()
```

In [88]:

```
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between the train and cv is less
# Note: based on the method you use you might get different hyperparameter values as best one
# so, you choose according to the method you choose, you use gridsearch if you are having more computing power and note it will take more time
# if you increase the cv values in the GridSearchCV you will get more rebust results.

#here we are choosing the best_k based on forloop results
opt_k_bow=90
```

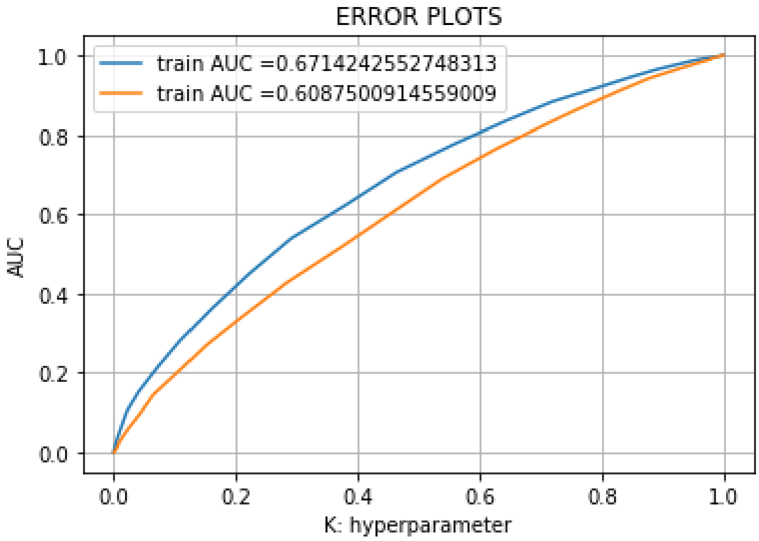
Apply best hyperparameter on test dataset, SET 1

You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

IF Your system is getting stuck when you are working with the Knn: YOU NEED TO USE BATCH WISE PREDICTION

In [89]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#skle
arn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=opt_k_bow, n_jobs=-1)
neigh.fit(x_train_bow, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, x_train_bow)
y_test_pred = batch_predict(neigh, x_test_bow)

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)
tain_auc_bow=auc(train_fpr, train_tpr)
test_auc_bow=auc(test_fpr, test_tpr)

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


ERROR PLOTS
train AUC =0.6714242552748313
train AUC =0.6087500914559009
AUC
K: hyperparameter
0.0
0.2
0.4
0.6
0.8
1.0

```
In [ ]:
```

In [ ]:

```
'''knn1 = KNeighborsClassifier(n_neighbors=opt_k_bow,algorithm='brute',weights='unifor
m')
knn1.fit(x_train_bow,y_train)

pred_prob_test = knn1.predict_proba(x_test_bow)


#AUC of train dataset
pred_prob_train = knn1.predict_proba(x_train_bow)
fpr1, tpr1, thresholds = roc_curve(y_train,pred_prob_train[:, 1])
bow_roc_auc_train = auc(fpr1, tpr1)
print("Best AUC of train: ",bow_roc_auc_train)

#AUC of test dataset
pred_prob_test = knn1.predict_proba(x_test_bow)
fpr2, tpr2, thresholds = roc_curve(y_test,pred_prob_test[:, 1])
bow_roc_auc_test = auc(fpr2, tpr2)
print("Best AUC of test: ",bow_roc_auc_test)

#value taken from from GridsearchCV section
plt.title('Receiver Operating Characteristic')
plt.plot(fpr1, tpr1, 'r',label='AUC_train = %0.2f'% bow_roc_auc_train)
plt.plot(fpr2, tpr2, 'g',label='AUC_test = %0.2f'% bow_roc_auc_test)
plt.legend(loc='lower right')
plt.plot([0,1],[0,1],'r--')
plt.xlim([-0.1,1.1])
plt.ylim([-0.1,1.1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("Best AUC of train: ",bow_roc_auc_train)
print("Best AUC of test: ",bow_roc_auc_test)'''
```

In [90]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (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.rou
nd(t,3))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [ ]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

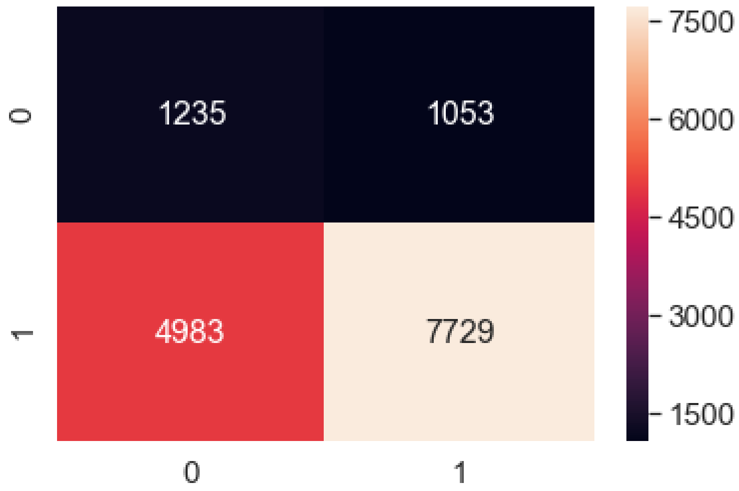
In [91]:

```
#CONFUSION MATRIX
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.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions



print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

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

```
==========================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3281862341953201 for threshold 0.822
[[1235 1053]
 [4983 7729]]
the maximum value of tpr*(1-fpr) 0.3281862341953201 for threshold 0.822
```

Out[91]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x178aa550>
```



In [ ]:

Feature selection with `SelectKBest` (top 2000) , SET 1

In [59]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.f_classif.
html#sklearn.feature_selection.f_classif
#https://stackoverflow.com/questions/49300193/feature-selection-f-classif-scikit-learn
from sklearn.feature_selection import SelectKBest, chi2
from sklearn.feature_selection import f_classif

x_train_bow_2000 = SelectKBest(f_classif, k=2000).fit_transform(x_train_bow, y_train)
x_cv_bow_2000 = SelectKBest(f_classif, k=2000).fit_transform(x_cv_bow, y_cv)
x_test_bow_2000 = SelectKBest(f_classif, k=2000).fit_transform(x_test_bow, y_test)
print(x_train_bow_2000.shape)
print(x_cv_bow_2000.shape)
print(x_test_bow_2000.shape)
```

```
C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\sklearn\feature_selection
\univariate_selection.py:114: UserWarning:

Features [0 0 0 0 0 0 0 0 0] are constant.

C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\sklearn\feature_selection
\univariate_selection.py:114: UserWarning:

Features [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
 0 0 0 0 0] are constant.

C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\sklearn\feature_selection
\univariate_selection.py:114: UserWarning:

Features [0 0 0 0 0 0 0 0 0 0 0 0 0 0] are constant.


(24500, 2000)
(10500, 2000)
(15000, 2000)
```

In [ ]:

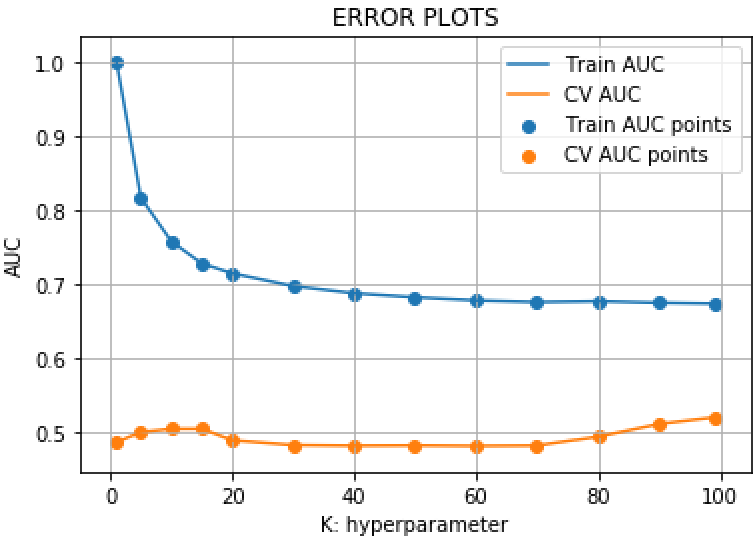
```
type(x_train_bow_2000)
```

Parameter tuning using Gridsearch

In [60]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    neigh.fit(x_train_bow_2000, y_train)


    y_train_pred = batch_predict(neigh, x_train_bow_2000)
    y_cv_pred = batch_predict(neigh, x_cv_bow_2000)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 13/13 [10:35<00:00, 49.12
s/it]
```



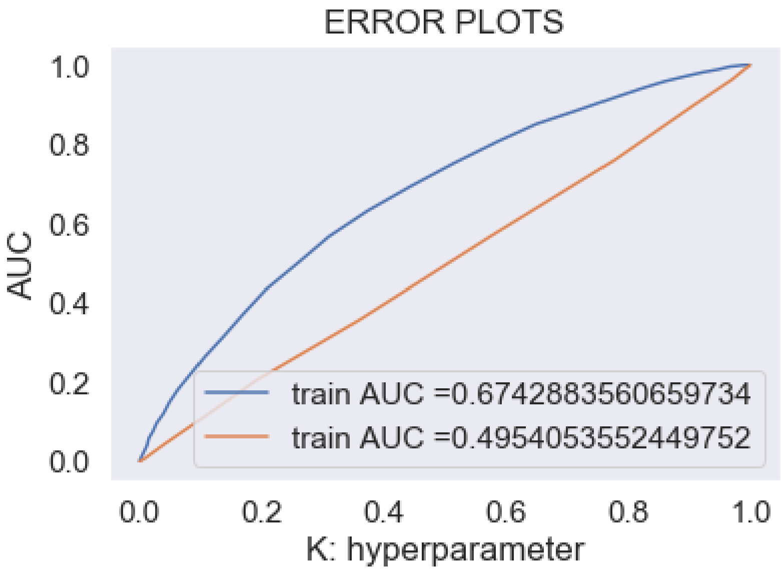
In [92]:

```
opt_k_bow_2000=100
```

Applying on Test data and ROC

In [93]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#skle
arn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=opt_k_bow_2000, n_jobs=-1)
neigh.fit(x_train_bow_2000, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, x_train_bow_2000)
y_test_pred = batch_predict(neigh, x_test_bow_2000)

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)
tain_auc_bow_2000=auc(train_fpr, train_tpr)
test_auc_bow_2000=auc(test_fpr, test_tpr)

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



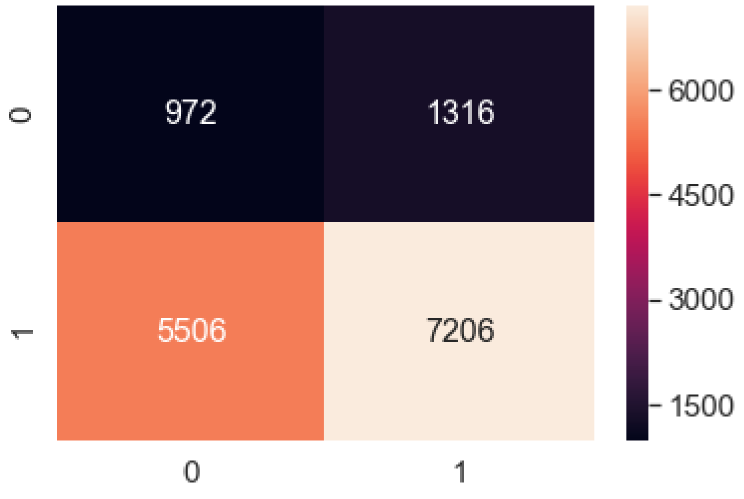
In [94]:

```
#CONFUSION MATRIX
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.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions



print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

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

```
===========================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24081892776826694 for threshold 0.73
[[ 972 1316]
 [5506 7206]]
the maximum value of tpr*(1-fpr) 0.24081892776826694 for threshold 0.73
```

Out[94]:

```
<matplotlib.axes._subplots.AxesSubplot at 0xbe3b3cc0>
```



2.4.2 Applying KNN brute force on TFIDF, SET 2

TFIDF Vectorizing essy and title variable, SET 2

In [ ]:

```
# Please write all the code with proper documentation
```

In [61]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf = TfidfVectorizer(min_df=10,  ngram_range=(1,4), max_features=5000)
vectorizer_tfidf.fit(x_train['preprocessed_essays'].values)# fit has to apply only on t
rain data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_essays = vectorizer.transform(x_train['preprocessed_essays'].values)
x_cv_tfidf_essays = vectorizer.transform(x_cv['preprocessed_essays'].values)
x_test_tfidf_essays = vectorizer.transform(x_test['preprocessed_essays'].values)

print("Shape of matrix after one hot encodig ",x_train_tfidf_essays.shape, y_train.shap
e)
print("Shape of matrix after one hot encodig ",x_cv_tfidf_essays.shape)
print("Shape of matrix after one hot encodig ",x_test_tfidf_essays.shape)
```

```
Shape of matrix after one hot encodig  (24500, 2152) (24500,)
Shape of matrix after one hot encodig  (10500, 2152)
Shape of matrix after one hot encodig  (15000, 2152)
```

In [62]:

```
#TFIDF Vectorizer on `project_title`

from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf = TfidfVectorizer(min_df=10, ngram_range=(1,4), max_features=5000)
vectorizer_tfidf.fit(x_train['preprocessed_project_title'].values)# fit has to apply on
ly on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_title = vectorizer.transform(x_train['preprocessed_project_title'].values
)
x_cv_tfidf_title = vectorizer.transform(x_cv['preprocessed_project_title'].values)
x_test_tfidf_title = vectorizer.transform(x_test['preprocessed_project_title'].values)

print("Shape of matrix after one hot encodig ",x_train_tfidf_title.shape)
print("Shape of matrix after one hot encodig ",x_cv_tfidf_title.shape)
print("Shape of matrix after one hot encodig ",x_test_tfidf_title.shape)
```

```
Shape of matrix after one hot encodig  (24500, 2152)
Shape of matrix after one hot encodig  (10500, 2152)
Shape of matrix after one hot encodig  (15000, 2152)
```

merge all sparse data, SET 2

In [63]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_tfidf = hstack((x_train_ohe, x_train_tfidf_essays, x_train_tfidf_title)).tocsr
()
x_cv_tfidf = hstack((x_cv_ohe, x_cv_tfidf_essays, x_cv_tfidf_title)).tocsr()
x_test_tfidf = hstack((x_test_ohe, x_test_tfidf_essays, x_test_tfidf_title)).tocsr()

print(x_train_tfidf.shape)
print(x_cv_tfidf.shape)
print(x_test_tfidf.shape)
```

```
(24500, 4405)
(10500, 4405)
(15000, 4405)
```

In [64]:

```
type(x_train_tfidf)
```

Out[64]:

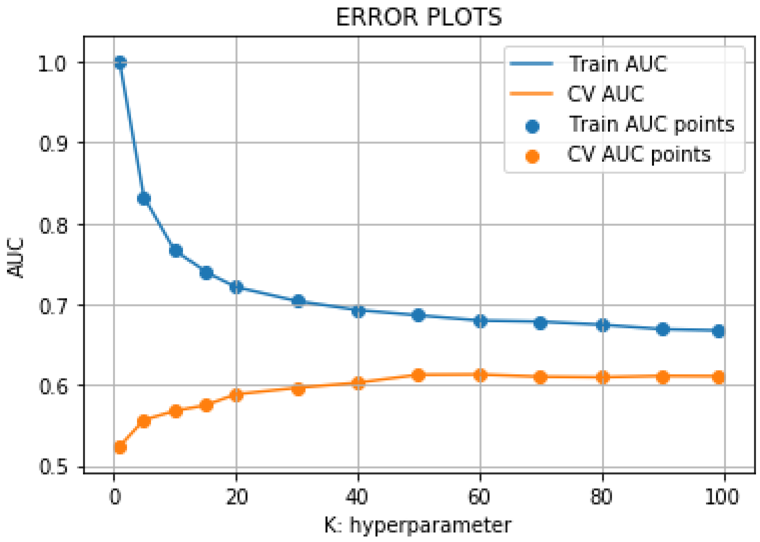
```
scipy.sparse.csr.csr_matrix
```

Hyperparameter tuning by AUC plot for cv and train dataset, SET 2

In [65]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    neigh.fit(x_train_tfidf, y_train)


    y_train_pred = batch_predict(neigh, x_train_tfidf)
    y_cv_pred = batch_predict(neigh, x_cv_tfidf)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 13/13 [11:40<00:00, 54.25
s/it]
```



In [95]:

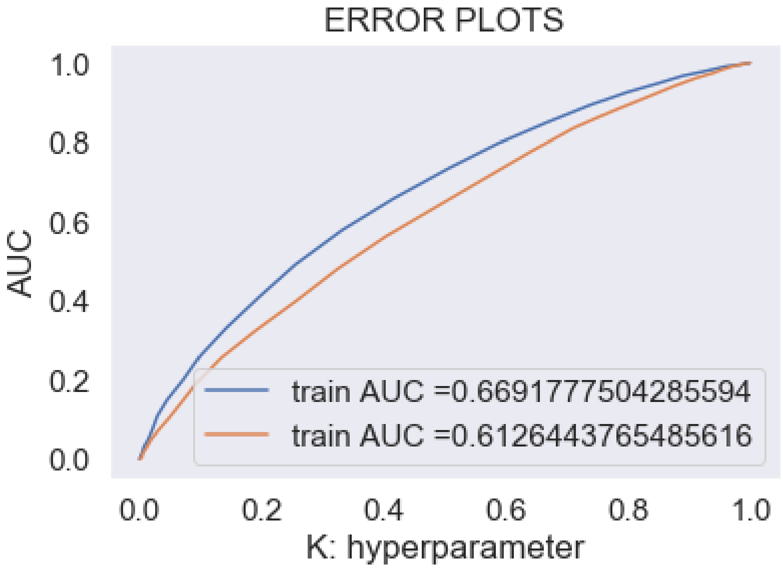
```
opt_k_tfidf=90
```

Apply best hyperparameter on test dataset, SET 2

You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

In [96]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#skle
arn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

neigh = KNeighborsClassifier(n_neighbors=opt_k_tfidf, n_jobs=-1)
neigh.fit(x_train_tfidf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, x_train_tfidf)
y_test_pred = batch_predict(neigh, x_test_tfidf)

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)
tain_auc_tfidf=auc(train_fpr, train_tpr)
test_auc_tfidf=auc(test_fpr, test_tpr)

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



CONFUSION MATRIX

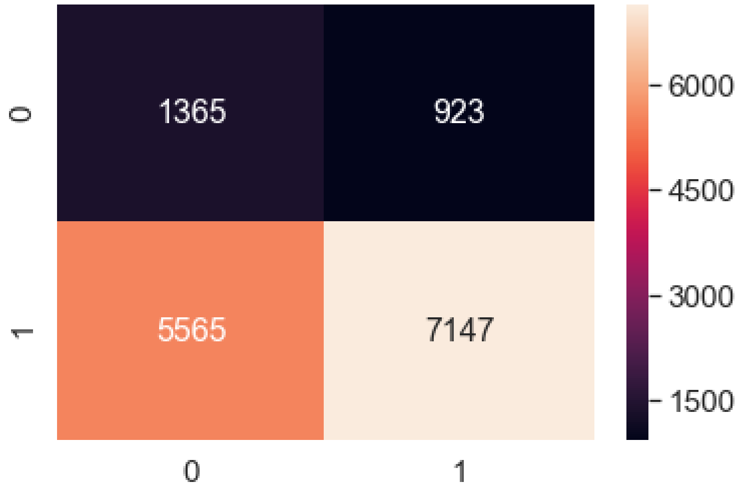
In [97]:

```
#CONFUSION MATRIX
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.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions



print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

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

```
==========================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3354181267521026 for threshold 0.822
[[1365  923]
 [5565 7147]]
the maximum value of tpr*(1-fpr) 0.3354181267521026 for threshold 0.822
```

Out[97]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x273a90f0>
```



In [ ]:

```

```

2.4.3 Applying KNN brute force on AVG W2V, SET 3

vectorize using AVG W2V, SET 3

In [66]:

```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

# ============================
Output:

Loading Glove Model
1917495it [06:32, 4879.69it/s]
Done. 1917495  words loaded!

# ============================

words = []
for i in preproced_texts:
    words.extend(i.split(' '))

for i in preproced_titles:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

inter_words = set(model.keys()).intersection(words)
print("The number of words that are present in both glove vectors and our coupus", \
      len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")

words_courpus = {}
words_glove = set(model.keys())
for i in words:
    if i in words_glove:
        words_courpus[i] = model[i]
print("word 2 vec length", len(words_courpus))


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-p
ickle-to-save-and-load-variables-in-python/

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


'''
```

Out[66]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/3823034
9/4084039\ndef loadGloveModel(gloveFile):\n    print ("Loading Glove Mode
l")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    f
or line in tqdm(f):\n        splitLine = line.split()\n        word = spli
tLine[0]\n        embedding = np.array([float(val) for val in splitLine
[1:]])\n        model[word] = embedding\n    print ("Done.",len(model)," w
ords loaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.
txt\')\n\n# ============================\nOutput:\n    \nLoading Glove Mod
el\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n# ====
========================\n\nwords = []\nfor i in preproced_texts:\n    wor
ds.extend(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend
(i.split(\' \'))\nprint("all the words in the coupus", len(words))\nwords
= set(words)\nprint("the unique words in the coupus", len(words))\n\ninter
_words = set(model.keys()).intersection(words)\nprint("The number of words
that are present in both glove vectors and our coupus",       len(inter_wo
rds),"(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpu
s = {}\nwords_glove = set(model.keys())\nfor i in words:\n    if i in word
s_glove:\n        words_courpus[i] = model[i]\nprint("word 2 vec length",
len(words_courpus))\n\n\n# stronging variables into pickle files python: h
ttp://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-
python/\n\nimport pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n
pickle.dump(words_courpus, f)\n\n\n'
```

In [67]:

```
# Please write all the code with proper documentation
```

In [68]:

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

In [69]:

```
# Using Pretrained Models: AVG W2V on `essay`
#_______________________________________________

# -----average Word2Vec on train
# compute average word2vec for each review.
avg_w2v_vectors_essays_train = []; # the avg-w2v for each sentence/review is stored in
 this list
for sentence in tqdm(x_train['preprocessed_essays']): # 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_essays_train.append(vector)

print(len(avg_w2v_vectors_essays_train))
print(len(avg_w2v_vectors_essays_train[0]))
```

```
100%|██████████████████████████████████| 24500/24500 [00:06<00:00, 3620.84
it/s]

24500
300
```

In [70]:

```
# -----average Word2Vec on CV
# compute average word2vec for each review.
avg_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review is stored in thi
s list
for sentence in tqdm(x_cv['preprocessed_essays']): # 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_essays_cv.append(vector)

print(len(avg_w2v_vectors_essays_cv))
print(len(avg_w2v_vectors_essays_cv[0]))
```

```
100%|██████████████████████████████████| 10500/10500 [00:02<00:00, 3591.99
it/s]

10500
300
```

In [71]:

```
# -----average Word2Vec on test
# compute average word2vec for each review.
avg_w2v_vectors_essays_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['preprocessed_essays']): # 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_essays_test.append(vector)

print(len(avg_w2v_vectors_essays_test))
print(len(avg_w2v_vectors_essays_test[0]))
```

```
100%|██████████████████████████████████| 15000/15000 [00:04<00:00, 3575.48 it/s]

15000
300
```

In [72]:

```
# Using Pretrained Models: AVG W2V on `project_title`
#_____________________________________________________

# ------average Word2Vec on train
# compute average word2vec for each review.
avg_w2v_vectors_project_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['preprocessed_project_title']): # 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_project_title_train.append(vector)

print(len(avg_w2v_vectors_project_title_train))
print(len(avg_w2v_vectors_project_title_train[0]))
```

```
100%|█████████████████████████████████| 24500/24500 [00:00<00:00, 71424.51 it/s]

24500
300
```

In [73]:

```
# ------average Word2Vec on cv
# compute average word2vec for each review.
avg_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentence/review is stored
in this list
for sentence in tqdm(x_cv['preprocessed_project_title']): # 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_project_title_cv.append(vector)

print(len(avg_w2v_vectors_project_title_cv))
print(len(avg_w2v_vectors_project_title_cv[0]))
```

```
100%|████████████████████████████████| 10500/10500 [00:00<00:00, 69532.46
it/s]

10500
300
```

In [74]:

```
# ------average Word2Vec on test
# compute average word2vec for each review.
avg_w2v_vectors_project_title_test = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm(x_test['preprocessed_project_title']): # 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_project_title_test.append(vector)

print(len(avg_w2v_vectors_project_title_test))
print(len(avg_w2v_vectors_project_title_test[0]))
```

```
100%|████████████████████████████████| 15000/15000 [00:00<00:00, 70418.50
it/s]

15000
300
```

merge all sparse data, SET 3

In [75]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
x_train_AVGW2V = hstack((x_train_ohe, avg_w2v_vectors_essays_train, avg_w2v_vectors_project_title_train)).tocsr()
x_cv_AVGW2V = hstack((x_cv_ohe, avg_w2v_vectors_essays_cv, avg_w2v_vectors_project_title_cv)).tocsr()
x_test_AVGW2V = hstack((x_test_ohe, avg_w2v_vectors_essays_test, avg_w2v_vectors_project_title_test)).tocsr()

print(x_train_AVGW2V.shape)
print(x_cv_AVGW2V.shape)
print(x_test_AVGW2V.shape)
```

```
(24500, 701)
(10500, 701)
(15000, 701)
```

In [76]:

```
type(x_train_AVGW2V)
```

Out[76]:

```
scipy.sparse.csr.csr_matrix
```

In [ ]:

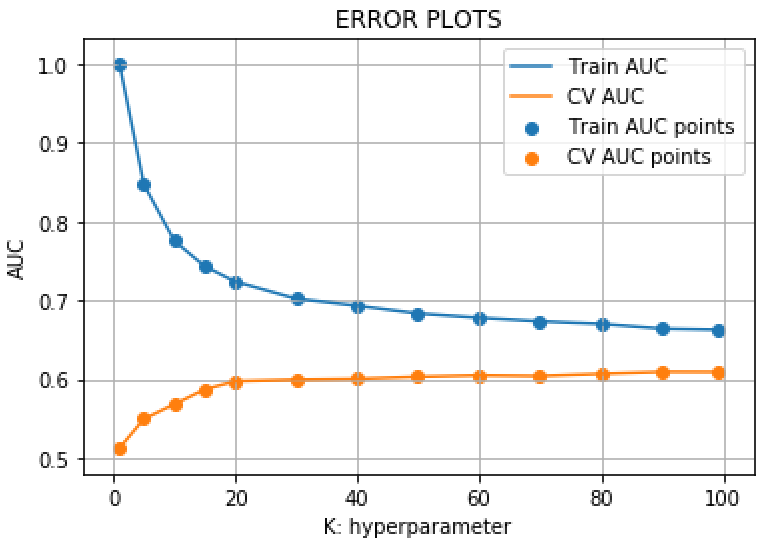
```

```

Hyperparameter tuning by AUC plot for cv and train dataset, SET 3

In [77]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    neigh.fit(x_train_AVGW2V, y_train)


    y_train_pred = batch_predict(neigh, x_train_AVGW2V)
    y_cv_pred = batch_predict(neigh, x_cv_AVGW2V)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 13/13 [1:54:34<00:00, 529.46
s/it]
```



In [98]:

```
opt_k_AVGW2V=100
```

In [ ]:

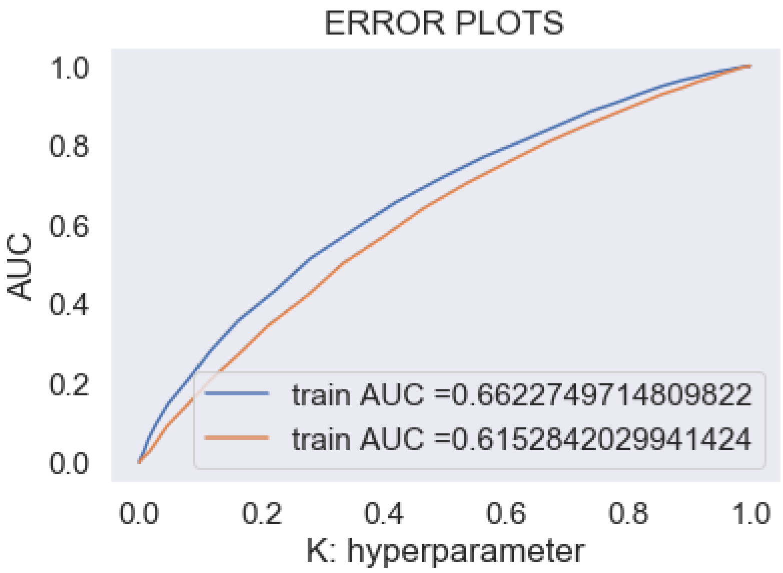
```

```

Apply best hyperparameter on test dataset, SET 3

You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

In [99]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#skle
arn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

neigh = KNeighborsClassifier(n_neighbors=opt_k_AVGW2V, n_jobs=-1)
neigh.fit(x_train_AVGW2V, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, x_train_AVGW2V)
y_test_pred = batch_predict(neigh, x_test_AVGW2V)

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)
tain_auc_AVGW2V=auc(train_fpr, train_tpr)
test_auc_AVGW2V=auc(test_fpr, test_tpr)

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



CONFUSION MATRIX, SET 3

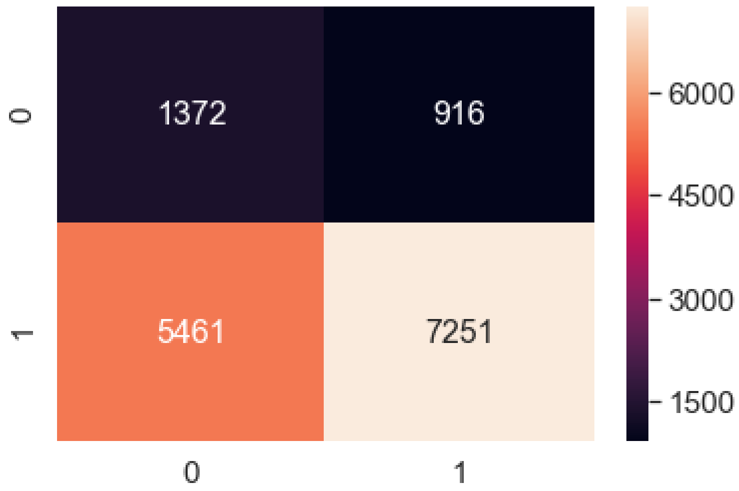
In [100]:

```
#CONFUSION MATRIX
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.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions



print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

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

```
==========================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3427979647004978 for threshold 0.86
[[1372  916]
 [5461 7251]]
the maximum value of tpr*(1-fpr) 0.3427979647004978 for threshold 0.86
```

Out[100]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x18ea2160>
```



In [ ]:

```

```

2.4.4 Applying KNN brute force on TFIDF W2V, SET 4

Vectorize using TFIDF W2V, SET 4

In [ ]:

```
# Please write all the code with proper documentation
```

In [101]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(x_train['preprocessed_essays'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary_essay = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words_essay = set(tfidf_model.get_feature_names())
```

In [102]:

```
#Using Pretrained Models: TFIDFW weighted W2V on `essay
#___________________________________

# average Word2Vec---train
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_train = []; # the avg-w2v for each sentence/review is stored i
n this list
for sentence in tqdm(x_train['preprocessed_essays']): # 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_essay):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary_essay[word]*(sentence.count(word)/len(sentence.split
())) # getting the tfidf value for each word
            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_essays_train.append(vector)

print(len(tfidf_w2v_vectors_essays_train))
print(len(tfidf_w2v_vectors_essays_train[0]))
```

```
100%|██████████████████████████████████| 24500/24500 [00:50<00:00, 488.79
it/s]

24500
300
```

In [103]:

```
# average Word2Vec---cv
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(x_cv['preprocessed_essays']): # 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_essay):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary_essay[word]*(sentence.count(word)/len(sentence.split
())) # getting the tfidf value for each word
            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_essays_cv.append(vector)

print(len(tfidf_w2v_vectors_essays_cv))
print(len(tfidf_w2v_vectors_essays_cv[0]))
```

```
100%|██████████| 10500/10500 [00:21<00:00, 497.46
it/s]

10500
300
```

In [104]:

```
# average Word2Vec---test
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['preprocessed_essays']): # 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_essay):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary_essay[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            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_essays_test.append(vector)

print(len(tfidf_w2v_vectors_essays_test))
print(len(tfidf_w2v_vectors_essays_test[0]))
```

```
100%|██████████| 15000/15000 [00:30<00:00, 492.08it/s]

15000
300
```

In [105]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(x_train['preprocessed_project_title'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary_title = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words_title = set(tfidf_model.get_feature_names())
```

In [106]:

```
# average Word2Vec--train
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_train = []; # the avg-w2v for each sentence/review is s
tored in this list
for sentence in tqdm(x_train['preprocessed_project_title']): # 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_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary_title[word]*(sentence.count(word)/len(sentence.split
())) # getting the tfidf value for each word
            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_project_title_train.append(vector)

print(len(tfidf_w2v_vectors_project_title_train))
print(len(tfidf_w2v_vectors_project_title_train[0]))
```

```
100%|██████████████████████████████| 24500/24500 [00:00<00:00, 34263.77
it/s]

24500
300
```

In [107]:

```
# average Word2Vec--cv
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_cv['preprocessed_project_title']): # 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_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary_title[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            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_project_title_cv.append(vector)

print(len(tfidf_w2v_vectors_project_title_cv))
print(len(tfidf_w2v_vectors_project_title_cv[0]))
```

```
100%|██████████████████████████████| 10500/10500 [00:00<00:00, 34088.97 it/s]

10500
300
```

In [108]:

```
# average Word2Vec--test
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['preprocessed_project_title']): # 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_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary_title[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            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_project_title_test.append(vector)

print(len(tfidf_w2v_vectors_project_title_test))
print(len(tfidf_w2v_vectors_project_title_test[0]))
```

```
100%|██████████████████████████████| 15000/15000 [00:00<00:00, 34088.97
it/s]

15000
300
```

merge all aparse data, SET 4

In [109]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
x_train_TFIDFW2V = hstack((x_train_ohe, tfidf_w2v_vectors_essays_train, tfidf_w2v_vectors_project_title_train)).tocsr()
x_cv_TFIDFW2V = hstack((x_cv_ohe, tfidf_w2v_vectors_essays_cv, tfidf_w2v_vectors_project_title_cv)).tocsr()
x_test_TFIDFW2V = hstack((x_test_ohe, tfidf_w2v_vectors_essays_test, tfidf_w2v_vectors_project_title_test)).tocsr()

print(x_train_TFIDFW2V.shape)
print(x_cv_TFIDFW2V.shape)
print(x_test_TFIDFW2V.shape)
```

```
(24500, 701)
(10500, 701)
(15000, 701)
```

In [110]:

```
type(x_train_TFIDFW2V)
```

Out[110]:

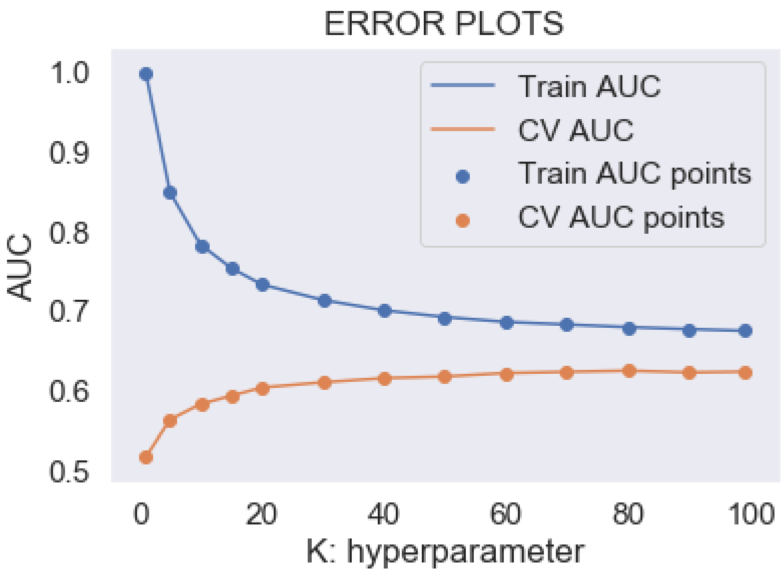
```
scipy.sparse.csr.csr_matrix
```

Hyperparameter tuning by AUC plot for cv and train dataset, SET 4

In [111]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 99]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    neigh.fit(x_train_TFIDFW2V, y_train)


    y_train_pred = batch_predict(neigh, x_train_TFIDFW2V)
    y_cv_pred = batch_predict(neigh, x_cv_TFIDFW2V)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # 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("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|████████████████████████████████████████| 13/13 [2:04:57<00:00, 556.41
s/it]
```



In [117]:

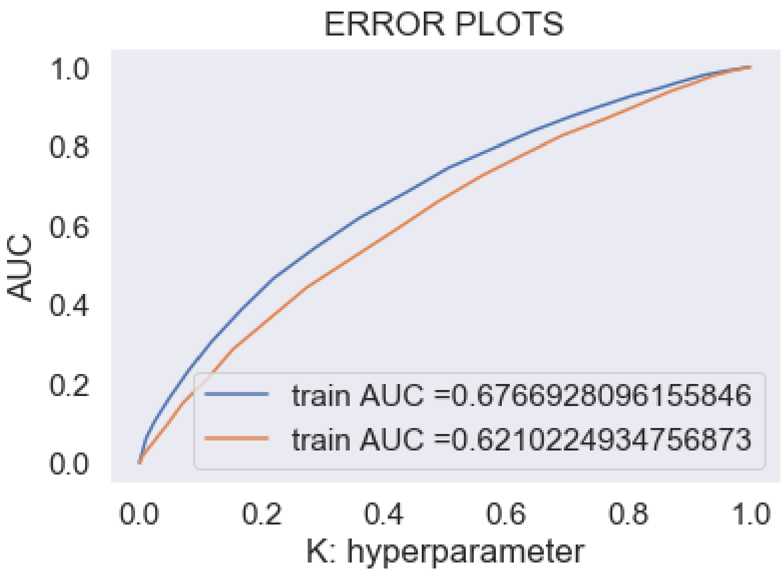
```
opt_k_TFIDFW2V=90
```

Apply best hyperparameter on test dataset, SET 4

You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

In [118]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

neigh = KNeighborsClassifier(n_neighbors=opt_k_TFIDFW2V, n_jobs=-1)
neigh.fit(x_train_TFIDFW2V, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(neigh, x_train_TFIDFW2V)
y_test_pred = batch_predict(neigh, x_test_TFIDFW2V)

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)
tain_auc_TFIDFW2V=auc(train_fpr, train_tpr)
test_auc_TFIDFW2V=auc(test_fpr, test_tpr)

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



CONFUSION MATRIX, SET 4

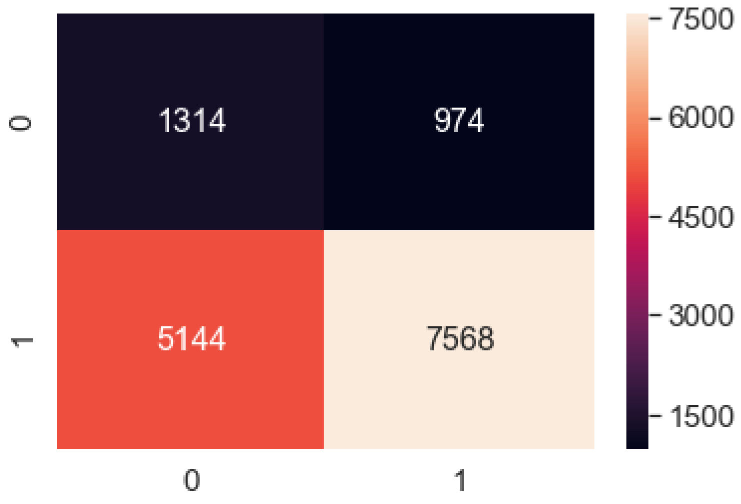
In [119]:

```
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.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions


print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

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

```
==========================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3419058914653629 for threshold 0.856
[[1314  974]
 [5144 7568]]
the maximum value of tpr*(1-fpr) 0.3419058914653629 for threshold 0.856
```

Out[119]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x27edc518>
```



Conclusion

In [116]:

```
# Please compare all your models using Prettytable library
```

In [120]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyper parameter k","AUC_train", "AUC_test"]
x.add_row(["BOW", "Brute", opt_k_bow, tain_auc_bow,test_auc_bow])
x.add_row(["BOW_top2000", "Brute", opt_k_bow_2000, tain_auc_bow_2000,test_auc_bow_2000
])
x.add_row(["TFIDF", "Brute", opt_k_tfidf, tain_auc_tfidf,tain_auc_tfidf])
x.add_row(["AVG W2V", "Brute", opt_k_AVGW2V, tain_auc_AVGW2V,tain_auc_AVGW2V])
x.add_row(["TFIDF W2V", "Brute", opt_k_TFIDFW2V, tain_auc_TFIDFW2V,test_auc_TFIDFW2V])
print(x)
```

```
+-------------+-------+-------------------+--------------------+----------
----------+
|  Vectorizer | Model | Hyper parameter k |     AUC_train      |      AUC_
test      |
+-------------+-------+-------------------+--------------------+----------
----------+
|     BOW     | Brute |         90        | 0.6714242552748313 | 0.6087500
914559009 |
| BOW_top2000 | Brute |        100        | 0.6742883560659734 | 0.4954053
552449752 |
|    TFIDF    | Brute |         90        | 0.6691777504285594 | 0.6691777
504285594 |
|   AVG W2V   | Brute |        100        | 0.6622749714809822 | 0.6622749
714809822 |
|  TFIDF W2V  | Brute |         90        | 0.6766928096155846 | 0.6210224
934756873 |
+-------------+-------+-------------------+--------------------+----------
----------+
```

Observation: 1) Data set taken 50000 because memory limit

1)Hyper parameter value k is varies from 90 to 100.

2)there is not much difference in AUC value of train and test value except second case and AUC value not much low that shows that model is neither underfit nor overfit.

3) most of error occuring in FN box of confusion where actual value is 1 but predicted 0.

In [ ]: