DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	
`project_id`	A unique identifier for the proposed project.
`project_title`	Title of th • `Art Will` •
`project_grade_category`	Grade level of students for which the project is targeted. • • • •

Feature	
project_subject_categories	One or more (comma-separated) subject categories fo following enum • • • • • Lit • • • • • • `Literacy & Language`
school_state	State where school is located [(Two-le (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviati](https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviati)
project_subject_subcategories	One or more (comma-separated) subject subcateg • • `Literature & Writing,`
project_resource_summary	An explanation of the resources needed for th • `My students need hands on literacy mate sens`
project_essay_1	Fi
project_essay_2	Seco
project_essay_3	Thi
project_essay_4	Fou
project_submitted_datetime	Datetime when project application was submitted. **Exa**
teacher_id	A unique identifier for the teacher of the propos `bdf8baa8fedef6bf`
teacher_prefix	Teacher's title. One of the following • • • • • •
teacher_number_of_previously_posted_projects	Number of project applications previously submitted

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

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

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

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

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

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the 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."
- **project_essay_2:** "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [0]:

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

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'scho
ol_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [0]:

```python
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[4]:

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

1.2 preprocessing of `project_subject_categories`

In [3]:

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

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

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

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

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

1.3 preprocessing of project_subject_subcategories

In [4]:

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

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

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

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

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

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

1.3 Text preprocessing

In [5]:

```
# 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 [0]:

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

Out[8]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sul
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	20

In [0]:

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

In [0]:

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

```
My students are English learners that are working on English as their second or
third languages. We are a melting pot of refugees, immigrants, and native-born
Americans bringing the gift of language to our school. \r\n\r\n We have over 24
languages represented in our English Learner program with students at every lev
el of mastery.  We also have over 40 countries represented with the families wi
thin our school.  Each student brings a wealth of knowledge and experiences to
us that open our eyes to new cultures, beliefs, and respect.\"The limits of you
r language are the limits of your world.\"-Ludwig Wittgenstein  Our English lea
rner's have a strong support system at home that begs for more resources.  Many
times our parents are learning to read and speak English along side of their ch
ildren.  Sometimes this creates barriers for parents to be able to help their c
hild learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy p
roviding these dvd's and players, students are able to continue their mastery o
f the English language even if no one at home is able to assist.  All families
with students within the Level 1 proficiency status, will be a offered to be a
part of this program.  These educational videos will be specially chosen by the
English Learner Teacher and will be sent home regularly to watch.  The videos a
re to help the child develop early reading skills.\r\n\r\nParents that do not h
ave access to a dvd player will have the opportunity to check out a dvd player
to use for the year.  The plan is to use these videos and educational dvd's for
the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all
love learning, at least most of the time. At our school, 97.3% of the students
receive free or reduced price lunch. Of the 560 students, 97.3% are minority st
udents. \r\nThe school has a vibrant community that loves to get together and c
elebrate. Around Halloween there is a whole school parade to show off the beaut
iful costumes that students wear. On Cinco de Mayo we put on a big festival wit
h crafts made by the students, dances, and games. At the end of the year the sc
hool hosts a carnival to celebrate the hard work put in during the school year,
with a dunk tank being the most popular activity.My students will use these fiv
e brightly colored Hokki stools in place of regular, stationary, 4-legged chair
s. As I will only have a total of ten in the classroom and not enough for each
student to have an individual one, they will be used in a variety of ways. Duri
ng independent reading time they will be used as special chairs students will e
ach use on occasion. I will utilize them in place of chairs at my small group t
ables during math and reading times. The rest of the day they will be used by t
he students who need the highest amount of movement in their life in order to s
tay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my
students always say more Hokki Stools. They can't get their fill of the 5 stool
s we already have. When the students are sitting in group with me on the Hokki
Stools, they are always moving, but at the same time doing their work. Anytime
the students get to pick where they can sit, the Hokki Stools are the first to
be taken. There are always students who head over to the kidney table to get on
e of the stools who are disappointed as there are not enough of them. \r\n\r\nW
```

```
e ask a lot of students to sit for 7 hours a day. The Hokki stools will be a co
mpromise that allow my students to do desk work and move at the same time. Thes
e stools will help students to meet their 60 minutes a day of movement by allow
ing them to activate their core muscles for balance while they sit. For many of
my students, these chairs will take away the barrier that exists in schools for
a child who can't sit still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with p
lain walls, rows of desks, and a teacher in front of the room? A typical day in
our room is nothing like that. I work hard to create a warm inviting themed roo
m for my students look forward to coming to each day.\r\n\r\nMy class is made u
p of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey a
ttend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept,
which is very unique as there are no walls separating the classrooms. These 9 a
nd 10 year-old students are very eager learners; they are like sponges, absorbi
ng all the information and experiences and keep on wanting more.With these reso
urces such as the comfy red throw pillows and the whimsical nautical hanging de
cor and the blue fish nets, I will be able to help create the mood in our class
room setting to be one of a themed nautical environment. Creating a classroom e
nvironment is very important in the success in each and every child's educatio
n. The nautical photo props will be used with each child as they step foot into
our classroom for the first time on Meet the Teacher evening. I'll take picture
s of each child with them, have them developed, and then hung in our classroom
ready for their first day of 4th grade.  This kind gesture will set the tone be
fore even the first day of school! The nautical thank you cards will be used th
roughout the year by the students as they create thank you cards to their team
groups.\r\n\r\nYour generous donations will help me to help make our classroom
a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of mon
ey out of my own pocket on resources to get our classroom ready. Please conside
r helping with this project to make our new school year a very successful one.
Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and langu
age delays, cognitive delays, gross/fine motor delays, to autism. They are eage
r beavers and always strive to work their hardest working past their limitation
s. \r\n\r\nThe materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price
lunch.  Despite their disabilities and limitations, my students love coming to
school and come eager to learn and explore.Have you ever felt like you had ants
in your pants and you needed to groove and move as you were in a meeting? This
is how my kids feel all the time. The want to be able to move as they learn or
so they say.Wobble chairs are the answer and I love then because they develop t
heir core, which enhances gross motor and in Turn fine motor skills. \r\nThey a
lso want to learn through games, my kids don't want to sit and do worksheets. T
hey want to learn to count by jumping and playing. Physical engagement is the k
ey to our success. The number toss and color and shape mats can make that happe
n. My students will forget they are doing work and just have the fun a 6 year o
ld deserves.nannan
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher dem
onstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school has 80
3 students which is makeup is 97.6% African-American, making up the largest seg
ment of the student body. A typical school in Dallas is made up of 23.2% Africa
n-American students. Most of the students are on free or reduced lunch. We are
n't receiving doctors, lawyers, or engineers children from rich backgrounds or
neighborhoods. As an educator I am inspiring minds of young children and we foc
```

```
us not only on academics but one smart, effective, efficient, and disciplined s
tudents with good character.In our classroom we can utilize the Bluetooth for s
wift transitions during class. I use a speaker which doesn't amplify the sound
enough to receive the message. Due to the volume of my speaker my students ca
n't hear videos or books clearly and it isn't making the lessons as meaningful.
But with the bluetooth speaker my students will be able to hear and I can stop,
pause and replay it at any time.\r\nThe cart will allow me to have more room fo
r storage of things that are needed for the day and has an extra part to it I c
an use.  The table top chart has all of the letter, words and pictures for stud
ents to learn about different letters and it is more accessible.nannan
==================================================
```

In [6]:

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

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

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

In [0]:

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

```
My kindergarten students have varied disabilities ranging from speech and langu
age delays, cognitive delays, gross/fine motor delays, to autism. They are eage
r beavers and always strive to work their hardest working past their limitation
s. \r\n\r\nThe materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price
lunch.  Despite their disabilities and limitations, my students love coming to
school and come eager to learn and explore.Have you ever felt like you had ants
in your pants and you needed to groove and move as you were in a meeting? This
is how my kids feel all the time. The want to be able to move as they learn or
so they say.Wobble chairs are the answer and I love then because they develop t
heir core, which enhances gross motor and in Turn fine motor skills. \r\nThey a
lso want to learn through games, my kids do not want to sit and do worksheets.
They want to learn to count by jumping and playing. Physical engagement is the
key to our success. The number toss and color and shape mats can make that happ
en. My students will forget they are doing work and just have the fun a 6 year
old deserves.nannan
==================================================
```

In [0]:

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

```
My kindergarten students have varied disabilities ranging from speech and langu
age delays, cognitive delays, gross/fine motor delays, to autism. They are eage
r beavers and always strive to work their hardest working past their limitation
s.     The materials we have are the ones I seek out for my students. I teach i
n a Title I school where most of the students receive free or reduced price lun
ch.  Despite their disabilities and limitations, my students love coming to sch
ool and come eager to learn and explore.Have you ever felt like you had ants in
your pants and you needed to groove and move as you were in a meeting? This is
how my kids feel all the time. The want to be able to move as they learn or so
they say.Wobble chairs are the answer and I love then because they develop thei
r core, which enhances gross motor and in Turn fine motor skills.   They also w
ant to learn through games, my kids do not want to sit and do worksheets. They
want to learn to count by jumping and playing. Physical engagement is the key t
o our success. The number toss and color and shape mats can make that happen. M
y students will forget they are doing work and just have the fun a 6 year old d
eserves.nannan
```

In [0]:

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

```
My kindergarten students have varied disabilities ranging from speech and langu
age delays cognitive delays gross fine motor delays to autism They are eager be
avers and always strive to work their hardest working past their limitations Th
e materials we have are the ones I seek out for my students I teach in a Title
I school where most of the students receive free or reduced price lunch Despite
their disabilities and limitations my students love coming to school and come e
ager to learn and explore Have you ever felt like you had ants in your pants an
d you needed to groove and move as you were in a meeting This is how my kids fe
el all the time The want to be able to move as they learn or so they say Wobble
chairs are the answer and I love then because they develop their core which enh
ances gross motor and in Turn fine motor skills They also want to learn through
games my kids do not want to sit and do worksheets They want to learn to count
by jumping and playing Physical engagement is the key to our success The number
toss and color and shape mats can make that happen My students will forget they
are doing work and just have the fun a 6 year old deserves nannan
```

In [7]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "
             "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', '
             'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itsel
             'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that
             'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has
             'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because'
             'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'th
             'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off
             'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all'
             'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than',
             's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've
             've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "di
             "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma',
             "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn'
             'won', "won't", 'wouldn', "wouldn't"]
```

In [8]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
project_data['essay']= preprocessed_essays
```

```
100%|██████████| 109248/109248 [01:21<00:00, 1335.05it/s]
```

In [0]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[17]:
```
'my kindergarten students varied disabilities ranging speech language delays co
gnitive delays gross fine motor delays autism they eager beavers always strive
work hardest working past limitations the materials ones i seek students i teac
h title i school students receive free reduced price lunch despite disabilities
limitations students love coming school come eager learn explore have ever felt
like ants pants needed groove move meeting this kids feel time the want able mo
ve learn say wobble chairs answer i love develop core enhances gross motor turn
fine motor skills they also want learn games kids not want sit worksheets they
want learn count jumping playing physical engagement key success the number tos
s color shape mats make happen my students forget work fun 6 year old deserves
nannan'
```

1.4 Preprocessing of `project_title`

In [9]:

```
# similarly you can preprocess the titles also
# Similarly you can vectorize for title also
from tqdm import tqdm
preprocessed_title = []
print(project_data['project_title'].values[0])
print("......................")
for i in project_data['project_title']:
    i = decontracted(i)
    i = i.replace(':', ' ')
    i = i.replace('/', ' ')
    i = i.replace(',', ' ')
    i = i.replace('(', ' ')
    i = i.replace(')', ' ')
    i = i.replace('!', ' ')
    i = re.sub('[^A-Za-z0-9]+', ' ', i)
    # https://gist.github.com/sebleier/554280
    i = ' '.join(e for e in i.split() if e not in stopwords)
    preprocessed_title.append(i.lower().strip())
project_data['project_title']=preprocessed_title
```

```
Educational Support for English Learners at Home
......................
```

1.5 Preparing data for models

In [0]:

```
project_data.columns
```

Out[19]:

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

we are going to consider

```
- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- project_grade_category : categorical data
- teacher_prefix : categorical data

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

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

1.5.1 Vectorizing Categorical data

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

In [0]:

```
# 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=F
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].va
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'S
pecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (109248, 9)
```

In [0]:

```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowerca
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategori
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Ex
tracurricular', 'Civics_Government', 'ForeignLanguages', 'NutritionEducation',
'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts', 'CharacterEducatio
n', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_Geography',
'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness', 'EnvironmentalS
cience', 'VisualArts', 'Health_Wellness', 'AppliedSciences', 'SpecialNeeds', 'L
iterature_Writing', 'Mathematics', 'Literacy']
Shape of matrix after one hot encodig  (109248, 30)
```

In [0]:

```
# you can do the similar thing with state, teacher_prefix and project_grade_categ
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [0]:

```
# We are considering only the words which appeared in at least 10 documents(rows
vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16623)
```

In [0]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

1.5.2.2 TFIDF vectorizer

In [0]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16623)
```

1.5.2.3 Using Pretrained Models: Avg W2V

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

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

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

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

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

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

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

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


# stronging variables into pickle files python: http://www.jessicayung.com/how-to

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


'''
```

Out[26]:
```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084
```

```
039\ndef (https://stackoverflow.com/a/38230349/4084039\ndef) loadGloveModel(glo
veFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', enco
ding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = lin
e.split()\n        word = splitLine[0]\n        embedding = np.array([float(va
l) for val in splitLine[1:]])\n        model[word] = embedding\n    print ("Don
e.",len(model)," words loaded!")\n    return model\nmodel = loadGloveModel(\'gl
ove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n# =
===========================\n\nwords = []\nfor i in preproced_texts:\n    word
s.extend(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend(i.spli
t(\' \'))\nprint("all the words in the coupus", len(words))\nwords = set(words)
\nprint("the unique words in the coupus", len(words))\n\ninter_words = set(mode
l.keys()).intersection(words)\nprint("The number of words that are present in b
oth glove vectors and our coupus",       len(inter_words),"(",np.round(len(inte
r_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(mode
l.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i]
 = model[i]\nprint("word 2 vec length", len(words_courpus))\n\n\n# stronging va
riables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-
to-save-and-load-variables-in-python/\n\nimport (http://www.jessicayung.com/how
-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport) pickle\nwith op
en(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [0]:

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

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|████████████████████████████████████████████████████████████|
109248/109248 [00:27<00:00, 3953.36it/s]

109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

```
In [0]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
        tfidf_model = TfidfVectorizer()
        tfidf_model.fit(preprocessed_essays)
        # we are converting a dictionary with word as a key, and the idf as a value
        dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
        tfidf_words = set(tfidf_model.get_feature_names())
```

```
In [0]: # average Word2Vec
        # compute average word2vec for each review.
        tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
        for sentence in tqdm(preprocessed_essays): # for each review/sentence
            vector = np.zeros(300) # as word vectors are of zero length
            tf_idf_weight =0; # num of words with a valid vector in the sentence/review
            for word in sentence.split(): # for each word in a review/sentence
                if (word in glove_words) and (word in tfidf_words):
                    vec = model[word] # getting the vector for each word
                    # here we are multiplying idf value(dictionary[word]) and the tf valu
                    tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
                    vector += (vec * tf_idf) # calculating tfidf weighted w2v
                    tf_idf_weight += tf_idf
            if tf_idf_weight != 0:
                vector /= tf_idf_weight
            tfidf_w2v_vectors.append(vector)

        print(len(tfidf_w2v_vectors))
        print(len(tfidf_w2v_vectors[0]))
```

```
100%|████████████████████████████████████████████████████████████|
109248/109248 [03:22<00:00, 539.44it/s]

109248
300
```

```
In [0]: # Similarly you can vectorize for title also
```

1.5.3 Vectorizing Numerical features

```
In [10]: price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).r
         project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [0]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/skle
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.
# 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 a
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scala

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(
```

In [0]:
```
price_standardized
```

Out[34]:
```
array([[0.00098843, 0.00191166, 0.00330448, ..., 0.00153418, 0.00046704,
        0.00070265]])
```

1.5.4 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [0]:
```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 16623)
(109248, 1)
```

In [0]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense 
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardi
X.shape
```

Out[36]:
```
(109248, 16663)
```

In [0]:
```
# please write all the code with proper documentation, and proper titles for each
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

Computing Sentiment Scores

In [0]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the sm
for learning my students learn in many different ways using all of our senses and
of techniques to help all my students succeed students in my class come from a va
for wonderful sharing of experiences and cultures including native americans our
learners which can be seen through collaborative student project based learning i
in my class love to work with hands on materials and have many different opportun
mastered having the social skills to work cooperatively with friends is a crucial
montana is the perfect place to learn about agriculture and nutrition my students
in the early childhood classroom i have had several kids ask me can we try cookin
and create common core cooking lessons where we learn important math and writing
food for snack time my students will have a grounded appreciation for the work th
of where the ingredients came from as well as how it is healthy for their bodies
nutrition and agricultural cooking recipes by having us peel our own apples to ma
and mix up healthy plants from our classroom garden in the spring we will also cr
shared with families students will gain math and literature skills as well as a l
nannan'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
D:\installed\Anaconda3\lib\site-packages\nltk\twitter\__init__.py:20: UserWarni
ng:

The twython library has not been installed. Some functionality from the twitter
package will not be available.


neg: 0.01, neu: 0.745, pos: 0.245, compound: 0.9975,
```

Assignment 8: DT

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
   - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
   - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **Hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**

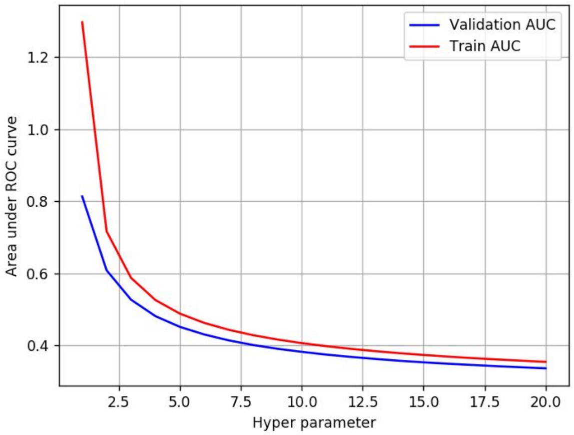
    - Find the best hyper parameter which will give the maximum [AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/)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

3. **Graphviz**

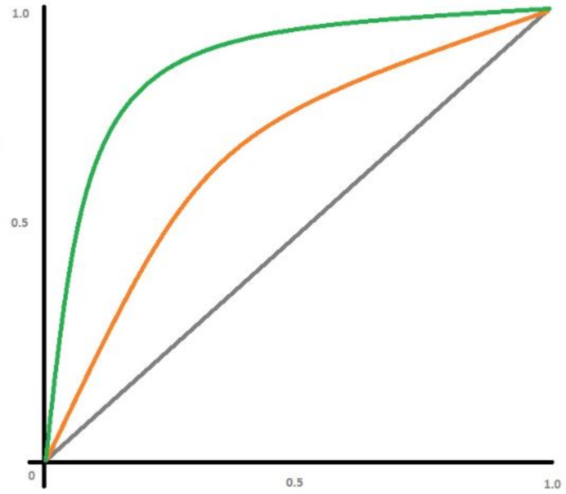
    - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
    - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
    - Make sure to print the words in each node of the decision tree instead of printing its index.
    - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.

4. **Representation of results**

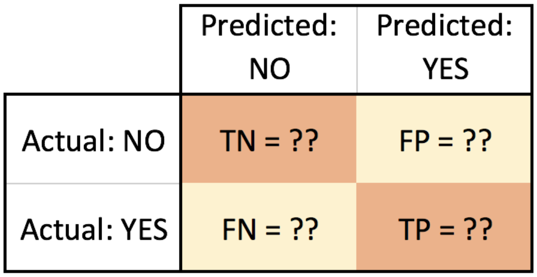
    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.



- Along with plotting ROC curve, you need to print the [confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points



	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

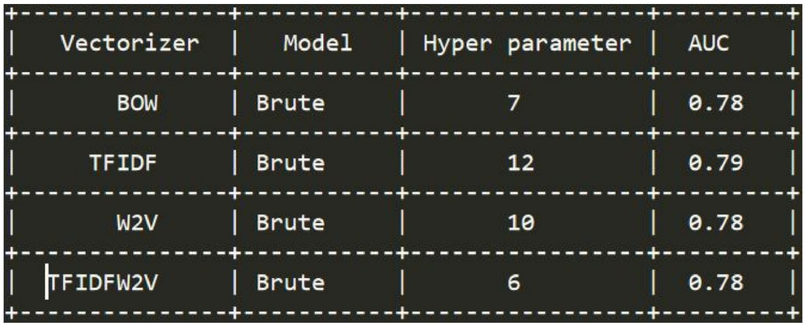
- Once after you plot the confusion matrix with the test data, get all the `false positive data points`
  - Plot the WordCloud [WordCloud (https://www.geeksforgeeks.org/generating-word-cloud-python/)](https://www.geeksforgeeks.org/generating-word-cloud-python/)
  - Plot the box plot with the `price` of these `false positive data points`
  - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

5. **[Task-2]**

- Select 5k best features from features of Set 2 using [`feature_importances_` (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html)](https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

6. **Conclusion**

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



```
+---------------+-----------+-------------------+----------+
|  Vectorizer   |   Model   |  Hyper parameter  |   AUC    |
+---------------+-----------+-------------------+----------+
|      BOW      |  Brute    |         7         |   0.78   |
+---------------+-----------+-------------------+----------+
|     TFIDF     |  Brute    |         12        |   0.79   |
+---------------+-----------+-------------------+----------+
|      W2V      |  Brute    |         10        |   0.78   |
+---------------+-----------+-------------------+----------+
|  TFIDFW2V     |  Brute    |         6         |   0.78   |
+---------------+-----------+-------------------+----------+
```

2. Decision Tree

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

In [68]:

```
# please write all the code with proper documentation, and proper titles for each
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debuggin
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
# prefix=project_data['teacher_prefix']
# x=['Mrs.', 'Mr.', 'Ms.', 'Teacher', 'Dr.']
# for i in prefix:
# x=prefix.str.replace('Mr.','0')
# x
```

In [11]:

```
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
project_data.head(1)
```

Out[11]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_subn
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016

In [12]:

```
x = project_data
x.columns.values
```

Out[12]:

```
array(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'price', 'quantity'], dtype=object)
```

In [13]:

```
x.shape,y.shape
```

Out[13]:

```
((109248, 19), (109248,))
```

In [14]:

```
# split data into train ,test.cv
x=x.values
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=2)
for train_index, test_index in tscv.split(x):
    X_train, X_test = x[train_index], x[test_index]
    y_train, y_test = y[train_index], y[test_index]
tscv = TimeSeriesSplit(n_splits=2)
for train_index, cv_index in tscv.split(X_train):
    X_train, X_cv = x[train_index], x[cv_index]
    y_train, y_cv = y[train_index], y[cv_index]
```

In [15]:

```
X_train.shape,y_train.shape,X_test.shape,y_test.shape,X_cv.shape,y_cv.shape
```

Out[15]:

```
((48555, 19), (48555,), (36416, 19), (36416,), (24277, 19), (24277,))
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [16]:
```
#catogorical features: school_state
# X_train_state = X_train[:,4]
# X_cv_state = X_cv[:,4]
# X_test_state = X_test[:,4]
# X_train_state.shape,X_cv_state.shape,X_test_state.shape
#one hot encoding the catogorical features: school_state
state=np.unique(project_data['school_state'].values)
state
vectorizer = CountVectorizer(vocabulary=list(state), lowercase=False, binary=True
vectorizer.fit(X_train[:,4]) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train[:,4])
X_cv_state_ohe = vectorizer.transform(X_cv[:,4])
X_test_state_ohe = vectorizer.transform(X_test[:,4])
print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(48555, 51) (48555,)
(24277, 51) (24277,)
(36416, 51) (36416,)
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI', 'IA',
'ID', 'IL', 'IN', 'KS', 'KY', 'LA', 'MA', 'MD', 'ME', 'MI', 'MN', 'MO', 'MS',
'MT', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM', 'NV', 'NY', 'OH', 'OK', 'OR', 'PA',
'RI', 'SC', 'SD', 'TN', 'TX', 'UT', 'VA', 'VT', 'WA', 'WI', 'WV', 'WY']
===============================================================================
=====================
```

In [17]:

```
#catogorical features: clean_categories
# X_train_clean_categories = X_train[:,14]
# X_cv_clean_categories = X_cv[:,14]
# X_test_clean_categories = X_test[:,14]
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=F
vectorizer.fit(X_train[:,14])
# # we use the fitted CountVectorizer to convert the text to vector
X_train_clean_categories_ohe = vectorizer.transform(X_train[:,14])
X_cv_clean_categories_ohe = vectorizer.transform(X_cv[:,14])
X_test_clean_categories_ohe = vectorizer.transform(X_test[:,14])
print("After vectorizations")
print(X_train_clean_categories_ohe.shape, y_train.shape)
print(X_cv_clean_categories_ohe.shape, y_cv.shape)
print(X_test_clean_categories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(48555, 9) (48555,)
(24277, 9) (24277,)
(36416, 9) (36416,)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'S
pecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
================================================================================
====================
```

In [18]:

```
#catogorical features: clean_subcategories
# X_train_clean_subcategories = X_train[:,15]
# X_cv_clean_subcategories = X_cv[:,15]
# X_test_clean_subcategories = X_test[:,15]
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=F
vectorizer.fit(X_train[:,15])
# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_subcategories_ohe = vectorizer.transform(X_train[:,15])
X_cv_clean_subcategories_ohe = vectorizer.transform(X_cv[:,15])
X_test_clean_subcategories_ohe = vectorizer.transform(X_test[:,15])
print("After vectorizations")
print(X_train_clean_subcategories_ohe.shape, y_train.shape)
print(X_cv_clean_subcategories_ohe.shape, y_cv.shape)
print(X_test_clean_subcategories_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(48555, 9) (48555,)
(24277, 9) (24277,)
(36416, 9) (36416,)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'S
pecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
================================================================================
====================
```

In [19]:

```
#catogorical features: project_grade_category
# X_train_grade = X_train[:,6]
# X_cv_grade = X_cv[:,6]
# X_test_grade = X_test[:,6]
#one hot encoding the catogorical features:project_grade_category

grade=project_data['project_grade_category'].unique()
vectorizer = CountVectorizer(vocabulary=list(grade), lowercase=False, binary=True
vectorizer.fit(X_train[:,6]) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer.transform(X_train[:,6])
X_cv_grade_ohe = vectorizer.transform(X_cv[:,6])
X_test_grade_ohe = vectorizer.transform(X_test[:,6])

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(48555, 4) (48555,)
(24277, 4) (24277,)
(36416, 4) (36416,)
['Grades PreK-2', 'Grades 6-8', 'Grades 3-5', 'Grades 9-12']
===============================================================================
=====================
```

In [20]:

```
#catogorical features: teacher_prefix
# X_train_teacher = X_train[:,3]
# X_cv_teacher = X_cv[:,3]
# X_test_teacher= X_test[:,3]
#one hot encoding the catogorical features:teacher_prefix
prefix=project_data['teacher_prefix'].unique()
#https://stackoverflow.com/questions/21011777/how-can-i-remove-nan-from-list-pyth
cleanedprefix = [x for x in prefix if str(x) != 'nan']
cleanedprefix
vectorizer = CountVectorizer(vocabulary=list(cleanedprefix), lowercase=False, bin
vectorizer.fit(X_train[:,3].astype('U')) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train[:,3].astype('U'))
X_cv_teacher_ohe = vectorizer.transform(X_cv[:,3].astype('U'))
X_test_teacher_ohe = vectorizer.transform(X_test[:,3].astype('U'))

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(48555, 5) (48555,)
(24277, 5) (24277,)
(36416, 5) (36416,)
['Mrs.', 'Mr.', 'Ms.', 'Teacher', 'Dr.']
================================================================================
====================
```

In [21]:

```
#encoding teacher_number_of_previously_posted_projects : numerical

from sklearn.preprocessing import StandardScaler

price_scalar = StandardScaler()
price_scalar.fit(X_train[:,13].reshape(-1,1)) # finding the mean and standard dev
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scala

# Now standardize the data with above maen and variance.
previously_posted_projects_standardized_train = price_scalar.transform(X_train[:,
previously_posted_projects_standardized_cv = price_scalar.transform(X_cv[:,13].re
previously_posted_projects_standardized_test = price_scalar.transform(X_test[:,13
```

```
C:\Users\Bhumiben.Patel\AppData\Local\Continuum\anaconda3\lib\site-packages\skl
earn\utils\validation.py:595: DataConversionWarning:

Data with input dtype object was converted to float64 by StandardScaler.


Mean : 11.257069302852436, Standard deviation : 28.106157990742027

C:\Users\Bhumiben.Patel\AppData\Local\Continuum\anaconda3\lib\site-packages\skl
earn\utils\validation.py:595: DataConversionWarning:

Data with input dtype object was converted to float64 by StandardScaler.

C:\Users\Bhumiben.Patel\AppData\Local\Continuum\anaconda3\lib\site-packages\skl
earn\utils\validation.py:595: DataConversionWarning:

Data with input dtype object was converted to float64 by StandardScaler.

C:\Users\Bhumiben.Patel\AppData\Local\Continuum\anaconda3\lib\site-packages\skl
earn\utils\validation.py:595: DataConversionWarning:

Data with input dtype object was converted to float64 by StandardScaler.
```

In [22]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train[:,17].reshape(-1,1))

price_train = normalizer.transform(X_train[:,17].reshape(-1,1))
price_cv = normalizer.transform(X_cv[:,17].reshape(-1,1))
price_test= normalizer.transform(X_test[:,17].reshape(-1,1))

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

```
After vectorizations
(48555, 1) (48555,)
(24277, 1) (24277,)
(36416, 1) (36416,)
===============================================================================
=====================
```

In [23]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train[:,18].reshape(-1,1))

quantity_train = normalizer.transform(X_train[:,18].reshape(-1,1))
quantity_cv = normalizer.transform(X_cv[:,18].reshape(-1,1))
quantity_test= normalizer.transform(X_test[:,18].reshape(-1,1))

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

```
After vectorizations
(48555, 1) (48555,)
(24277, 1) (24277,)
(36416, 1) (36416,)
===============================================================================
=====================
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [24]:

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

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

BOW for essay and project title

In [24]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(ngram_range=(1,2))
vectorizer.fit(X_train[:,16]) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train[:,16])
X_cv_essay_bow = vectorizer.transform(X_cv[:,16])
X_test_essay_bow = vectorizer.transform(X_test[:,16])

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
bow_eassy=vectorizer.get_feature_names()
```

```
After vectorizations
(48555, 1570632) (48555,)
(24277, 1570632) (24277,)
(36416, 1570632) (36416,)
================================================================================
====================
```

In [25]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer()
vectorizer.fit(X_train[:,7]) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train[:,7])
X_cv_title_bow = vectorizer.transform(X_cv[:,7])
X_test_title_bow = vectorizer.transform(X_test[:,7])

print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
print("="*100)
bow_title=vectorizer.get_feature_names()
```

```
After vectorizations
(48555, 11897) (48555,)
(24277, 11897) (24277,)
(36416, 11897) (36416,)
===============================================================================
=====================
```

TFIDF for essay and project title

In [24]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer()
vectorizer.fit(X_train[:,16])

X_train_eassy_tfidf = vectorizer.transform(X_train[:,16])
X_cv_eassy_tfidf = vectorizer.transform(X_cv[:,16])
X_test_eassy_tfidf = vectorizer.transform(X_test[:,16])

print("After vectorizations")
print(X_train_eassy_tfidf.shape, y_train.shape)
print(X_cv_eassy_tfidf.shape, y_cv.shape)
print(X_test_eassy_tfidf.shape, y_test.shape)
print("="*100)
tfidf_eassy=vectorizer.get_feature_names()
```

```
After vectorizations
(48555, 40870) (48555,)
(24277, 40870) (24277,)
(36416, 40870) (36416,)
===============================================================================
=====================
```

In [25]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2),max_features=5000)
vectorizer.fit(X_train[:,7])

X_train_title_tfidf = vectorizer.transform(X_train[:,7])
X_cv_title_tfidf = vectorizer.transform(X_cv[:,7])
X_test_title_tfidf = vectorizer.transform(X_test[:,7])

print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_test_title_tfidf.shape, y_test.shape)
print("="*100)
tfidf_title=vectorizer.get_feature_names()
```

```
After vectorizations
(48555, 3732) (48555,)
(24277, 3732) (24277,)
(36416, 3732) (36416,)
===============================================================================
=====================
```

AVG W2V for essay and project title

In [74]:

```
import pickle
with open('glove_vectors', 'rb') as f:

    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [75]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in t
for sentence in tqdm(X_train[:,16]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

print(len(avg_w2v_vectors_train))

# compute average word2vec for each review.
avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in th
for sentence in tqdm(X_test[:,16]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)


avg_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm(X_cv[:,16]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)

print(len(avg_w2v_vectors_cv))
```

```
100%|██████████| 48555/48555 [00:18<00:00, 2571.85it/s]

48555

100%|██████████| 36416/36416 [00:13<00:00, 2627.28it/s]
100%|██████████| 24277/24277 [00:09<00:00, 2661.24it/s]

24277
```

```
In [76]: # Similarly you can vectorize for title also
         # average Word2Vec
         # compute average word2vec for each review.
         avg_w2v_vectors_train_title = []; # the avg-w2v for each sentence/review is store
         for sentence in tqdm(X_train[:,7]): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_train_title.append(vector)

         print(len(avg_w2v_vectors_train_title))

         # compute average word2vec for each review.
         avg_w2v_vectors_test_title = []; # the avg-w2v for each sentence/review is stored
         for sentence in tqdm(X_test[:,7]): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_test_title.append(vector)

         print(len(avg_w2v_vectors_test_title))

         avg_w2v_vectors_cv_title = []; # the avg-w2v for each sentence/review is stored i
         for sentence in tqdm(X_cv[:,7]): # for each review/sentence
             vector = np.zeros(300) # as word vectors are of zero length
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sentence.split(): # for each word in a review/sentence
                 if word in glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_cv_title.append(vector)

         print(len(avg_w2v_vectors_cv_title))
```

```
100%|██████████| 48555/48555 [00:01<00:00, 46120.71it/s]

48555

100%|██████████| 36416/36416 [00:01<00:00, 33894.72it/s]

36416

100%|██████████| 24277/24277 [00:00<00:00, 42287.43it/s]

24277
```

TFIDF W2V for essay and project title

In [77]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train[:,16])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [78]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_eassy_train = []; # the avg-w2v for each sentence/review is sto
for sentence in tqdm(X_train[:,16]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_eassy_train.append(vector)

print(len(tfidf_w2v_vectors_eassy_train))
print(len(tfidf_w2v_vectors_eassy_train[0]))



tfidf_w2v_vectors_eassy_test = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(X_test[:,16]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_eassy_test.append(vector)

print(len(tfidf_w2v_vectors_eassy_test))
print(len(tfidf_w2v_vectors_eassy_test[0]))

tfidf_w2v_vectors_eassy_cv = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(X_cv[:,16]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_eassy_cv.append(vector)

print(len(tfidf_w2v_vectors_eassy_cv))
print(len(tfidf_w2v_vectors_eassy_cv[0]))
```

```
100%|██████████| 48555/48555 [02:30<00:00, 322.22it/s]

48555
300

100%|██████████| 36416/36416 [01:53<00:00, 320.58it/s]

36416
300

100%|██████████| 24277/24277 [01:12<00:00, 333.45it/s]

24277
300
```

In [79]:

```
# Similarly you can vectorize for title also
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train[:,7])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [80]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_title_train = []; # the avg-w2v for each sentence/review is sto
for sentence in tqdm(X_train[:,7]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_train.append(vector)

print(len(tfidf_w2v_vectors_title_train))
print(len(tfidf_w2v_vectors_title_train[0]))


tfidf_w2v_vectors_title_test = []; # the avg-w2v for each sentence/review is stor
for sentence in tqdm(X_test[:,7]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_test.append(vector)

print(len(tfidf_w2v_vectors_title_test))

tfidf_w2v_vectors_title_cv = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(X_cv[:,7]): # 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 valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title_cv.append(vector)

print(len(tfidf_w2v_vectors_title_cv))
```

```
100%|██████████| 48555/48555 [00:02<00:00, 20172.41it/s]
```

```
48555
300

100%|██████████| 36416/36416 [00:01<00:00, 18975.56it/s]

36416

100%|██████████| 24277/24277 [00:01<00:00, 21176.73it/s]

24277
```

In [81]:

```
# Please write all the code with proper documentation
# X_train_state.shape,X_train_clean_categories.shape,X_train_clean_subcategories..
```

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

Apply Decision Tree on different kind of featurization as mentioned in the instructions
For Every model that you work on make sure you do the step 2 and step 3 of instrucations

2.4.1 Applying Decision Trees on BOW, SET 1

In [66]:

```
from scipy.sparse import hstack
from sklearn.metrics import accuracy_score
X_tr_st1 = hstack((X_train_state_ohe,X_train_clean_categories_ohe,X_train_clean_s
               X_train_teacher_ohe,previously_posted_projects_standardized_train,
X_cv_st1 = hstack((X_cv_state_ohe,X_cv_clean_categories_ohe,X_cv_clean_subcategor
               X_cv_teacher_ohe,previously_posted_projects_standardized_cv,price_
X_te_st1 = hstack((X_test_state_ohe,X_test_clean_categories_ohe,X_test_clean_subc
               X_test_teacher_ohe,previously_posted_projects_standardized_test,pr

print("Final Data matrix")
print(X_tr_st1.shape, y_train.shape)
print(X_cv_st1.shape, y_cv.shape)
print(X_te_st1.shape, y_test.shape)
print("="*100)
```

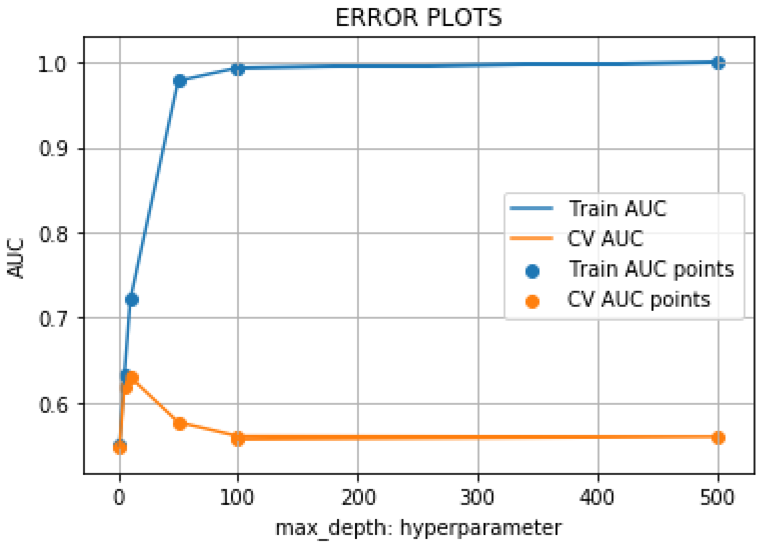
```
Final Data matrix
(48555, 1582610) (48555,)
(24277, 1582610) (24277,)
(36416, 1582610) (36416,)
================================================================================
====================
```

In [161]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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%1
    # 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 [45]:
```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
max_depth = [1, 5, 10, 50, 100, 500, 1000]
for i in tqdm(max_depth):
    clf = DecisionTreeClassifier(max_depth=i,class_weight="balanced")
    clf.fit(X_tr_st1,y_train)
    y_train_pred = batch_predict(clf, X_tr_st1)
    y_cv_pred = batch_predict(clf, X_cv_st1)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(max_depth, train_auc, label='Train AUC')
plt.plot(max_depth, cv_auc, label='CV AUC')

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

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

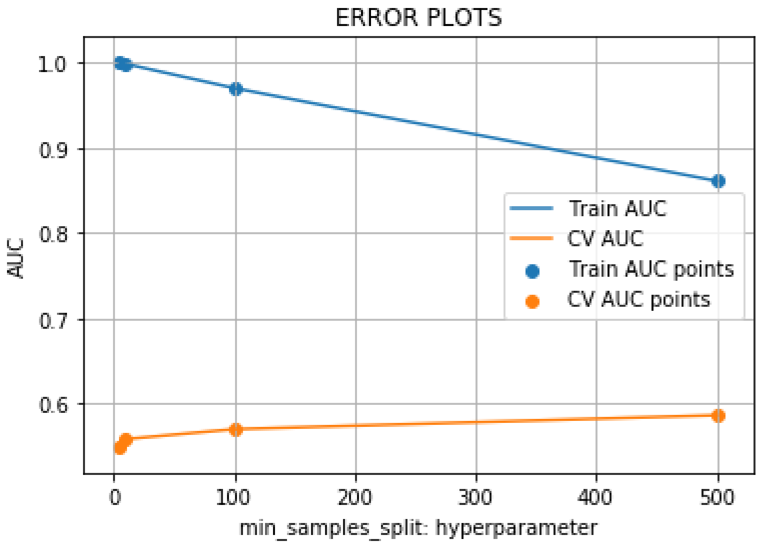
```
  0%|          | 0/7 [00:00<?, ?it/s]

 14%|█▍        | 1/7 [00:48<04:52, 48.69s/it]

 29%|██▊       | 2/7 [02:01<04:39, 55.83s/it]

 43%|████▎     | 3/7 [03:44<04:40, 70.08s/it]

 57%|█████▋    | 4/7 [10:56<08:56, 178.79s/it]

 71%|███████▏  | 5/7 [19:41<09:24, 282.42s/it]

 86%|████████▌ | 6/7 [30:16<06:28, 388.31s/it]

100%|██████████| 7/7 [38:38<00:00, 422.30s/it]
```


ERROR PLOTS
AUC
1.0
0.9
0.8
0.7
0.6
0
100
200
300
400
500
max_depth: hyperparameter
Train AUC
CV AUC
Train AUC points
CV AUC points

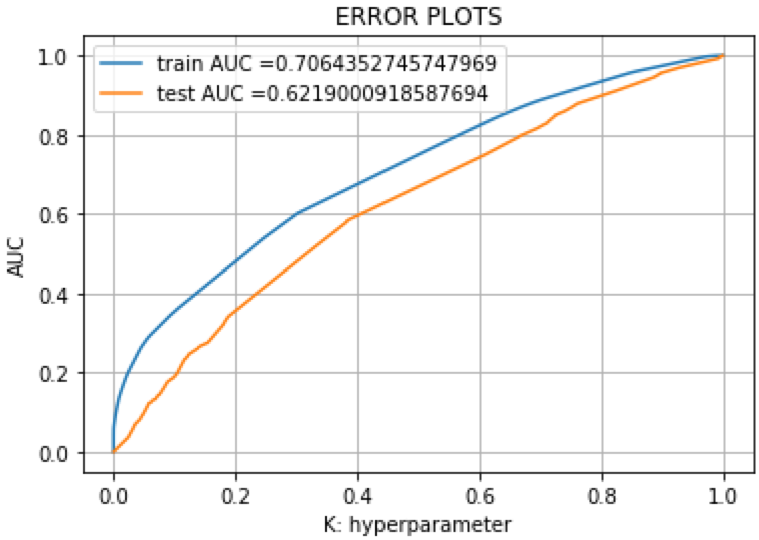
In [46]:

```python
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
min_samples_split = [5, 10, 100, 500]
for i in tqdm(min_samples_split):
    clf = DecisionTreeClassifier(min_samples_split=i,class_weight="balanced")
    clf.fit(X_tr_st1,y_train)
    y_train_pred = batch_predict(clf, X_tr_st1)
    y_cv_pred = batch_predict(clf, X_cv_st1)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(min_samples_split, train_auc, label='Train AUC')
plt.plot(min_samples_split, cv_auc, label='CV AUC')

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

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

```
  0%|          | 0/4 [00:00<?, ?it/s]

 25%|██▌       | 1/4 [10:39<31:58, 639.56s/it]

 50%|█████     | 2/4 [20:27<20:48, 624.13s/it]

 75%|███████▌  | 3/4 [28:13<09:36, 576.54s/it]

100%|██████████| 4/4 [32:48<00:00, 486.10s/it]
```



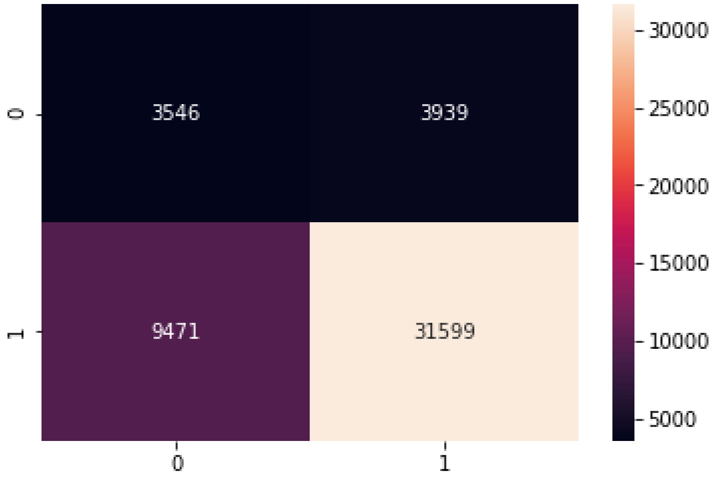
In [49]:
```
from sklearn.metrics import roc_curve, auc


clf = DecisionTreeClassifier(min_samples_split=100,max_depth=10,class_weight="bal
clf.fit(X_tr_st1,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_st1)
y_test_pred = batch_predict(clf, X_te_st1)

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

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



In [50]:
```
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

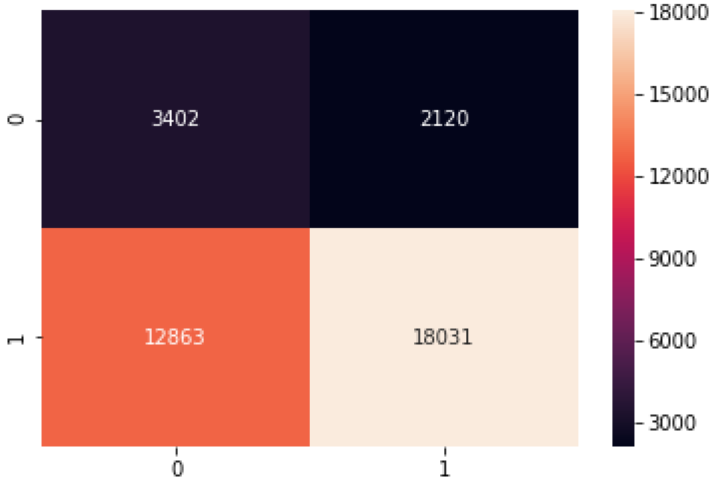
In [51]:
```
import seaborn as sns
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tr=confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
ax = sns.heatmap(tr,annot=True,fmt="d")
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24931080598069888 for threshold 0.428
```



In [52]:
```
print("Test confusion matrix")
te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
ax = sns.heatmap(te,annot=True,fmt="d")
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.23779699285896158 for threshold 0.447
```



2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [48]:
```
# Please write all the code with proper documentation
import graphviz
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
clf = DecisionTreeClassifier(max_depth=3,class_weight="balanced")
clf.fit(X_train_essay_bow,y_train)
dot_data = tree.export_graphviz(clf, out_file=None,feature_names=bow_eassy,class_
graph = graphviz.Source(dot_data)
graph
```

Out[48]:
```
<graphviz.files.Source at 0x4e0b9d30>
```

In [49]:
```
import graphviz
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
clf = DecisionTreeClassifier(max_depth=3,class_weight="balanced")
clf.fit(X_train_title_bow,y_train)
dot_data = tree.export_graphviz(clf, out_file=None,feature_names=bow_title,class_
graph = graphviz.Source(dot_data)
graph
```

Out[49]:
```
<graphviz.files.Source at 0x4c73a828>
```

2.4.2 Applying Decision Trees on TFIDF, SET 2

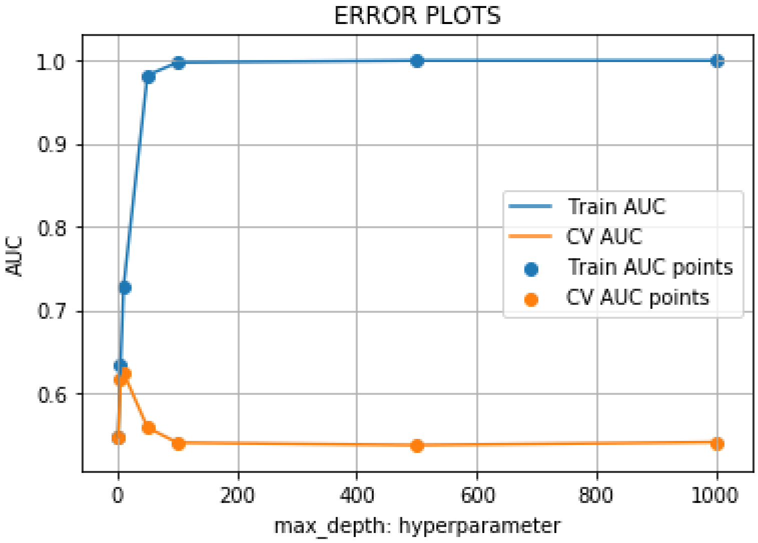
In [26]:

```
from scipy.sparse import hstack
X_tr_st2 = hstack((X_train_state_ohe,X_train_clean_categories_ohe,X_train_clean_s
               X_train_teacher_ohe,previously_posted_projects_standardized_train,

X_te_st2 = hstack((X_test_state_ohe,X_test_clean_categories_ohe,X_test_clean_subc
               X_test_teacher_ohe,previously_posted_projects_standardized_test,pr
X_cv_st2 = hstack((X_cv_state_ohe,X_cv_clean_categories_ohe,X_cv_clean_subcategor
               X_cv_teacher_ohe,previously_posted_projects_standardized_cv,price_

print("Final Data matrix")
print(X_tr_st2.shape, y_train.shape)
print(X_cv_st2.shape, y_cv.shape)
print(X_te_st2.shape, y_test.shape)

print("="*100)
```

```
Final Data matrix
(48555, 44683) (48555,)
(24277, 44683) (24277,)
(36416, 44683) (36416,)
================================================================================
====================
```

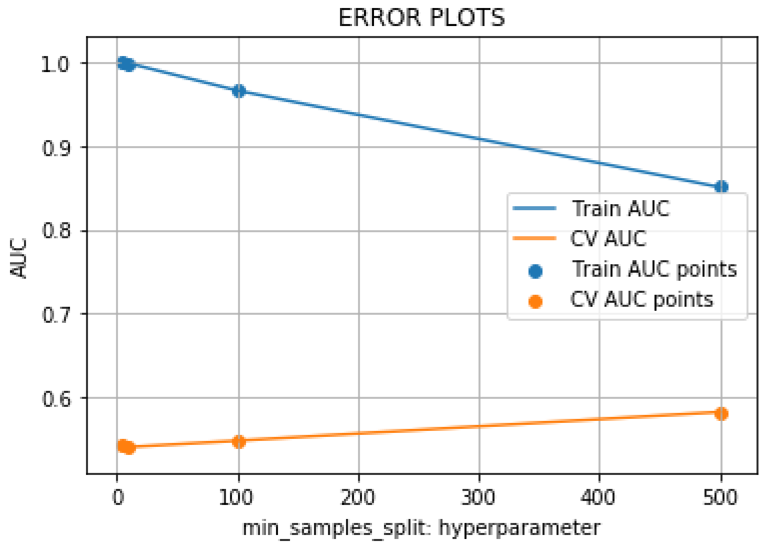
In [57]:
```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
max_depth = [1, 5, 10, 50, 100, 500, 1000]
for i in tqdm(max_depth):
    clf = DecisionTreeClassifier(max_depth=i,class_weight="balanced")
    clf.fit(X_tr_st2,y_train)
    y_train_pred = batch_predict(clf, X_tr_st2)
    y_cv_pred = batch_predict(clf, X_cv_st2)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(max_depth, train_auc, label='Train AUC')
plt.plot(max_depth, cv_auc, label='CV AUC')

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

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

```
  0%|          | 0/7 [00:00<?, ?it/s]

 14%|█▍        | 1/7 [00:01<00:11,  1.90s/it]

 29%|██▊       | 2/7 [00:07<00:14,  2.94s/it]

 43%|████▎     | 3/7 [00:20<00:23,  5.95s/it]

 57%|█████▋    | 4/7 [01:29<01:15, 25.07s/it]

 71%|███████▏  | 5/7 [02:58<01:28, 44.10s/it]

 86%|████████▌ | 6/7 [04:35<01:00, 60.13s/it]

100%|██████████| 7/7 [06:14<00:00, 71.66s/it]
```


ERROR PLOTS
AUC
1.0
0.9
0.8
0.7
0.6
0
200
400
600
800
1000
max_depth: hyperparameter
Train AUC
CV AUC
Train AUC points
CV AUC points

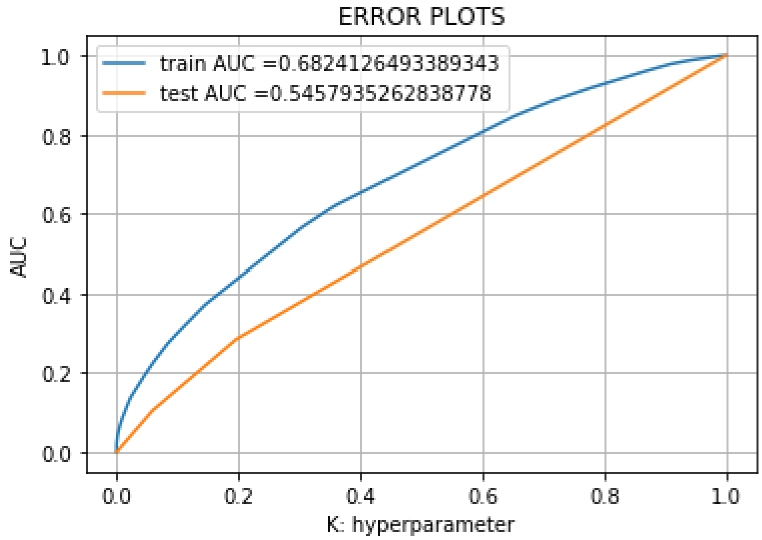
In [58]:
```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
min_samples_split = [5, 10, 100, 500]
for i in tqdm(min_samples_split):
    clf = DecisionTreeClassifier(min_samples_split=i,class_weight="balanced")
    clf.fit(X_tr_st2,y_train)
    y_train_pred = batch_predict(clf, X_tr_st2)
    y_cv_pred = batch_predict(clf, X_cv_st2)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(min_samples_split, train_auc, label='Train AUC')
plt.plot(min_samples_split, cv_auc, label='CV AUC')

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

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

```
  0%|          | 0/4 [00:00<?, ?it/s]

 25%|██▌       | 1/4 [01:37<04:51, 97.07s/it]

 50%|█████     | 2/4 [03:14<03:14, 97.21s/it]

 75%|███████▌  | 3/4 [04:34<01:31, 92.00s/it]

100%|██████████| 4/4 [05:11<00:00, 75.62s/it]
```



In [85]:

```
###### from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier

clf = DecisionTreeClassifier(min_samples_split=110,max_depth=8,class_weight="bala
clf.fit(X_tr_st2,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate.
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_st2)
y_test_pred = batch_predict(clf, X_te_st2)

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

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



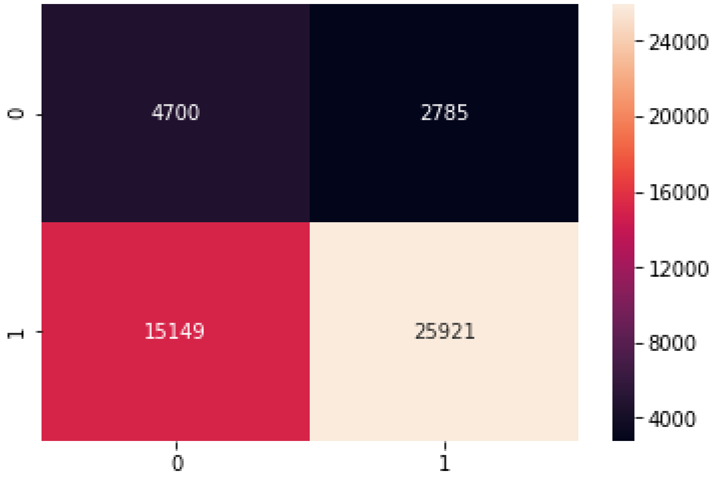
In [86]:

```
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [87]:

```
import seaborn as sns
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tr=confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
ax = sns.heatmap(tr,annot=True,fmt="d")
```

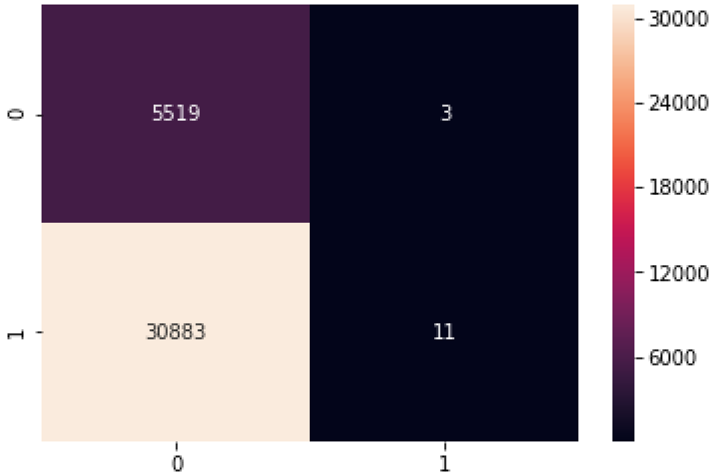
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.23363583100290986 for threshold 0.438
```



In [88]:

```
print("Test confusion matrix")
te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
ax = sns.heatmap(te,annot=True,fmt="d")
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.1586476195248639 for threshold 0.926
```



2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [51]:

```
# Please write all the code with proper documentation
import graphviz
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
clf = DecisionTreeClassifier(max_depth=3,class_weight="balanced")
clf.fit(X_train_eassy_tfidf,y_train)
dot_data = tree.export_graphviz(clf, out_file=None,feature_names=tfidf_eassy,clas
graph = graphviz.Source(dot_data)
graph
```

Out[51]:

```
<graphviz.files.Source at 0x4c73a780>
```

In [52]:

```
import graphviz
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
clf = DecisionTreeClassifier(max_depth=3,class_weight="balanced")
clf.fit(X_train_title_tfidf,y_train)
dot_data = tree.export_graphviz(clf, out_file=None,feature_names=tfidf_title,clas
graph = graphviz.Source(dot_data)
graph
```

Out[52]:

```
<graphviz.files.Source at 0x4b81ee10>
```

2.4.3 Applying Decision Trees on AVG W2V, SET 3

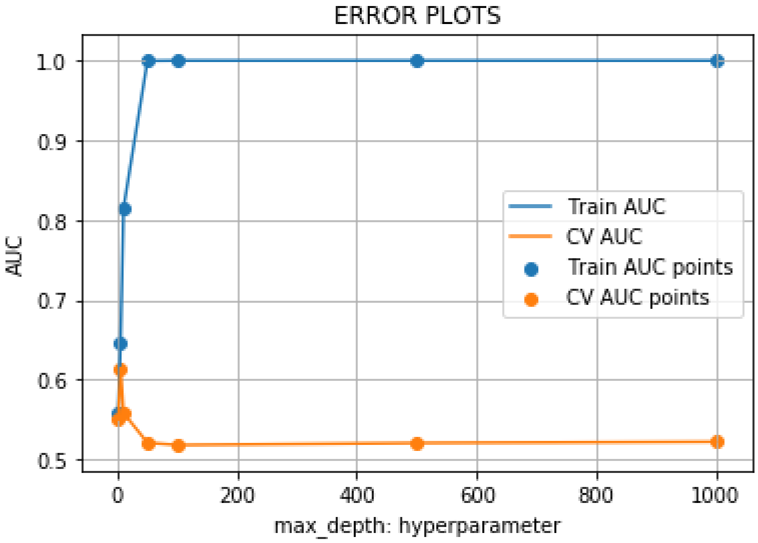
In [90]:
```
from scipy.sparse import hstack
X_tr_st3 = hstack((X_train_state_ohe,X_train_clean_categories_ohe,X_train_clean_s
               X_train_teacher_ohe,previously_posted_projects_standardized_train,

X_te_st3 = hstack((X_test_state_ohe,X_test_clean_categories_ohe,X_test_clean_subc
               X_test_teacher_ohe,previously_posted_projects_standardized_test,pr
X_cv_st3 = hstack((X_cv_state_ohe,X_cv_clean_categories_ohe,X_cv_clean_subcategor
               X_cv_teacher_ohe,previously_posted_projects_standardized_cv,price_

print("Final Data matrix")
print(X_tr_st3.shape, y_train.shape)
print(X_cv_st3.shape, y_cv.shape)
print(X_te_st3.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(48555, 681) (48555,)
(24277, 681) (24277,)
(36416, 681) (36416,)
===============================================================================
=====================
```

In [60]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
max_depth = [1, 5, 10, 50, 100, 500, 1000]
for i in tqdm(max_depth):
    clf = DecisionTreeClassifier(max_depth=i,class_weight="balanced")
    clf.fit(X_tr_st3,y_train)
    y_train_pred = batch_predict(clf, X_tr_st3)
    y_cv_pred = batch_predict(clf, X_cv_st3)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(max_depth, train_auc, label='Train AUC')
plt.plot(max_depth, cv_auc, label='CV AUC')

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

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

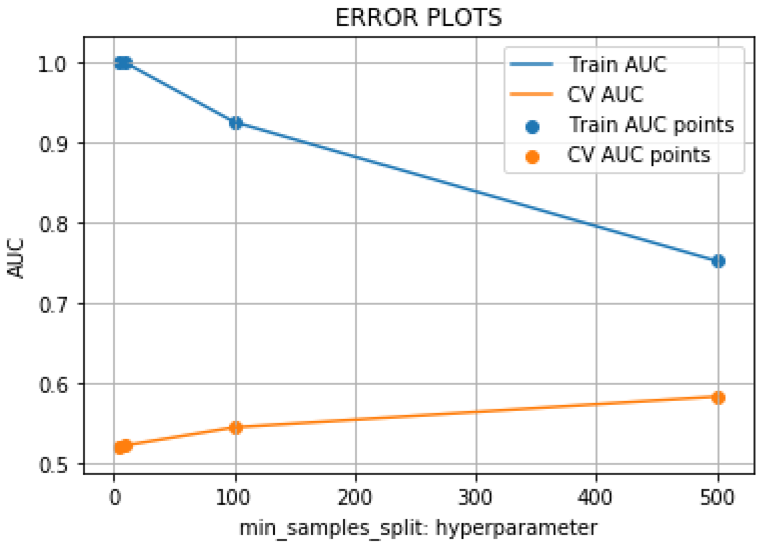
```
  0%|          | 0/7 [00:00<?, ?it/s]

 14%|█▍         | 1/7 [00:05<00:35,  5.92s/it]

 29%|██▊        | 2/7 [00:29<00:56, 11.31s/it]

 43%|████▎      | 3/7 [01:37<01:52, 28.17s/it]

 57%|█████▋     | 4/7 [04:27<03:31, 70.63s/it]

 71%|███████▏   | 5/7 [07:22<03:23, 101.94s/it]

 86%|████████▌ | 6/7 [10:21<02:05, 125.26s/it]

100%|██████████| 7/7 [13:21<00:00, 141.51s/it]
```


ERROR PLOTS
AUC
1.0
0.9
0.8
0.7
0.6
0.5
0
200
400
600
800
1000
max_depth: hyperparameter
Train AUC
CV AUC
Train AUC points
CV AUC points

In [61]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
min_samples_split = [5, 10, 100, 500]
for i in tqdm(min_samples_split):
    clf = DecisionTreeClassifier(min_samples_split=i,class_weight="balanced")
    clf.fit(X_tr_st3,y_train)
    y_train_pred = batch_predict(clf, X_tr_st3)
    y_cv_pred = batch_predict(clf, X_cv_st3)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(min_samples_split, train_auc, label='Train AUC')
plt.plot(min_samples_split, cv_auc, label='CV AUC')

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

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

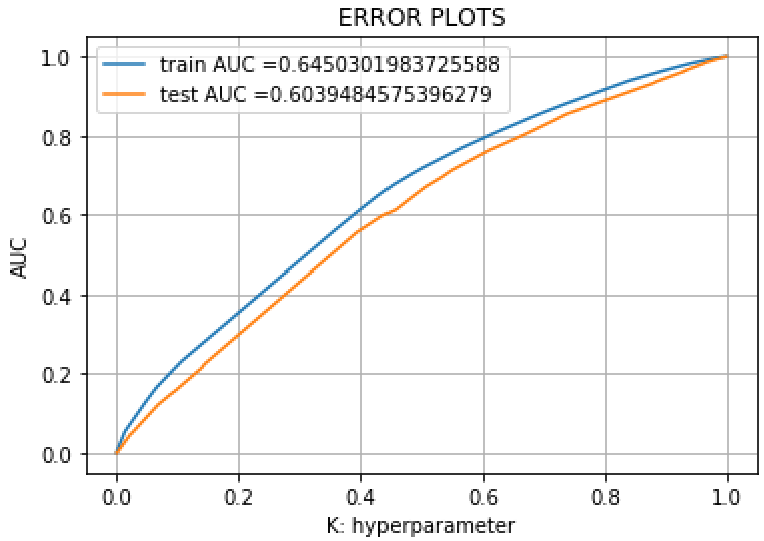
```
  0%|          | 0/4 [00:00<?, ?it/s]

 25%|██▌       | 1/4 [03:00<09:01, 180.36s/it]

 50%|█████     | 2/4 [05:54<05:57, 178.59s/it]

 75%|███████▌  | 3/4 [08:32<02:52, 172.32s/it]

100%|██████████| 4/4 [09:38<00:00, 140.41s/it]
```



In [98]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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%1
    # 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
```

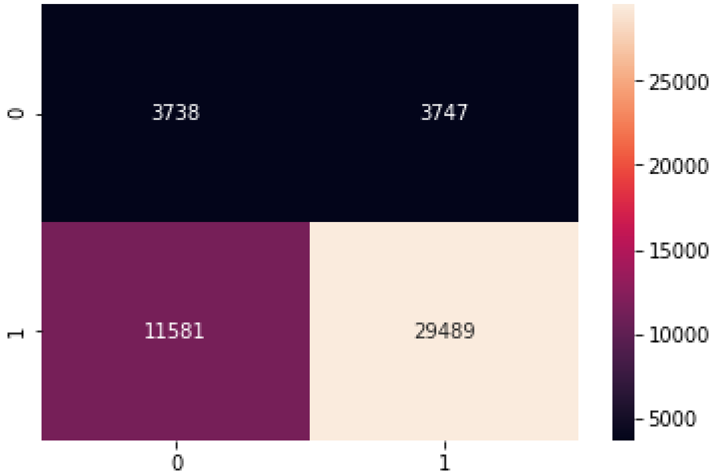
In [97]:
```
from sklearn.tree import DecisionTreeClassifier

clf = DecisionTreeClassifier(min_samples_split=100,max_depth=5,class_weight="bala
clf.fit(X_tr_st3,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate.
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_st3)
y_test_pred = batch_predict(clf, X_te_st3)

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

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



In [99]:
```
def predict(proba, threshould, fpr, tpr):

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

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

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

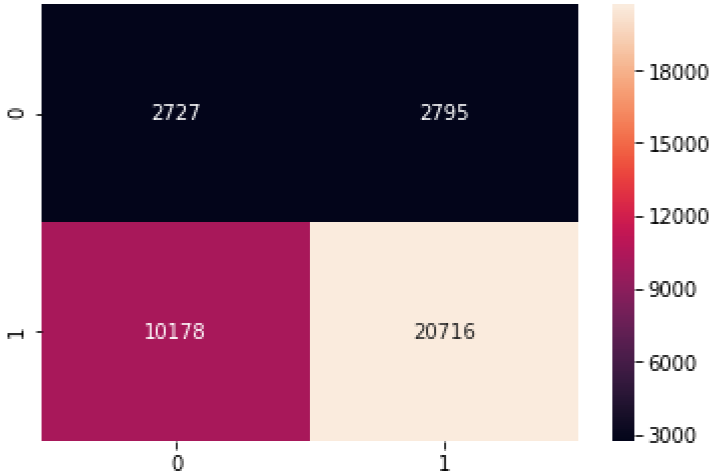
In [100]:
```
import seaborn as sns
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tr=confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
ax = sns.heatmap(tr,annot=True,fmt="d")
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999963855566845 for threshold -0.764
```



In [101]:
```
print("Test confusion matrix")
te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
ax = sns.heatmap(te,annot=True,fmt="d")
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24996208901839548 for threshold -0.636
```



2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

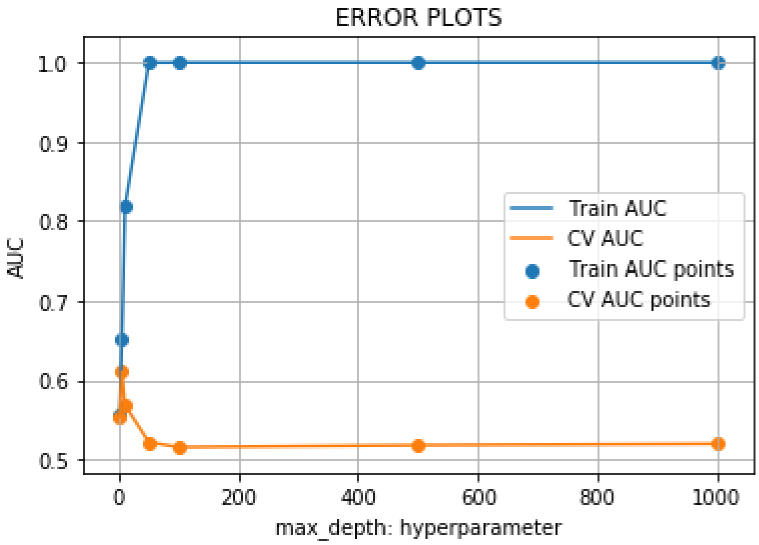
In [102]:
```
# Please write all the code with proper documentation
from scipy.sparse import hstack
X_tr_st4 = hstack((X_train_state_ohe,X_train_clean_categories_ohe,X_train_clean_s
               X_train_teacher_ohe,previously_posted_projects_standardized_train,
X_cv_st4 = hstack((X_cv_state_ohe,X_cv_clean_categories_ohe,X_cv_clean_subcategor
               X_cv_teacher_ohe,previously_posted_projects_standardized_cv,price_

X_te_st4 = hstack((X_test_state_ohe,X_test_clean_categories_ohe,X_test_clean_subc
               X_test_teacher_ohe,previously_posted_projects_standardized_test,pr

print("Final Data matrix")
print(X_tr_st4.shape, y_train.shape)
print(X_cv_st4.shape, y_cv.shape)
print(X_te_st4.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(48555, 681) (48555,)
(24277, 681) (24277,)
(36416, 681) (36416,)
================================================================================
====================
```

In [63]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
max_depth = [1, 5, 10, 50, 100, 500, 1000]
for i in tqdm(max_depth):
    clf = DecisionTreeClassifier(max_depth=i,class_weight="balanced")
    clf.fit(X_tr_st4,y_train)
    y_train_pred = batch_predict(clf, X_tr_st4)
    y_cv_pred = batch_predict(clf, X_cv_st4)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(max_depth, train_auc, label='Train AUC')
plt.plot(max_depth, cv_auc, label='CV AUC')

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

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

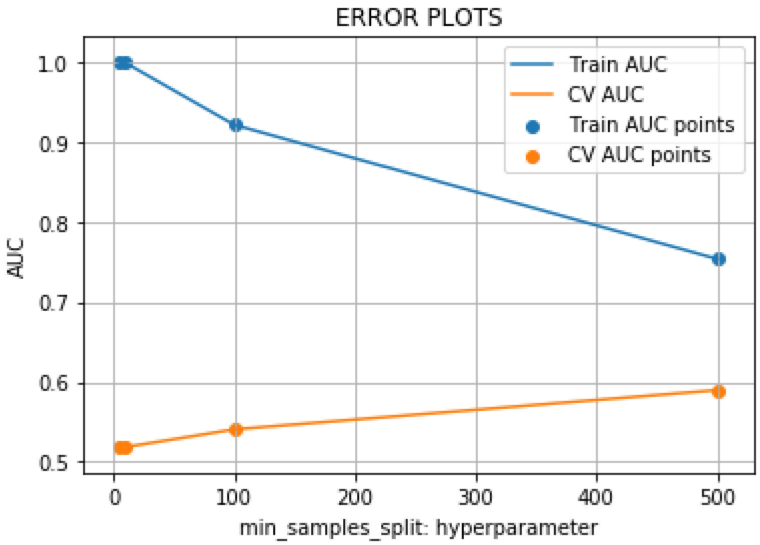
```
  0%|          | 0/7 [00:00<?, ?it/s]

 14%|█▍        | 1/7 [00:05<00:35,  5.91s/it]

 29%|██▊       | 2/7 [00:30<00:56, 11.36s/it]

 43%|████▎     | 3/7 [01:39<01:55, 28.84s/it]

 57%|█████▋    | 4/7 [04:20<03:25, 68.42s/it]

 71%|███████▏  | 5/7 [07:05<03:14, 97.36s/it]

 86%|████████▌ | 6/7 [09:51<01:58, 118.04s/it]

100%|██████████| 7/7 [12:38<00:00, 132.76s/it]
```


ERROR PLOTS
AUC
1.0
0.9
0.8
0.7
0.6
0.5
0
200
400
600
800
1000
max_depth: hyperparameter
Train AUC
CV AUC
Train AUC points
CV AUC points

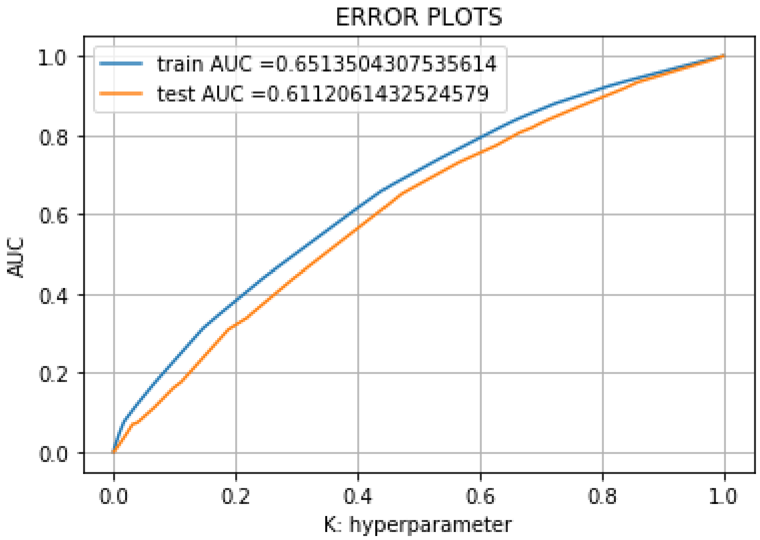
In [64]:

```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []
min_samples_split = [5, 10, 100, 500]
for i in tqdm(min_samples_split):
    clf = DecisionTreeClassifier(min_samples_split=i,class_weight="balanced")
    clf.fit(X_tr_st4,y_train)
    y_train_pred = batch_predict(clf, X_tr_st4)
    y_cv_pred = batch_predict(clf, X_cv_st4)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability esti
    # 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(min_samples_split, train_auc, label='Train AUC')
plt.plot(min_samples_split, cv_auc, label='CV AUC')

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

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

```
  0%|          | 0/4 [00:00<?, ?it/s]

 25%|██▌       | 1/4 [02:45<08:17, 165.85s/it]

 50%|█████     | 2/4 [05:24<05:27, 163.84s/it]

 75%|███████▌  | 3/4 [07:45<02:36, 156.89s/it]

100%|██████████| 4/4 [08:50<00:00, 129.25s/it]
```



In [103]:
```
from sklearn.tree import DecisionTreeClassifier

clf = DecisionTreeClassifier(min_samples_split=100,max_depth=5,class_weight="bala
clf.fit(X_tr_st4,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = batch_predict(clf, X_tr_st4)
y_test_pred = batch_predict(clf, X_te_st4)

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

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



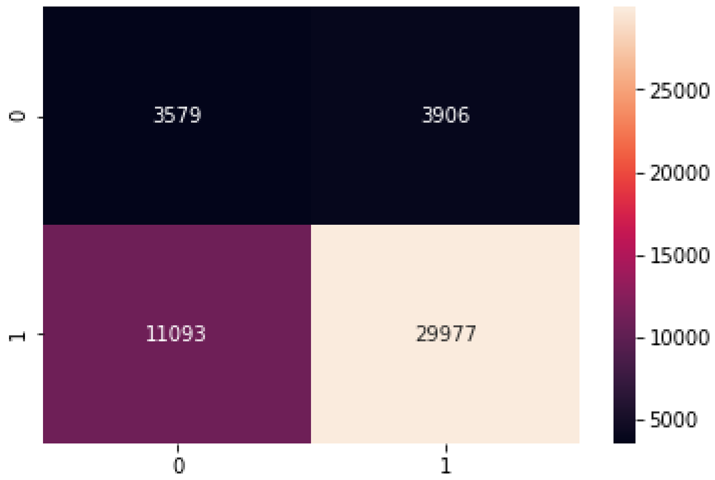
In [104]:

```
def predict(proba, threshould, fpr, tpr):

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

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

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

In [105]:

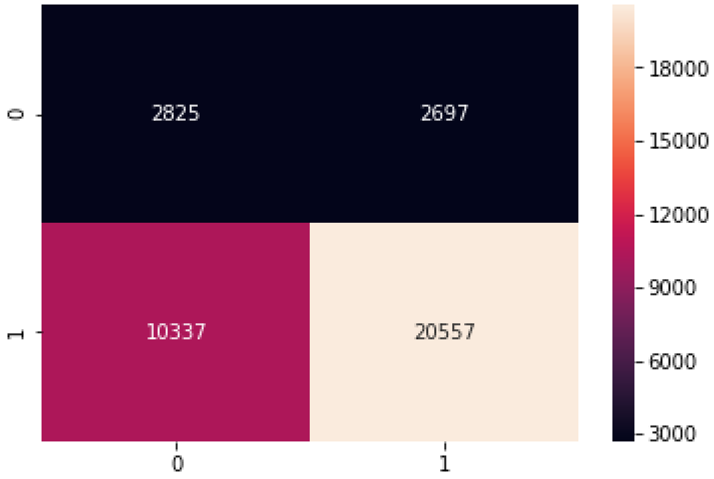
```
import seaborn as sns
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tr=confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
ax = sns.heatmap(tr,annot=True,fmt="d")
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2495228533218742 for threshold 0.459
```



In [106]:
```
print("Test confusion matrix")
te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
ax = sns.heatmap(te,annot=True,fmt="d")
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2498656718160449 for threshold 0.485
```



2.5 [Task-2]Getting top 5k features using `feature_importances_`

In [0]:
```
# please write all the code with proper documentation, and proper titles for each
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debuggin
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

In [27]:
```
print("Final Data matrix")
print(X_tr_st2.shape, y_train.shape)
print(X_cv_st2.shape, y_cv.shape)
print(X_te_st2.shape, y_test.shape)

print("="*100)
```

```
Final Data matrix
(48555, 44683) (48555,)
(24277, 44683) (24277,)
(36416, 44683) (36416,)
================================================================================
====================
```

In [29]:
```
from sklearn.tree import DecisionTreeClassifier
clf = DecisionTreeClassifier(class_weight="balanced")
clf.fit(X_tr_st2,y_train)
importances = clf.feature_importances_
```

In [42]:
```
indices=np.argsort(importances)[::-1][:5000]
#while converting saparce matrix to pdf i am gatting memory error so i took 20k r
df = pd.DataFrame(X_tr_st2[:20000].toarray())
```

In [49]:
```
final_data=df.iloc[:, indices]
```

In [70]:
```
df_cv = pd.DataFrame(X_cv_st2[:10000].toarray())
```

In [73]:
```
final_data_cv=df_cv.iloc[:, indices]
```

In [71]:
```
df_test = pd.DataFrame(X_te_st2[:10000].toarray())
```

In [74]:
```
final_data_test=df_test.iloc[:, indices]
```

In [79]:
```
print(final_data.shape,final_data_cv.shape,final_data_test.shape)
```

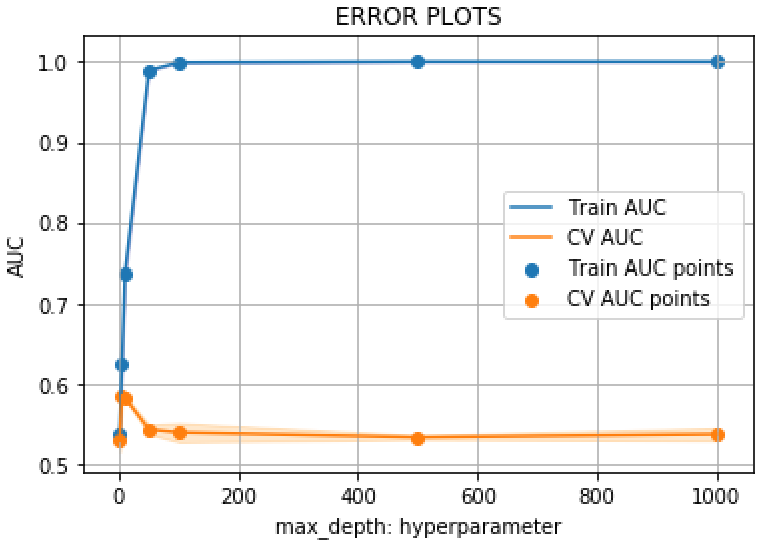
```
(20000, 5000) (10000, 5000) (10000, 5000)
```

In [87]:
```
import scipy.sparse
dense_matrix = np.array(final_data.as_matrix(columns = None), dtype=bool).astype(
train_matrix = scipy.sparse.csr_matrix(dense_matrix)
```

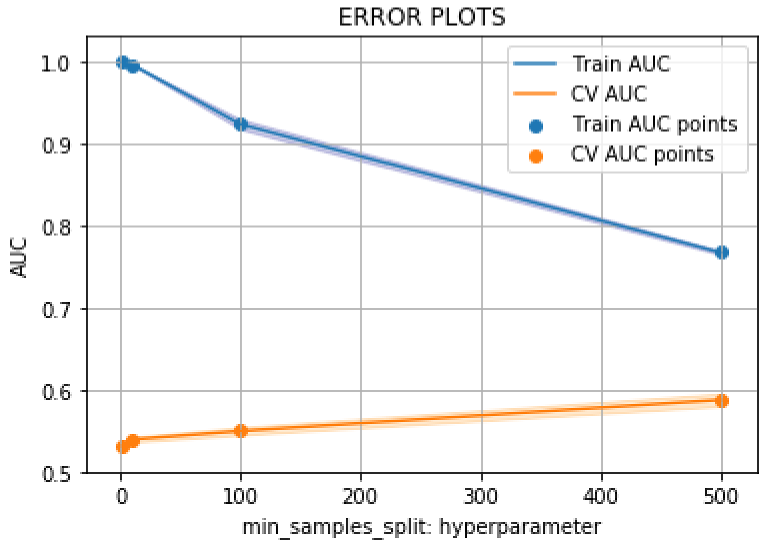
In [91]:
```
dense_matrix = np.array(final_data_cv.as_matrix(columns = None), dtype=bool).asty
cv_matrix = scipy.sparse.csr_matrix(dense_matrix)
```

In [124]:
```
dense_matrix = np.array(final_data_test.as_matrix(columns = None), dtype=bool).as
test_matrix = scipy.sparse.csr_matrix(dense_matrix)
```

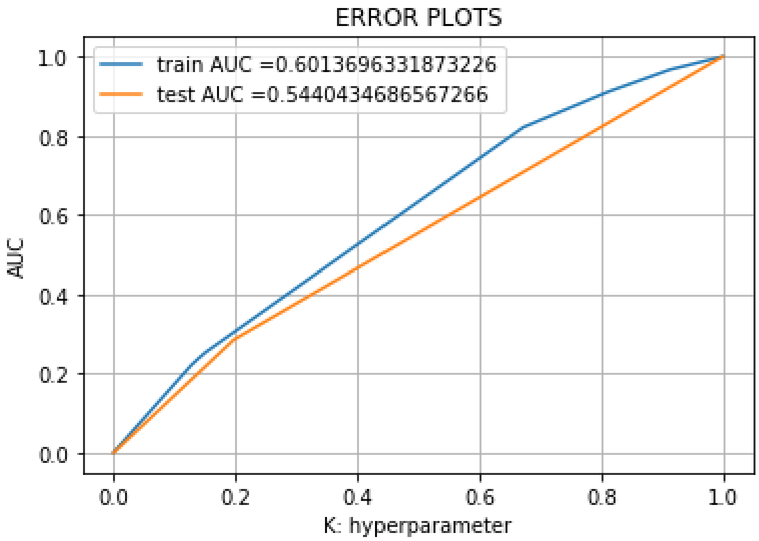
In [120]:
```
from sklearn.model_selection import GridSearchCV

clf = DecisionTreeClassifier(class_weight="balanced")
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000]}
clf = GridSearchCV(clf, parameters, cv=3, scoring='roc_auc')
clf.fit(train_matrix, y_train[:20000])

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

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

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

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


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



In [122]:
```
from sklearn.model_selection import GridSearchCV

clf = DecisionTreeClassifier(class_weight="balanced")
parameters = {'min_samples_split': [2,10,100,500]}
clf = GridSearchCV(clf, parameters, cv=3, scoring='roc_auc')
clf.fit(train_matrix, y_train[:20000])

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

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

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

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


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



```
In [164]: from sklearn.tree import DecisionTreeClassifier

          clf = DecisionTreeClassifier(min_samples_split=100,max_depth=5,class_weight="bala
          clf.fit(train_matrix,y_train[:20000])
          # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
          # not the predicted outputs

          y_train_pred = batch_predict(clf, train_matrix)
          y_test_pred = batch_predict(clf, test_matrix)

          train_fpr, train_tpr, tr_thresholds = roc_curve(y_train[:20000], y_train_pred)
          test_fpr, test_tpr, te_thresholds = roc_curve(y_test[:20000], y_test_pred)

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



3. Conclusion

In [168]:

```python
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["vectorizer", "min_samples_split","max_depth","class_weight","tr
x.add_row(['BOW','100','10',"balanced","0.7064","0.6210"])
x.add_row(['TFIDF','110','8',"balanced","0.6824","0.5457"])
x.add_row(['AVG W2V','100','5',"balanced","0.6439","0.6039"])
x.add_row(['TFIDF W2V','100','5',"balanced","0.6513",'0.6112'])
x.add_row(['TFIDF feature_importance','100',"5","balanced","0.6413","0.5440"])
print(x)
```

```
+--------------------------+-------------------+-----------+--------------+----
-------+---------+
|        vectorizer        | min_samples_split | max_depth | class_weight | tra
in AUC | testAUC |
+--------------------------+-------------------+-----------+--------------+----
-------+---------+
|           BOW            |        100        |     10    |   balanced   |  
0.7064  |  0.6210 |
|          TFIDF           |        110        |     8     |   balanced   |  
0.6824  |  0.5457 |
|         AVG W2V          |        100        |     5     |   balanced   |  
0.6439  |  0.6039 |
|        TFIDF W2V         |        100        |     5     |   balanced   |  
0.6513  |  0.6112 |
| TFIDF feature_importance |        100        |     5     |   balanced   |  
0.6413  |  0.5440 |
+--------------------------+-------------------+-----------+--------------+----
-------+---------+
```

step:

1.perform one hot encoding for categarical value and standalization aor normalization for numeric value column

2.on text data we perform BOW,TFIDF,AVF W2V,IFIDF W2V

3.for categorical value we perform one hot encoding and for numarical value make it normalized.

4.perform hypothesis tuning to find best min_sample_split and max_depth

5.after finding best min_sample_split and max_depth we plot train and test AUC ROC curve.

6.find feature_importances_ score using DecisionTreeClassifier

7.after shorting importance value took 5000 value and find their indicies

8.after that we convert our train , test cv test to data frame. and find their apropeiate value and again conver to soarce matrix.

9.using Gridsearch CV done hypothesis tuning for min_sample_split and max_depth

10 and then plot ROC curve for that data.

concusion: for BOWVectorizer we are getting good train and test AUC value. feature importance on TfidfVectorizer we are getting less AUC compare to simple TFIDF vectorizer.

In [ ]:

In [ ]:

In [ ]:

In [ ]: