Assignment no -3 kNN Classification

Donorchoose

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.
</p>

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:

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Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`

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Feature	Description
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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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 project was not approved, and a value of `1` indicates the project was approved.

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."

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- __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.

1. Preprocess essays and titles.
2. Split the dataset.
3. Vectorize seperately as per the split. standardize data
4. Applyig knn

Intially all the text preprocessing has to be performed on the whole dataset and then we have to split the dataset into train, Cv and test datasets. After that we have to apply featurization techniques and then perform Cross validtion and build the models.

Objective

The primary objective is to implement the k-Nearest Neighbor Algorithm on the DonorChoose Dataset and measure the accuracy on the Test dataset

In [1]:
```
#Import data and modules
%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
```

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```
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 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/
```

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```
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

import chart_studio.plotly as py
from collections import Counter
```

1.1 Reading Data

In [2]:
```
#reading the DonorsChoose training data into a DataFrame
#we are loading two datas in pandas dataframe
#NOTE: Only 25000 datapoints are considered as ROC and AUC curve takes
 lot of time to plot and Due to computational constraints!
project_data = pd.read_csv(r'C:\Users\SAI\Downloads\Assignment_donorcho
ose 2018\train_data.csv',nrows=25000)
resource_data = pd.read_csv(r'C:\Users\SAI\Downloads\Assignment_donorch
oose 2018\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 (25000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefi
x' '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'
```

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```
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

observation

here we have 25000 projects and 17 different attributes i.e.'teacher_id' 'teacher_prefix' 'school_state''project_submitted_datetime' 'project_grade_category' and others

In [4]:
```
# how to replace elements in list python: https://stackoverflow.com/a/2
582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(
project_data.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/
a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_d
atetime'])
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/131
48611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[4]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Da
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	20 04- 00:53
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	Ms.	CA	20 04-

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

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

Out[5]:

	id	description	quantity	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

Observation

Here we can see the there are 1541272 resources whicih more than no of projects also there are 4 columns of resorces 'id' 'description' 'quantity' 'price'.

1.2 preprocessing of 'project_subject_categories'

In [6]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stacko
verflow.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 = ""
```

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```
    # consider we have text like this "Math & Science, Warmth, Care & H
unger"
    for j in i.split(','): # it will split it in three parts ["Math & S
cience", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory b
ased on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are g
oing 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 int
o
    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 [7]:

```
sub_catogories = list(project_data['project_subject_subcategories'].val
ues)
# remove special characters from list of strings python: https://stacko
verflow.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
```

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```
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python

sub_subcat_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", "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('&','_')
    sub_subcat_list.append(temp.strip())

project_data['clean_subcategories'] = sub_subcat_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_subcat_dict = dict(my_counter)
sorted_sub_subcat_dict = dict(sorted(sub_subcat_dict.items(), key=lambda kv: kv[1]))
```

1.4 preprocessing of teacher_prefix

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In [8]:
```
##NaN values in techer prefix will create a problem while One Hot encod
ing,so we replace NaN values with the mode of that particular column
###removing dot(.) since it is a special character
####https://www.geeksforgeeks.org/python-pandas-dataframe-fillna-to-rep
lace-null-values-in-dataframe/

mode_of_teacher_prefix = project_data['teacher_prefix'].value_counts().
index[0]
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(
mode_of_teacher_prefix)
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(
mode_of_teacher_prefix)


prefixes = []
for i in range(len(project_data)):
    a = project_data["teacher_prefix"][i].replace(".", "")
    prefixes.append(a)

project_data.drop(['teacher_prefix'], axis = 1, inplace = True)
project_data["teacher_prefix"] = prefixes
print("After removing the special characters ,Column values:")
np.unique(project_data["teacher_prefix"].values)
```

```
After removing the special characters ,Column values:
```

Out[8]:
```
array(['Mr', 'Mrs', 'Ms', 'Teacher'], dtype=object)
```

In [9]:
```
# We need to get rid of The spaces between the text and the hyphens bec
ause they're special characters.
#Removing multiple characters from a string in Python
#https://stackoverflow.com/questions/3411771/multiple-character-replace
-with-python
project_grade_category = []
for i in range(len(project_data)):
    a = project_data["project_grade_category"][i].replace(" ", "_").rep
lace("-", "_")
    project_grade_category.append(a)
```

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```
project_data.drop(['project_grade_category'], axis = 1, inplace = True)
project_data["project_grade_category"] = project_grade_category
print("After removing the special characters ,Column values:")
np.unique(project_data["project_grade_category"].values)
```

```
After removing the special characters ,Column values:
```

Out[9]:
```
array(['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2'],
      dtype=object)
```

1.5 Text preprocessing

In [10]:
```
# 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 [11]:
```
project_data.head(5)
```

Out[11]:

	Unnamed: 0	id	teacher_id	school_state	Date	project_titl
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	GA	2016-04-27 00:53:00	Flexible Seating fo Flexible Learning
23374	72317	p087808	598621c141cda5fb184ee7e8ccdd3fcc	CA	2016-04-27 02:04:15	iPad fo Learners

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	Unnamed: 0	id	teacher_id	school_state	Date	project_titl
7176	79341	p091436	bb2599c4a114d211b3381abe9f899bf8	OH	2016-04-27 07:24:47	Robots ar Taking ove 2nd Grad
5145	50256	p203475	63e9a9f2c9811a247f1aa32ee6f92644	CA	2016-04-27 08:45:34	Books t Powe Powerfu Book Clubs
2521	164738	p248458	40da977f63fb3d85589a063471304b11	NJ	2016-04-27 09:33:03	Supplies t Support m Struggling Readers!

In [12]:
```
# printing some random reviews

print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[500])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[2000])
print("="*50)
```

```
I recently read an article about giving students a choice about how the
y learn. We already set goals; why not let them choose where to sit, an
d give them options of what to sit on?I teach at a low-income (Title 1)
school. Every year, I have a class with a range of abilities, yet they
are all the same age. They learn differently, and they have different i
nterests. Some have ADHD, and some are fast learners. Yet they are eage
r and active learners that want and need to be able to move around the
room, yet have a place that they can be comfortable to complete their w
```

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ork.We need a classroom rug that we can use as a class for reading tim
e, and students can use during other learning times. I have also reques
ted four Kore Kids wobble chairs and four Back Jack padded portable cha
irs so that students can still move during whole group lessons without
disrupting the class. Having these areas will provide these little ones
with a way to wiggle while working.Benjamin Franklin once said, \"Tell
me and I forget, teach me and I may remember, involve me and I learn.\"
I want these children to be involved in their learning by having a choi
ce on where to sit and how to learn, all by giving them options for com
fortable flexible seating.
==========
Wasn't recess one of your favorite times of day in school? I know it wa
s mine, and most of my students! It is also important as it is a time t
o teach social skills, compassion, and teamwork.I teach 24 very energet
ic and enthusiastic kindergarteners at a preK-8 inner city school. Our
school building used to be a high school and therefore, while there is
open space to run around at recess time, there is no playground equipme
nt for the students to use. Our kindergarten program is full day theref
ore it is very important for my students to have time outside to play a
nd take a \"brain break\". It is a time that they can get some energy o
ut and they can learn about working together without even realizing it.
The materials that I have requested in this project will be used outsid
e for the students during recess time. They will help the students with
their gross motor skills, in learning how to use certain equipment appr
opriately. Some of the materials, such as the jump ropes will also help
them learn to work together and improve their social skills.I truly bel
ieve that the donations to this project will help my students keep a ha
ppy disposition and help them look forward to coming to school. While w
e work to teach the students games and activities that do not require e
quipment now, it is difficult to send them off on their own to work tog
ether, therefore impeding on the development of their social and team b
uilding skills. The materials will help them work together, therefore
improving how they will work together in the classroom.
==========
My students have become artists! This school year they dove head first
into a new art program developed for student in special day programs wh
o are classified as Emotionally Disturbed. These kids tend to work bet
ter in small groups and have projects that allow them to get up, move a
round, listen to music, work with their hands and freely be themselves.

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Often times, out in regular education, the classrooms have too many k
ids, the rigor of work can be overwhelming and the kids sometimes do
n't know how to work through their emotions. To help them out, we crea
ted an art program focusing on 3D Art and pottery that allows them to a
ccess their creative juices, but do so in an environment that feels saf
e and welcoming.\r\nAs the art program has been such a success, the sch
ool has asked me to teach a 2nd class of art to students in our special
day classes who are classified as intellectually disabled. I am so exc
ited to be able to expand our pottery project and allow other students
to experience art on a daily basis.This school year we launched our Pot
tery Project and introduced pottery to the students each week on Thursd
ays and Fridays. The students had so much fun. They learned how to th
row on the wheels and they learned how to hand build with clay. The r
est of the week they spent doing 2D and 3D art projects, which included
making 3D conversational heart, 3D words, trees created out of wire and
paper mache, masks, boxes and used wood burning tools.\r\nNext school y
ear multiple students in the SDC program on our campus will be able to
take an art class designed specifically with the in mind, focusing in o
n their own personal learning styles. It is so very exciting to create
an art program that will challenge the students to empower art.nannan
==========
My students are hardworking, dedicated, students who come to school eve
ry day in spite of the daily challenges they face. They live in a high
poverty neighborhood, and each and every student receives a free breakf
ast and lunch from school. The surrounding neighborhood is gang infeste
d, and often violent, but that does not deter my students from coming t
o school.\r\n\r\n   After seeing \"He Named Me Malala\" my students ca
me back to school with a new found appreciation for their free and publ
ic education.\r\nMy students will read \"I am Malala\" aloud, together
with their classmates, over several weeks. After they have read the boo
k they will use the Kindle Fires to do a research project on education,
and the lack thereof, in countries other than the United States. They w
ill choose a country that does not provide a free and public education
for its children, or a country that limits education to boys only. They
may also choose to research the Syrian refugee crisis and how it is aff
ecting the children involved by keeping them out of school. Once their
research is done, we will go to the computer lab where they will type a
n essay reflecting their research.\r\n The goal is for my students to g
ain a deep understanding of how important education is, and how privile

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```
ged they are in this country to get to come to school for free.nannan
==================================================
```

In [13]:
```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):#https://stackoverflow.com/a/47091490/4084039
    # 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 [14]:
```
sent = decontracted(project_data['essay'].values[2000])
print(sent)
print("="*50)
```

```
My students are hardworking, dedicated, students who come to school eve
ry day in spite of the daily challenges they face. They live in a high
poverty neighborhood, and each and every student receives a free breakf
ast and lunch from school. The surrounding neighborhood is gang infeste
d, and often violent, but that does not deter my students from coming t
o school.\r\n\r\n    After seeing \"He Named Me Malala\" my students ca
me back to school with a new found appreciation for their free and publ
ic education.\r\nMy students will read \"I am Malala\" aloud, together
with their classmates, over several weeks. After they have read the boo
k they will use the Kindle Fires to do a research project on education,
and the lack thereof, in countries other than the United States. They w
ill choose a country that does not provide a free and public education
for its children, or a country that limits education to boys only. They
```

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```
may also choose to research the Syrian refugee crisis and how it is aff
ecting the children involved by keeping them out of school. Once their
research is done, we will go to the computer lab where they will type a
n essay reflecting their research.\r\n The goal is for my students to g
ain a deep understanding of how important education is, and how privile
ged they are in this country to get to come to school for free.nannan
==================================================
```

In [15]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remov
e-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My students are hardworking, dedicated, students who come to school eve
ry day in spite of the daily challenges they face. They live in a high
poverty neighborhood, and each and every student receives a free breakf
ast and lunch from school. The surrounding neighborhood is gang infeste
d, and often violent, but that does not deter my students from coming t
o school.        After seeing  He Named Me Malala  my students came bac
k to school with a new found appreciation for their free and public edu
cation.  My students will read  I am Malala  aloud, together with their
classmates, over several weeks. After they have read the book they will
use the Kindle Fires to do a research project on education, and the lac
k thereof, in countries other than the United States. They will choose
a country that does not provide a free and public education for its chi
ldren, or a country that limits education to boys only. They may also c
hoose to research the Syrian refugee crisis and how it is affecting the
children involved by keeping them out of school. Once their research is
done, we will go to the computer lab where they will type an essay refl
ecting their research.   The goal is for my students to gain a deep und
erstanding of how important education is, and how privileged they are i
n this country to get to come to school for free.nannan
```

In [16]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

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```
My students are hardworking dedicated students who come to school every
day in spite of the daily challenges they face They live in a high pove
rty neighborhood and each and every student receives a free breakfast a
nd lunch from school The surrounding neighborhood is gang infested and
often violent but that does not deter my students from coming to school
After seeing He Named Me Malala my students came back to school with a
new found appreciation for their free and public education My students
will read I am Malala aloud together with their classmates over several
weeks After they have read the book they will use the Kindle Fires to d
o a research project on education and the lack thereof in countries oth
er than the United States They will choose a country that does not prov
ide a free and public education for its children or a country that limi
ts education to boys only They may also choose to research the Syrian r
efugee crisis and how it is affecting the children involved by keeping
them out of school Once their research is done we will go to the comput
er lab where they will type an essay reflecting their research The goal
is for my students to gain a deep understanding of how important educat
ion is and how privileged they are in this country to get to come to sc
hool for free nannan
```

In [17]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'no
t'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves'
, 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselve
s', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'it
s', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'th
is', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'h
ave', 'has', 'had', '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', 'over', 'under', 'again', 'further',\
```

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```
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'h
ow', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 's
o', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should',
"should've", 'now', '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', "is
n't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn',
 "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [18]:
```
#Combining all above the statesment.
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.lower() not in stopwor
ds)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████| 25000/25000 [00:25<00:00, 96
8.97it/s]
```

In [19]:
```
# after preprocesing
preprocessed_essays[1000]
```

Out[19]:
```
'students become artists school year dove head first new art program de
veloped student special day programs classified emotionally disturbed k
ids tend work better small groups projects allow get move around listen
music work hands freely often times regular education classrooms many k
```

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```
ids rigor work overwhelming kids sometimes not know work emotions help
created art program focusing 3d art pottery allows access creative juic
es environment feels safe welcoming art program success school asked te
ach 2nd class art students special day classes classified intellectuall
y disabled excited able expand pottery project allow students experienc
e art daily basis school year launched pottery project introduced potte
ry students week thursdays fridays students much fun learned throw whee
ls learned hand build clay rest week spent 2d 3d art projects included
making 3d conversational heart 3d words trees created wire paper mache
masks boxes used wood burning tools next school year multiple students
sdc program campus able take art class designed specifically mind focus
ing personal learning styles exciting create art program challenge stud
ents empower art nannan'
```

1.5-b Preprocessing of `project_title`

In [20]:
```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentence in tqdm(project_data['project_title'].values):
    sent = decontracted(sentence)
    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_titles.append(sent.lower().strip())
```

```
100%|██████████████████████████████████| 25000/25000 [00:01<00:00, 1716
3.68it/s]
```

In [21]:
```
preprocessed_titles[1000]
```

Out[21]:
```
'art a hard days work'
```

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In [22]:
```
project_data['clean_titles'] = preprocessed_titles
```

In [23]:
```
project_data.count()
```

Out[23]:
```
Unnamed: 0                                        25000
id                                                25000
teacher_id                                        25000
school_state                                      25000
Date                                              25000
project_title                                     25000
project_essay_1                                   25000
project_essay_2                                   25000
project_essay_3                                     831
project_essay_4                                     831
project_resource_summary                          25000
teacher_number_of_previously_posted_projects      25000
project_is_approved                               25000
clean_categories                                  25000
clean_subcategories                               25000
teacher_prefix                                    25000
project_grade_category                            25000
essay                                             25000
clean_titles                                      25000
dtype: int64
```

Uptil here we preprocessed donor choose data. Next is to split data in train,test and CV then we have to vectorize data for BoW,TFIDF,Avg W2Vec and TFIDF weighted W2Vec

1.6 Test - Train Data Spliting

In [24]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(project_data,projec
t_data['project_is_approved'],\
test_size=0.33, stratify = project_data['project_is_approved'])
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_
size=0.33, stratify=y_train)
```

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In [25]:
```
X_train.drop(['project_is_approved'], axis=1, inplace=True)
X_test.drop(['project_is_approved'], axis=1, inplace=True)
X_cv.drop(['project_is_approved'], axis=1, inplace=True)
```

In [26]:
```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)
```

```
(11222, 18) (11222,)
(5528, 18) (5528,)
(8250, 18) (8250,)
====================================================================================================
```

1.7 Preparing Data for Models

In [27]:
```
project_data.columns
```

Out[27]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'school_state', 'Date',
       'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summar
y',
       'teacher_number_of_previously_posted_projects', 'project_is_appr
oved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix',
       'project_grade_category', 'essay', 'clean_titles'],
      dtype='object')
```

we are going to consider

- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data

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```
- project_grade_category : categorical data
- teacher_prefix : categorical data

- project_title : text data
- text : text data
- project_resource_summary: text data (optinal)

- quantity : numerical (optinal)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical
```

1.7.1 Vectorizing Categorical data

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

1.7.1.a) One hot encode - Clean categories of project_subject_category

In [28]:
```
# 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)
vectorizer.fit(X_train['clean_categories'].values)
categories_one_hot_train = vectorizer.fit_transform(X_train['clean_categories'].values)
categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)
categories_one_hot_cv = vectorizer.transform(X_cv['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix of Train data after one hot encoding ",categorie
```

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```
s_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",categories
_one_hot_test.shape)
print("Shape of matrix of CV data after one hot encoding ",categories_o
ne_hot_cv.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearn
ing', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Langua
ge']
Shape of matrix of Train data after one hot encoding  (11222, 9)
Shape of matrix of Test data after one hot encoding  (8250, 9)
Shape of matrix of CV data after one hot encoding  (5528, 9)
```

1.7.1.b)One hot encode-Clean categories of project_sub_subcategories

In [29]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_subcat_dict.key
s()), lowercase=False,
binary=True)
vectorizer.fit(X_train['clean_subcategories'].values)
sub_categories_one_hot_train = vectorizer.fit_transform(X_train['clean_
subcategories'].values)
sub_categories_one_hot_test = vectorizer.transform(X_test['clean_subcat
egories'].values)
sub_categories_one_hot_cv = vectorizer.transform(X_cv['clean_subcategor
ies'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix of Train data after one hot encoding ",sub_categ
ories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",sub_catego
ries_one_hot_test.shape)
print("Shape of matrix of Cross Validation data after one hot encoding
 ",sub_categories_one_hot_cv
.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolveme
nt', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'Nutri
```

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```
tionEducation', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingA
rts', 'CharacterEducation', 'TeamSports', 'Other', 'College_CareerPre
p', 'Music', 'History_Geography', 'Health_LifeScience', 'ESL', 'EarlyDe
velopment', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Healt
h_Wellness', 'AppliedSciences', 'SpecialNeeds', 'Literature_Writing',
'Mathematics', 'Literacy']
Shape of matrix of Train data after one hot encoding  (11222, 30)
Shape of matrix of Test data after one hot encoding  (8250, 30)
Shape of matrix of Cross Validation data after one hot encoding  (5528,
30)
```

1.7.1.c)One hot encode - School states

In [30]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/
22898595/4084039
my_counter = Counter()
for word in project_data['school_state'].values:
    my_counter.update(word.split())
```

In [31]:
```
school_states_dict = dict(my_counter)
sorted_school_states_dict = dict(sorted(school_states_dict.items(), key
=lambda kv: kv[1]))
```

In [32]:
```
## we use count vectorizer to convert the values into one hot encoded f
eatures
vectorizer = CountVectorizer(vocabulary=list(sorted_school_states_dict.
keys()), lowercase=False, binary=True)
vectorizer.fit(X_train['school_state'].values)



school_state_categories_one_hot_train = vectorizer.fit_transform(X_trai
n['school_state'].values)
school_state_categories_one_hot_test = vectorizer.transform(X_test['sch
ool_state'].values)
```

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```
school_state_categories_one_hot_cv = vectorizer.transform(X_cv['school_
state'].values)


print("Shape of matrix of Train data after one hot encoding",school_sta
te_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",school_sta
te_categories_one_hot_test.shape)
print("Shape of matrix of Cross Validation data after one hot encoding"
,school_state_categories_one_hot_cv.shape)
```

```
Shape of matrix of Train data after one hot encoding (11222, 51)
Shape of matrix of Test data after one hot encoding  (8250, 51)
Shape of matrix of Cross Validation data after one hot encoding (5528,
51)
```

1.7.1.d) One hot encode - Teacher_prefix

In [33]:
```
my_counter = Counter()
for teacher_prefix in project_data['teacher_prefix'].values:
    teacher_prefix = str(teacher_prefix)
    my_counter.update(teacher_prefix.split())
```

In [34]:
```
teacher_prefix_cat_dict = dict(my_counter)
sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.it
ems(), key=lambda kv: kv[1]))
```

In [35]:
```
## we use count vectorizer to convert the values into one hot encoded f
eatures
#https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit
-learn-valueerror-np-nanis-an-invalid-document/39308809#39308809
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_
dict.keys()), lowercase=False, binary=True)
vectorizer.fit(X_train['teacher_prefix'].values.astype("U"))

teacher_prefix_categories_one_hot_train = vectorizer.fit_transform(X_tr
ain['teacher_prefix'].values.astype("U"))
```

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```
teacher_prefix_categories_one_hot_test = vectorizer.transform(X_test['t
eacher_prefix'].values.astype("U"))
teacher_prefix_categories_one_hot_cv = vectorizer.transform(X_cv['teach
er_prefix'].values.astype("U"))
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encoding ",teacher_prefix_categori
es_one_hot_train.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_categori
es_one_hot_test.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_categori
es_one_hot_cv.shape)
```

```
['Teacher', 'Mr', 'Ms', 'Mrs']
Shape of matrix after one hot encoding  (11222, 4)
Shape of matrix after one hot encoding  (8250, 4)
Shape of matrix after one hot encoding  (5528, 4)
```

1.7.1.e) One hot encode - project_grade_category

In [36]:
```
my_counter = Counter()
for project_grade in project_data['project_grade_category'].values:
    my_counter.update(project_grade.split())
```

In [37]:
```
project_grade_cat_dict = dict(my_counter)
sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.item
s(), key=lambda kv: kv[1]))
```

In [38]:
```
## we use count vectorizer to convert the values into one hot encoded f
eatures
vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_cat_d
ict.keys()), lowercase=False, binary=True)
vectorizer.fit(X_train['project_grade_category'].values)
project_grade_categories_one_hot_train = vectorizer.fit_transform(X_tra
in['project_grade_category'].values)
project_grade_categories_one_hot_test = vectorizer.transform(X_test['pr
oject_grade_category'].values)
project_grade_categories_one_hot_cv = vectorizer.transform(X_cv['projec
```

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```
t_grade_category'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix of Train data after one hot encoding",project_gr
ade_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",project_gr
ade_categories_one_hot_test.shape)
print("Shape of matrix of Cross Validation data after one hot encoding"
,project_grade_categories_one_hot_cv.shape)
```

```
['Grades_9_12', 'Grades_6_8', 'Grades_3_5', 'Grades_PreK_2']
Shape of matrix of Train data after one hot encoding (11222, 4)
Shape of matrix of Test data after one hot encoding  (8250, 4)
Shape of matrix of Cross Validation data after one hot encoding (5528,
4)
```

1.7.2 Vectorizing Text data

1.7.2.1-a Bag of words project essays

In [39]:

```
# We are considering only the words which appeared in at least 10 docum
ents(rows or projects).
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extr
action.text.CountVectorizer.html
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10, max_features=5000)
vectorizer.fit(X_train['essay'].values) # fit has to happen only on tra
in data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.fit_transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer.transform(X_test['essay'].values)

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
```

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```
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(11222, 5000) (11222,)
(5528, 5000) (5528,)
(8250, 5000) (8250,)
==========================================================================
============================
```

1.7.2.1-b Bag of words of project title

In [40]:
```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10, max_features=5000)
vectorizer.fit(X_train['clean_titles'].values) # fit has to happen only
 on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizer.fit_transform(X_train['clean_titles'].v
alues)
X_cv_titles_bow = vectorizer.transform(X_cv['clean_titles'].values)
X_test_titles_bow = vectorizer.transform(X_test['clean_titles'].values)

print("After vectorizations")
print(X_train_titles_bow.shape, y_train.shape)
print(X_cv_titles_bow.shape, y_cv.shape)
print(X_test_titles_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(11222, 732) (11222,)
(5528, 732) (5528,)
(8250, 732) (8250,)
==========================================================================
============================
```

1.7.2.2 -a TFIDF vectorizer project_essays

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In [41]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfTransformer.html#sklearn.feature_extraction.text.TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
X_train_essay_tfidf = vectorizer.fit_transform((X_train['essay'].values))
X_cv_essay_tfidf = vectorizer.transform((X_cv['essay'].values))
X_test_essay_tfidf = vectorizer.transform((X_test['essay'].values))
print("After vectorizations")
print("Shape of matrix after one hot encodig ",X_train_essay_tfidf.shape)
print("Shape of matrix after one hot encodig ",X_cv_essay_tfidf.shape)
print("Shape of matrix after one hot encodig ",X_test_essay_tfidf.shape)
```

```
After vectorizations
Shape of matrix after one hot encodig  (11222, 6763)
Shape of matrix after one hot encodig  (5528, 6763)
Shape of matrix after one hot encodig  (8250, 6763)
```

1.7.2.2 -b TFIDF vectorizer project_titles

In [42]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
X_train_titles_tfidf = vectorizer.fit_transform((X_train['clean_titles'].values))
X_cv_titles_tfidf = vectorizer.transform((X_cv['clean_titles'].values))
X_test_titles_tfidf = vectorizer.transform((X_test['clean_titles'].values))
print("Shape of matrix after one hot encodig ",X_train_titles_tfidf.shape)
print("Shape of matrix after one hot encodig ",X_cv_titles_tfidf.shape)
print("Shape of matrix after one hot encodig ",X_test_titles_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (11222, 732)
```

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```
Shape of matrix after one hot encodig  (5528, 732)
Shape of matrix after one hot encodig  (8250, 732)
```

1.7.2.3-a Using Pretrained Models: Avg W2V

In [43]:
```
'''
# 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)
```

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```
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 o
ur 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-pickle-to-save-and-load-variables-in-python/

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


'''
```

Out[43]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230
349/4084039\ndef loadGloveModel(gloveFile):\n    print ("Loading Glove
Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}
\n    for line in tqdm(f):\n        splitLine = line.split()\n        w
ord = splitLine[0]\n        embedding = np.array([float(val) for val in
splitLine[1:]])\n        model[word] = embedding\n    print ("Done.",le
n(model)," words loaded!")\n    return model\nmodel = loadGloveModel
(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n
  \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495
words loaded!\n\n# ============================\n\nwords = []\nfor i in
preproced_texts:\n    words.extend(i.split(\' \'))\n\nfor i in preproce
d_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in th
e coupus", len(words))\nwords = set(words)\nprint("the unique words in
the coupus", len(words))\n\ninter_words = set(model.keys()).intersectio
```

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```
n(words)\nprint("The number of words that are present in both glove vec
tors and our coupus",       len(inter_words),"(",np.round(len(inter_wor
ds)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(mo
del.keys())\nfor i in words:\n    if i in words_glove:\n        words_c
ourpus[i] = model[i]\nprint("word 2 vec length", len(words_courpus))\n
\n\n# stronging variables into pickle files python: http://www.jessicay
ung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimpo
rt pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump
(words_courpus, f)\n\n\n'
```

In [44]:
```
# stronging variables into pickle files python: http://www.jessicayung.
com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open(r'C:\Users\SAI\Downloads\Assignment_donorchoose 2018\glove_ve
ctors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

Avg W2V Train Essay

In [45]:
```
avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is s
tored in this list
for sentence in tqdm((X_train['essay'].values)): # for each review/sent
ence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

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

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```
100%|██████████████████████████████████| 11222/11222 [00:14<00:00, 79
0.97it/s]

11222
300
```

Avg W2V CV Essay

In [46]:
```
avg_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm((X_cv['essay'].values)): # for each review/sentenc
e
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)

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

```
100%|██████████████████████████████████| 5528/5528 [00:06<00:00, 79
5.63it/s]

5528
300
```

Avg W2V Test Essay

In [47]:
```
avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is st
ored in this list
for sentence in tqdm((X_test['essay'].values)): # for each review/sente
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

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

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

```
100%|██████████████████████████████████| 8250/8250 [00:07<00:00, 109
0.76it/s]
```

```
8250
300
```

Avg W2V - project_title for Train,CV and Test

In [48]:

```
# Similarly we can vectorize for title also
avg_w2v_vectors_train_titles = []; # the avg-w2v for each sentence/revi
ew is stored in this list
for sentence in tqdm((X_train['clean_titles'].values)): # for each revi
ew/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/re
view
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train_titles.append(vector)
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
print(len(avg_w2v_vectors_train_titles))
print(len(avg_w2v_vectors_train_titles[0]))
```

```
100%|██████████████████████████████████| 11222/11222 [00:00<00:00, 1851
6.36it/s]
```

```
11222
300
```

In [49]:

```
avg_w2v_vectors_cv_titles = []; # the avg-w2v for each sentence/review
 is stored in this list
for sentence in tqdm((X_cv['clean_titles'].values)): # 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/re
view
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv_titles.append(vector)

print(len(avg_w2v_vectors_cv_titles))
print(len(avg_w2v_vectors_cv_titles[0]))
```

```
100%|██████████████████████████████████| 5528/5528 [00:00<00:00, 2282
9.04it/s]
```

```
5528
300
```

In [50]:

```
avg_w2v_vectors_test_titles = []; # the avg-w2v for each sentence/revie
w is stored in this list
for sentence in tqdm((X_test['clean_titles'].values)): # for each revie
w/sentence
    vector = np.zeros(300) # as word vectors are of zero length
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test_titles.append(vector)

print(len(avg_w2v_vectors_test_titles))
print(len(avg_w2v_vectors_test_titles[0]))
```

```
100%|██████████████████████████████| 8250/8250 [00:00<00:00, 1824
6.91it/s]
```

```
8250
300
```

1.7.2.3-b Using Pretrained Models: TFIDF weighted W2V

In [51]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit((X_train['essay'].values))
# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model
.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [52]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train_essay = []; # the avg-w2v for each sentence/rev
iew is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/senten
ce
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentenc
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
e/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and t
he tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentenc
e.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_train_essay.append(vector)

print(len(tfidf_w2v_vectors_train_essay))
print(len(tfidf_w2v_vectors_train_essay[0]))
```

```
100%|██████████████████████████████| 11222/11222 [01:34<00:00, 11
9.02it/s]
```

```
11222
300
```

In [53]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_test_essay = []; # the avg-w2v for each sentence/revi
ew is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentenc
e
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentenc
e/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and t
he tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentenc
e.split())) # getting the tfidf value for each word
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test_essay.append(vector)

print(len(tfidf_w2v_vectors_test_essay))
print(len(tfidf_w2v_vectors_test_essay[0]))
```

```
100%|██████████| 8250/8250 [01:07<00:00, 122.07it/s]
```

```
8250
300
```

In [54]:

```
# compute average word2vec for each review.
tfidf_w2v_vectors_cv_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[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_cv_essay.append(vector)

print(len(tfidf_w2v_vectors_cv_essay))
print(len(tfidf_w2v_vectors_cv_essay[0]))
```

```
100%|██████████| 5528/5528 [00:45<00:00, 122.47it/s]
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
5528
300
```

TFIDF weighted W2V - project_title for Train, Test and CV

In [55]:
```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_titles'].values)
# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model
.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [56]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train_titles = []; # the avg-w2v for each sentence/re
view is stored in this list
for sentence in tqdm(X_train['clean_titles'].values): # for each revie
w/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 sentenc
e/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and t
he tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentenc
e.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_train_titles.append(vector)
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
print(len(tfidf_w2v_vectors_train_titles))
print(len(tfidf_w2v_vectors_train_titles[0]))
```

```
100%|██████████████████████████████| 11222/11222 [00:00<00:00, 1262
1.21it/s]
```

```
11222
300
```

In [57]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_cv_titles = []; # the avg-w2v for each sentence/revie
w is stored in this list
for sentence in tqdm(X_cv['clean_titles'].values): # for each review/se
ntence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentenc
e/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and t
he tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentenc
e.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_cv_titles.append(vector)

print(len(tfidf_w2v_vectors_cv_titles))
print(len(tfidf_w2v_vectors_cv_titles[0]))
```

```
100%|██████████████████████████████| 5528/5528 [00:00<00:00, 1178
2.87it/s]
```

```
5528
300
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

In [58]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_test_titles = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[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_test_titles.append(vector)

print(len(tfidf_w2v_vectors_test_titles))
print(len(tfidf_w2v_vectors_test_titles[0]))
```

```
100%|██████████████████████████████████| 8250/8250 [00:00<00:00, 11760.70it/s]
```

```
8250
300
```

1.7.3 Vectorizing Numerical features

1.7.3 - a-Price

In [59]:
```
import pandas as pd
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
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 [60]:
```
price_data.head(2)
```

Out[60]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [61]:
```
# join two dataframes in python:
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [62]:
```
from sklearn.preprocessing import StandardScaler
standard_vec = StandardScaler(with_mean = False)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
standard_vec.fit(X_train['price'].values.reshape(-1,1))

X_train_price_std = standard_vec.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_std = standard_vec.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_std = standard_vec.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_std.shape, y_train.shape)
print(X_cv_price_std.shape, y_cv.shape)
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
print(X_test_price_std.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(11222, 1) (11222,)
(5528, 1) (5528,)
(8250, 1) (8250,)
============================================================================
============================
```

In [63]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/gene
rated/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 21
3.03 329.   ... 399.   287.73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['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(p
rice_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].value
s.reshape(-1, 1))
```

```
Mean : 298.7497976, Standard deviation : 374.8142029086185
```

In [64]:
```
price_standardized
```

Out[64]:
```
array([[ 0.48634817],
       [ 0.00330885],
       [-0.66110034],
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

```
       ...,
       [ 0.20599594],
       [-0.31242092],
       [-0.08051935]])
```

1.7.3-b Vectorizing numerical features: teacher_number_of_previously_posted projects

In [65]:
```
from sklearn.preprocessing import StandardScaler
standard_vec = StandardScaler(with_mean = False)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
standard_vec.fit(X_train['teacher_number_of_previously_posted_projects'
].values.reshape(-1,1))

X_train_projects_std = standard_vec.transform(X_train['teacher_number_o
f_previously_posted_projects'].values.reshape(-1,1))
X_cv_projects_std = standard_vec.transform(X_cv['teacher_number_of_prev
iously_posted_projects'].values.reshape(-1,1))
X_test_projects_std = standard_vec.transform(X_test['teacher_number_of_
previously_posted_projects'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_projects_std.shape, y_train.shape)
print(X_cv_projects_std.shape, y_cv.shape)
print(X_test_projects_std.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(11222, 1) (11222,)
(5528, 1) (5528,)
(8250, 1) (8250,)
====================================================================
============================
```

Create PDF in your applications with the Pdfcrowd HTML to PDF API PDFCROWD

1.7.3-c On Quantity

In [66]:
```
from sklearn.preprocessing import StandardScaler
standard_vec = StandardScaler(with_mean = False)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
standard_vec.fit(X_train['quantity'].values.reshape(-1,1))

X_train_qty_std = standard_vec.transform(X_train['quantity'].values.res
hape(-1,1))
X_cv_qty_std = standard_vec.transform(X_cv['quantity'].values.reshape(-
1,1))
X_test_qty_std = standard_vec.transform(X_test['quantity'].values.resha
pe(-1,1))

print("After vectorizations")
print(X_train_projects_std.shape, y_train.shape)
print(X_cv_projects_std.shape, y_cv.shape)
print(X_test_projects_std.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(11222, 1) (11222,)
(5528, 1) (5528,)
(8250, 1) (8250,)
====================================================================
============================
```

In [67]:
```
#function to get heatmap confusion matrix
def get_confusion_matrix(clf,X_te,y_test):
    y_pred = clf.predict(X_te)
    df_cm = pd.DataFrame(confusion_matrix(y_test, y_pred), range(2),ran
ge(2))
    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})
```

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

In [68]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_categories_one_hot_train,teacher_prefix_categories_one_hot_train,project_grade_categories_one_hot_train,X_train_essay_bow,X_train_titles_bow,X_train_price_std,X_train_projects_std,X_train_qty_std)).tocsr()
X_cv = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_categories_one_hot_cv,teacher_prefix_categories_one_hot_cv,project_grade_categories_one_hot_cv,X_cv_essay_bow,X_cv_titles_bow,X_cv_price_std,X_cv_projects_std,X_cv_qty_std)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_categories_one_hot_test,teacher_prefix_categories_one_hot_test,project_grade_categories_one_hot_test,X_test_essay_bow,X_test_titles_bow,X_test_price_std,X_test_projects_std,X_test_qty_std)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(11222, 5833) (11222,)
(5528, 5833) (5528,)
(8250, 5833) (8250,)
====================================================================================================
```

Apply KNN

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

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- 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 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 with predicted and original labels of test data points

4. **[Task-2]**

- Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features
-

```
                    from sklearn.datasets import load_digits
                    from sklearn.feature_selection import Sele
ctKBest, chi2
```

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```
                    X, y = load_digits(return_X_y=True)
                    X.shape
                    X_new = SelectKBest(chi2, k=20).fit_transf
orm(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

note

k- Nearest Neighbors(kNN) algorithm is one of the simplest,non-parametric,lazy classification learning algorithm. Its purpose is to use a database in which the data points are separated into several classes to predict the classification of a new sample point.

This algorithm is one of the more simple techniques used in machine learning. It is a method preferred by many in the industry because of its ease of use and low calculation time.

https://towardsdatascience.com/understanding-auc-roc-curve-68b2303cc9c5

Note-

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When we need to check or visualize the performance of the multi - class classification problem, we use AUC (Area Under The Curve) ROC (Receiver Operating Characteristics) curve. It is one of the most important evaluation metrics for checking any classification model's performance. It is also written as AUROC (Area Under the Receiver Operating Characteristics)

2.1 [Set 1] - Categorical, numerical features + project_title (BoW)+preprocessed_essays(BoW)

2.1 a) Find the best hyper parameter which results in the maximum AUC value

In [69]:
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probab
ility 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 cr_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
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [70]:
```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive clas
```

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```
s, confidence values, or no
n-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 wit
h greater label.
"""
train_auc = []
cv_auc = []
a = []
b = []

K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71,85,91,101]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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))
    a.append(y_train_pred)
    b.append(y_cv_pred)

plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 14/14 [10:15<00:00, 4
4.25s/it]
```

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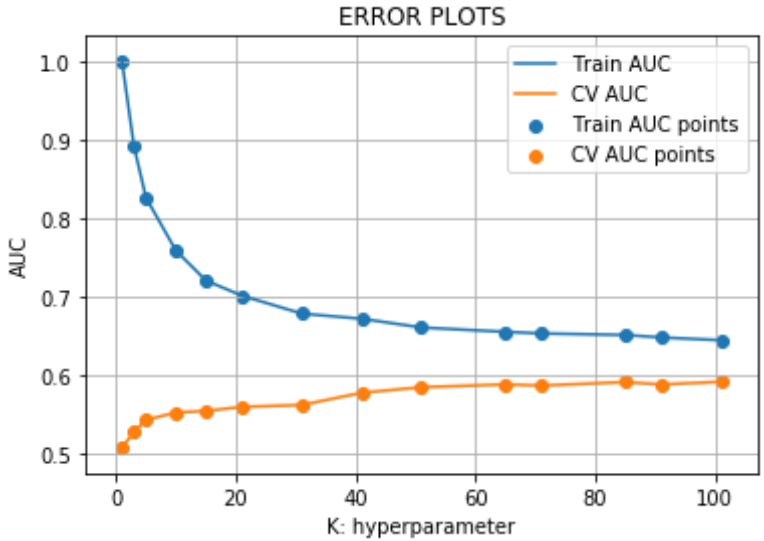

2.1-b) Simple CV

In [71]:
```
%%time
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]

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

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)
```

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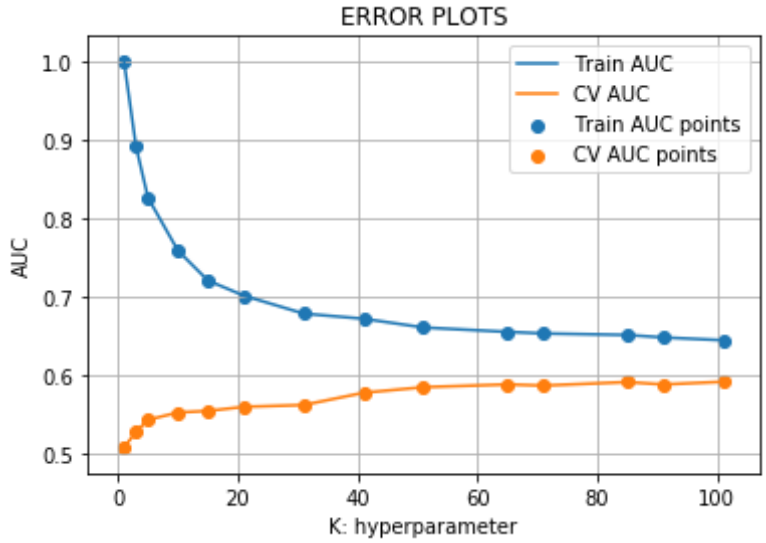
```
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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()
```




```
Wall time: 10min 7s
```

In [72]:
```
best_k_1 = 51
```

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2.1- c) Train the model for the best hyper parameter value

In [73]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_
curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
neigh = KNeighborsClassifier(n_neighbors=best_k_1)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_te)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_
tpr)))

plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

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2.1-d Confusion Matrix

In [74]:
```
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 th
reshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

For Train data

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In [75]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24805741881815135 for threshold 0.824
[[ 932  781]
 [3077 6432]]
```

In [76]:
```
conf_matr_df_train = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,train_fpr, train_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24805741881815135 for threshold 0.824
```

In [77]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[77]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b8b0bfac8>
```

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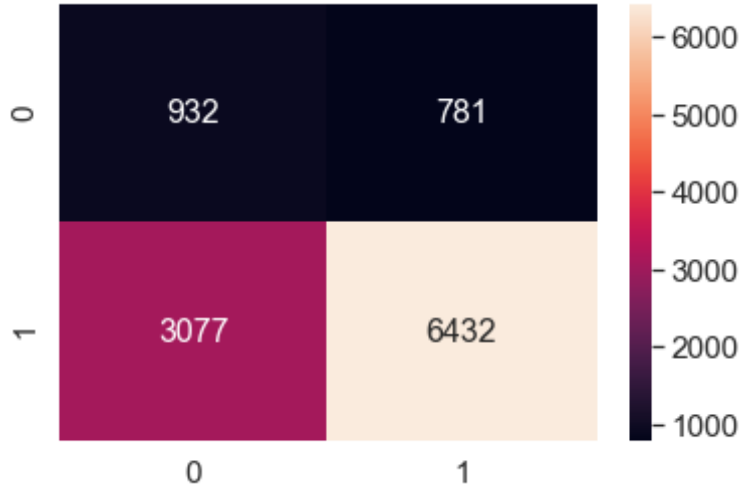

for test data

In [78]:
```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test
_fpr, test_fpr)))
```

```
====================================================================
============================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24886046832937875 for threshold 0.84
3
[[ 752  507]
 [3229 3762]]
```

In [79]:
```
conf_matr_df_test = pd.DataFrame(confusion_matrix(y_test, predict(y_tes
t_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24886046832937875 for threshold 0.84
3
```

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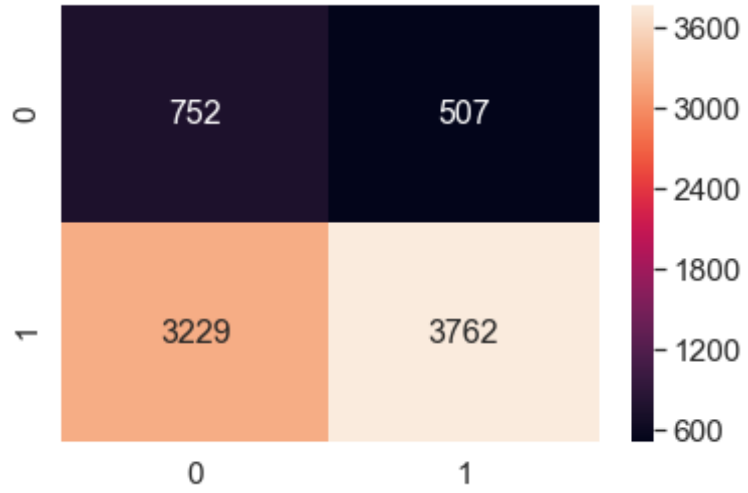
In [80]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt=
'g')
```

Out[80]: <matplotlib.axes._subplots.AxesSubplot at 0x8b84111780>



2.2 [Set 2] - Categorical, numerical features + project_title (TFIDF) +preprocessed_essays(TFIDF)

In [81]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/40840
39
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,sc
hool_state_categories_one_hot_train,teacher_prefix_categories_one_hot_t
rain,project_grade_categories_one_hot_train,X_train_essay_tfidf,X_train
_titles_tfidf,X_train_price_std,X_train_projects_std,X_train_qty_std)).
tocsr()
X_cv = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_s
tate_categories_one_hot_cv,teacher_prefix_categories_one_hot_cv,project
_grade_categories_one_hot_cv,X_cv_essay_tfidf,X_cv_titles_tfidf,X_cv_pr
ice_std,X_cv_projects_std,X_cv_qty_std)).tocsr()
```

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```
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,scho
ol_state_categories_one_hot_test,teacher_prefix_categories_one_hot_test
,project_grade_categories_one_hot_test,X_test_essay_tfidf,X_test_titles
_tfidf,X_test_price_std,X_test_projects_std,X_test_qty_std)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(11222, 7596) (11222,)
(5528, 7596) (5528,)
(8250, 7596) (8250,)
====================================================================
============================
```

2.2 a) Find the best hyper parameter which results in the maximum AUC value

In [82]:

```
%%time
train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]

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

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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))
```

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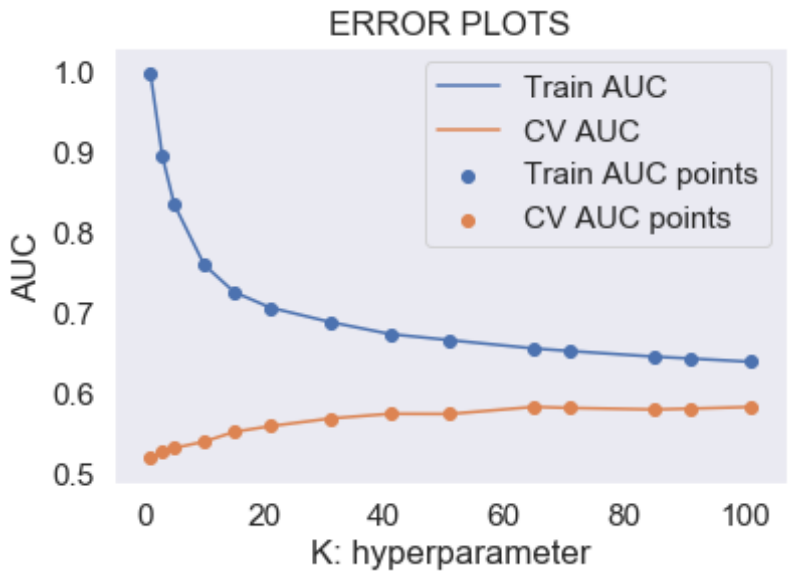
```
    a.append(y_train_pred)
    b.append(y_cv_pred)

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

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

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

```
100%|██████████████████████████████████████████| 14/14 [09:37<00:00, 4
1.49s/it]
```




```
Wall time: 9min 37s
```

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2.2-b)Simple CV

In [83]:
```
%%time
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score
train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]

for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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()
```

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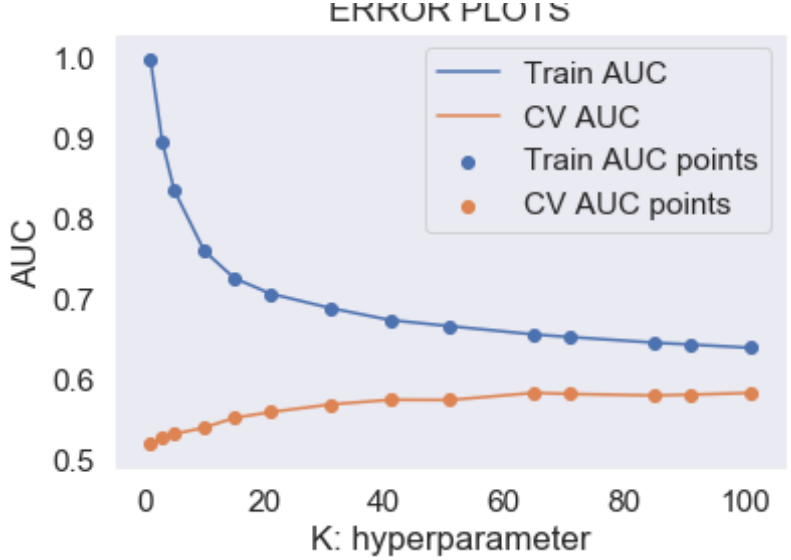


```
Wall time: 9min 28s
```

In [84]:
```
n_neighbors=65
```

2.2-c) Train the model for the best maximum AUC value

In [85]:
```
%%time
# 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=65)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs

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

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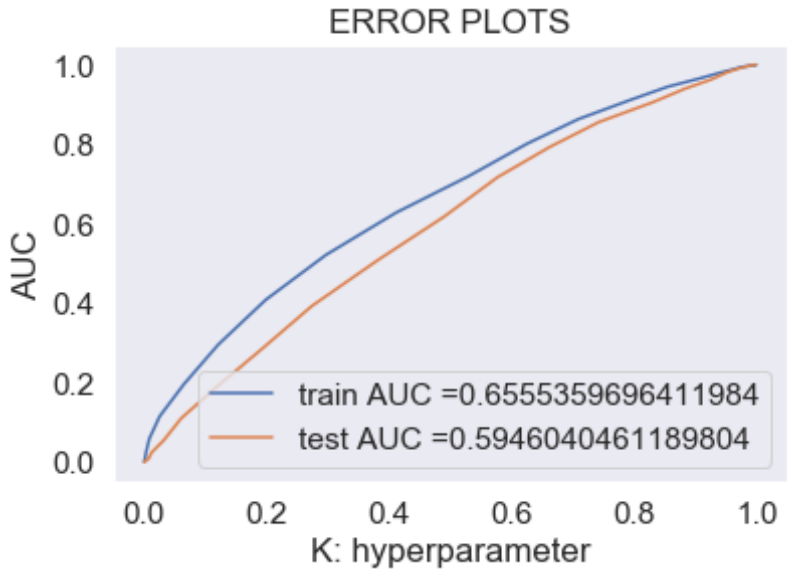
```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

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




```
Wall time: 47.5 s
```

2.2-d) Confusion Matrix

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For Train Data

In [86]:
```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, tr
ain_fpr, train_fpr)))
```

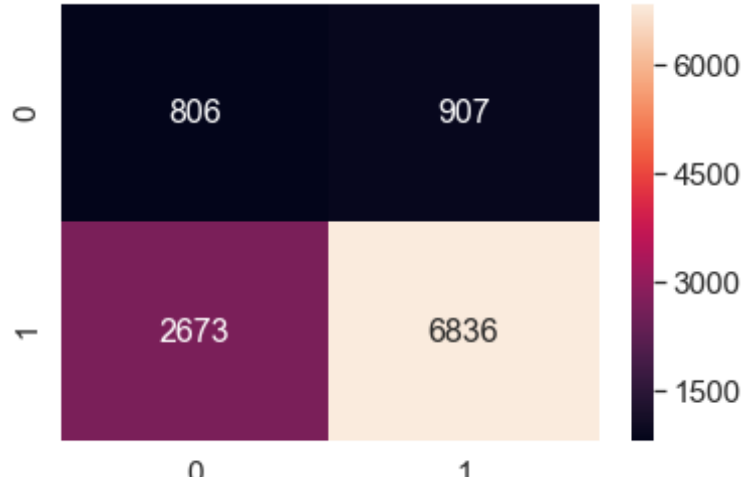
```
====================================================================
============================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2491309034412509 for threshold 0.831
[[ 806  907]
 [2673 6836]]
```

In [87]:
```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y
_train_pred, tr_thresholds,train_fpr, train_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.2491309034412509 for threshold 0.831
```

In [88]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fm
t='g')
```

Out[88]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b840b6668>
```



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For Test Data

In [89]:
```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test
_fpr, test_fpr)))
```

```
====================================================================
==============================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.249901424595967 for threshold 0.846
[[ 642  617]
 [2674 4317]]
```

In [90]:
```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_t
est_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.249901424595967 for threshold 0.846
```

In [91]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt
='g')
```

Out[91]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b840f5f98>
```

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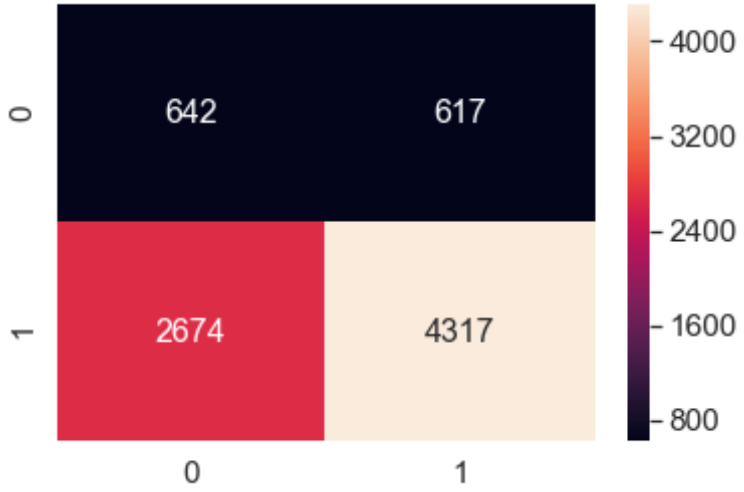

2.3) [Set 3] : categorical, numerical features + project_title(AVG W2V) +preprocessed_essay (AVG W2V)

In [92]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_categories_one_hot_train,teacher_prefix_categories_one_hot_train,project_grade_categories_one_hot_train,avg_w2v_vectors_train,avg_w2v_vectors_train_titles,X_train_price_std,X_train_projects_std,X_train_qty_std)).tocsr()
X_cv = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_categories_one_hot_cv,teacher_prefix_categories_one_hot_cv,project_grade_categories_one_hot_cv,avg_w2v_vectors_cv,avg_w2v_vectors_cv_titles,X_cv_price_std,X_cv_projects_std,X_cv_qty_std)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_categories_one_hot_test,teacher_prefix_categories_one_hot_test,project_grade_categories_one_hot_test,avg_w2v_vectors_test,avg_w2v_vectors_test_titles,X_test_price_std,X_test_projects_std,X_test_qty_std)).
```

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```
tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(11222, 701) (11222,)
(5528, 701) (5528,)
(8250, 701) (8250,)
====================================================================
==============================
```

2.3-a) Find the best hyper parameter which results in the maximum AUC value

In [93]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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()
```

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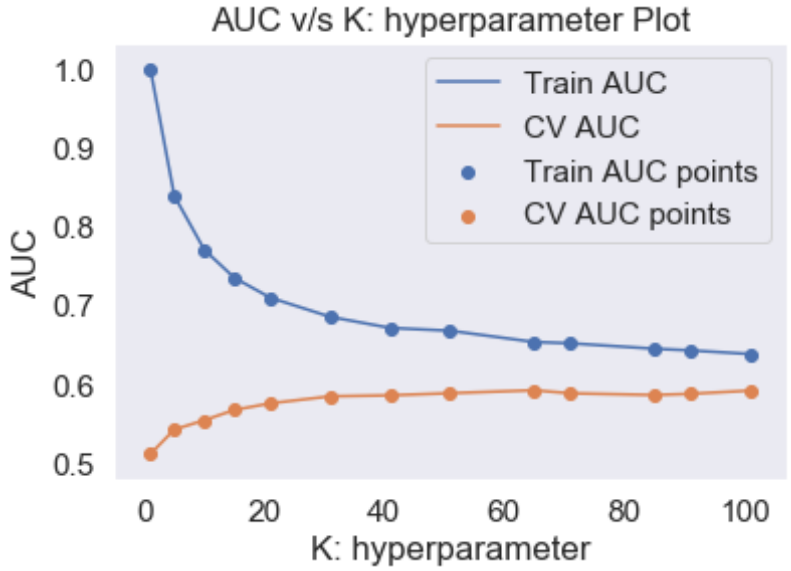
```
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC v/s K: hyperparameter Plot")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████| 13/13 [1:30:37<00:00, 44
9.52s/it]
```



2.3-b) Simple-cv

In [94]:
```
%%time
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]
```

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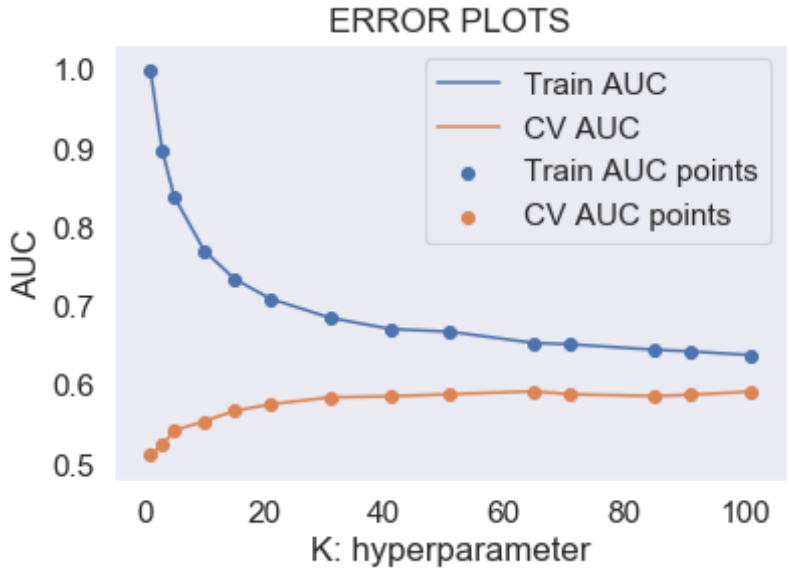
```
for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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()
```



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```
Wall time: 1h 33min 40s
```

In [95]:
```
best_k_3 = 65
```

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

In [96]:
```
%%time
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_
curve.html#sklearn.metrics.roc_curve
neigh = KNeighborsClassifier(n_neighbors=best_k_3)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_te)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

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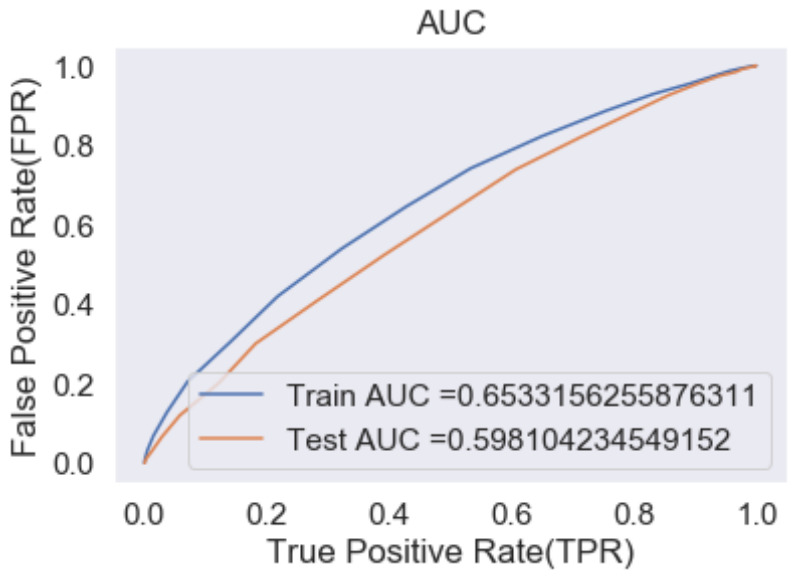


```
Wall time: 7min 49s
```

2.3-D)Confusion Matrix

For Train Data

In [97]:
```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, tr
ain_fpr, train_fpr)))
```

```
====================================================================
============================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24891211705140015 for threshold 0.83
1
```

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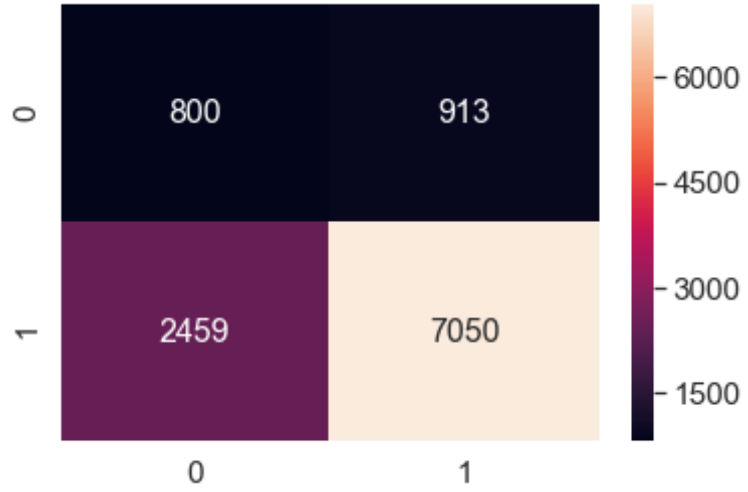
```
[[ 800  913]
 [2459 7050]]
```

In [98]:
```
conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y
_train_pred, tr_thresholds,train_fpr, train_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24891211705140015 for threshold 0.83
1
```

In [99]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_2, annot=True,annot_kws={"size": 16}, fm
t='g')
```

Out[99]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b9988a828>
```



For Test Data

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

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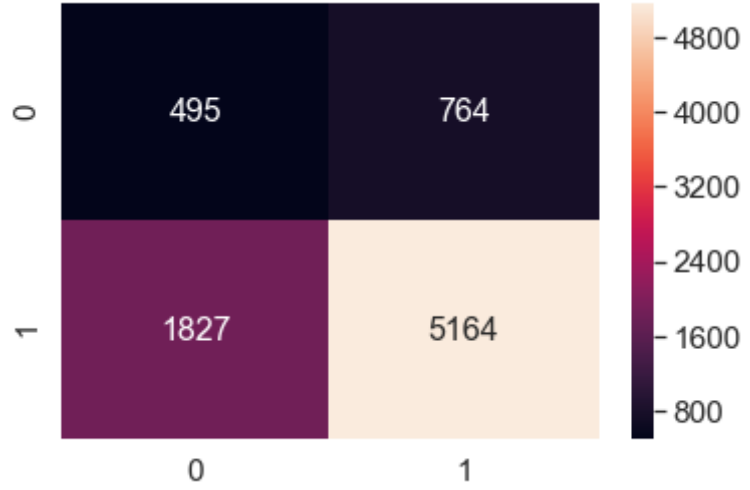
```
==========================================================================
============================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24995441873317514 for threshold 0.83
1
[[ 495  764]
 [1827 5164]]
```

In [101]:
```
conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_t
est_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24995441873317514 for threshold 0.83
1
```

In [102]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_2, annot=True,annot_kws={"size": 16}, fmt
='g')
```

Out[102]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b84123c50>
```



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

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+preprocessed_essay (TFIDF W2V)

In [103]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_categories_one_hot_train,teacher_prefix_categories_one_hot_train,project_grade_categories_one_hot_train,tfidf_w2v_vectors_train_essay,tfidf_w2v_vectors_train_titles,X_train_price_std,X_train_projects_std,X_train_qty_std)).tocsr()
X_cv = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_categories_one_hot_cv,teacher_prefix_categories_one_hot_cv,project_grade_categories_one_hot_cv,tfidf_w2v_vectors_cv_essay,tfidf_w2v_vectors_cv_titles,X_cv_price_std,X_cv_projects_std,X_cv_qty_std)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_categories_one_hot_test,teacher_prefix_categories_one_hot_test,project_grade_categories_one_hot_test,tfidf_w2v_vectors_test_essay,tfidf_w2v_vectors_test_titles,X_test_price_std,X_test_projects_std,X_test_qty_std)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(11222, 701) (11222,)
(5528, 701) (5528,)
(8250, 701) (8250,)
====================================================================================================
```

2.4-a) Find the best hyper paramter which results in the maximum AUC value

In [104]:
```
%%time
```

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```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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("AUC v/s K: hyperparameter Plot")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 13/13 [1:29:48<00:00, 41
0.56s/it]
```

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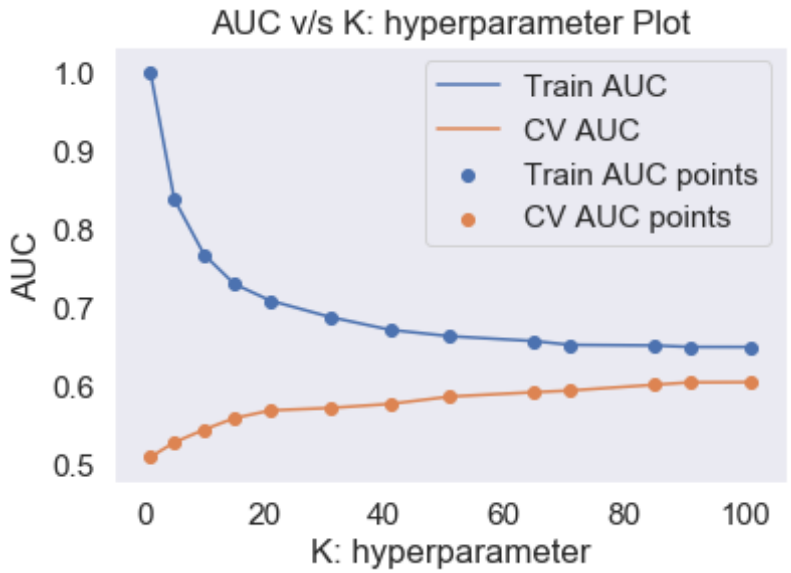


```
Wall time: 1h 29min 48s
```

2.4-b) Simple cv

In [105]:

```
%%time
%%time
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91, 101]

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

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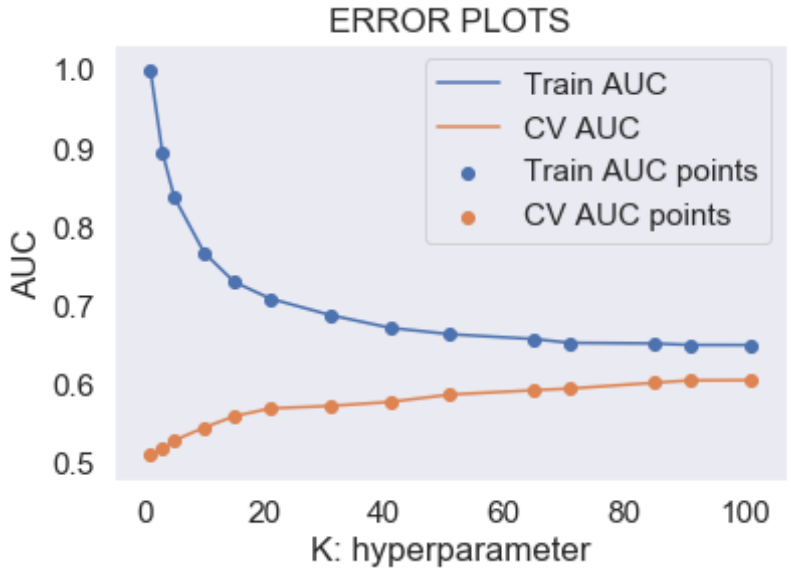
```
    y_cv_pred = batch_predict(neigh, X_cv)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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()
```




```
Wall time: 1h 32min 2s
Wall time: 1h 32min 2s
```

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In [106]:
```
best_k_4 = 71
```

2.4-c) Train model using the best hyper-parameter value

In [107]:
```
%%time
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_
curve.html#sklearn.metrics.roc_curve
neigh = KNeighborsClassifier(n_neighbors=best_k_4)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs
y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_te)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

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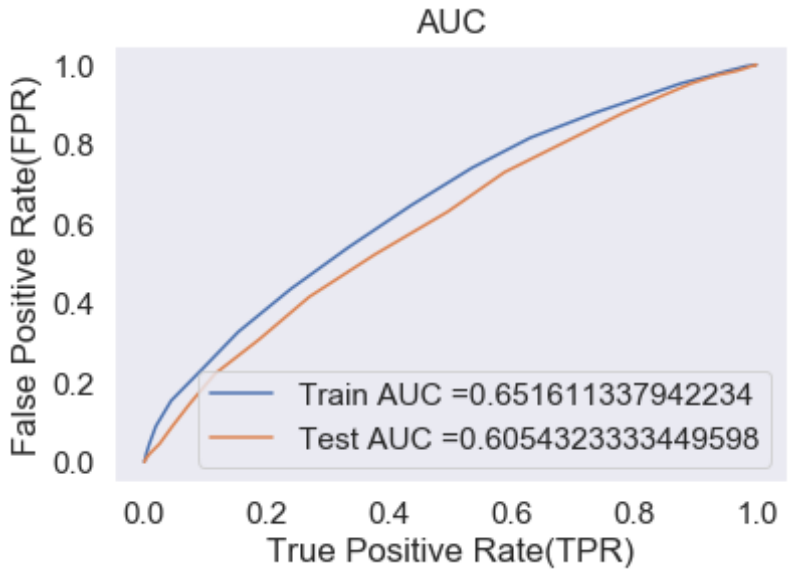


```
Wall time: 7min 13s
```

2.4-d) Confusion Matrix

For Train Data

In [108]:
```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, tr
ain_fpr, train_fpr)))
```

```
====================================================================
============================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2487526279073968 for threshold 0.831
[[ 796  917]
 [2470 7039]]
```

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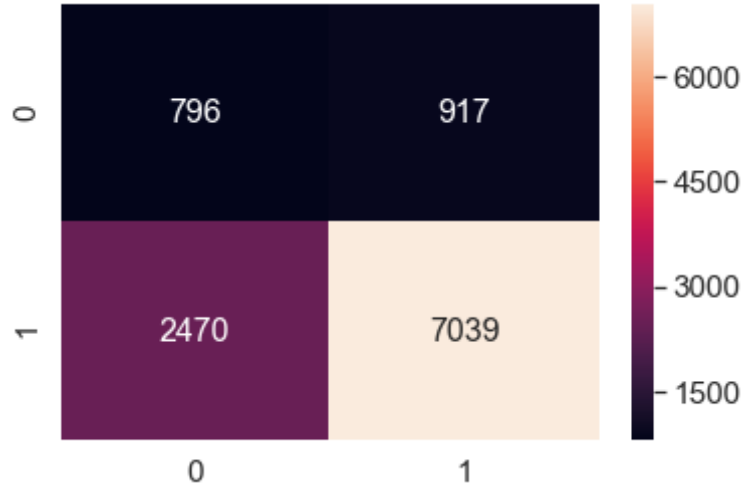
In [109]:
```
conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train, predict(y
_train_pred, tr_thresholds,train_fpr, train_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.2487526279073968 for threshold 0.831
```

In [110]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_3, annot=True,annot_kws={"size": 16}, fm
t='g')
```

Out[110]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b840f1be0>
```



For Test Data

In [111]:
```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test
_fpr, test_fpr)))
```

```
====================================================================
============================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499899158017795 for threshold 0.84
```

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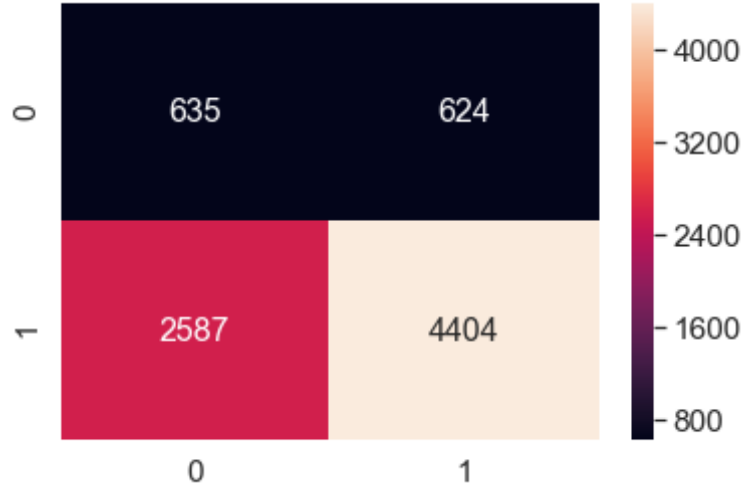
```
the maximum value of tpr*(1-fpr) 0.24998091580177925 for threshold 0.84
5
[[ 635  624]
 [2587 4404]]
```

In [112]:
```
conf_matr_df_test_3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24998091580177925 for threshold 0.84
5
```

In [113]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[113]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b840eb9e8>
```



2.5 Feature selection with `SelectKBest`

In [151]:
```
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,sc
```

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```
hool_state_categories_one_hot_train,teacher_prefix_categories_one_hot_t
rain,project_grade_categories_one_hot_train,X_train_essay_tfidf,X_train
_titles_tfidf,X_train_price_std,X_train_projects_std,X_train_qty_std)).
tocsr()
X_cv = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_s
tate_categories_one_hot_cv,teacher_prefix_categories_one_hot_cv,project
_grade_categories_one_hot_cv,X_cv_essay_tfidf,X_cv_titles_tfidf,X_cv_pr
ice_std,X_cv_projects_std,X_cv_qty_std)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,scho
ol_state_categories_one_hot_test,teacher_prefix_categories_one_hot_test
,project_grade_categories_one_hot_test,X_test_essay_tfidf,X_test_titles
_tfidf,X_test_price_std,X_test_projects_std,X_test_qty_std)).tocsr()
```

In [166]:
```
from sklearn.feature_selection import SelectKBest, chi2
X_tr_new = SelectKBest(chi2, k=2000).fit_transform(X_tr, y_train)
X_te_new = SelectKBest(chi2, k=2000).fit_transform(X_te, y_test)
X_cv_new = SelectKBest(chi2, k=2000).fit_transform(X_cv, y_cv)
```

In [167]:
```
print("Final Data matrix")
print(X_tr_new.shape, y_train.shape)
print(X_cv_new.shape, y_cv.shape)
print(X_te_new.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(11222, 2000) (11222,)
(5528, 2000) (5528,)
(8250, 2000) (8250,)
====================================================================================================
```

2.5-a) Find the best hyper parameter which results in the maximum AUC value

In [168]:
```
train_auc = []
cv_auc = []
```

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

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

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

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probab
ility 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("AUC v/s K: hyperparameter Plot")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████| 12/12 [03:14<00:00, 1
6.26s/it]
```

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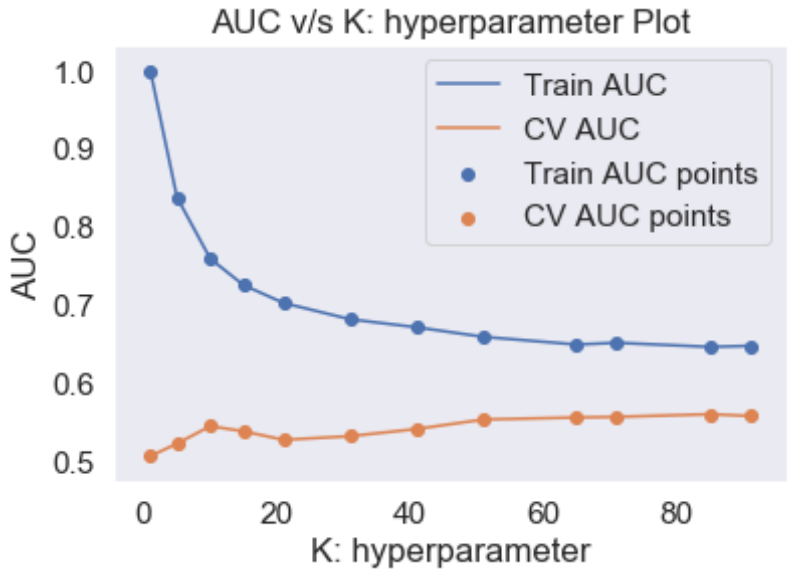

2.5-b) Simple-cv

In [169]:
```
train_auc = []
cv_auc = []
K = [1, 3, 5, 10, 15, 21, 31, 41, 51, 61, 71, 81, 91, 101]

for i in K:
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)
    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y 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))
```

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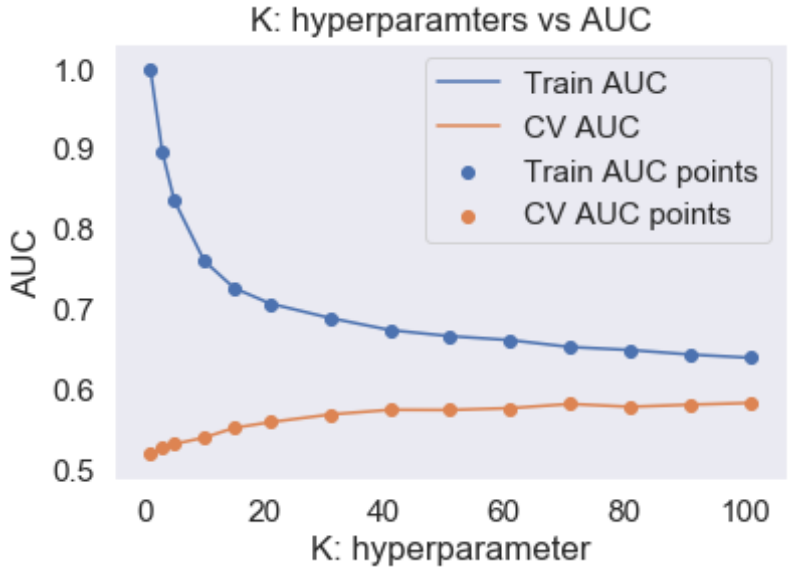
```
plt.plot(K, train_auc, label='Train AUC')
plt.plot(K, cv_auc, label='CV AUC')
plt.scatter(K, train_auc, label='Train AUC points')
plt.scatter(K, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("K: hyperparamters vs AUC")
plt.grid()
plt.show()
```



In [170]:
```
best_k_5 = 85
```

2.5-c) Train model using the best hyper-parameter value

In [171]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

neigh = KNeighborsClassifier(n_neighbors=best_k_5)
```

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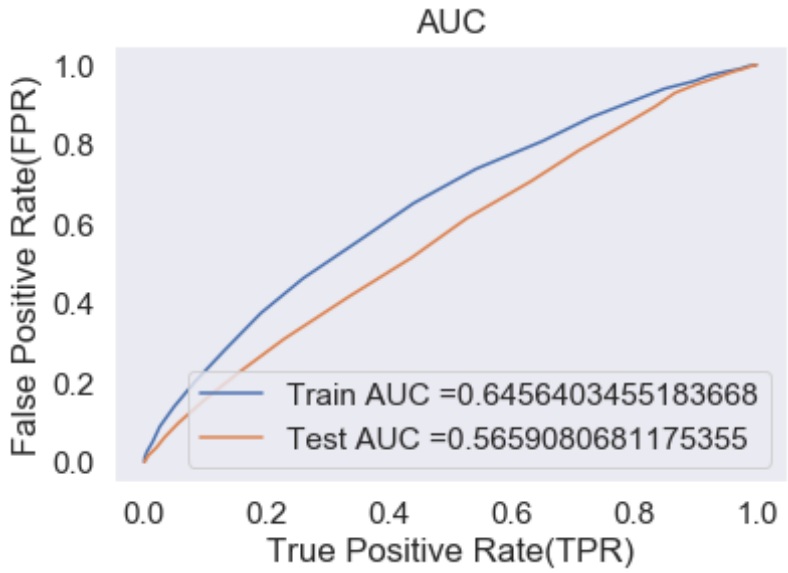
```
neigh.fit(X_tr_new, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probabilit
y estimates of the positive class
# not the predicted outputs

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

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

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



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2.5-d) Confusion Matrix

For Train Data

In [172]:
```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, tr
ain_fpr, train_fpr)))
```

```
====================================================================
============================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24825780261446329 for threshold 0.82
4
[[ 785  928]
 [2497 7012]]
```

In [173]:
```
conf_matr_df_train_4 = pd.DataFrame(confusion_matrix(y_train, predict(y
_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24825780261446329 for threshold 0.82
4
```

In [177]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_4, annot=True,annot_kws={"size": 16}, fm
t='g')
```

Out[177]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x8b8b0e1cf8>
```

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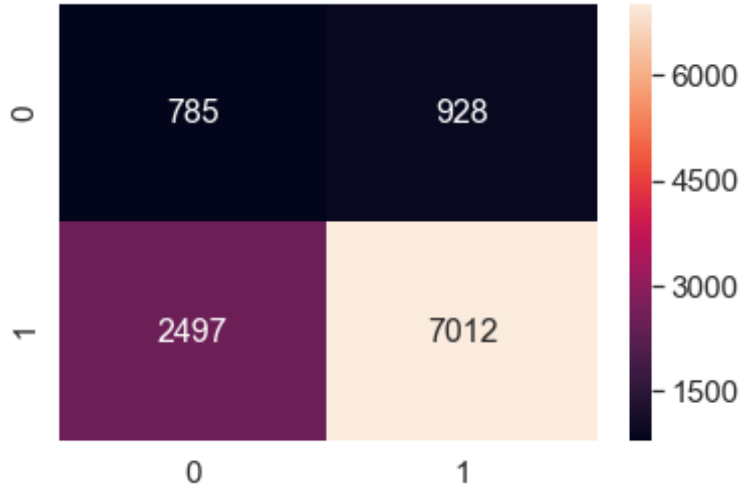

For Test Data

In [178]:
```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test
_fpr, test_fpr)))
```

```
====================================================================
============================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24924909200223838 for threshold 0.84
7
[[ 595  664]
 [2699 4292]]
```

In [179]:
```
conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_t
est_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

```
the maximum value of tpr*(1-fpr) 0.24924909200223838 for threshold 0.84
7
```

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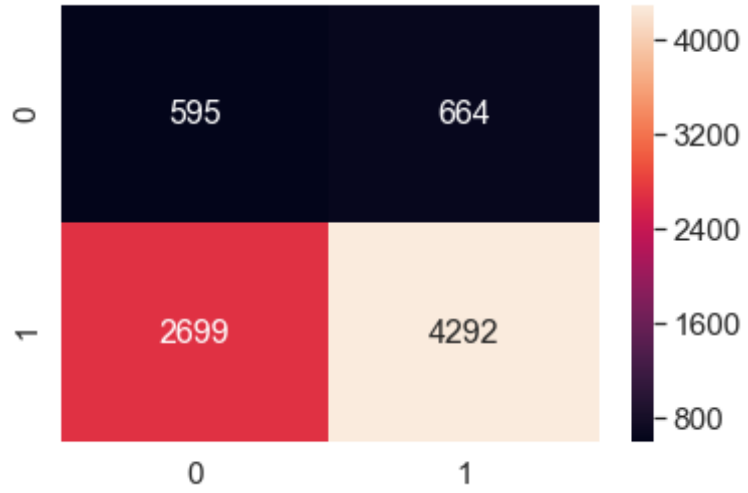
In [180]:
```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4, annot=True,annot_kws={"size": 16}, fmt
='g')
```

Out[180]: <matplotlib.axes._subplots.AxesSubplot at 0x8b8ae3a9b0>



Conclusions

In [182]:
```
# Compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pi
p3 install prettytable

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

x.add_row(["BOW", "Brute", 51, 0.58])
x.add_row(["TFIDF", "Brute", 65, 0.59])
```

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```
x.add_row(["AVG W2V", "Brute", 65, 0.59])
x.add_row(["TFIDF W2V", "Brute", 71, 0.60])
x.add_row(["TFIDF", "Top 2000", 85, 0.56])

print(x)
```

```
+------------+----------+-----------------+------+
| Vectorizer |  Model   | Hyper Parameter | AUC  |
+------------+----------+-----------------+------+
|    BOW     |  Brute   |        51       | 0.58 |
|   TFIDF    |  Brute   |        65       | 0.59 |
|  AVG W2V   |  Brute   |        65       | 0.59 |
| TFIDF W2V  |  Brute   |        71       | 0.6  |
|   TFIDF    | Top 2000 |        85       | 0.56 |
+------------+----------+-----------------+------+
```

In [ ]:

In [ ]:

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