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

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

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

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:

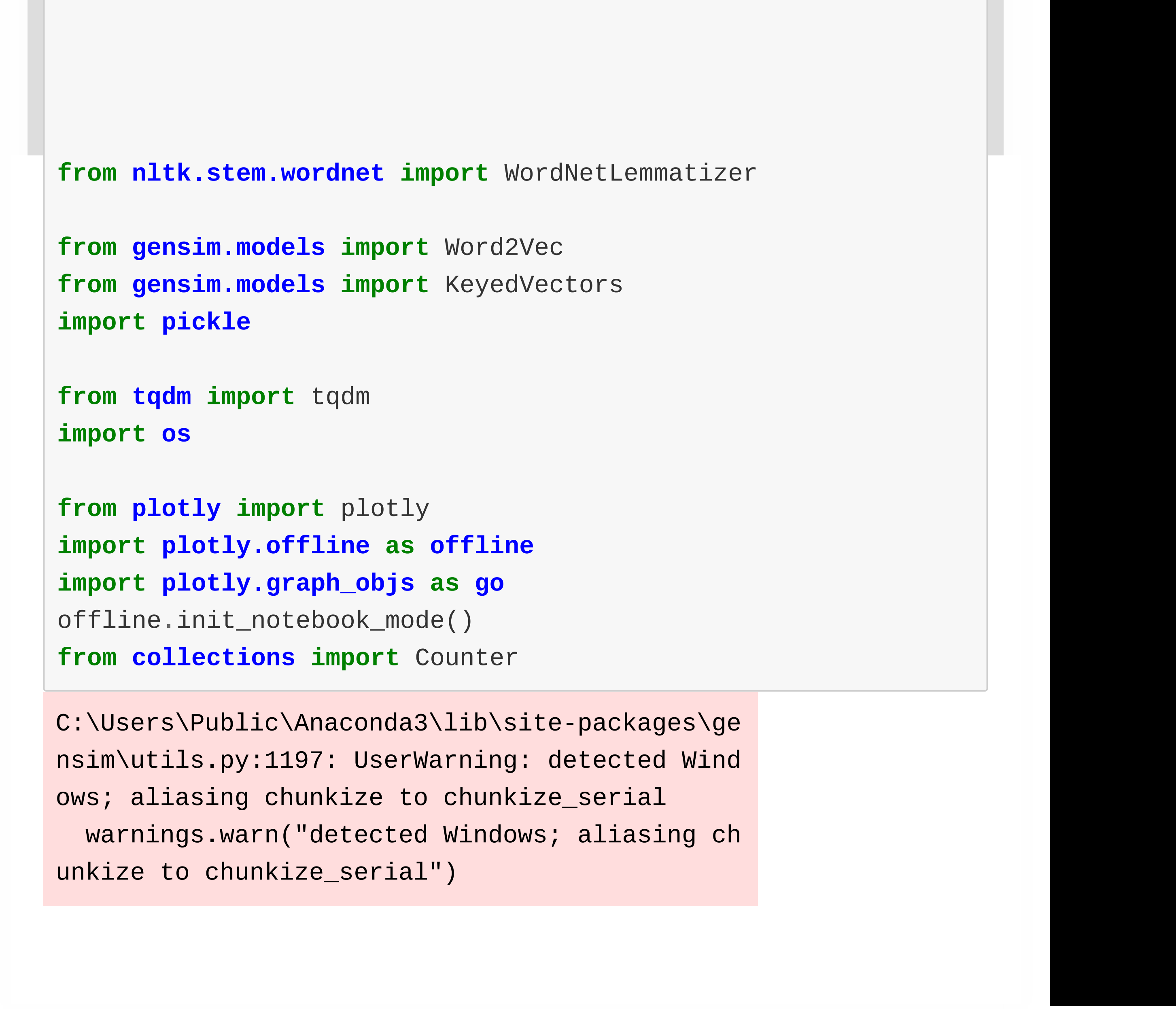
- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

- __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
```

```
C:\Users\Public\Anaconda3\lib\site-packages\ge
nsim\utils.py:1197: UserWarning: detected Wind
ows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing ch
unkize to chunkize_serial")
```

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('C:/Users/pramod reddy chandi/Desk
top/pram/applied ai course/DonorsChoose_2018/train_data.csv')
resource_data = pd.read_csv('C:/Users/pramod reddy chandi/Des
ktop/pram/applied ai course/DonorsChoose_2018/resources.csv')
```

In [3]:

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

```
Number of data points in train data (109248, 1
7)
---------------------------------------------
----
The attributes of data : ['Unnamed: 0' 'id' 't
eacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_c
ategory'
 'project_subject_categories' 'project_subject
_subcategories'
 'project_title' 'project_essay_1' 'project_es
say_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects
' 'project_is_approved']
```

In [4]:

```
print("Number of data points inb resource train data", resour
ce_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

```
Number of data points inb resource 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 [5]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [6]:

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

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

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

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

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

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

1.3 Text preprocessing

In [7]:

```
# 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 [8]:

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

Out[8]:

	Unnamed: 0	id	teacher_id
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc
1	140945	p258326	897464ce9ddc600bced1151f324dd63a

In [9]:

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

In [10]:

```
# 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 work
ing on English as their second or third langua
ges. We are a melting pot of refugees, immigra
nts, and native-born Americans bringing the gi
ft of language to our school. \r\n\r\n We have
 over 24 languages represented in our English
Learner program with students at every level o
f mastery.  We also have over 40 countries rep
resented with the families within our school.
 Each student brings a wealth of knowledge and
 experiences to us that open our eyes to new c
ultures, beliefs, and respect.\"The limits of
your language are the limits of your world.\"-
Ludwig Wittgenstein  Our English learner's hav
e a strong support system at home that begs fo
r more resources.  Many times our parents are
learning to read and speak English along side
of their children.  Sometimes this creates bar
riers for parents to be able to help their chi
ld learn phonetics, letter recognition, and ot
```

her reading skills.\r\n\r\nBy providing these dvd's and players, students are able to continue their mastery of 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 are to help the child develop early reading skills.\r\n\r\nParents that do not have 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 students. \r\nThe school has a vibrant community that loves to get together and celebrate. Around Halloween there is a whole school parade to show off the beautiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and games. At the end of the year the school 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 five brightly colored Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in the classroom and not enough for each stud ent to have an individual one, they will be used in a variety of ways. During independent reading time they will be used as special chairs students will each use on occasion. I will utilize them in place of chairs at my small group tables during math and reading times. The rest of the day they will be used by the students who need the highest amount of movement in their life in order to stay 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 stools 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 one of the stools who are disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The Hokki stools will be a compromise that allow my students to do desk work and move at the same time. These stools will help students to meet their 60 minutes a day of movement by allowing 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 plain 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 th

```
emed room for my students look forward to comi
ng to each day.\r\n\r\nMy class is made up of
28 wonderfully unique boys and girls of mixed
races in Arkansas.\r\nThey attend a Title I sc
hool, which means there is a high enough perce
ntage of free and reduced-price lunch to quali
fy. Our school is an \"open classroom\" concep
t, which is very unique as there are no walls
separating the classrooms. These 9 and 10 year
-old students are very eager learners; they ar
e like sponges, absorbing all the information
and experiences and keep on wanting more.With
these resources such as the comfy red throw pi
llows and the whimsical nautical hanging decor
 and the blue fish nets, I will be able to hel
p create the mood in our classroom setting to
be one of a themed nautical environment. Creat
ing a classroom environment is very important
in the success in each and every child's educa
tion. The nautical photo props will be used wi
th each child as they step foot into our class
room for the first time on Meet the Teacher ev
ening. I'll take pictures of each child with t
hem, have them developed, and then hung in our
 classroom ready for their first day of 4th gr
ade.  This kind gesture will set the tone befo
re even the first day of school! The nautical
thank you cards will be used throughout the ye
ar by the students as they create thank you ca
rds to their team groups.\r\n\r\nYour generous
 donations will help me to help make our class
room a fun, inviting, learning environment fro
m day one.\r\n\r\nIt costs lost of money out o
f my own pocket on resources to get our classr
oom ready. Please consider helping with this p
roject to make our new school year a very succ
essful one. Thank you!nannan
```

==

My kindergarten students have varied disabilities ranging from speech and language delays, cognitive delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest working past their limitations. \r\n\r\nThe 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 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 their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to learn through games, my kids don't 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

==

The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-American, making up the largest segment of the student body. A typical sch

```
ool in Dallas is made up of 23.2% African-Amer
ican students. Most of the students are on fre
e or reduced lunch. We aren't receiving doctor
s, lawyers, or engineers children from rich ba
ckgrounds or neighborhoods. As an educator I a
m inspiring minds of young children and we foc
us not only on academics but one smart, effect
ive, efficient, and disciplined students with 
good character.In our classroom we can utilize
 the Bluetooth for swift transitions during cl
ass. I use a speaker which doesn't amplify the
 sound enough to receive the message. Due to t
he volume of my speaker my students can't hear
 videos or books clearly and it isn't making t
he lessons as meaningful. But with the bluetoo
th speaker my students will be able to hear an
d I can stop, pause and replay it at any time.
\r\nThe cart will allow me to have more room f
or storage of things that are needed for the d
ay and has an extra part to it I can use.  The
 table top chart has all of the letter, words 
and pictures for students to learn about diffe
rent letters and it is more accessible.nannan
==============================================
====
```

In [11]:

```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 [12]:

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

```
My kindergarten students have varied disabilit
ies ranging from speech and language delays, c
ognitive delays, gross/fine motor delays, to a
utism. They are eager beavers and always striv
e to work their hardest working past their lim
itations. \r\n\r\nThe materials we have are th
e ones I seek out for my students. I teach in
a Title I school where most of the students re
ceive free or reduced price lunch.  Despite th
eir disabilities and limitations, my students
love coming to school and come eager to learn
and explore.Have you ever felt like you had an
ts 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 chai
rs are the answer and I love then because they
 develop their core, which enhances gross moto
r and in Turn fine motor skills. \r\nThey also
 want to learn through games, my kids do not w
ant to sit and do worksheets. They want to lea
rn to count by jumping and playing. Physical e
```

```
ngagement is the key to our success. The numbe
r 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 deser
ves.nannan
==============================================
====
```

In [13]:

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

```
My kindergarten students have varied disabilit
ies ranging from speech and language delays, c
ognitive delays, gross/fine motor delays, to a
utism. They are eager beavers and always striv
e to work their hardest working past their lim
itations.     The materials we have are the on
es I seek out for my students. I teach in a Ti
tle I school where most of the students receiv
e 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 i
n 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 mov
e as they learn or so they say.Wobble chairs a
re the answer and I love then because they dev
elop their core, which enhances gross motor an
d 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 engagem
ent 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.na
nnan
```

In [14]:

```
#remove spacial character: https://stackoverflow.com/a/584354
7/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilit
ies ranging from speech and language delays co
gnitive delays gross fine motor delays to auti
sm They are eager beavers and always strive to
 work their hardest working past their limitat
ions The materials we have are the ones I seek
 out for my students I teach in a Title I scho
ol where most of the students receive free or 
reduced price lunch Despite their disabilities
 and limitations my students love coming to sc
hool 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 a
nd I love then because they develop their core
 which enhances gross motor and in Turn fine m
otor skills They also want to learn through ga
mes my kids do not want to sit and do workshee
ts 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 ma
ts can make that happen My students will forge
```

```
t they are doing work and just have the fun a
6 year old deserves nannan
```

In [15]:

```
# 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're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', '
yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "
it's", 'its', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', '
whom', 'this', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', '
being', 'have', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', '
if', 'or', 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'b
etween', 'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in
', 'out', 'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where',
 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', '
same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't",
'should', "should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "co
uldn't", 'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", '
isn', "isn't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't",
'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "weren't",
 \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [16]:

```
# 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 stopw
ords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:57<00:00, 1
911.47it/s]
```

In [17]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[17]:

```
'my kindergarten students varied disabilities
ranging speech language delays cognitive delay
s gross fine motor delays autism they eager be
avers always strive work hardest working past
limitations the materials ones i seek students
 i teach title i school students receive free
reduced price lunch despite disabilities limit
ations students love coming school come eager
learn explore have ever felt like ants pants n
eeded groove move meeting this kids feel time
```

```
the want able move learn say wobble chairs ans
wer i love develop core enhances gross motor t
urn fine motor skills they also want learn gam
es kids not want sit worksheets they want lear
n count jumping playing physical engagement ke
y success the number toss color shape mats mak
e happen my students forget work fun 6 year ol
d deserves nannan'
```

In [18]:

```python
#Project essay word count

essay_word_count = []

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

project_data["essay_word_count"] = essay_word_count

project_data['preprocessed_essays'] = preprocessed_essays
```

In [19]:

```python
import nltk
#nltk.download()
```

In [20]:

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

analyser = SentimentIntensityAnalyzer()

pos =[]
neg = []
neu = []
compound = []
```

```python
for a in tqdm(project_data["preprocessed_essays"]) :
    b = analyser.polarity_scores(a)['neg']
    c = analyser.polarity_scores(a)['pos']
    d = analyser.polarity_scores(a)['neu']
    e = analyser.polarity_scores(a)['compound']
    neg.append(b)
    pos.append(c)
    neu.append(d)
    compound.append(e)
```

```
100%|██████████| 109248/109248 [12:57<00:00, 1
40.47it/s]
```

In [21]:

```python
project_data["pos"] = pos
project_data["neg"] = neg
project_data["neu"] = neu
project_data["compound"] = compound
```

1.4 Preprocessing of $project_tit \leq$

In [22]:

```
# similarly you can preprocess the titles also

project_data.columns
#sent1= decontracted(project_data['project_title'].values[20000])
preprocessed_title = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent1 = decontracted(sentance)
    sent1 = sent1.replace('\\r', ' ')
    sent1 = sent1.replace('\\"', ' ')
    sent1 = sent1.replace('\\n', ' ')
    sent1 = re.sub('[^A-Za-z0-9]+', ' ', sent1)
    # https://gist.github.com/sebleier/554280
    sent1 = ' '.join(e for e in sent1.split() if e not in stopwords)
    preprocessed_title.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:03<00:00, 33745.90it/s]
```

In [23]:

```
#Project title word count
title_word_count = []

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

project_data["title_word_count"] = title_word_count
```

```
project_data['preprocessed_title'] = preprocessed_title
```

1.5 Preparing data for models

In [24]:

```
project_data.columns
```

Out[24]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teac
her_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_su
mmary',
       'teacher_number_of_previously_posted_pr
ojects', 'project_is_approved',
       'clean_categories', 'clean_subcategorie
s', 'essay', 'essay_word_count',
       'preprocessed_essays', 'pos', 'neg', 'n
eu', 'compound',
       'title_word_count', 'preprocessed_title
'],
      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 : nu
merical
    - price : numerical
```

In [25]:

```
Y=project_data['project_is_approved']

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

column_values=['clean_categories', 'clean_subcategories', 'sc
hool_state', 'project_grade_category', 'teacher_prefix','prep
rocessed_essays','preprocessed_title' ,'price','quantity','te
acher_number_of_previously_posted_projects','pos','neg','neu',
'compound','title_word_count','essay_word_count']

def select_columns(dataframe, column_names):
    new_frame = dataframe.loc[:, column_names]
    return new_frame

process_columns=select_columns(project_data,column_values)
```

In [26]:

```
process_columns.head()
```

Out[26]:

	clean_categories	clean_subcategories	school_state	project_grade_category
0	Literacy_Language	ESL Literacy	IN	Grades PreK-2

1	History_Civics Health_Sports	Civics_Government TeamSports	FL	Grades 6-8
2	Health_Sports	Health_Wellness TeamSports	AZ	Grades 6-8
3	Literacy_Language Math_Science	Literacy Mathematics	KY	Grades PreK-2
4	Math_Science	Mathematics	TX	Grades PreK-2

In [27]:

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

# X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.33, shuffle=Flase)# this is for time series split
X_train, X_test, y_train, y_test = train_test_split(process_columns, Y, test_size=0.33,random_state=42) # this is random splitting
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33 ,random_state=42) # this is random splitting



print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)
```

```
(49041, 16) (49041,)
(24155, 16) (24155,)
(36052, 16) (36052,)
```

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

In [28]:

```python
print("train columns",X_train.columns)

print("cv columns",X_cv.columns)

print("test columns",X_test.columns)
```

```
train columns Index(['clean_categories', 'clea
n_subcategories', 'school_state',
       'project_grade_category', 'teacher_pref
ix', 'preprocessed_essays',
       'preprocessed_title', 'price', 'quantit
y',
       'teacher_number_of_previously_posted_pr
ojects', 'pos', 'neg', 'neu',
       'compound', 'title_word_count', 'essay_
word_count'],
      dtype='object')
cv columns Index(['clean_categories', 'clean_s
ubcategories', 'school_state',
       'project_grade_category', 'teacher_pref
ix', 'preprocessed_essays',
       'preprocessed_title', 'price', 'quantit
y',
       'teacher_number_of_previously_posted_pr
ojects', 'pos', 'neg', 'neu',
       'compound', 'title_word_count', 'essay_
word_count'],
      dtype='object')
test columns Index(['clean_categories', 'clean
_subcategories', 'school_state',
       'project_grade_category', 'teacher_pref
ix', 'preprocessed_essays',
       'preprocessed_title', 'price', 'quantit
y',
       'teacher_number_of_previously_posted_pr
ojects', 'pos', 'neg', 'neu',
       'compound', 'title_word_count', 'essay_
word_count'],
      dtype='object')
```

1.5.1 Vectorizing Categorical data

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

In [29]:

```python
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_categories= CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)

vectorizer_categories.fit(X_train['clean_categories'].values)

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

print(vectorizer_categories.get_feature_names())

print("Shape of train matrix after one hot encodig ",categories_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",categories_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",categories_
one_hot_cv.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'M
usic_Arts', 'AppliedLearning', 'SpecialNeeds',
 'Health_Sports', 'Math_Science', 'Literacy_La
nguage']
Shape of train matrix after one hot encodig  (
49041, 9)
Shape of test matrix after one hot encodig  (3
6052, 9)
Shape of cv matrix after one hot encodig  (241
55, 9)
```

In [30]:

```
# we use count vectorizer to convert the values into one
# splitting subcategories data
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_subcategories = CountVectorizer(vocabulary=list(so
rted_sub_cat_dict.keys()), lowercase=False, binary=True)
vectorizer_subcategories.fit(X_train['clean_subcategories'].v
alues)

print(vectorizer_subcategories.get_feature_names())

sub_categories_one_hot_train = vectorizer_subcategories.trans
form(X_train['clean_subcategories'].values)
sub_categories_one_hot_test = vectorizer_subcategories.transf
orm(X_test['clean_subcategories'].values)
sub_categories_one_hot_cv = vectorizer_subcategories.transfor
m(X_cv['clean_subcategories'].values)

print("Shape of train matrix after one hot encodig ",sub_cate
gories_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",sub_categ
ories_one_hot_test.shape)
```

```
print("Shape of cv matrix after one hot encodig ",sub_categor
ies_one_hot_cv.shape)
```

```
['Economics', 'CommunityService', 'FinancialLi
teracy', 'ParentInvolvement', 'Extracurricular
', 'Civics_Government', 'ForeignLanguages', 'N
utritionEducation', 'Warmth', 'Care_Hunger', '
SocialSciences', 'PerformingArts', 'CharacterE
ducation', 'TeamSports', 'Other', 'College_Car
eerPrep', 'Music', 'History_Geography', 'Healt
h_LifeScience', 'EarlyDevelopment', 'ESL', 'Gy
m_Fitness', 'EnvironmentalScience', 'VisualArt
s', 'Health_Wellness', 'AppliedSciences', 'Spe
cialNeeds', 'Literature_Writing', 'Mathematics
', 'Literacy']
Shape of train matrix after one hot encodig  (
49041, 30)
Shape of test matrix after one hot encodig  (3
6052, 30)
Shape of cv matrix after one hot encodig  (241
55, 30)
```

In [31]:

```
# we use count vectorizer to convert the values of categorica
l data :school_state
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_schoolstate= CountVectorizer()
vectorizer_schoolstate.fit(X_train['school_state'])

print(vectorizer_schoolstate.get_feature_names())

school_state_one_hot_train = vectorizer_schoolstate.transform
(X_train['school_state'].values)
school_state_one_hot_test = vectorizer_schoolstate.transform(
X_test['school_state'].values)
school_state_one_hot_cv = vectorizer_schoolstate.transform(X_
cv['school_state'].values)

print("Shape of train matrix after one hot encodig ",school_state_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",school_state_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",school_state_one_hot_cv.shape)
```

```
['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']
Shape of train matrix after one hot encodig  (
49041, 51)
Shape of test matrix after one hot encodig  (3
6052, 51)
Shape of cv matrix after one hot encodig  (241
55, 51)
```

In [32]:

```
#we use count vectorizer to convert the values of categorical data :project_grade_category
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_project_grade_category = CountVectorizer(stop_words=None)

k=X_train['project_grade_category']
l=X_test['project_grade_category']
m=X_test['project_grade_category']

k.replace(['Grades PreK-2', 'Grades 6-8', 'Grades 3-5','Grades 9-12'], ['A1', 'B2' ,'C3', 'D4'],inplace=True)
l.replace(['Grades PreK-2', 'Grades 6-8', 'Grades 3-5','Grade
s 9-12'], ['A1', 'B2' ,'C3', 'D4'],inplace=True)
m.replace(['Grades PreK-2', 'Grades 6-8', 'Grades 3-5','Grade
s 9-12'], ['A1', 'B2' ,'C3', 'D4'],inplace=True)

vectorizer_project_grade_category.fit(k)

project_grade_category_one_hot_train=vectorizer_project_grade
_category.transform(X_train['project_grade_category'].values)
project_grade_category_one_hot_test=vectorizer_project_grade_
category.transform(X_test['project_grade_category'].values)
project_grade_category_one_hot_cv=vectorizer_project_grade_ca
tegory.transform(X_cv['project_grade_category'].values)

print("Shape of train matrix after one hot encodig ",project_
grade_category_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",project_g
rade_category_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",project_gra
de_category_one_hot_cv.shape)
```

```
Shape of train matrix after one hot encodig  (
49041, 4)
Shape of test matrix after one hot encodig  (3
6052, 4)
Shape of cv matrix after one hot encodig  (241
55, 4)
```

In [33]:

```
#we use count vectorizer to convert the values of categorical
 data : teacher_prefix
# getting error as we have null balues replacing them with 0
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_teacher_prefix = CountVectorizer()
project_data['teacher_prefix'].unique()

X_train['teacher_prefix'].fillna("", inplace = True)
```

```
X_test['teacher_prefix'].fillna("", inplace = True)
X_cv['teacher_prefix'].fillna("", inplace = True)

vectorizer_teacher_prefix.fit(X_train['teacher_prefix'].values)
print(vectorizer_teacher_prefix.get_feature_names())

teacher_prefix_one_hot_train = vectorizer_teacher_prefix.transform(X_train['teacher_prefix'].values)
teacher_prefix_one_hot_test = vectorizer_teacher_prefix.transform(X_test['teacher_prefix'].values)
teacher_prefix_one_hot_cv = vectorizer_teacher_prefix.transform(X_cv['teacher_prefix'].values)

print("Shape of train matrix after one hot encodig ",teacher_prefix_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",teacher_prefix_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",teacher_prefix_one_hot_cv.shape)
```

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
Shape of train matrix after one hot encodig  (49041, 5)
Shape of test matrix after one hot encodig  (36052, 5)
Shape of cv matrix after one hot encodig  (24155, 5)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [34]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_bow_essay = CountVectorizer(min_df=10, ngram_range =(1,2),max_features=5000)
vectorizer_bow_essay.fit(X_train['preprocessed_essays'])

text_bow_train= vectorizer_bow_essay.transform(X_train['preprocessed_essays'])
text_bow_test= vectorizer_bow_essay.transform(X_test['preprocessed_essays'])
text_bow_cv= vectorizer_bow_essay.transform(X_cv['preprocessed_essays'])

print("Shape of train matrix after one hot encodig ",text_bow_train.shape)
print("Shape of test matrix after one hot encodig ",text_bow_test.shape)
print("Shape of cv matrix after one hot encodig ",text_bow_cv.shape)
```

```
Shape of train matrix after one hot encodig  (49041, 5000)
Shape of test matrix after one hot encodig  (36052, 5000)
Shape of cv matrix after one hot encodig  (24155, 5000)
```

In [35]:

```
# before you vectorize the title make sure you preprocess it
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_bow_title = CountVectorizer(min_df=10)
vectorizer_bow_title.fit(X_train['preprocessed_title'])
```

```
title_bow_train = vectorizer_bow_title.transform(X_train['pre
processed_title'])
title_bow_test = vectorizer_bow_title.transform(X_test['prepr
ocessed_title'])
title_bow_cv= vectorizer_bow_title.transform(X_cv['preprocess
ed_title'])

print("Shape of train matrix after one hot encodig title_bow"
,title_bow_train.shape)
print("Shape of test matrix after one hot encodig title_bow",
title_bow_test.shape)
print("Shape of cv matrix after one hot encodig title_bow",ti
tle_bow_cv.shape)
```

```
Shape of train matrix after one hot encodig ti
tle_bow (49041, 132)
Shape of test matrix after one hot encodig tit
le_bow (36052, 132)
Shape of cv matrix after one hot encodig title
_bow (24155, 132)
```

1.5.2.2 TFIDF vectorizer

In [36]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_essay= TfidfVectorizer(min_df=10,ngram_range
 =(1,2),max_features=5000)
vectorizer_tfidf_essay.fit(X_train['preprocessed_essays'])

text_tfidf_train= vectorizer_tfidf_essay.transform(X_train['p
reprocessed_essays'])
text_tfidf_test= vectorizer_tfidf_essay.transform(X_test['pre
processed_essays'])
```

```
text_tfidf_cv = vectorizer_tfidf_essay.transform(X_cv['preprocessed_essays'])

print("Shape of train matrix after one hot encodig ",text_tfidf_train.shape)
print("Shape of test matrix after one hot encodig ",text_tfidf_test.shape)
print("Shape of cv matrix after one hot encodig ",text_tfidf_cv.shape)
```

```
Shape of train matrix after one hot encodig  (49041, 5000)
Shape of test matrix after one hot encodig  (36052, 5000)
Shape of cv matrix after one hot encodig  (24155, 5000)
```

In [37]:

```
# Similarly you can vectorize for title also

from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(X_train['preprocessed_title'])

title_tfidf_train = vectorizer_tfidf_title.transform(X_train['preprocessed_title'])
title_tfidf_test = vectorizer_tfidf_title.transform(X_test['preprocessed_title'])
title_tfidf_cv = vectorizer_tfidf_title.transform(X_cv['preprocessed_title'])

print("Shape of train matrix after one hot encodig ",title_tfidf_train.shape)
print("Shape of test matrix after one hot encodig ",title_tfidf_test.shape)
print("Shape of cv matrix after one hot encodig ",title_tfidf
_cv.shape)
```

```
Shape of train matrix after one hot encodig  (
49041, 132)
Shape of test matrix after one hot encodig  (3
6052, 132)
Shape of cv matrix after one hot encodig  (241
55, 132)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [38]:

```
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
```

In [39]:

```
i=0
list_of_sentance_train=[]
for sentance in X_train['preprocessed_essays']:
    list_of_sentance_train.append(sentance.split())
```

In [40]:

```
# this line of code trains your w2v model on the give list of
 sentances
w2v_model=Word2Vec(list_of_sentance_train,min_count=25,size=50
, workers=32)
```

In [41]:

```
w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 25 times ",len(w2
v_words))
print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 25 times
 8657
sample words  ['my', 'students', 'inquisitive'
, 'bunch', 'love', 'learn', 'they', 'ask', 'me
aningful', 'questions', 'work', 'hard', 'find'
, 'answers', 'important', 'foundational', 'ski
lls', 'help', 'throughout', 'lives', 'many', '
not', 'support', 'need', 'home', 'build', 'suc
cessful', 'we', 'recently', 'acquired', 'title
', 'i', 'status', 'meaning', 'large', 'percent
age', 'kids', 'school', 'poverty', 'level', 't
hat', 'makes', 'much', 'get', 'materials', 'se
cond', 'graders', 'use', 'books', 'everything'
]
```

In [42]:

```
# average Word2Vec of essays
# compute average word2vec for each review.
essay_vectors_train = []; # the avg-w2v for each sentence/rev
iew is stored in this list
for sent in tqdm(list_of_sentance_train): # for each review/s
entence
    sent_vec = np.zeros(50) # as word vectors are of zero len
gth 50, you might need to change this to 300 if you use googl
e's w2v
    cnt_words =0; # num of words with a valid vector in the s
entence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    essay_vectors_train.append(sent_vec)
essay_vectors_train = np.array(essay_vectors_train)
```

```
print(essay_vectors_train.shape)
print(essay_vectors_train[0])
```

```
100%|██████████| 49041/49041 [02:25<00:00, 337
.77it/s]
```

```
(49041, 50)
[-2.90032371e-01  8.60346435e-01  4.71845976e-
01 -9.33003174e-01
 -1.42434026e+00 -7.70083409e-02 -3.17232735e-
01 -2.85122908e-01
  5.45779104e-01 -8.82538100e-02 -5.18708233e-
01 -2.95204313e-01
 -5.53593144e-01  6.97392470e-01 -9.64462360e-
01 -4.85311871e-01
  5.74981939e-01 -8.53537832e-01 -6.70320508e-
01 -1.27511097e+00
  6.70201442e-01  1.41863361e+00  4.00496795e-
01  2.25621624e-01
 -7.12999494e-02  8.62108673e-02  1.31490542e-
01 -9.53090388e-01
  2.57622198e-01 -5.59114673e-01  1.05532903e+
00 -1.29514274e-04
 -1.33721452e+00  1.33187763e-01  3.38800237e-
01 -6.85873697e-01
  3.69696160e-01  2.26529077e-01  3.59959778e-
02 -2.64510601e-02
  2.62752173e-01 -3.37871651e-02 -8.48864091e-
01 -1.26758133e-01
  3.85386051e-01 -9.52597343e-01 -1.11065713e+
00 -1.30310406e-01
  7.98677945e-01 -5.78991215e-01]
```

In [43]:

```
i=0
list_of_sentance_cv=[]
for sentance in X_cv['preprocessed_essays']:
    list_of_sentance_cv.append(sentance.split())
```

In [44]:

```
# average Word2Vec
# compute average word2vec for each review.
essay_vectors_cv = []; # the avg-w2v for each sentence/review
 is stored in this list
for sent in tqdm(list_of_sentance_cv): # for each review/sent
ence
    sent_vec = np.zeros(50) # as word vectors are of zero len
gth 50, you might need to change this to 300 if you use googl
e's w2v
    cnt_words =0; # num of words with a valid vector in the s
entence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    essay_vectors_cv.append(sent_vec)
essay_vectors_cv = np.array(essay_vectors_cv)
print(essay_vectors_cv.shape)
print(essay_vectors_cv[0])
```

```
100%|██████████| 24155/24155 [01:10<00:00, 341
.91it/s]
```

```
(24155, 50)
[-0.55039159  0.59011163  0.24628711 -0.260274
67 -0.84319991 -0.04216174
 -0.2941092   0.24774508  0.53412312 -0.211579
75 -0.28470101 -0.20901095
 -0.2312968   0.74251095 -0.62059205 -0.429687
63  0.5047573  -0.69660745
 -0.362852   -0.43788939 -0.0377819   0.970809
45  0.45159597 -0.21092321
  0.02045978  0.36423509  0.09696841 -0.655525
9  -0.21511891 -0.06870055
  0.51406031 -0.53535687 -0.82368416  0.081589
26  0.26144682 -0.23740696
  0.26095449  0.02328642  0.44013315 -0.386383
69  0.09382806  0.25171685
 -0.87513149 -0.37982243 -0.29462404 -0.481962
53 -0.50476139 -0.14513916
  0.45029426 -0.04290274]
```

In [45]:

```
i=0
list_of_sentance_test=[]
for sentance in X_test['preprocessed_essays']:
    list_of_sentance_test.append(sentance.split())

# average Word2Vec
# compute average word2vec for each review.
essay_vectors_test = []; # the avg-w2v for each sentence/revi
ew is stored in this list
for sent in tqdm(list_of_sentance_test): # for each review/se
ntence
    sent_vec = np.zeros(50) # as word vectors are of zero len
gth 50, you might need to change this to 300 if you use googl
e's w2v
    cnt_words =0; # num of words with a valid vector in the s
entence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    essay_vectors_test.append(sent_vec)
```

```
essay_vectors_test = np.array(essay_vectors_test)
print(essay_vectors_test.shape)
print(essay_vectors_test[0])
```

```
100%|██████████| 36052/36052 [01:47<00:00, 336
.80it/s]
```

```
(36052, 50)
[-0.18338155  0.27479871 -0.55788103  0.127461
29  0.01409558  0.35013343
  0.08363152 -0.54946905  0.12060037  0.071419
26 -0.2809623   0.57492357
 -0.1288473   0.21367326  0.0543469  -0.078163
51  0.38693463 -0.34759596
  0.33371484  0.31323147 -0.07776975  0.538781
21 -0.42424201  0.63003903
 -0.05073655  0.39573375 -0.26926656 -0.221981
81  0.13946151  0.07928236
  0.31881085  0.19788873 -0.30730346  0.343906
71  0.49633279  0.02482942
  0.44806973 -0.14102771  0.6577633  -0.068007
85  0.10928333  0.21594461
 -0.15724255 -0.0538225  -0.11482365 -0.599431
24 -0.29543823  0.46235607
  0.90685505 -0.4225088 ]
```

In [46]:

```
#similarly doing it for preprocessed title
i=0
list_of_sentance_train=[]
for sentance in X_train['preprocessed_title']:
    list_of_sentance_train.append(sentance.split())
```

In [47]:

```
# this line of code trains your w2v model on the give list of
 sentances
```

```
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50
, workers=16)
```

In [48]:

```
w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v
_words))
print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times
133
sample words  ['when', 'last', 'time', 'used',
 'math', 'probably', 'within', 'hour', 'yet',
'go', 'school', 'believing', 'never', 'use', '
my', 'students', 'engage', 'authentic', 'exper
iences', 'routinely', 'help', 'understand', 'c
ritical', 'truly', 'i', 'teach', 'small', 'tow
n', 'big', 'dreams', 'fantastic', 'opportuniti
es', 'surround', 'ultimate', 'goal', 'achieve'
, 'success', 'seeking', 'drive', 'potential',
'take', 'world', 'storm', 'graduation', 'all',
 'need', 'little', 'according', 'forbes', 'mag
azine']
```

In [49]:

```
# compute average word2vec for each review.
title_vectors_train = []; # the avg-w2v for each sentence/rev
iew is stored in this list
for sent in tqdm(list_of_sentance_train): # for each review/s
entence
    sent_vec = np.zeros(50) # as word vectors are of zero len
gth 50, you might need to change this to 300 if you use googl
e's w2v
    cnt_words =0; # num of words with a valid vector in the s
entence/review
    for word in sent: # for each word in a review/sentence
```

```
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    title_vectors_train.append(sent_vec)
title_vectors_train = np.array(title_vectors_train)
print(title_vectors_train.shape)
print(title_vectors_train[0])
```

```
100%|██████████| 49041/49041 [00:34<00:00, 142
0.51it/s]
```

```
(49041, 50)
[-0.22603481  0.18219405  0.14234805 -0.529365
99 -0.05597928 -0.11619637
  0.18648741 -0.00675527 -0.10553605 -0.184322
76 -0.18391618  0.0371584
 -0.21090107 -0.05495312 -0.05989448  0.001685
78  0.02508071 -0.1552339
  0.04561668  0.05217044  0.01767509 -0.234749
42 -0.00212379 -0.18953898
 -0.2117985   0.13818566 -0.03957217 -0.096074
98 -0.1313086   0.10757296
  0.27171492 -0.08762729  0.13972145 -0.245058
62  0.07055349  0.40019021
  0.30766648  0.10271249  0.00800345  0.107214
45  0.19809488  0.30790366
 -0.05007584  0.55640632 -0.02711264  0.019195
6  -0.2827339   0.04990862
 -0.16155619 -0.21958311]
```

In [50]:

```
# compute average word2vec for each review.
title_vectors_cv = []; # the avg-w2v for each sentence/review
 is stored in this list
```

```
for sent in tqdm(list_of_sentance_cv): # for each review/sent
ence
    sent_vec = np.zeros(50) # as word vectors are of zero len
gth 50, you might need to change this to 300 if you use googl
e's w2v
    cnt_words =0; # num of words with a valid vector in the s
entence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    title_vectors_cv.append(sent_vec)
title_vectors_cv = np.array(title_vectors_cv)
print(title_vectors_cv.shape)
print(title_vectors_cv[0])
```

```
100%|██████████| 24155/24155 [00:07<00:00, 336
2.67it/s]
```

```
(24155, 50)
[-1.26873282 -0.55528475 -0.32512808 -1.794162
37  0.69773454 -0.74045961
 -0.81945579  1.81800211 -0.66946012 -0.461866
69 -2.11974083  0.89261514
 -0.10923577 -0.7598766   0.44168713 -2.064020
67  1.21054869  0.56179923
  0.33671115  1.1140868   1.8356533  -1.112918
05 -0.39223275 -0.76215849
 -1.03308401  1.92000418  0.35476627  1.375452
37 -0.88452895 -2.93544148
 -0.99263266 -1.61019693  0.55320493 -2.090623
74  0.17006834 -0.91716269
 -0.99925702  1.18069801  0.63799557 -1.210131
17  0.43781493  2.36404183
 -1.2397333   1.16537101  0.42278777  0.099371
58  0.25261509  2.07074756
 -0.56345393  2.0197793 ]
```

In [51]:

```python
i=0
list_of_sentance_test=[]
for sentance in X_test['preprocessed_title']:
    list_of_sentance_test.append(sentance.split())
```

In [52]:

```python
# compute average word2vec for each review.
title_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(list_of_sentance_test): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    title_vectors_test.append(sent_vec)
title_vectors_test = np.array(title_vectors_test)
print(title_vectors_test.shape)
print(title_vectors_test[0])
```

```
100%|██████████| 36052/36052 [00:23<00:00, 1542.46it/s]
```

```
(36052, 50)
```

```
[-0.22603481  0.18219405  0.14234805 -0.529365
99 -0.05597928 -0.11619637
  0.18648741 -0.00675527 -0.10553605 -0.184322
76 -0.18391618  0.0371584
 -0.21090107 -0.05495312 -0.05989448  0.001685
78  0.02508071 -0.1552339
  0.04561668  0.05217044  0.01767509 -0.234749
42 -0.00212379 -0.18953898
 -0.2117985   0.13818566 -0.03957217 -0.096074
98 -0.1313086   0.10757296
  0.27171492 -0.08762729  0.13972145 -0.245058
62  0.07055349  0.40019021
  0.30766648  0.10271249  0.00800345  0.107214
45  0.19809488  0.30790366
 -0.05007584  0.55640632 -0.02711264  0.019195
6  -0.2827339   0.04990862
 -0.16155619 -0.21958311]
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [53]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_essays'])
# we are converting a dictionary with word as a key, and the
idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(t
fidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [54]:

```
# stronging variables into pickle files python: http://www.je
ssicayung.com/how-to-use-pickle-to-save-and-load-variables-in
-python/
```

```
# make sure you have the glove_vectors file
with open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai course/DonorsChoose_2018/glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [55]:

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

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

```
100%|██████████| 49041/49041 [01:34<00:00, 516.25it/s]
```

```
49041
300
```

In [56]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)

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

```
100%|██████████| 36052/36052 [01:11<00:00, 505.05it/s]
```

```
36052
300
```

In [57]:

```python
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_cv.append(vector)

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

```
100%|██████████| 24155/24155 [00:48<00:00, 502.33it/s]
```

```
24155
300
```

In [58]:

```python
# Similarly you can vectorize for title also
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_title'])
# 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 [59]:

```python
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/l
en(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weig
hted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_train.append(vector)

print(len(tfidf_w2v_title_train))
print(len(tfidf_w2v_title_train[0]))
```

```
100%|██████████| 49041/49041 [01:35<00:00, 513
.03it/s]
```

```
49041
300
```

In [60]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_test = []; # the avg-w2v for each sentence/re
view is stored in this list
for sentence in tqdm(X_test['preprocessed_title']): # for eac
h review/sentence
    vector = np.zeros(300) # as word vectors are of zero leng
th
    tf_idf_weight =0; # num of words with a valid vector in t
he 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 w
ord
            # here we are multiplying idf value(dictionary[wo
rd]) and the tf value((sentence.count(word)/len(sentence.spli
t())))
            tf_idf = dictionary[word]*(sentence.count(word)/l
en(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weig
hted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_test.append(vector)

print(len(tfidf_w2v_title_test))
print(len(tfidf_w2v_title_test[0]))
```

```
100%|██████████| 36052/36052 [01:12<00:00, 498
.63it/s]
```

```
36052
300
```

In [61]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_cv = []; # the avg-w2v for each sentence/revi
ew is stored in this list
for sentence in tqdm(X_cv['preprocessed_title']): # for each
review/sentence
    vector = np.zeros(300) # as word vectors are of zero leng
th
    tf_idf_weight =0; # num of words with a valid vector in t
he 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 w
ord
            # here we are multiplying idf value(dictionary[wo
rd]) and the tf value((sentence.count(word)/len(sentence.spli
t())))
            tf_idf = dictionary[word]*(sentence.count(word)/l
en(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weig
hted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_cv.append(vector)

print(len(tfidf_w2v_title_cv))
print(len(tfidf_w2v_title_cv[0]))
```

```
100%|██████████| 24155/24155 [00:46<00:00, 518
.12it/s]
```

```
24155
300
```

1.5.3 Vectorizing Numerical features

In [62]:

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

In [63]:

```
#scaling of price feature

# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4
&t=530s
# standardization sklearn: https://scikit-learn.org/stable/mo
dules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import Normalizer

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

price_scalar = Normalizer()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard deviation of this data


# Now standardize the data with above maen and variance.
price_standardized_train= price_scalar.transform(X_train['price'].values.reshape(-1, 1))
price_standardized_test= price_scalar.transform(X_test['price'].values.reshape(-1, 1))
price_standardized_cv= price_scalar.transform(X_cv['price'].values.reshape(-1, 1))

print("After vectorizations")
print(price_standardized_train.shape, y_train.shape)
print(price_standardized_test.shape, y_test.shape)
print(price_standardized_cv.shape, y_cv.shape)
```

```
After vectorizations
(49041, 1) (49041,)
(36052, 1) (36052,)
(24155, 1) (24155,)
```

In [64]:

```
#scaling of qunatity feature

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

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

quantity_scalar = Normalizer()
quantity_scalar.fit(X_train['quantity'].values.reshape(-1,1))
 # finding the mean and standard deviation of this data


# Now standardize the data with above maen and variance.
quantity_standardized_train= quantity_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
quantity_standardized_test= quantity_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_cv= quantity_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))

print("After vectorizations")
print(quantity_standardized_train.shape, y_train.shape)
print(quantity_standardized_test.shape, y_test.shape)
print(quantity_standardized_cv.shape, y_cv.shape)
```

```
After vectorizations
(49041, 1) (49041,)
(36052, 1) (36052,)
(24155, 1) (24155,)
```

In [65]:

```
#scaling of teachers number of previously posted projects

from sklearn.preprocessing import Normalizer

normalizer_projects_num = Normalizer()
```

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

normalizer_projects_num.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

prev_projects_train = normalizer_projects_num.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_projects_cv = normalizer_projects_num.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_projects_test = normalizer_projects_num.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [66]:

```python
# normalixing the title word count

from sklearn.preprocessing import Normalizer
```

```
normalizer_title_word = Normalizer()

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

title_word_count_train = normalizer_title_word.transform(X_tr
ain['title_word_count'].values.reshape(-1,1))
title_word_count_cv = normalizer_title_word.transform(X_cv['t
itle_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer_title_word.transform(X_tes
t['title_word_count'].values.reshape(-1,1))

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
==============================================
==============================================
========
```

In [67]:

```
# normalixing the essay word count

from sklearn.preprocessing import Normalizer

normalizer_ess_count = Normalizer()

normalizer_ess_count.fit(X_train['essay_word_count'].values.r
eshape(-1,1))
```

```
essay_word_count_train = normalizer_ess_count.transform(X_train['essay_word_count'].values.reshape(-1,1))
essay_word_count_cv = normalizer_ess_count.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer_ess_count.transform(X_test['essay_word_count'].values.reshape(-1,1))

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

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [68]:

```
#normalizing the data for  essay sentiment-pos
from sklearn.preprocessing import Normalizer
normalizer_pos = Normalizer()

normalizer_pos.fit(X_train['pos'].values.reshape(-1,1))

essay_sent_pos_train = normalizer_pos.transform(X_train['pos'].values.reshape(-1,1))
essay_sent_pos_cv = normalizer_pos.transform(X_cv['pos'].values.reshape(-1,1))
essay_sent_pos_test = normalizer_pos.transform(X_test['pos'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_pos_train.shape, y_train.shape)
print(essay_sent_pos_cv.shape, y_cv.shape)
print(essay_sent_pos_test.shape, y_test.shape)
```

```
After vectorizations
```

```
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [69]:

```
#normalizing the data for  essay sentiment-neg
from sklearn.preprocessing import Normalizer

normalizer_neg= Normalizer()

normalizer_neg.fit(X_train['neg'].values.reshape(-1,1))

essay_sent_neg_train = normalizer_neg.transform(X_train['neg'
].values.reshape(-1,1))
essay_sent_neg_cv = normalizer_neg.transform(X_cv['neg'].valu
es.reshape(-1,1))
essay_sent_neg_test = normalizer_neg.transform(X_test['neg'].
values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_neg_train.shape, y_train.shape)
print(essay_sent_neg_cv.shape, y_cv.shape)
print(essay_sent_neg_test.shape, y_test.shape)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [70]:

```
#normalizing the data for  essay sentiment-neu
from sklearn.preprocessing import Normalizer

normalizer_nue= Normalizer()

normalizer_nue.fit(X_train['neu'].values.reshape(-1,1))
```

```
essay_sent_nue_train = normalizer_nue.transform(X_train['neu'].values.reshape(-1,1))
essay_sent_nue_cv = normalizer_nue.transform(X_cv['neu'].values.reshape(-1,1))
essay_sent_nue_test = normalizer_nue.transform(X_test['neu'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_nue_train.shape, y_train.shape)
print(essay_sent_nue_cv.shape, y_cv.shape)
print(essay_sent_nue_test.shape, y_test.shape)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [71]:

```
#normalizing the data for  essay sentiment-compound
from sklearn.preprocessing import Normalizer

normalizer_compound= Normalizer()

normalizer_compound.fit(X_train['compound'].values.reshape(-1,1))

essay_sent_comp_train = normalizer_compound.transform(X_train['compound'].values.reshape(-1,1))
essay_sent_comp_cv = normalizer_compound.transform(X_cv['compound'].values.reshape(-1,1))
essay_sent_comp_test = normalizer_compound.transform(X_test['compound'].values.reshape(-1,1))

print("After vectorizations")
print(essay_sent_comp_train.shape, y_train.shape)
print(essay_sent_comp_cv.shape, y_cv.shape)
print(essay_sent_comp_test.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
==============================================
==============================================
========
```

1.5.4 Merging all the above features

In [72]:

```
from scipy.sparse import hstack

#define categorical and numerical features
cat_num_train=hstack((school_state_one_hot_train,categories_o
ne_hot_train,sub_categories_one_hot_train,teacher_prefix_one_
hot_train,project_grade_category_one_hot_train,price_standard
ized_train, quantity_standardized_train, prev_projects_train,
 title_word_count_train, essay_word_count_train, essay_sent_p
os_train, essay_sent_neg_train, essay_sent_nue_train, essay_s
ent_comp_train))

cat_num_test=hstack((school_state_one_hot_test,categories_one
_hot_test,sub_categories_one_hot_test,teacher_prefix_one_hot_
test,project_grade_category_one_hot_test, price_standardized_
test, quantity_standardized_test, prev_projects_test, title_w
ord_count_test, essay_word_count_test, essay_sent_pos_test, e
ssay_sent_neg_test, essay_sent_nue_test, essay_sent_comp_test
))

cat_num_cv=hstack((school_state_one_hot_cv,categories_one_hot
_cv,sub_categories_one_hot_cv,teacher_prefix_one_hot_cv,project_grade_category_one_hot_cv, price_standardized_cv, quantity_standardized_cv, prev_projects_cv, title_word_count_cv, essay_word_count_cv, essay_sent_pos_cv, essay_sent_neg_cv, essay_sent_nue_cv, essay_sent_comp_cv))

#combining categorical  numerical ,project_title(BOW)  and preprocessed_essay (BOW)
set1_train = hstack((cat_num_train, text_bow_train,title_bow_train))
set1_test = hstack((cat_num_test, text_bow_test,title_bow_test))
set1_cv = hstack((cat_num_cv, text_bow_cv,title_bow_cv))

#categorical +numerical + project_title(TFIDF)+ preprocessed_essay (TFIDF)
set2_train = hstack((cat_num_train, text_tfidf_train, title_tfidf_train))
set2_test = hstack((cat_num_test, text_tfidf_test, title_tfidf_test))
set2_cv = hstack((cat_num_cv, text_tfidf_cv, title_tfidf_cv))

#categorical ,numerical + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)

set3_train = hstack((cat_num_train, essay_vectors_train,title_vectors_train))
set3_test = hstack((cat_num_test, essay_vectors_test,title_vectors_test))
set3_cv = hstack((cat_num_cv, essay_vectors_cv,title_vectors_cv))

#categorical ,numerical+project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

set4_train = hstack((cat_num_train, tfidf_w2v_vectors_train,
tfidf_w2v_title_train))
```

```
set4_test = hstack((cat_num_test, tfidf_w2v_vectors_test, tfidf_w2v_title_test))
set4_cv = hstack((cat_num_cv, tfidf_w2v_vectors_cv, tfidf_w2v_title_cv))
```

In [170]:

```
#saving all the variables for future use

import pickle
f=open('set1_dt.pckl','wb')
pickle.dump([set1_train, set1_test, set1_cv],f)
f.close()
```

In [171]:

```
import pickle
f=open('set2_dt.pckl','wb')
pickle.dump([set2_train, set2_test, set2_cv],f)
f.close()
```

In [174]:

```
import pickle
f=open('set3.pckl','wb')
pickle.dump([set3_train, set3_test, set3_cv],f)
f.close()
```

In [175]:

```
import pickle
f=open('set4.pckl','wb')
pickle.dump([set4_train, set4_test, set4_cv],f)
f.close()
```

In [176]:

```
import pickle
f=open('y_values.pckl','wb')
```

```
pickle.dump([y_train,y_test,y_cv],f)
f.close()
```

In [1]:

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set1_dt.pckl','rb')
set1_train, set1_test, set1_cv=pickle.load(f)
f.close()
```

In [1]:

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set2_dt.pckl','rb')
set2_train, set2_test, set2_cv=pickle.load(f)
f.close()
```

In [2]:

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/y_values.pckl','rb')
y_train,y_test,y_cv=pickle.load(f)
f.close()
```

In [3]:

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/dt_features.pckl','rb')
bow_features_names,tfidf_features_names=pickle.load(f)
f.close()
```

In [ ]:

```
#saving all the variables for future use

import pickle
f=open('dt_features.pckl','wb')
pickle.dump([bow_features_names,tfidf_features_names],f)
f.close()
```

In [1]:

```
'''import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set1.pckl','rb')
set1_train, set1_test, set1_cv=pickle.load(f)
f.close()

import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set2.pckl','rb')
set2_train, set2_test, set2_cv=pickle.load(f)
f.close()

import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set3.pckl','rb')
set3_train, set3_test, set3_cv=pickle.load(f)
f.close()
```

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/set4.pckl','rb')
set4_train, set4_test, set4_cv=pickle.load(f)
f.close()

import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied
 ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai
course/DonorsChoose_2018/y_values.pckl','rb')
y_train,y_test,y_cv=pickle.load(f)
f.close()
'''
```

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 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 with predicted and original labels of test data points

- Once after you plot the confusion matrix with the test data, get all the `false positive data points`
    - Plot the WordCloud WordCloud
    - 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_`, 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

2. Decision Tree

2.4.1 Applying Decision Trees on BOW set1 , SET 1

In [73]:

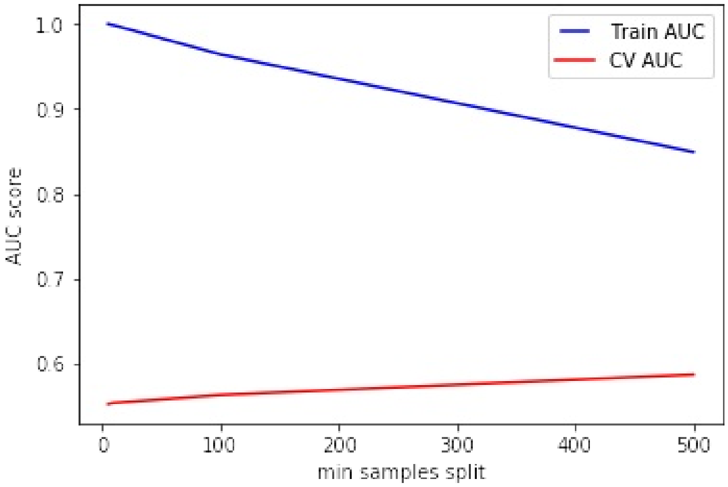
```
#preparing data
X_tr=set1_train.tocsr()
X_cr=set1_cv.tocsr()
X_te=set1_test.tocsr()
```

hyperparameter tuning

In [74]:

```
%%time
# tuning of hyperparameter min samples split
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

min_samples=[5, 10, 100, 500]

train_results = []
cv_results = []

for i in min_samples:
    classifier = DecisionTreeClassifier(min_samples_split = i
,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)
```

```
from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(min_samples, train_results, 'b', label="Train AUC")
line2, = plt.plot(min_samples, cv_results, 'r', label="CV AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("min samples split")
plt.show()
```

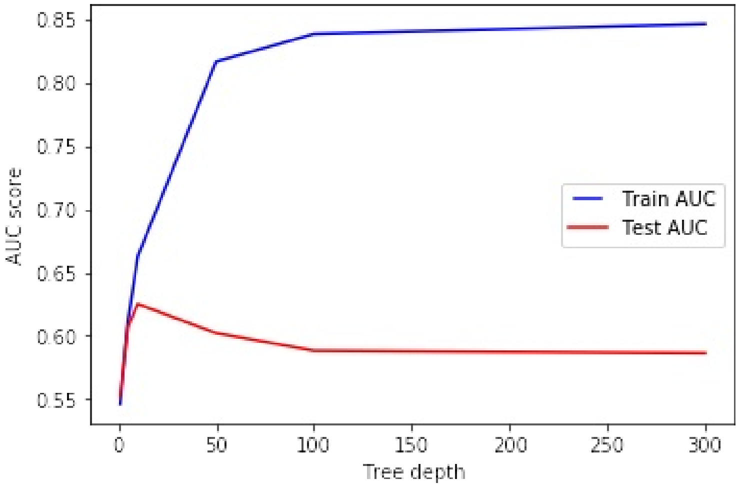


```
Wall time: 5min 17s
```

let us consider value of 500 as min samples split

In [75]:

```
%%time
#tuning of hyperparameter max depth
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

max_depth_param=[1, 5, 10, 50, 100, 300]

train_results = []
cv_results = []

for i in max_depth_param:
    classifier = DecisionTreeClassifier(max_depth=i ,min_samples_split =500,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(max_depth_param, train_results, 'b', label="Train AUC")
line2, = plt.plot(max_depth_param, cv_results, 'r', label="Test AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("Tree depth")
plt.show()
```



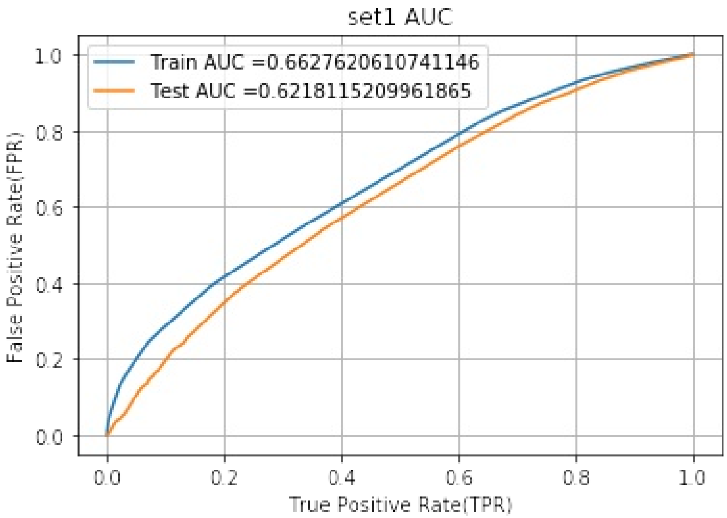
```
Wall time: 1min 29s
```

we can infer that as tree depth incresasing the model is overfitting.considering tree depth close to 10 we get train AUC max with gap between both the curves is min.

max_depth=10 ,min_samples_split =500

In [79]:

```
# finding the train and test AU
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
model = DecisionTreeClassifier(max_depth=10 ,min_samples_split =500,class_weight='balanced')
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.predict_proba(X_tr)[:,1]
y_test_pred = model.predict_proba(X_te)[:,1]



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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("set1 AUC")
plt.grid()
plt.show()
```



Confusion matrix

In [80]:

```
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 a
nd tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)
), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [81]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thre
sholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24433187240
951215 for threshold 0.477
[[ 3145  4260]
 [ 9675 31961]]
```

In [82]:

```
conf_matr_df_trainl2_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

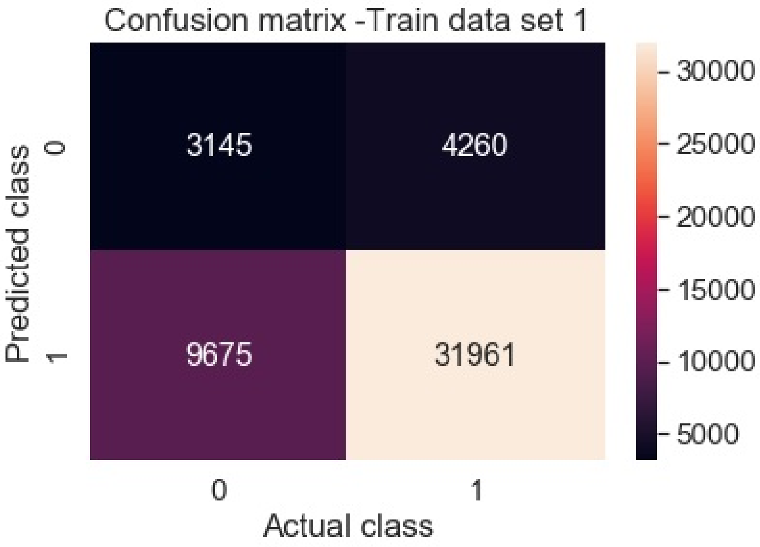
```
the maximum value of tpr*(1-fpr) 0.24433187240951215 for threshold 0.477
```

In [83]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_trainl2_1, annot=True,annot_kws={"size": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Train data set 1")
```

Out[83]:

```
Text(0.5, 1.0, 'Confusion matrix -Train data set 1')
```



In [87]:

```
from sklearn.metrics import confusion_matrix
```

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.23986239524403458 for threshold 0.477
[[ 2213  3329]
 [ 7370 23140]]
```

In [88]:

```
conf_matr_df_testl2_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

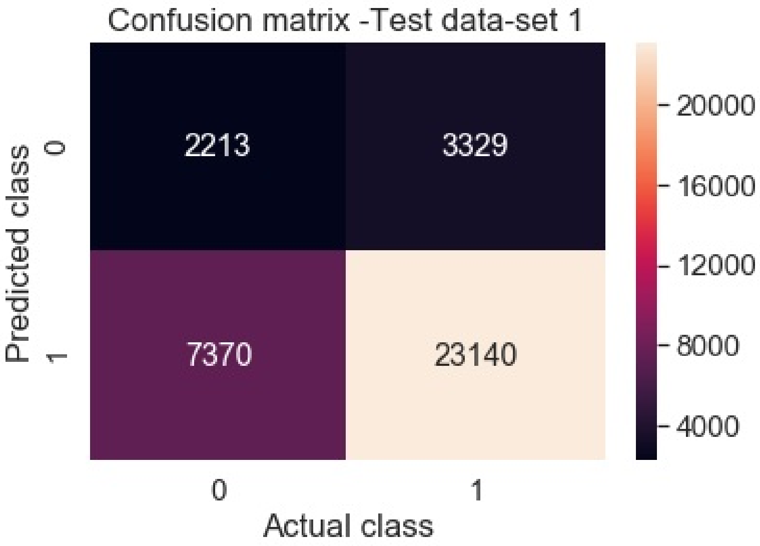
```
the maximum value of tpr*(1-fpr) 0.23986239524403458 for threshold 0.477
```

In [89]:

```
#for label size
import seaborn as sns
sns.set(font_scale=1.4)
sns.heatmap(conf_matr_df_testl2_1, annot=True,annot_kws={"size": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Test data-set 1")
```

Out[89]:

```
Text(0.5, 1.0, 'Confusion matrix -Test data-set 1')
```


Confusion matrix -Test data-set 1
Predicted class
0
1
2213
3329
7370
23140
0
1
Actual class
20000
16000
12000
8000
4000

Obtaining the False Positive words from BOW encoded Essays

In [90]:

```
#storingbow features
#from sklearn.feature_extraction.text import CountVectorizer

#vectorizer_bow_essay = CountVectorizer(min_df=10, ngram_range =(1,2),max_features=5000)
#vectorizer_bow_essay.fit(X_train['preprocessed_essays'])
#text_bow_train= vectorizer_bow_essay.transform(X_train['preprocessed_essays'])
#text_bow_test= vectorizer_bow_essay.transform(X_test['preprocessed_essays'])
#text_bow_cv= vectorizer_bow_essay.transform(X_cv['preprocessed_essays'])

bow_feature_names=vectorizer_bow_essay.get_feature_names()
```

In [91]:

```
bow_test=text_bow_test.todense()
```

In [92]:

```
bow_test.shape
```

Out[92]:

```
(36052, 5000)
```

In [93]:

```
y_test_converted = list(y_test[::])
```

In [94]:

```
false_positives_index_a = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= 0.477:
        false_positives_index_a.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████| 36052/36052 [00:00<00:00, 672
976.23it/s]
```

In [95]:

```
fp_count
```

Out[95]:

```
3514
```

In [96]:

```
df1 = pd.DataFrame(bow_test)
df1_final = df1.iloc[false_positives_index_a,:]
```

In [97]:

```
best_indices = []

for j in range(5000):

    s = df1_final[j].sum()

    if s >= 100 :
        best_indices.append(j)
    else :
        continue
```

In [98]:

```
len(best_indices)
```

Out[98]:

```
980
```

In [99]:

```
fp_words = []

for a in best_indices :
    fp_words.append(str(bow_feature_names[a]))
```

In [100]:

```
len(fp_words)
```

Out[100]:

```
980
```

In [101]:

```
fp_words[0:10]
```

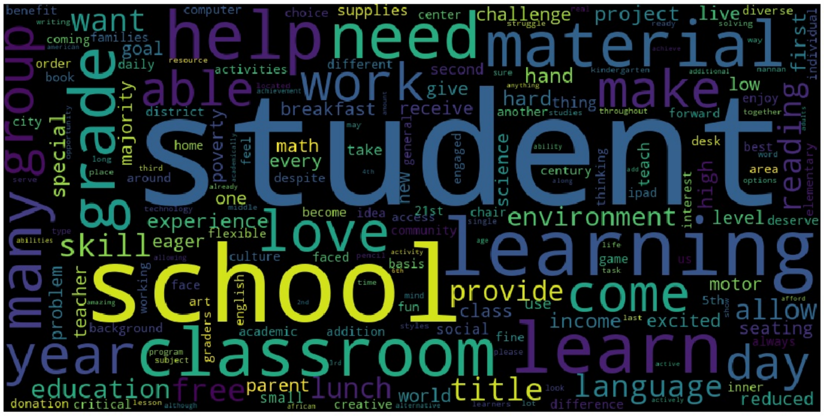
Out[101]:

```
['100',
 '21st',
 '21st century',
 '2nd',
 '3rd',
 '4th',
 '5th',
 '5th grade',
 '6th',
 '90']
```

word cloud for False Positive words

In [102]:

```
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(un
ique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



Box - Plot with the price of the False positive data points

In [103]:

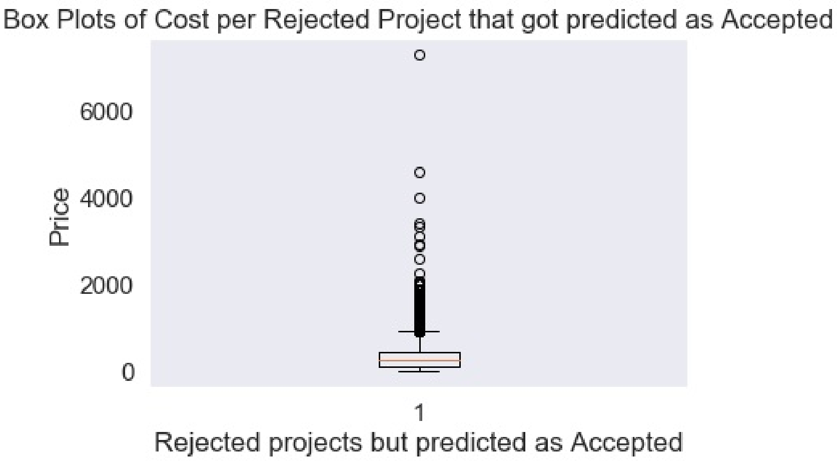
```
len(false_positives_index_a)
```

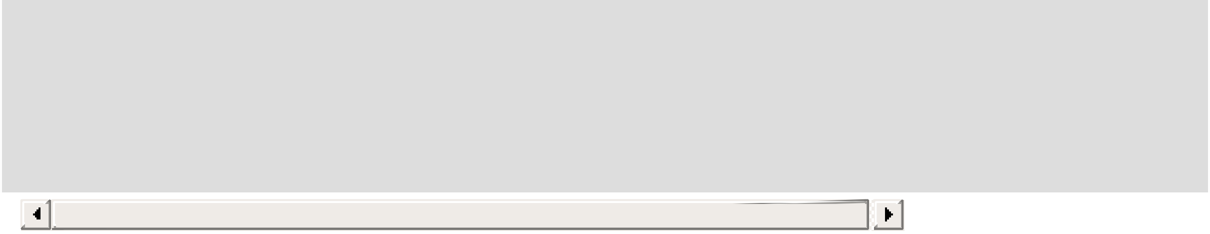
Out[103]:

```
3514
```

In [104]:

```
df= pd.DataFrame(X_test['price'])

df2_final = df.iloc[false_positives_index_a,:]

plt.boxplot(df2_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```





it means many projects which are wrongly classified as positive costs close to less than 500 dollars

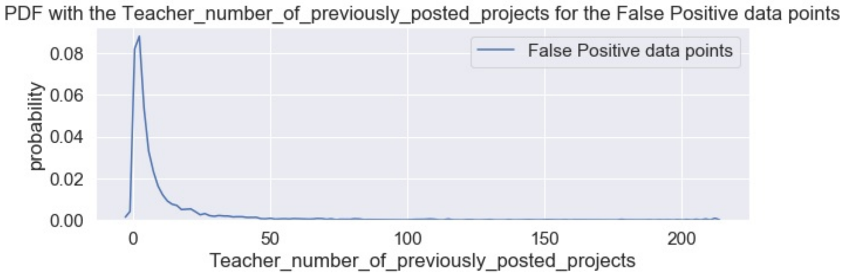
PDF with the Teacher_number_of_previously_poste of these False Positive data points

In [105]:

```
df= pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])

df3_final = df.iloc[false_positives_index_a,:]
```

In [106]:

```
plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [107]:

```
set1_train.shape
```

Out[107]:

```
(49041, 5240)
```

In [108]:

```
bow_features_names = []
```

In [109]:

```
for c in vectorizer_schoolstate.get_feature_names() :
    bow_features_names.append(c)

for a in vectorizer_categories.get_feature_names() :
    bow_features_names.append(a)

for b in vectorizer_subcategories.get_feature_names() :
    bow_features_names.append(b)

for e in vectorizer_teacher_prefix.get_feature_names() :
    bow_features_names.append(e)

for d in vectorizer_project_grade_category.get_feature_names(
) :
    bow_features_names.append(d)

bow_features_names.append("price")
bow_features_names.append("quantity")
bow_features_names.append("previous posted projects")
bow_features_names.append("count words title")
bow_features_names.append("essay word count")
bow_features_names.append("pos")
bow_features_names.append("neg")
bow_features_names.append("nue")
bow_features_names.append("compound")

for f in vectorizer_bow_essay.get_feature_names() :
    bow_features_names.append(f)

for g in vectorizer_bow_title.get_feature_names() :
    bow_features_names.append(g)
```

In [110]:

```
len(bow_features_names)
```

Out[110]:

```
5240
```

In [111]:

```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(max_depth=3)
```

In [112]:

```
X_tr=set1_train.tocsr()
```

In [113]:

```
clf = dtree.fit(X_tr, y_train)
```

In [115]:

```
# Visualize data
import graphviz
from sklearn import tree
from graphviz import Source
```

```
dot_data = tree.export_graphviz(dtree, out_file= None, feature_names=bow_features_names)

graph = graphviz.Source(dot_data)
graph.render("Bow Tree",view = True)
```

Out[115]:

```
'Bow Tree.pdf'
```

2.4.2 Applying Decision Trees on TFIDF, SET 2

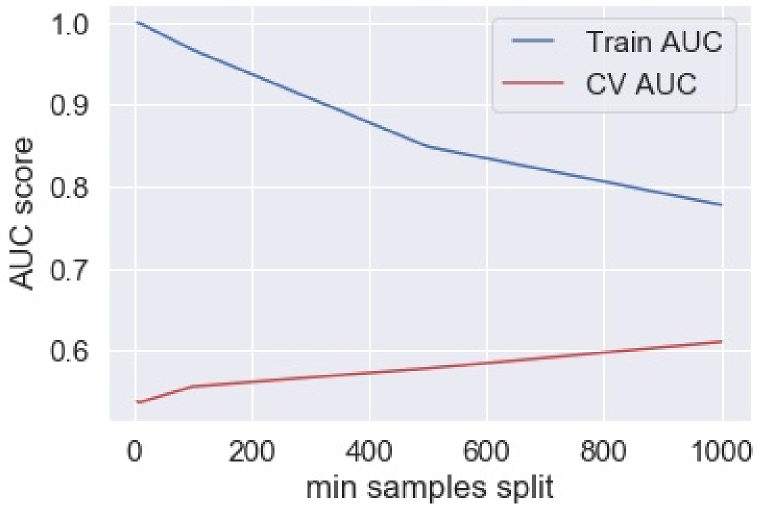
In [116]:

```
#preparing data
X_tr=set2_train.tocsr()
X_cr=set2_cv.tocsr()
X_te=set2_test.tocsr()
```

hyperparameter tuning

In [117]:

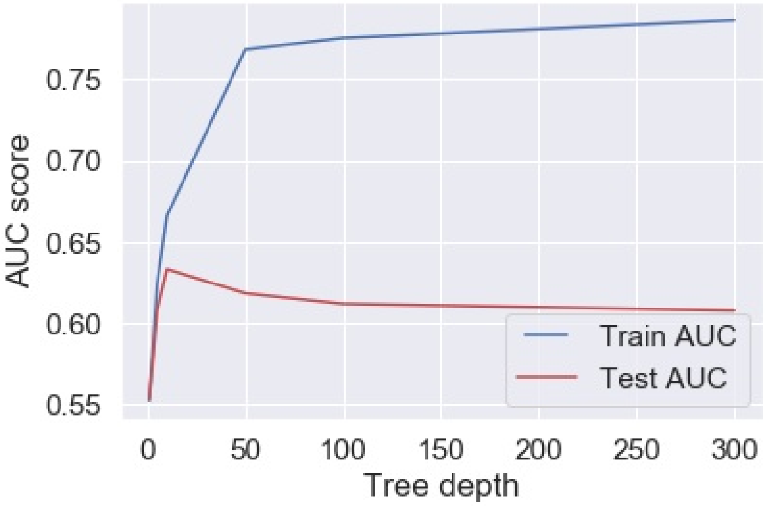
```
# tuning of hyperparameter min samples split
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

min_samples=[5, 10, 100, 500,1000]

train_results = []
cv_results = []

for i in min_samples:
    classifier = DecisionTreeClassifier(min_samples_split = i
,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(min_samples, train_results, 'b', label="Tra
in AUC")
line2, = plt.plot(min_samples, cv_results, 'r', label="CV AUC
")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("min samples split")
plt.show()
```



Though the train AUC seems close to 1 which means the data seems to overfit with min split close to zero and it tends to fit somewhat better with increase in value of min samples split.let us consider min split value as 1000 in this case for best results.

In [118]:

```
%%time
#tuning of hyperparameter max depth
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

max_depth_param=[1, 5, 10, 50, 100, 300]

train_results = []
cv_results = []

for i in max_depth_param:
    classifier = DecisionTreeClassifier(max_depth=i ,min_samples_split =1000,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(max_depth_param, train_results, 'b', label="Train AUC")
line2, = plt.plot(max_depth_param, cv_results, 'r', label="Test AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("Tree depth")
plt.show()
```



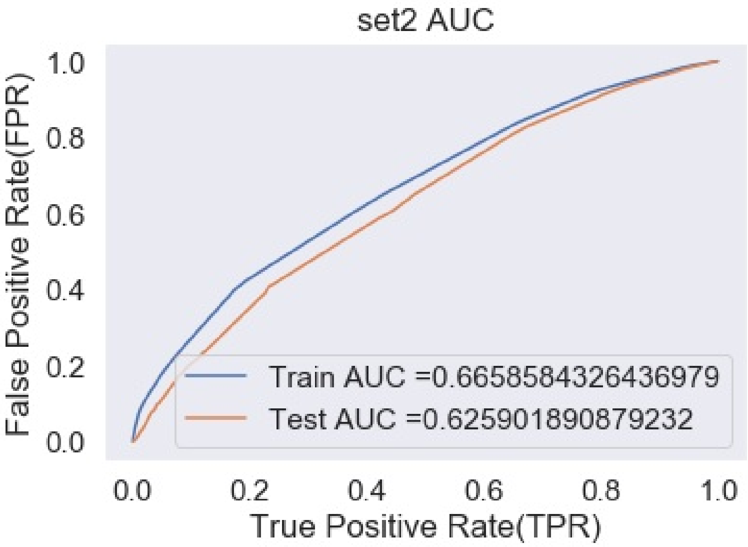
```
Wall time: 1min 28s
```

we can infer that as tree depth incresasing the model is overfitting.considering tree depth close to 10 we get train AUC max with gap between both the curves is min.

hyperparameter values #max_depth=10 ,min_samples_split =1000

In [119]:

```
# finding the train and test AU
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
model1 = DecisionTreeClassifier(max_depth = 10 ,min_samples_split = 1000,class_weight='balanced')
model1.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model1.predict_proba(X_tr)[:,1]
y_test_pred = model1.predict_proba(X_te)[:,1]


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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("set2 AUC")
plt.grid()
plt.show()
```



Confusion matrix

In [120]:

```
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 a
nd tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)
), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [121]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thre
sholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24629882632
179567 for threshold 0.452
[[ 4153  3252]
 [14200 27436]]
```

In [122]:

```
conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train,
 predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)),
 range(2),range(2))
```

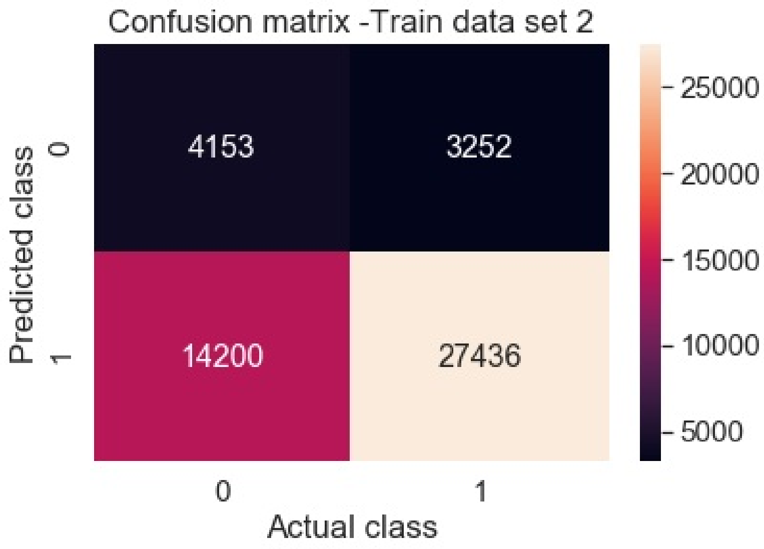
```
the maximum value of tpr*(1-fpr) 0.24629882632
179567 for threshold 0.452
```

In [123]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Train data set 2")
```

Out[123]:

```
Text(0.5, 1.0, 'Confusion matrix -Train data s
et 2')
```



In [124]:

```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24945819079
680365 for threshold 0.452
[[ 2900  2642]
 [10819 19691]]
```

In [125]:

```
conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

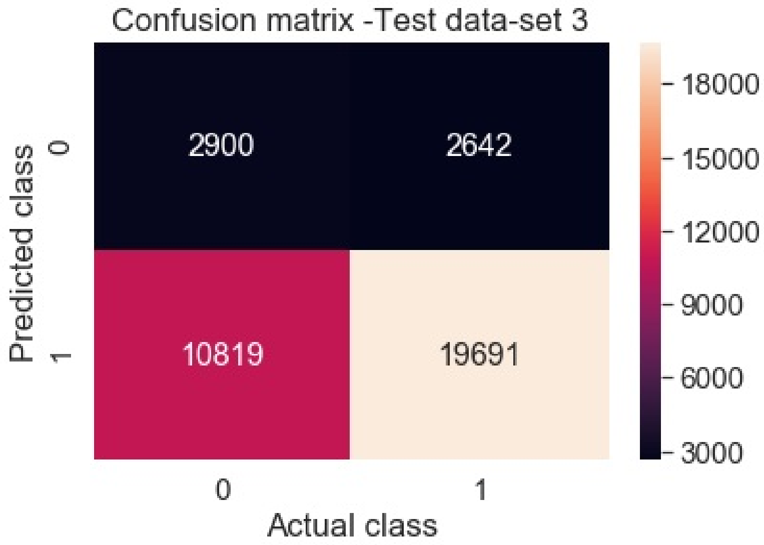
```
the maximum value of tpr*(1-fpr) 0.24945819079
680365 for threshold 0.452
```

In [126]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Test data-set 3")
```

Out[126]:

```
Text(0.5, 1.0, 'Confusion matrix -Test data-se
t 3')
```



Obtaining the False Positive words from TFIDF encoded Essays

In [127]:

```
#considering the features of TFIDF preprocessed essay
#from sklearn.feature_extraction.text import TfidfVectorizer

#vectorizer_tfidf_essay= TfidfVectorizer(min_df=10,ngram_range =(1,2),max_features=5000)
#vectorizer_tfidf_essay.fit(X_train['preprocessed_essays'])

#text_tfidf_train= vectorizer_tfidf_essay.transform(X_train['preprocessed_essays'])
#text_tfidf_test= vectorizer_tfidf_essay.transform(X_test['preprocessed_essays'])
#text_tfidf_cv = vectorizer_tfidf_essay.transform(X_cv['preprocessed_essays'])
feature_names_tfidf=vectorizer_tfidf_essay.get_feature_names()
```

In [128]:

```
len(feature_names_tfidf)
```

Out[128]:

```
5000
```

In [129]:

```
tfidf_test=text_tfidf_test.todense()
```

In [130]:

```
tfidf_test.shape
```

Out[130]:

```
(36052, 5000)
```

In [131]:

```
y_test_converted = list(y_test[::])
```

In [132]:

```
false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= 0.452:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue
```

```
100%|██████████| 36052/36052 [00:00<00:00, 840
684.32it/s]
```

In [133]:

```
fp_count
```

Out[133]:

```
2900
```

In [134]:

```
len(false_positives_index_b)
```

Out[134]:

```
2900
```

In [135]:

```
df2= pd.DataFrame(tfidf_test)
```

In [136]:

```
df2.shape
```

Out[136]:

```
(36052, 5000)
```

In [137]:

```
df2_final = df2.iloc[false_positives_index_a,:]
```

In [138]:

```
df2_final.shape
```

Out[138]:

```
(3514, 5000)
```

In [140]:

```
best_indices_b = []

for j in range(5000):

    s = df2_final[j].sum()

    if s >= 10 :
        best_indices_b.append(j)
    else :
        continue
```

In [141]:

```
len(best_indices_b)
```

Out[141]:

```
764
```

In [142]:

```
fp_words = []

for a in best_indices_b :
    fp_words.append(str(feature_names_tfidf[a]))

len(fp_words)
```

Out[142]:

```
764
```

In [143]:

```
fp_words[0:10]
```

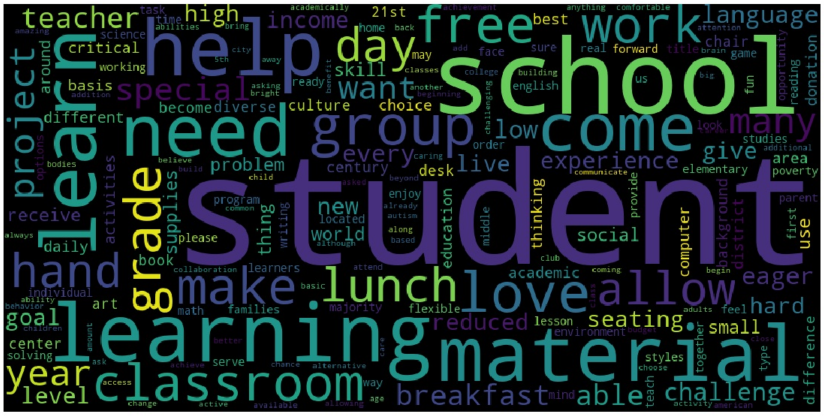
Out[143]:

```
['100',
 '21st',
 '21st century',
 '5th',
 'abilities',
 'ability',
 'able',
 'academic',
 'academically',
 'academics']
```

word cloud for False Positive words

In [144]:

```
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



Box - Plot with the price of the False positive data points

In [145]:

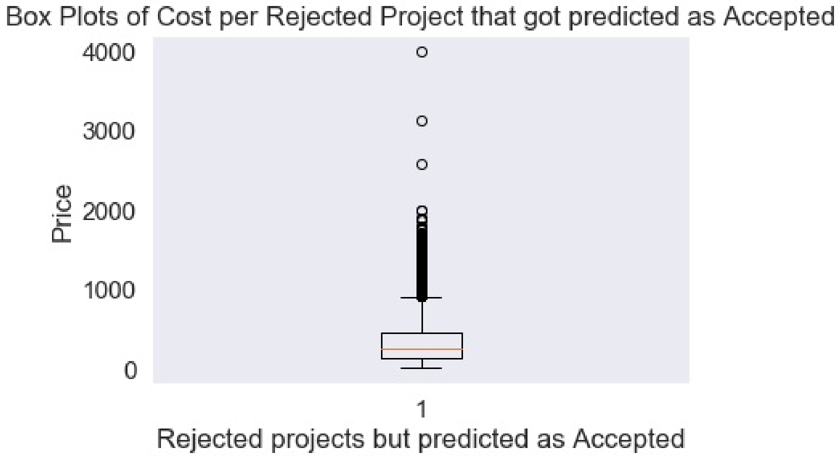
```
len(false_positives_index_b)
```

Out[145]:

```
2900
```

In [146]:

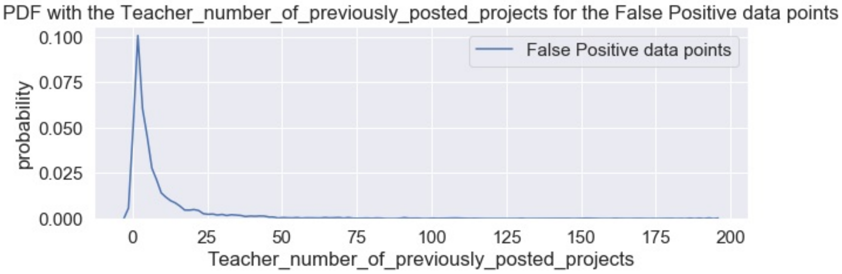
```
df= pd.DataFrame(X_test['price'])

df2_final = df.iloc[false_positives_index_b,:]

plt.boxplot(df2_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()

#it means many projects which are wrongly classified as positive costs close to less than 500 dollars
```



PDF with the Teacher_number_of_previously_posted_ of these False Positive data points

In [147]:

```
df= pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])

df3_final = df.iloc[false_positives_index_b,:]



plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```



2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [148]:

```
set2_train.shape
```

Out[148]:

```
(49041, 5240)
```

In [149]:

```
tfidf_features_names=[]
```

In [150]:

```
for c in vectorizer_schoolstate.get_feature_names() :
    tfidf_features_names.append(c)

for a in vectorizer_categories.get_feature_names() :
    tfidf_features_names.append(a)

for b in vectorizer_subcategories.get_feature_names() :
    tfidf_features_names.append(b)

for e in vectorizer_teacher_prefix.get_feature_names() :
    tfidf_features_names.append(e)

for d in vectorizer_project_grade_category.get_feature_names(
) :
    tfidf_features_names.append(d)



tfidf_features_names.append("price")
tfidf_features_names.append("quantity")
tfidf_features_names.append("previous posted projects")
tfidf_features_names.append("count words title")
tfidf_features_names.append("essay word count")
tfidf_features_names.append("pos")
tfidf_features_names.append("neg")
tfidf_features_names.append("nue")
tfidf_features_names.append("compound")

for f in vectorizer_tfidf_essay.get_feature_names() :
    tfidf_features_names.append(f)



for g in vectorizer_tfidf_title.get_feature_names() :
    tfidf_features_names.append(g)
```

In [151]:

```
len(tfidf_features_names)
```

Out[151]:

```
5240
```

In [172]:

```
#saving all the variables for future use

import pickle
f=open('dt_features.pckl','wb')
pickle.dump([bow_features_names,tfidf_features_names],f)
f.close()
```

In [152]:

```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(max_depth=3)
clf = dtree.fit(X_tr, y_train)
```

In [153]:

```
# Visualize data
import graphviz
from sklearn import tree
from graphviz import Source

dot_data = tree.export_graphviz(dtree, out_file= None, featur
e_names=tfidf_features_names)

graph = graphviz.Source(dot_data)
graph.render("TFIDF tree",view = True)
```

Out[153]:

```
'TFIDF tree.pdf'
```

2.4.3 Applying Decision Trees on AVG W2V, SET 3

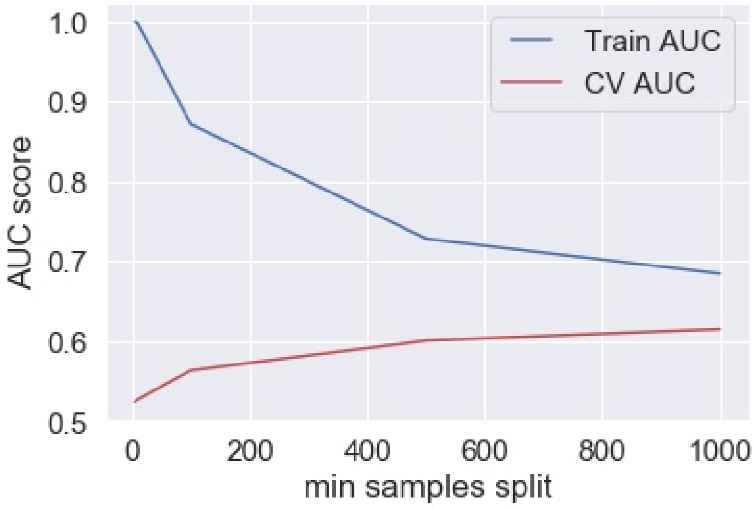
In [154]:

```
#preparing data
X_tr=set3_train.tocsr()
X_cr=set3_cv.tocsr()
X_te=set3_test.tocsr()
```

hyperparameter tuning

In [155]:

```
%%time
# tuning of hyperparameter min samples split
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

min_samples=[5, 10, 100, 500,1000]

train_results = []
cv_results = []

for i in min_samples:
    classifier = DecisionTreeClassifier(min_samples_split = i
,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(min_samples, train_results, 'b', label="Train AUC")
line2, = plt.plot(min_samples, cv_results, 'r', label="CV AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("min samples split")
plt.show()
```

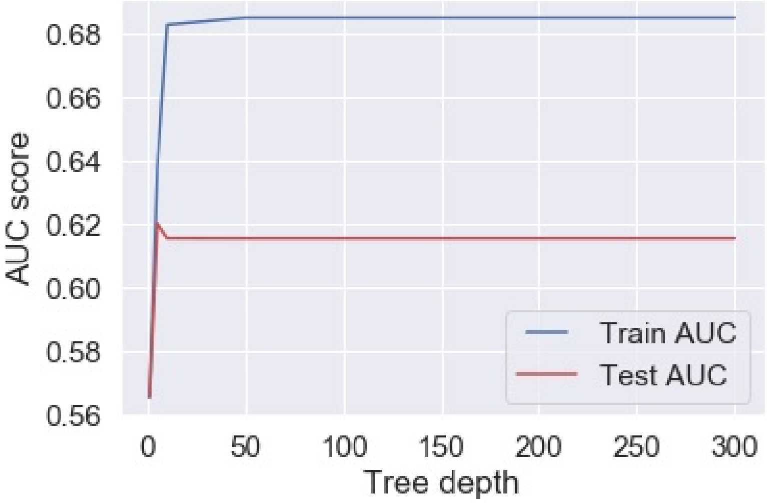


```
Wall time: 50.5 s
```

we can observe from this hyperparameter that as min split value increases the AUC value is becoming better .let us consider value of 1000 as min samples split

In [156]:

```
%%time
#tuning of hyperparameter max depth
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

max_depth_param=[1, 5, 10, 50, 100, 300]

train_results = []
cv_results = []

for i in max_depth_param:
    classifier = DecisionTreeClassifier(max_depth=i ,min_samp
les_split =1000,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(max_depth_param, train_results, 'b', label=
"Train AUC")
line2, = plt.plot(max_depth_param, cv_results, 'r', label="Te
st AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("Tree depth")
plt.show()
```



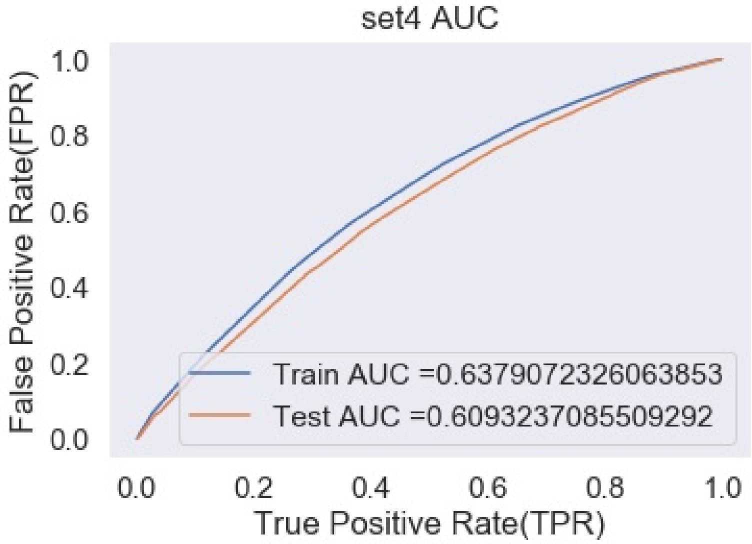
```
Wall time: 15.8 s
```

we can infer that as tree depth incresasing the model is overfitting.considering tree depth close to 5 we get train AUC max with gap between both the curves is min.

max_depth=05 ,min_samples_split =1000

In [157]:

```
# finding the train and test AU
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
model = DecisionTreeClassifier(max_depth=5 ,min_samples_split =1000,class_weight='balanced')
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.predict_proba(X_tr)[:,1]
y_test_pred = model.predict_proba(X_te)[:,1]



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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("set4 AUC")
plt.grid()
plt.show()
```



Confusion matrix

In [158]:

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

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

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

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [159]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thre
sholds, train_fpr, train_fpr)))

conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train,
 predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)),
 range(2),range(2))
```

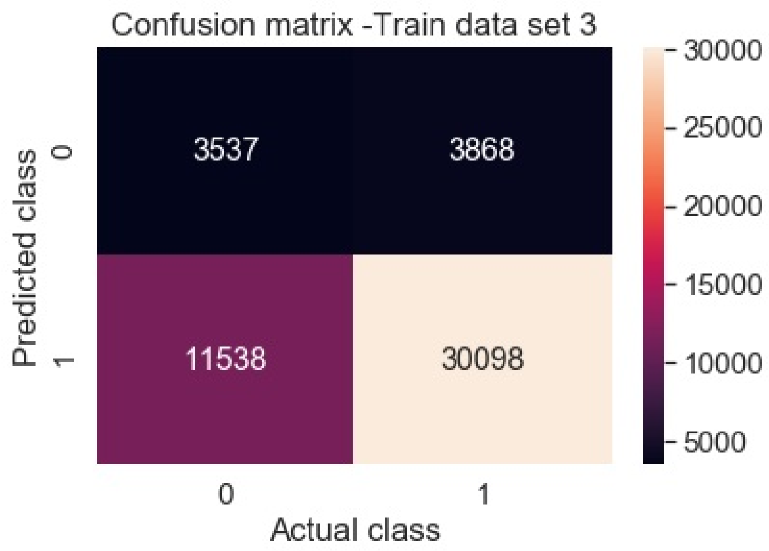
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24950048806
375238 for threshold 0.493
[[ 3537  3868]
 [11538 30098]]
the maximum value of tpr*(1-fpr) 0.24950048806
375238 for threshold 0.493
```

In [160]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Train data set 3")
```

Out[160]:

```
Text(0.5, 1.0, 'Confusion matrix -Train data s
et 3')
```



In [161]:

```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24987077454915652 for threshold 0.497
[[ 2708  2834]
 [10057 20453]]
```

In [162]:

```
conf_matr_df_test_3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

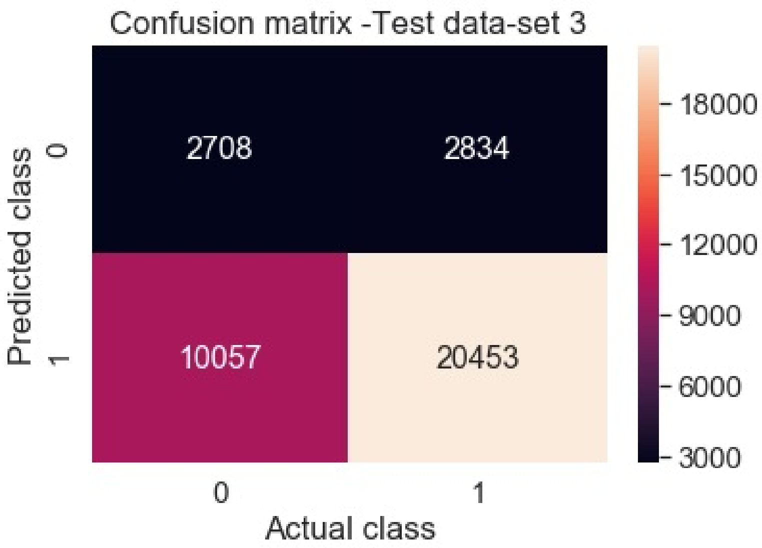
```
the maximum value of tpr*(1-fpr) 0.24987077454915652 for threshold 0.497
```

In [163]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Test data-set 3")
```

Out[163]:

```
Text(0.5, 1.0, 'Confusion matrix -Test data-se
t 3')
```



2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

In [164]:

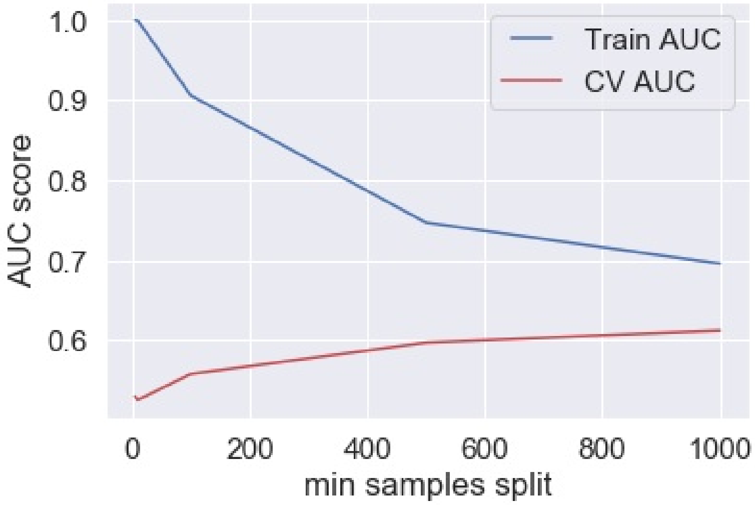
```
#preparing data
X_tr=set4_train.tocsr()
X_cr=set4_cv.tocsr()
X_te=set4_test.tocsr()
```

hyperparameter tuning

In [165]:

```
# tuning of hyperparameter min samples split
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

min_samples=[5, 10, 100, 500,1000]

train_results = []
cv_results = []

for i in min_samples:
    classifier = DecisionTreeClassifier(min_samples_split = i
,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc
_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(min_samples, train_results, 'b', label="Tra
in AUC")
```

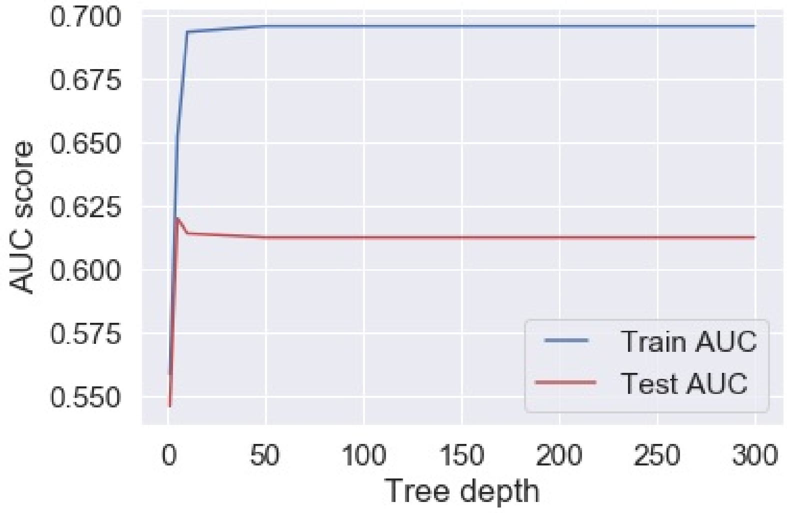
```
line2, = plt.plot(min_samples, cv_results, 'r', label="CV AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("min samples split")
plt.show()
```



we can infer that as min samples split increases the gap between ttrain and CV decreases.let us consider value of 1000 as min samples split

In [166]:

```
#tuning of hyperparameter max depth
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

max_depth_param=[1, 5, 10, 50, 100, 300]

train_results = []
cv_results = []

for i in max_depth_param:
    classifier = DecisionTreeClassifier(max_depth=i ,min_samples_split =1000,class_weight='balanced')
    classifier.fit(X_tr, y_train)

    y_train_pred = classifier.predict_proba(X_tr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_train, y_train_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous train results
    train_results.append(roc_auc)

    y_cv_pred = classifier.predict_proba(X_cr)[:,1]
    false_positive_rate, true_positive_rate, thresholds = roc_curve(y_cv, y_cv_pred)
    roc_auc = auc(false_positive_rate, true_positive_rate)
    # Add auc score to previous test results
    cv_results.append(roc_auc)

from matplotlib.legend_handler import HandlerLine2D
line1, = plt.plot(max_depth_param, train_results, 'b', label="Train AUC")
line2, = plt.plot(max_depth_param, cv_results, 'r', label="Test AUC")

plt.legend(handler_map={line1: HandlerLine2D(numpoints=2)})
plt.ylabel("AUC score")
plt.xlabel("Tree depth")
plt.show()
```

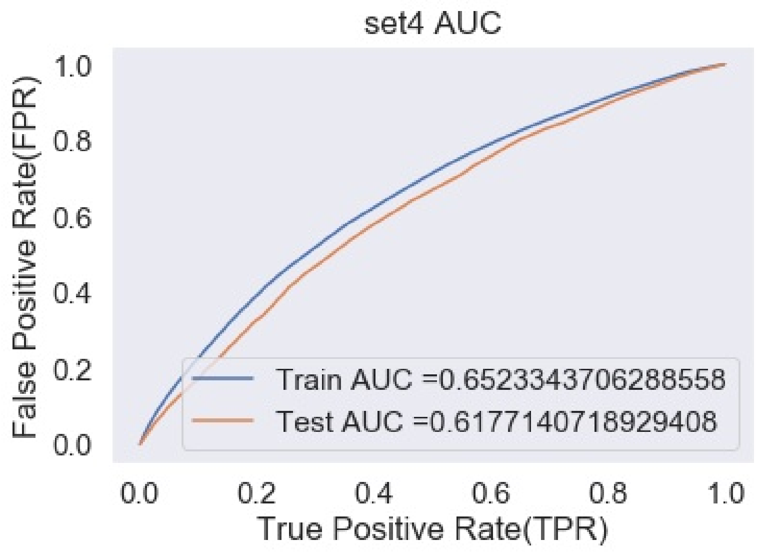


we can infer that as tree depth increasing the model is overfitting.considering tree depth close to 5 we get train AUC max with gap between both the curves is min.

max_depth=5 ,min_samples_split =1000

In [167]:

```python
# finding the train and test AU
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
model = DecisionTreeClassifier(max_depth=5 ,min_samples_split =1000,class_weight='balanced')
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.predict_proba(X_tr)[:,1]
y_test_pred = model.predict_proba(X_te)[:,1]



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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("set4 AUC")
plt.grid()
plt.show()
```



In [168]:

```
# Confusion matrix

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

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

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

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)
), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [169]:

```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24998412937
952302 for threshold 0.473
[[ 3673  3732]
 [11776 29860]]
```

In [170]:

```
conf_matr_df_train_4 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

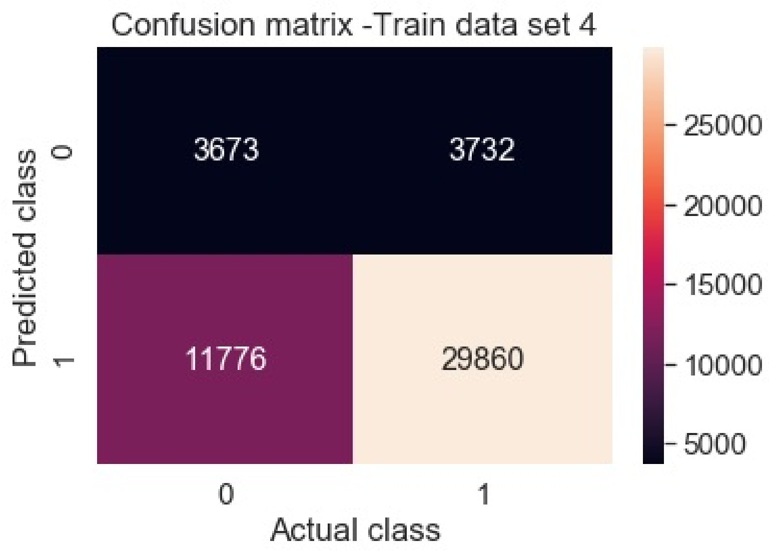
```
the maximum value of tpr*(1-fpr) 0.24998412937
952302 for threshold 0.473
```

In [171]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Train data set 4")
```

Out[171]:

```
Text(0.5, 1.0, 'Confusion matrix -Train data s
et 4')
```



In [172]:

```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24955430405729495 for threshold 0.476
[[ 2888  2654]
 [10619 19891]]
```

In [173]:

```
conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

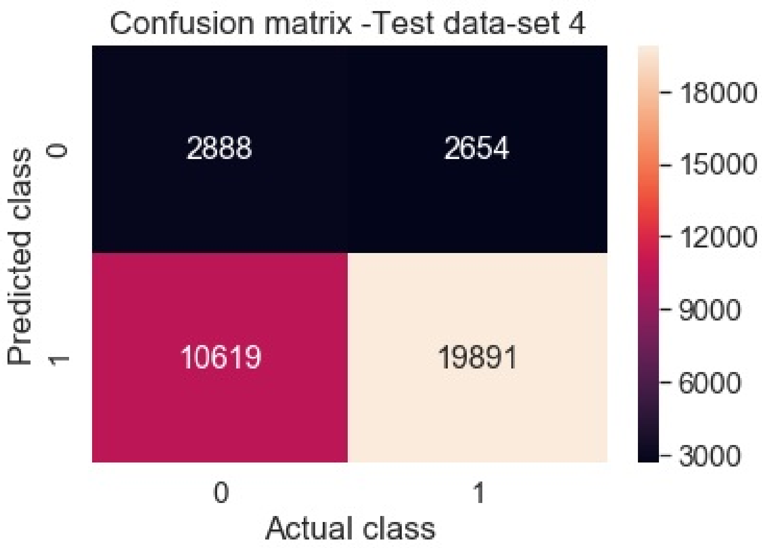
```
the maximum value of tpr*(1-fpr) 0.24955430405729495 for threshold 0.476
```

In [174]:

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

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -Test data-set 4")
```

Out[174]:

```
Text(0.5, 1.0, 'Confusion matrix -Test data-se
t 4')
```



2.5 [Task-2]Getting top 5k features using $feature_imp$ or $\tan ces$

In [3]:

```
#importing varibales from the stored pickle files.
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai course/DonorsChoose_2018/set2_dt.pckl','rb')
set2_train, set2_test, set2_cv=pickle.load(f)
f.close()
```

In [4]:

```
import pickle as pickle
#with open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai course/DonorsChoose_2018/cat_num.pckl', 'rb') as f:
f=open('C:/Users/pramod reddy chandi/Desktop/pram/applied ai course/DonorsChoose_2018/y_values.pckl','rb')
y_train,y_test,y_cv=pickle.load(f)
f.close()
```

In [175]:

```
y_test.shape
```

Out[175]:

```
(36052,)
```

In [176]:

```
#preparing data
X_tr=set2_train.tocsr()
```

```
X_cr=set2_cv.tocsr()
X_te=set2_test.tocsr()
```

In [177]:

```
X_te.shape
```

Out[177]:

```
(36052, 5240)
```

In [178]:

```
y_train.shape
```

Out[178]:

```
(49041,)
```

In [179]:

```
from sklearn.tree import DecisionTreeClassifier
model = DecisionTreeClassifier()
```

In [180]:

```
model.fit ( X_tr , y_train)
```

Out[180]:

```
DecisionTreeClassifier(class_weight=None, crit
erion='gini', max_depth=None,
            max_features=None, max_leaf_nodes=
None,
            min_impurity_decrease=0.0, min_imp
urity_split=None,
            min_samples_leaf=1, min_samples_sp
lit=2,
            min_weight_fraction_leaf=0.0, pres
ort=False, random_state=None,
            splitter='best')
```

In [181]:

```
## Compute the Feature importances for our Train Features

a=model.tree_.compute_feature_importances(normalize=False)
```

In [182]:

```
#converting feature importance to dataframe
import pandas as pd
df=pd.DataFrame(a)
```

In [183]:

```
import numpy as np
df=np.transpose(df)
```

In [184]:

```
df.shape
```

Out[184]:

```
(1, 5240)
```

In [185]:

```
set2_train.shape
```

Out[185]:

```
(49041, 5240)
```

In [186]:

```
## Store the indexes of the features with atleast some importance. Lets ignore the features with 0
## as the feature importance value and instead consider all the values other than these

best_ind = []
```

```
for j in range(5240):

    s = df[j].sum()

    if s > 0 :
        best_ind.append(j)
    else :
        continue
```

In [187]:

```
len(best_ind)
```

Out[187]:

```
2408
```

it means only 2408 features have some importance in predicting the model.

taking only those features and constructing the dataframe

In [188]:

```
a_train= X_tr.todense()
```

In [191]:

```
a_cv=X_cr.todense()
```

In [192]:

```
a_te=X_te.todense()
```

In [190]:

```
df_train=pd.DataFrame(a_train)
```

In [193]:

```
df_test=pd.DataFrame(a_te)
```

In [194]:

```
df_cv=pd.DataFrame(a_cv)
```

In [195]:

```
final_df_train = df_train.iloc[:, best_ind]
```

In [196]:

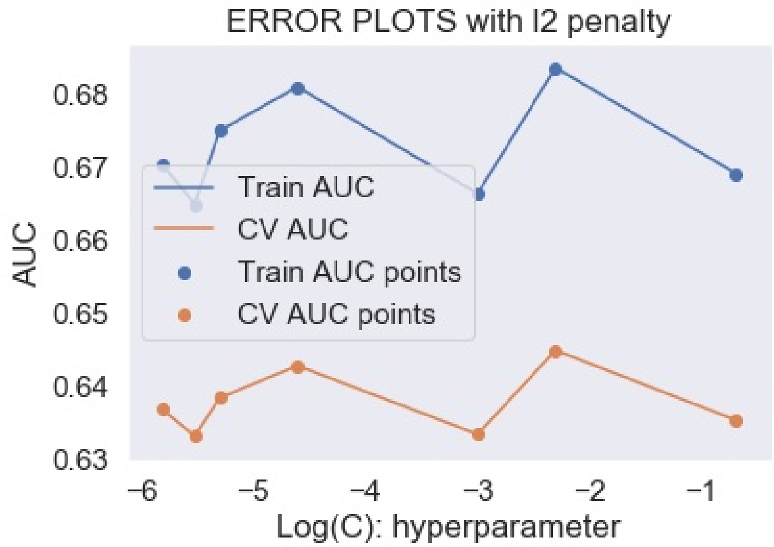
```
final_df_test = df_test.iloc[:, best_ind]
```

In [197]:

```
final_df_cv = df_cv.iloc[:, best_ind]
```

In [198]:

```
#doing Logistic regression on L2 penalty
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
import math

train_auc = []
cv_auc = []
log_parameter=[]
K = [0.5, 0.1, 0.05, 0.01, 0.005,0.004,0.003]
for i in K:
    classifier=SGDClassifier(loss='hinge',alpha = i,penalty='l2',random_state=42,n_jobs=-1)
    classifier.fit(final_df_train, y_train)
    y_train_pred = classifier.decision_function(final_df_train)
    y_cv_pred = classifier.decision_function(final_df_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter +should be probability estimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    log_parameter.append(math.log(i))

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

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

plt.legend()
plt.xlabel("Log(C): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS with l2 penalty")
plt.grid()
plt.show()
```



In [199]:

```
# We could see that the best hyperparameter for log(C) is -4.
5
import math
k_best=math.pow(2.718281,-4.5)
```

In [200]:

```
k_best
```

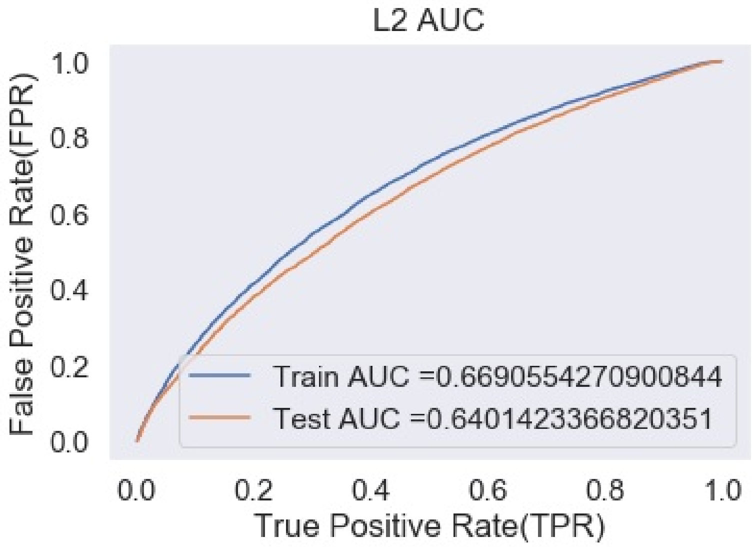
Out[200]:

```
0.011109011774007511
```

In [201]:

```
# finding AUC for train and test for L2 penalty
from sklearn.metrics import roc_curve, auc
```

```python
model = SGDClassifier(loss='hinge',alpha= k_best,penalty='l2',random_state=42,n_jobs=-1)
model.fit(final_df_train, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.decision_function(final_df_train)
y_test_pred = model.decision_function(final_df_test)


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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("L2 AUC")
plt.grid()
plt.show()
```



In [202]:

```
# Confusion matrix

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

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

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

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [203]:

```
from sklearn.metrics import confusion_matrix
```

```
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thre
sholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999544
0787 for threshold 1.003
[[ 3703  3702]
 [11017 30619]]
```

In [204]:

```
conf_matr_df_trainl2_5= pd.DataFrame(confusion_matrix(y_train
, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr))
, range(2),range(2))
```

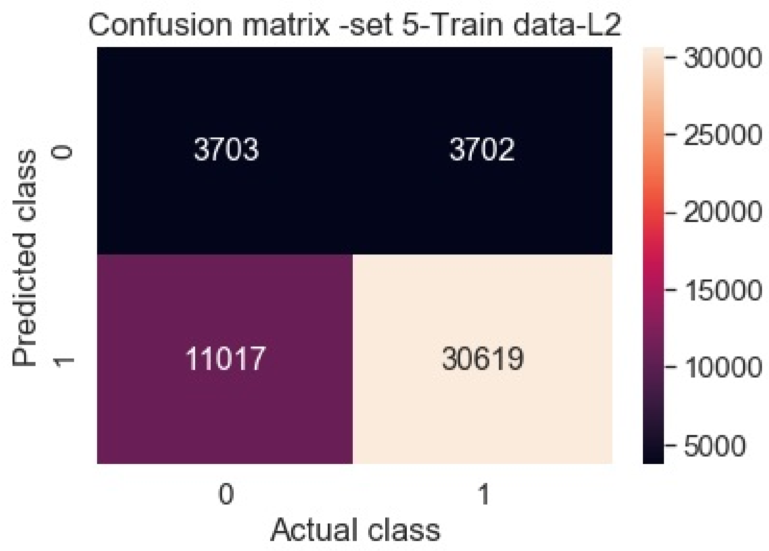
```
the maximum value of tpr*(1-fpr) 0.24999999544
0787 for threshold 1.003
```

In [205]:

```
import seaborn as sns
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_trainl2_5, annot=True,annot_kws={"si
ze": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -set 5-Train data-L2")
```

Out[205]:

```
Text(0.5, 1.0, 'Confusion matrix -set 5-Train
data-L2')
```



In [206]:

```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999996744130742 for threshold 1.004
[[ 3286  2256]
 [11926 18584]]
```

In [207]:

```
conf_matr_df_testl2_5 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), range(2),range(2))
```

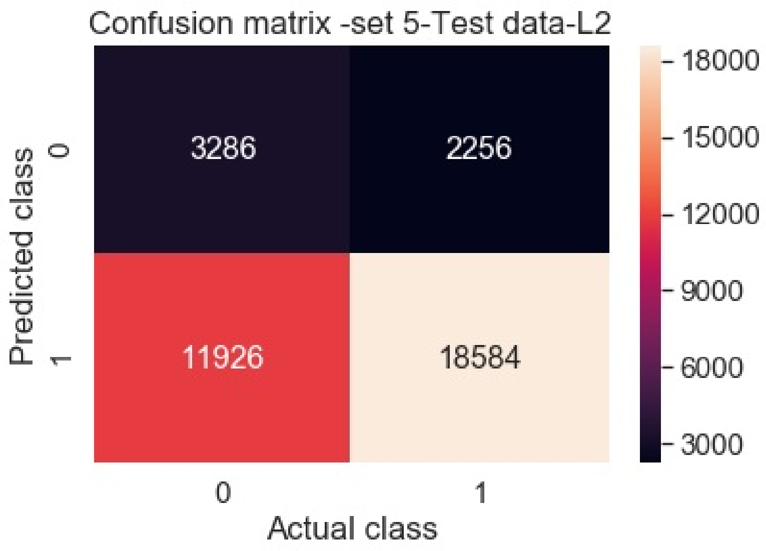
```
the maximum value of tpr*(1-fpr) 0.24999996744130742 for threshold 1.004
```

In [208]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_testl2_5, annot=True,annot_kws={"size": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -set 5-Test data-L2")
```

Out[208]:

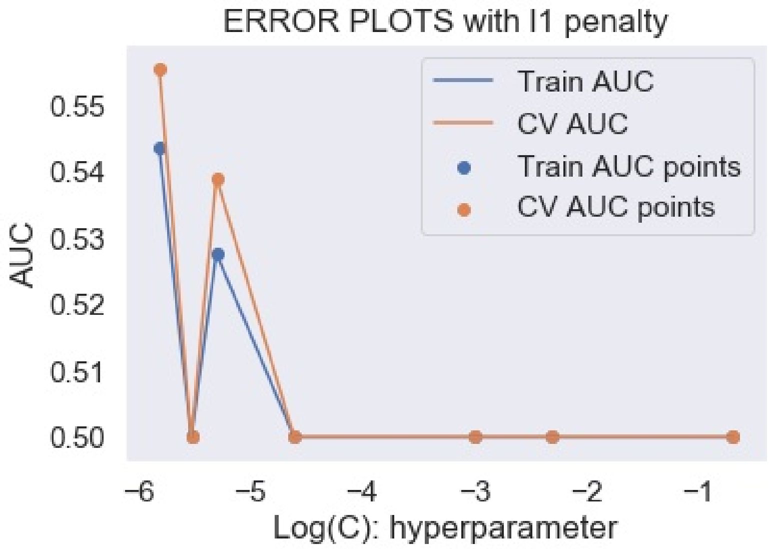
```
Text(0.5, 1.0, 'Confusion matrix -set 5-Test data-L2')
```



Set5:doing SGD classification with L1 penalty

In [209]:

```
#doing Logistic regression on L1 penalty

import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score
import math
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.
y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or non-thresholded measure of decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.
"""
train_auc = []
cv_auc = []
log_parameter=[]
K = [0.5, 0.1, 0.05, 0.01, 0.005, 0.004, 0.003]
for i in K:
    classifier=SGDClassifier(loss='hinge',alpha= i,penalty='l1',random_state=42,n_jobs=-1)
    classifier.fit(final_df_train, y_train)
    y_train_pred = classifier.decision_function(final_df_train)
    y_cv_pred = classifier.decision_function(final_df_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter +should be probability estimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    log_parameter.append(math.log(i))

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

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

plt.legend()
plt.xlabel("Log(C): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS with l1 penalty")
plt.grid()
plt.show()
```



In [210]:

```
# We could see that the best hyperparameter for log(C) is -6 for l1 penalty
import math
k_best=math.pow(2.718281,-6)
```

In [211]:

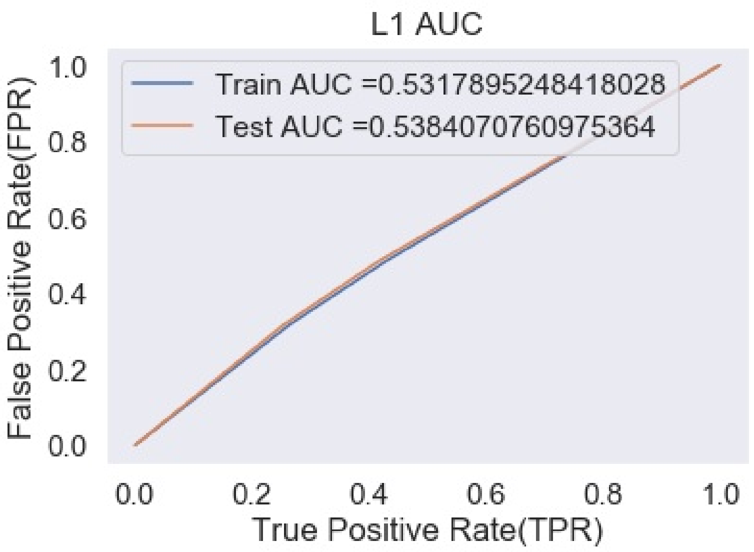
```
k_best
```

Out[211]:

```
0.0024787567094123678
```

In [212]:

```
# finding AUC for train and test for L1 penalty

from sklearn.metrics import roc_curve, auc

model = SGDClassifier(loss='hinge',alpha= k_best,penalty='l1',random_state=42,n_jobs=-1)
model.fit(final_df_train, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.decision_function(final_df_train)
y_test_pred = model.decision_function(final_df_test)



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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("L1 AUC")
plt.grid()
plt.show()
```



In [213]:

```
# Confusion matrix

from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24541339068
2154 for threshold 1.0
[[ 4204  3201]
 [21338 20298]]
```

In [214]:

```
conf_matr_df_trainl1_5 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

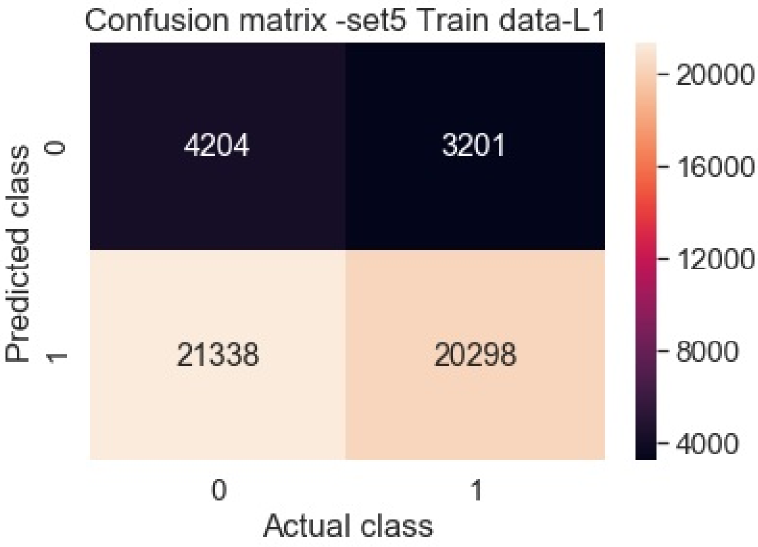
```
the maximum value of tpr*(1-fpr) 0.245413390682154 for threshold 1.0
```

In [215]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_trainl1_5, annot=True,annot_kws={"size": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -set5 Train data-L1")
```

Out[215]:

```
Text(0.5, 1.0, 'Confusion matrix -set5 Train data-L1')
```



In [216]:

```
from sklearn.metrics import confusion_matrix
```

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresh
olds, test_fpr, test_fpr)))
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24322987570
00282 for threshold 1.0
[[ 3227  2315]
 [15701 14809]]
```

In [217]:

```
conf_matr_df_testl1_5 = pd.DataFrame(confusion_matrix(y_test,
 predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)), ra
nge(2),range(2))
```

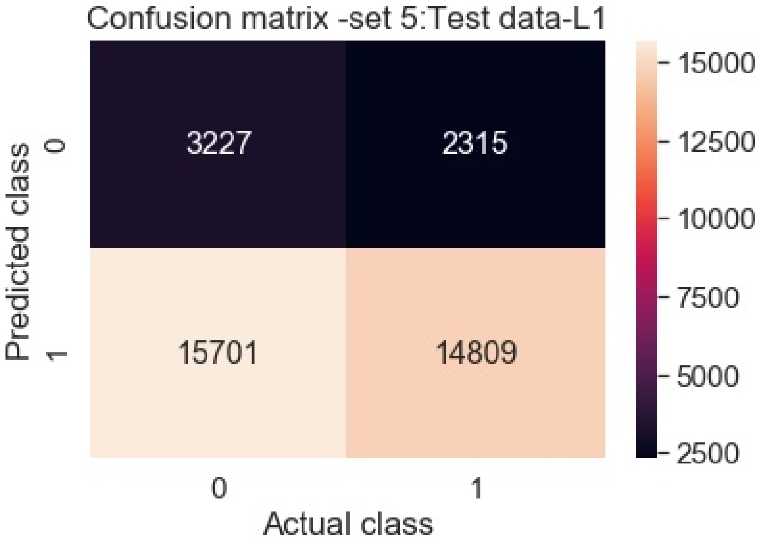
```
the maximum value of tpr*(1-fpr) 0.24322987570
00282 for threshold 1.0
```

In [218]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_testl1_5, annot=True,annot_kws={"siz
e": 16}, fmt='g')

plt.xlabel("Actual class")
plt.ylabel("Predicted class")
plt.title("Confusion matrix -set 5:Test data-L1")
```

Out[218]:

```
Text(0.5, 1.0, 'Confusion matrix -set 5:Test d
ata-L1')
```



Confusion matrix -set 5:Test data-L1

3. Conclusion

In [219]:

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameters(max
depth)" ,"min samples split", "Train AUC", "Test AUC"]

x.add_row(["BOW", "Decision Trees", 10, 500, 0.66, 0.62])
x.add_row(["TFIDF", "Decision Trees", 10, 1000, 0.66, 0.62])
x.add_row(["AVG W2V", "Decision Trees", 5, 1000, 0.63, 0.60])
x.add_row(["TFIDF W2V", "Decision Trees", 5, 1000, 0.65, 0.61
])
x.add_row(["TFIDF-5k Features", "Linear SVM", "Hinge", "L1",
0.53, 0.53])
x.add_row(["TFIDF-5k Features", "Linear SVM", "Hinge", "L2",
0.66, 0.64])



print(x)
```

```
+-------------------+----------------+--------
--------------------+-------------------+-----
------+----------+
|     Vectorizer    |     Model      | Hyperpa
rameters(max depth) | min samples split | Trai
n AUC | Test AUC |
+-------------------+----------------+--------
--------------------+-------------------+-----
```

```
------+----------+
|        BOW        | Decision Trees |
     10             |        500         |    0
.66   |   0.62   |
|       TFIDF       | Decision Trees |
     10             |        1000        |    0
.66   |   0.62   |
|      AVG W2V      | Decision Trees |
     5              |        1000        |    0
.63   |   0.6    |
|     TFIDF W2V     | Decision Trees |
     5              |        1000        |    0
.65   |   0.61   |
| TFIDF-5k Features |   Linear SVM   |
   Hinge            |         L1         |    0
.53   |   0.53   |
| TFIDF-5k Features |   Linear SVM   |
   Hinge            |         L2         |    0
.66   |   0.64   |
+-------------------+----------------+--------
--------------------+-------------------+-----
------+----------+
```

WE can conclude that with more important features the ROC tends to increase but only it is applicable for L2 penalty.