DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	
project_id	A unique identifier for the proposed project. **Examp**
project_title	Title of the proje • Art Will Make • First
project_grade_category	Grade level of students for which the project is targeted. One enum • Gra • • • (
project_subject_categories	One or more (comma-separated) subject categories for the p following enumerated • Applie • Ca • Healt • Histor • Literacy • Math • Music • Spe • • • Music • Literacy & Language, Math
school_state	State where school is located (Two-letter U (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#P
project_subject_subcategories	One or more (comma-separated) subject subcategories • • Literature & Writing, Socia
project_resource_summary	An explanation of the resources needed for the proj • My students need hands on literacy material sens
project_essay_1	First app
project_essay_2	Second app
project_essay_3	Third app
project_essay_4	Fourth app
project_submitted_datetime	Datetime when project application was submitted. **Example:** 12
teacher_id	A unique identifier for the teacher of the proposed pro bdf8baa8fedef6bfeec7ae

Feature	
teacher_prefix	Teacher's title. One of the following enum • • • • • •
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the

* 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

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 [9]:

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

Reading Data:

In [0]:

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

In [11]:

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

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_pr
efix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_
3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approve
d']
```

In [12]:

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

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

Out[12]:

	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

Preprocessing of data:

Preprocessing of 'categorical data':

preprocessing of `project_subject_categories` :

In [0]:

```
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]))
```

preprocessing of `project_subject_subcategories`:

In [0]:

```
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]))
```

Preprocessing of `project_grade_category`:

In [15]:

```
#https://stackoverflow.com/questions/22623375/python-remove-all-decimals-from-a-float
from tqdm import tqdm

preprocessed_grade=[]
for grade in tqdm(project_data['project_grade_category'].values):
    grade= grade.replace("Grades", '')
    grade= grade.replace("-", 'to')
    preprocessed_grade.append(grade)

#adding preprocessed grade to dataframe:
project_data['clean_grade']=preprocessed_grade
project_data.drop('project_grade_category', 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_grade'].values:
    my_counter.update(word.split())

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

```
100%|██████████| 109248/109248 [00:00<00:00, 1059447.05it/s]
```

Preprocessing of `teacher_prefix`:

In [16]:

```
#https://stackoverflow.com/questions/22623375/python-remove-all-decimals-from-a-float
from tqdm import tqdm

preprocessed_prefix=[]
for prefix in tqdm(project_data['teacher_prefix'].values):
    prefix= str(prefix).split('.')[0]
    preprocessed_prefix.append(prefix.lower().strip())

project_data['clean_prefix']= preprocessed_prefix
project_data.drop(['teacher_prefix'], 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_prefix'].values:
    my_counter.update(word.split())

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

```
100%|██████████| 109248/109248 [00:00<00:00, 1027600.34it/s]
```

Preprocessing of `school_state`:

In [17]:

```
preprocessed_states=[]

for state in tqdm(project_data['school_state'].values):
    state=state.lower()
    preprocessed_states.append(state)

project_data['clean_state']= preprocessed_states
project_data.drop(['school_state'], 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_state'].values:
    my_counter.update(word.split())

clean_state_dict = dict(my_counter)
sorted_clean_state_dict = dict(sorted(clean_state_dict.items(), key=lambda kv: k
v[1]))
```

```
100%|██████████| 109248/109248 [00:00<00:00, 1784044.43it/s]
```

Text preprocessing

In [0]:

```
# 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 [19]:

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

Out[19]:

	Unnamed: 0	id	teacher_id	project_submitted_datetime	proje
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	2016-12-05 13:43:57	Educ Sup I Lear
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	2016-10-25 09:22:10	W Proje I Le

In [0]:

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

In [21]:

```
# 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)
```

```
My students are English learners that are working on English as thei
r second or third languages. We are a melting pot of refugees, immig
rants, and native-born Americans bringing the gift of language to ou
r school. \r\n\r\n We have over 24 languages represented in our Engl
ish Learner program with students at every level of mastery.  We als
o have over 40 countries represented with the families within our sc
hool.  Each student brings a wealth of knowledge and experiences to
us that open our eyes to new cultures, beliefs, and respect.\"The li
mits of your language are the limits of your world.\"-Ludwig Wittgen
stein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to
read and speak English along side of their children.  Sometimes this
creates barriers for parents to be able to help their child learn ph
onetics, letter recognition, and other reading skills.\r\n\r\nBy pro
viding 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 as
sist.  All families with students within the Level 1 proficiency sta
tus, will be a offered to be a part of this program.  These educatio
nal videos will be specially chosen by the English Learner Teacher a
nd 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 edu
cational dvd's for the years to come for other EL students.\r\nnanna
n
==================================================
The 51 fifth grade students that will cycle through my classroom thi
s 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 56
0 students, 97.3% are minority students. \r\nThe school has a vibran
t community that loves to get together and celebrate. Around Hallowe
en 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 c
rafts made by the students, dances, and games. At the end of the yea
r the school hosts a carnival to celebrate the hard work put in duri
ng the school year, with a dunk tank being the most popular activit
y.My students will use these five brightly colored Hokki stools in p
lace of regular, stationary, 4-legged chairs. As I will only have a
total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During
independent reading time they will be used as special chairs student
s 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 amoun
t 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 the
ir work. Anytime the students get to pick where they can sit, the Ho
kki 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 disap
pointed as there are not enough of them. \r\n\r\nWe ask a lot of stu
dents to sit for 7 hours a day. The Hokki stools will be a compromis
e 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 mo
vement by allowing them to activate their core muscles for balance w
hile 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.n
annan
==================================================
```

How do you remember your days of school? Was it in a sterile environ
ment 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 themed room for my students look forward to c
oming to each day.\r\n\r\nMy class is made up of 28 wonderfully uniq
ue boys and girls of mixed races in Arkansas.\r\nThey attend a Title
I school, which means there is a high enough percentage of free and
reduced-price lunch to qualify. Our school is an \"open classroom\"
concept, which is very unique as there are no walls separating the c
lassrooms. These 9 and 10 year-old students are very eager learners;
they are like sponges, absorbing all the information and experiences
and keep on wanting more.With these resources such as the comfy red
throw pillows and the whimsical nautical hanging decor and the blue
fish nets, I will be able to help create the mood in our classroom s
etting to be one of a themed nautical environment. Creating a classr
oom environment is very important in the success in each and every c
hild's education. The nautical photo props will be used with each ch
ild as they step foot into our classroom for the first time on Meet
the Teacher evening. I'll take pictures of each child with them, hav
e them developed, and then hung in our classroom ready for their fir
st day of 4th grade. This kind gesture will set the tone before eve
n the first day of school! The nautical thank you cards will be used
throughout the year by the students as they create thank you cards t
o their team groups.\r\n\r\nYour generous donations will help me to
help make our classroom a fun, inviting, learning environment from d
ay one.\r\n\r\nIt costs lost of money out of my own pocket on resour
ces to get our classroom ready. Please consider helping with this pr
oject to make our new school year a very successful one. Thank you!n
annan

==

My kindergarten students have varied disabilities ranging from speec
h and language delays, cognitive delays, gross/fine motor delays, to
autism. They are eager beavers and always strive to work their harde
st 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 whe
re most of the students receive free or reduced price lunch. Despit
e their disabilities and limitations, my students love coming to sch
ool and come eager to learn and explore.Have you ever felt like you
had ants in your pants and you needed to groove and move as you were
in a meeting? This is how my kids feel all the time. The want to be
able to move as they learn or so they say.Wobble chairs are the answ
er and I love then because they develop their core, which enhances g
ross motor and in Turn fine motor skills. \r\nThey also want to lear
n through games, my kids don't want to sit and do worksheets. They w
ant 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 ju
st have the fun a 6 year old deserves.nannan

==

In [0]:

```
# 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 [23]:

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

```
My kindergarten students have varied disabilities ranging from speec
h and language delays, cognitive delays, gross/fine motor delays, to
autism. They are eager beavers and always strive to work their harde
st 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 whe
re most of the students receive free or reduced price lunch.  Despit
e their disabilities and limitations, my students love coming to sch
ool and come eager to learn and explore.Have you ever felt like you
had ants in your pants and you needed to groove and move as you were
in a meeting? This is how my kids feel all the time. The want to be
able to move as they learn or so they say.Wobble chairs are the answ
er and I love then because they develop their core, which enhances g
ross motor and in Turn fine motor skills. \r\nThey also want to lear
n through games, my kids do not want to sit and do worksheets. They
want to learn to count by jumping and playing. Physical engagement i
s the key to our success. The number toss and color and shape mats c
an make that happen. My students will forget they are doing work and
just have the fun a 6 year old deserves.nannan
==================================================
```

In [24]:

```
# \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 disabilities ranging from speec
h and language delays, cognitive delays, gross/fine motor delays, to
autism. They are eager beavers and always strive to work their harde
st working past their limitations.     The materials we have are the
ones I seek out for my students. I teach in a Title I school where m
ost of the students receive 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
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 abl
e 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 gros
s motor and in Turn fine motor skills.   They also want to learn thr
ough games, my kids do not want to sit and do worksheets. They want
to learn to count by jumping and playing. Physical engagement is the
key to our success. The number toss and color and shape mats can mak
e that happen. My students will forget they are doing work and just
have the fun a 6 year old deserves.nannan
```

In [25]:

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

```
My kindergarten students have varied disabilities ranging from speec
h and language delays cognitive delays gross fine motor delays to au
tism They are eager beavers and always strive to work their hardest
working past their limitations The materials we have are the ones I
seek out for my students I teach in a Title I school where most of t
he students receive free or reduced price lunch Despite their disabi
lities and limitations my students love coming to school and come ea
ger to learn and explore Have you ever felt like you had ants in you
r pants and you needed to groove and move as you were in a meeting T
his 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 th
en because they develop their core which enhances gross motor and in
Turn fine motor skills They also want to learn through games my kids
do not want to sit and do worksheets They want to learn to count by
jumping and playing Physical engagement is the key to our success Th
e number toss and color and shape mats can make that happen My stude
nts will forget they are doing work and just have the fun a 6 year o
ld deserves nannan
```

In [0]:

```
# 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', 'itse
lf', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'tha
t', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'ha
s', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'becaus
e', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 't
hrough', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'of
f', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'al
l', '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'v
e", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "d
idn'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', "should
n't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing of `essay` :

In [27]:

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

```
100%|██████████| 109248/109248 [00:55<00:00, 1963.40it/s]
```

In [28]:

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

Out[28]:

```
'my kindergarten students varied disabilities ranging speech languag
e delays cognitive delays gross fine motor delays autism they eager
beavers always strive work hardest working past limitations the mate
rials ones i seek students i teach title i school students receive f
ree reduced price lunch despite disabilities limitations students lo
ve coming school come eager learn explore have ever felt like ants p
ants needed groove move meeting this kids feel time the want able mo
ve learn say wobble chairs answer i love develop core enhances gross
motor turn fine motor skills they also want learn games kids not wan
t sit worksheets they want learn count jumping playing physical enga
gement key success the number toss color shape mats make happen my s
tudents forget work fun 6 year old deserves nannan'
```

Preprocessing of `project_title`:

In [29]:

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

```
100%|██████████| 109248/109248 [00:02<00:00, 42673.10it/s]
```

1.5 Preparing data for models

In [30]:

```
project_data.columns
```

Out[30]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'project_submitted_datetim
e',
       'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summa
ry',
       'teacher_number_of_previously_posted_projects', 'project_is_a
pproved',
       'clean_categories', 'clean_subcategories', 'clean_grade',
       'clean_prefix', 'clean_state', 'essay'],
      dtype='object')
```

we are going to consider

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

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

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

Splitting data into Train, Test and CV:

In [0]:

```
Y= project_data['project_is_approved'].values
X= project_data.drop(['project_is_approved'], axis=1)
```

In [0]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test= train_test_split(X, Y, test_size=0.3, stratify
=Y)
X_train, X_cv, Y_train, Y_cv= train_test_split(X_train, Y_train, test_size=0.3,
stratify=Y_train )
```

In [33]:

```
print(Y_train.shape, X_train.shape, )
print(Y_test.shape, X_test.shape, )
print(Y_cv.shape, X_cv.shape, )
```

```
(53531,) (53531, 17)
(32775,) (32775, 17)
(22942,) (22942, 17)
```

Preprocessing of Text Data:

essays:

In [34]:

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

```
100%|██████████| 53531/53531 [00:27<00:00, 1957.82it/s]
```

In [35]:

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

```
100%|██████████| 32775/32775 [00:16<00:00, 1965.86it/s]
```

In [36]:

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

100%|██████████| 22942/22942 [00:11<00:00, 1956.91it/s]

titles:

In [37]:

```
X_train.head(1)
```

Out[37]:

	Unnamed: 0	id	teacher_id	project_submitted_datetime	pr
56185	98347	p060491	927fa432efd79b96d8c7f3ddd7ce7dcf	2016-08-01 15:05:34	e

In [38]:

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

100%|██████████| 53531/53531 [00:01<00:00, 42151.37it/s]

In [39]:

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

100%|██████████| 32775/32775 [00:00<00:00, 41396.27it/s]

In [40]:

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

100%|██████████| 22942/22942 [00:00<00:00, 41983.06it/s]

Vectorization:

Vectorizing Categorical data:

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

Vectorizing `clean_categories`:

In [0]:

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

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

X_train_categories=vectorizer_c.transform(X_train['clean_categories'].values)
X_test_categories=vectorizer_c.transform(X_test['clean_categories'].values)
X_cv_categories=vectorizer_c.transform(X_cv['clean_categories'].values)
```

Vectorizing `clean_subcategories`:

In [0]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_sc = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), low
ercase=False, binary=True)

vectorizer_sc.fit(X_train['clean_subcategories'].values)

X_train_subcategories=vectorizer_sc.transform(X_train['clean_subcategories'].val
ues)
X_test_subcategories=vectorizer_sc.transform(X_test['clean_subcategories'].value
s)
X_cv_subcategories=vectorizer_sc.transform(X_cv['clean_subcategories'].values)
```

Vectorizing `clean_prefix`:

In [0]:

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

vectorizer_p.fit(X_train['clean_prefix'].values)

X_train_prefix=vectorizer_p.transform(X_train['clean_prefix'].values)
X_test_prefix=vectorizer_p.transform(X_test['clean_prefix'].values)
X_cv_prefix=vectorizer_p.transform(X_cv['clean_prefix'].values)
```

Vectorizing `States`:

In [0]:

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

vectorizer_st.fit(X_train['clean_state'].values)

X_train_states=vectorizer_st.transform(X_train['clean_state'].values)
X_test_states=vectorizer_st.transform(X_test['clean_state'].values)
X_cv_states=vectorizer_st.transform(X_cv['clean_state'].values)
```

Vectorizing Grades :

In [0]:

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

vectorizer_g.fit(X_train['clean_grade'].values)

X_train_grades=vectorizer_g.transform(X_train['clean_grade'].values)
X_test_grades=vectorizer_g.transform(X_test['clean_grade'].values)
X_cv_grades=vectorizer_g.transform(X_cv['clean_grade'].values)
```

Vectorizing Text data

TFIDF vectorizer

In [46]:

```
# ESSAYS:
# We are considering only the words which appeared in at least 10 documents(rows
or projects).
# fitting and transforming on processed data only
vectorizer_tf_essay = TfidfVectorizer(min_df=10, ngram_range= (1,2), max_feature
s= 5000)
X_train_tfidf_essay = vectorizer_tf_essay.fit(X_train_essays)

X_train_tfidf_essay = vectorizer_tf_essay.transform(X_train_essays)
X_test_tfidf_essay = vectorizer_tf_essay.transform(X_test_essays)
X_cv_tfidf_essay = vectorizer_tf_essay.transform(X_cv_essays)

print (X_train_tfidf_essay.shape)
print (X_test_tfidf_essay.shape)
print (X_cv_tfidf_essay.shape)
```

```
(53531, 5000)
(32775, 5000)
(22942, 5000)
```

In [47]:

```
# titleS:
# We are considering only the words which appeared in at least 10 documents(rows
or projects).
# fitting and transforming on processed data only
vectorizer_tf_title = TfidfVectorizer(min_df=10, ngram_range= (1,2), max_feature
s= 5000)
X_train_tfidf_title = vectorizer_tf_title.fit(X_train_titles)

X_train_tfidf_title = vectorizer_tf_title.transform(X_train_titles)
X_test_tfidf_title = vectorizer_tf_title.transform(X_test_titles)
X_cv_tfidf_title = vectorizer_tf_title.transform(X_cv_titles)

print (X_train_tfidf_title.shape)
print (X_test_tfidf_title.shape)
print (X_cv_tfidf_title.shape)
```

```
(53531, 4043)
(32775, 4043)
(22942, 4043)
```

Using Pretrained Models: TFIDF weighted W2V

In [48]:

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

```
0it [00:00, ?it/s]

Loading Glove Model

1917495it [03:49, 8345.98it/s]

Done. 1917495  words loaded!
```

In [0]:

```
glove_words= set(model.keys())
```

In [0]:

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

In [51]:

```
vectorizer_c.get_feature_names
```

Out[51]:

```
<bound method CountVectorizer.get_feature_names of CountVectorizer(a
nalyzer='word', binary=True, decode_error='strict',
                dtype=<class 'numpy.int64'>, encoding='utf-8', input
='content',
                lowercase=False, max_df=1.0, max_features=None, min_
df=1,
                ngram_range=(1, 1), preprocessor=None, stop_words=No
ne,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+
\\b',
                tokenizer=None,
                vocabulary=['Warmth', 'Care_Hunger', 'History_Civic
s',
                            'Music_Arts', 'AppliedLearning', 'Specia
lNeeds',
                            'Health_Sports', 'Math_Science',
                            'Literacy_Language'])>
```

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
def tfidf_w2v(preprocessed):
    tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in
 this list
    for sentence in tqdm(preprocessed): # 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/rev
iew
        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 val
ue((sentence.count(word)/len(sentence.split())))
                tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.spl
it())) # 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.append(vector)
    print(len(tfidf_w2v_vectors))
    print(len(tfidf_w2v_vectors[0]))
    return tfidf_w2v_vectors
```

In [53]:

```
X_train_tfidf_w2v_essay= tfidf_w2v(X_train_essays)
```

```
100%|██████████| 53531/53531 [01:47<00:00, 498.08it/s]

53531
300
```

In [54]:

```
X_test_tfidf_w2v_essay= tfidf_w2v(X_test_essays)
```

```
100%|██████████| 32775/32775 [01:05<00:00, 502.89it/s]

32775
300
```

In [55]:

```
X_cv_tfidf_w2v_essay= tfidf_w2v(X_cv_essays)
```

```
100%|██████████| 22942/22942 [00:45<00:00, 503.55it/s]

22942
300
```

In [0]:

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

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
def tfidf_w2v(preprocessed):
    tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in
 this list
    for sentence in tqdm(preprocessed): # 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/rev
iew
        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 val
ue((sentence.count(word)/len(sentence.split())))
                tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.spl
it())) # 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.append(vector)
    print(len(tfidf_w2v_vectors))
    print(len(tfidf_w2v_vectors[0]))
    return tfidf_w2v_vectors
```

In [58]:

```
X_train_tfidf_w2v_title= tfidf_w2v(X_train_titles)
```

```
100%|██████████| 53531/53531 [00:01<00:00, 31462.61it/s]

53531
300
```

In [59]:

```
X_test_tfidf_w2v_title= tfidf_w2v(X_test_titles)
```

```
100%|██████████| 32775/32775 [00:01<00:00, 30853.85it/s]

32775
300
```

In [60]:

```
X_cv_tfidf_w2v_title= tfidf_w2v(X_cv_titles)
```

```
100%|██████████| 22942/22942 [00:00<00:00, 29804.77it/s]

22942
300
```

In [0]:

```
#converting list to array
X_train_tfidf_w2v_essay= np.array(X_train_tfidf_w2v_essay)
X_test_tfidf_w2v_essay= np.array(X_test_tfidf_w2v_essay)
X_cv_tfidf_w2v_essay= np.array(X_cv_tfidf_w2v_essay)

X_train_tfidf_w2v_title= np.array(X_train_tfidf_w2v_title)
X_test_tfidf_w2v_title= np.array(X_test_tfidf_w2v_title)
X_cv_tfidf_w2v_title= np.array(X_cv_tfidf_w2v_title)
```

Vectorizing Numerical features

Price:

In [0]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
reset_index()

X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [63]:

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

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

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

# Now standardize the data with above maen and variance.
X_train_price_standardized = price_scalar.transform(X_train['price'].values.resh
ape(-1, 1))
X_test_price_standardized = price_scalar.transform(X_test['price'].values.reshap
e(-1, 1))
X_cv_price_standardized = price_scalar.transform(X_cv['price'].values.reshape(-1
, 1))
```

```
Mean : 297.9500774272917, Standard deviation : 368.7542771872802
```

Quantity:

In [0]:

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

quantity_scalar= StandardScaler()
quantity_scalar.fit(price_data['quantity'].values.reshape(-1,1))

X_train_quantity_standardized= quantity_scalar.transform(X_train['quantity'].values.reshape(-1,1))
X_test_quantity_standardized= quantity_scalar.transform(X_test['quantity'].values.reshape(-1,1))
X_cv_quantity_standardized= quantity_scalar.transform(X_cv['quantity'].values.reshape(-1,1))
```

Previous Projects:

In [0]:

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

previous_projects_scalar= StandardScaler()
previous_projects_scalar.fit(project_data['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

X_train_previous_projects_standardized= previous_projects_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_test_previous_projects_standardized= previous_projects_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_cv_previous_projects_standardized= previous_projects_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
```

Merging all the above features

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

In [66]:

```
print (X_train_categories.shape)
print (X_train_subcategories.shape)
print (X_train_prefix.shape)
print (X_train_states.shape)
print (X_train_grades.shape)
print (X_train_tfidf_essay.shape)
print (X_train_tfidf_title.shape)
print (X_train_tfidf_w2v_essay.shape)
print (X_train_tfidf_w2v_title.shape)
print (X_train_price_standardized.shape)
print (X_train_quantity_standardized.shape)
print (X_train_previous_projects_standardized.shape)
```

```
(53531, 9)
(53531, 30)
(53531, 6)
(53531, 51)
(53531, 4)
(53531, 5000)
(53531, 4043)
(53531, 300)
(53531, 300)
(53531, 1)
(53531, 1)
(53531, 1)
```

In [67]:

```
print (X_test_categories.shape)
print (X_test_subcategories.shape)
print (X_test_prefix.shape)
print (X_test_states.shape)
print (X_test_grades.shape)
print (X_test_tfidf_essay.shape)
print (X_test_tfidf_title.shape)
print (X_test_tfidf_w2v_essay.shape)
print (X_test_tfidf_w2v_title.shape)
print (X_test_price_standardized.shape)
print (X_test_quantity_standardized.shape)
print (X_test_previous_projects_standardized.shape)
```

```
(32775, 9)
(32775, 30)
(32775, 6)
(32775, 51)
(32775, 4)
(32775, 5000)
(32775, 4043)
(32775, 300)
(32775, 300)
(32775, 1)
(32775, 1)
(32775, 1)
```

In [68]:

```
print (X_cv_categories.shape)
print (X_cv_subcategories.shape)
print (X_cv_prefix.shape)
print (X_cv_states.shape)
print (X_cv_grades.shape)
print (X_cv_tfidf_essay.shape)
print (X_cv_tfidf_title.shape)
print (X_cv_tfidf_w2v_essay.shape)
print (X_cv_tfidf_w2v_title.shape)
print (X_cv_price_standardized.shape)
print (X_cv_quantity_standardized.shape)
print (X_cv_previous_projects_standardized.shape)
```

```
(22942, 9)
(22942, 30)
(22942, 6)
(22942, 51)
(22942, 4)
(22942, 5000)
(22942, 4043)
(22942, 300)
(22942, 300)
(22942, 1)
(22942, 1)
(22942, 1)
```

SET 1 (TFIDF):

In [69]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense
matirx :)
X_set1_train = hstack((  X_train_categories, X_train_subcategories ,X_train_pref
ix ,X_train_states
  ,X_train_grades ,X_train_tfidf_essay ,X_train_tfidf_title ,X_train_price_stand
ardized ,X_train_quantity_standardized,X_train_previous_projects_standardized))
X_set1_train.shape
```

Out[69]:

```
(53531, 9146)
```

In [70]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set1_test = hstack((  X_test_categories, X_test_subcategories ,X_test_prefix , X_test_states
  ,X_test_grades ,X_test_tfidf_essay ,X_test_tfidf_title ,X_test_price_standardized ,X_test_quantity_standardized,X_test_previous_projects_standardized))
X_set1_test.shape
```

Out[70]:

```
(32775, 9146)
```

In [71]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set1_cv = hstack((  X_cv_categories, X_cv_subcategories ,X_cv_prefix ,X_cv_states
  ,X_cv_grades ,X_cv_tfidf_essay ,X_cv_tfidf_title ,X_cv_price_standardized ,X_cv_quantity_standardized,X_cv_previous_projects_standardized))
X_set1_cv.shape
```

Out[71]:

```
(22942, 9146)
```

SET 2 (TFIDF W2V):

In [72]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_train = hstack((  X_train_categories, X_train_subcategories ,X_train_prefix ,X_train_states
  ,X_train_grades ,X_train_tfidf_w2v_essay ,X_train_tfidf_w2v_title ,X_train_price_standardized ,X_train_quantity_standardized,X_train_previous_projects_standardized))
X_set2_train.shape
```

Out[72]:

```
(53531, 703)
```

In [73]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense
matirx :)
X_set2_test = hstack((  X_test_categories, X_test_subcategories ,X_test_prefix ,
X_test_states
  ,X_test_grades ,X_test_tfidf_w2v_essay ,X_test_tfidf_w2v_title ,X_test_price_s
tandardized ,X_test_quantity_standardized,X_test_previous_projects_standardized
))
X_set2_test.shape
```

Out[73]:

```
(32775, 703)
```

In [74]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense
matirx :)
X_set2_cv = hstack((  X_cv_categories, X_cv_subcategories ,X_cv_prefix ,X_cv_sta
tes
  ,X_cv_grades ,X_cv_tfidf_w2v_essay ,X_cv_tfidf_w2v_title ,X_cv_price_standardi
zed ,X_cv_quantity_standardized,X_cv_previous_projects_standardized))
X_set2_cv.shape
```

Out[74]:

```
(22942, 703)
```

Assignment 7: Decision Trees

TFIDF, (SET 1):

In [75]:

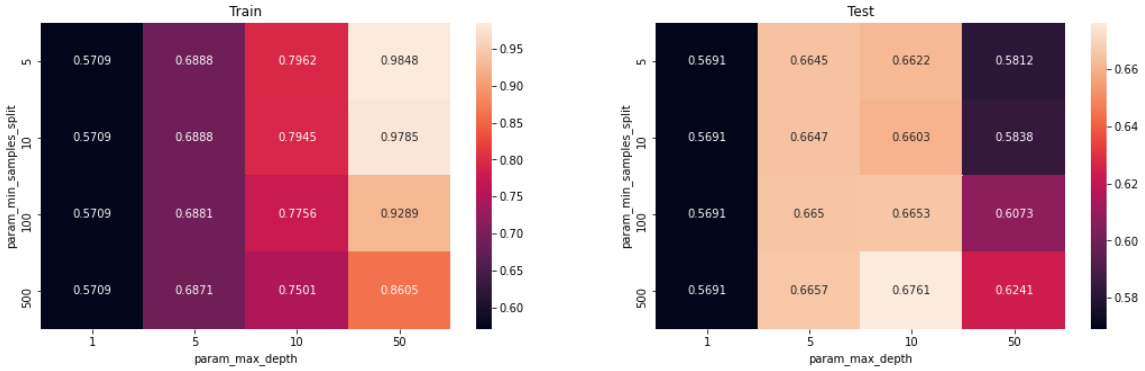
```
# https://scikit-learn.org/stable/modules/tree.html
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV

dt= DecisionTreeClassifier(class_weight= 'balanced',min_samples_split=500)
param= {'max_depth':[1,5,10,50], 'min_samples_split':[5,10,100,500]}

clf= GridSearchCV(dt, param, scoring= 'roc_auc', cv=3, return_train_score= True,
n_jobs=-1)
clf.fit(X_set1_train, Y_train)
```

Out[75]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
                                              class_weight='balance
d',
                                              criterion='gini', max_
depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=
0.0,
                                              min_impurity_split=Non
e,
                                              min_samples_leaf=1,
                                              min_samples_split=500,
                                              min_weight_fraction_le
af=0.0,
                                              presort='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score
=True,
             scoring='roc_auc', verbose=0)
```

In [76]:

```
#confusion matrix
# cv_results_ is A dict with keys as column headers and values as columns, that
 can be imported into a pandas DataFrame
scores= pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split','param_
max_depth']).max().unstack()[['mean_test_score','mean_train_score']]
#grouping by param_min_samples and param_max_depth and corrresponding to them, m
ax mean score obtained by gridsearch

fig, ax= plt.subplots(1,2, figsize=(18,5)) #18width,5 height of each plot
ax[0].set_title('Train') #title for first plot
ax[1].set_title('Test') #title for second plot

sns.heatmap(scores.mean_train_score,annot=True,fmt='.4g', ax=ax[0])
sns.heatmap(scores.mean_test_score,annot=True,fmt='.4g', ax=ax[1])

plt.show()
```



In [77]:

```
clf.best_params_ #best parameters as per gridsearch
```

Out[77]:

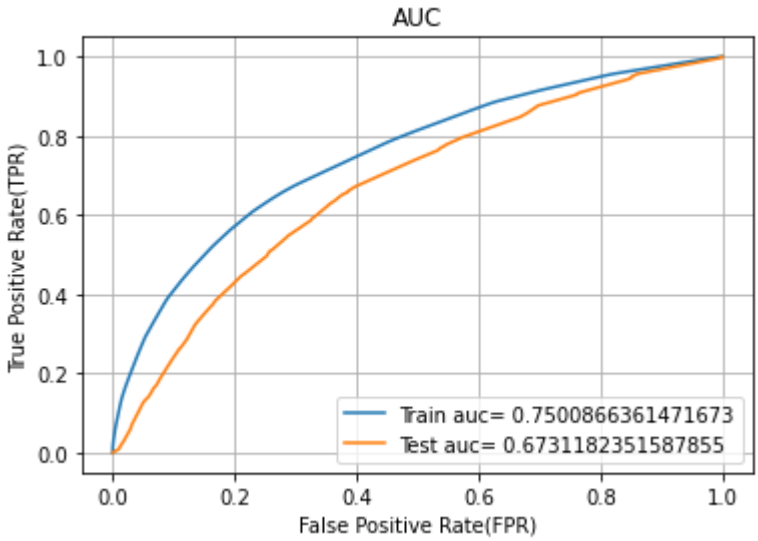
```
{'max_depth': 10, 'min_samples_split': 500}
```

In [0]:

```
def pred_proba(clf, data): #function to predict y
    y_pred = []
    y_pred = clf.predict_proba(data)[:,1]
    return y_pred
```

In [79]:

```
from sklearn.metrics import roc_curve, auc
dectree= DecisionTreeClassifier( class_weight= 'balanced', max_depth= clf.best_p
arams_['max_depth'], min_samples_split= clf.best_params_['min_samples_split'] )
dectree.fit(X_set1_train, Y_train)

Y_train_pred= pred_proba(dectree,X_set1_train)
Y_test_pred= pred_proba(dectree, X_set1_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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



Confusion Matrix:

Train:

In [0]:

```
#finding best threshold which gives minimum fpr:
def find_best_threshold(threshold, fpr, tpr):
    t = threshold[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold",
np.round(t,3))
    return t

#predicting with best thresholds:
def predict_with_best_t(proba, threshold):
    predictions = []
    global predictions_bow
    for i in proba:
        if i>=threshold:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions_bow=predictions
    return predictions
```

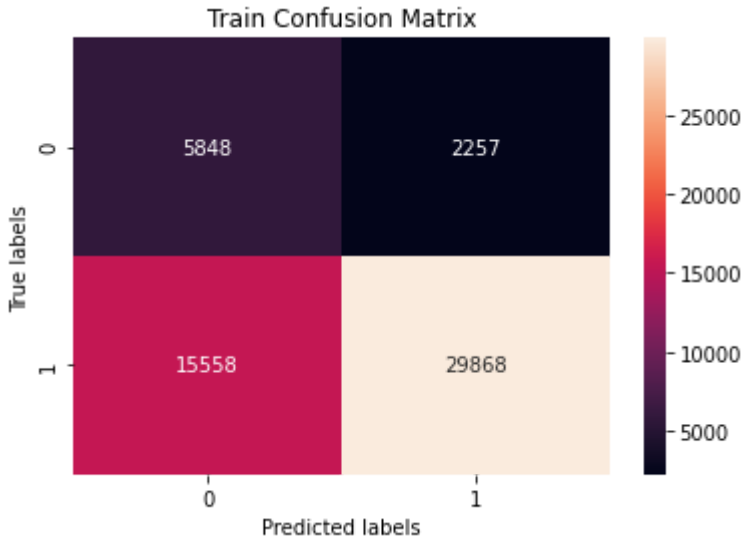
In [81]:

```
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(Y_train, predict_with_best_t(Y_train_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.4744123551416323 for threshold 0.
48
Train confusion matrix
[[ 5848  2257]
 [15558 29868]]
```

In [82]:

```
#heatmap
ax=plt.subplot()
sns.heatmap(confusion_matrix(Y_train, predict_with_best_t(Y_train_pred, best_t
)),ax=ax, annot=True,fmt='g');

ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Train Confusion Matrix');
```



Test:

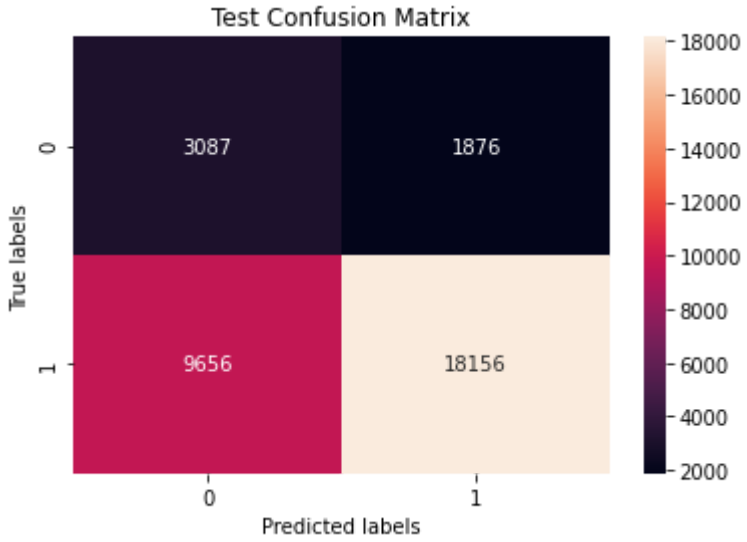
In [83]:

```
best_t = find_best_threshold(tr_thresholds, test_fpr, test_tpr)
print("Train confusion matrix")
print(confusion_matrix(Y_test, predict_with_best_t(Y_test_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.4060507412554615 for threshold 0.
457
Train confusion matrix
[[ 3087  1876]
 [ 9656 18156]]
```

In [84]:

```
#heatmap
ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, predict_with_best_t(Y_test_pred, best_t)),a
nnot=True,ax=ax,fmt='g');
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Test Confusion Matrix');
```



Aggregating Features:

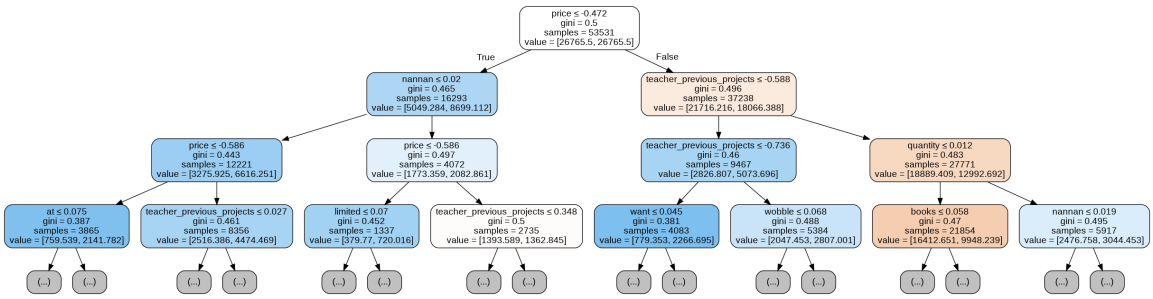
In [0]:

```
fn1=vectorizer_c.get_feature_names()
fn2=vectorizer_sc.get_feature_names()
fn3=vectorizer_p.get_feature_names()
fn4=vectorizer_g.get_feature_names()
fn5=vectorizer_st.get_feature_names()
fn6=vectorizer_tf_essay.get_feature_names()
fn7=vectorizer_tf_title.get_feature_names()

features_tfidf= fn1+fn2+fn3+fn4+fn5+fn6+fn7

features_tfidf.append('teacher_previous_projects')
features_tfidf.append('price')
features_tfidf.append('quantity')
```

In [87]:

```
from sklearn.externals.six import StringIO
from IPython.display import Image
import pydotplus
from sklearn.tree import export_graphviz

dt.fit(X_set1_train, Y_train)

dot_data=StringIO() #reads and writes a strings as files (also known as memory files)
# graphviz function generates a GraphViz representation of the decision tree, which is then written into out_file (DOT format)
export_graphviz(dt,out_file=dot_data,filled=True,rounded=True,special_characters=True,feature_names=features_tfidf, max_depth=3)
graph=pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png()) #takes graph and gives output as png image file
```

Out[87]:



Getting the false positives:

In [0]:

```
# finding the index of all the false positives that is 'actual negatives', wrongly classified as 'positives':
fp= []

for i in range(len(Y_test)):
  if (Y_test[i]==0) & (predictions_bow[i]==1):
    fp.append(i)
```

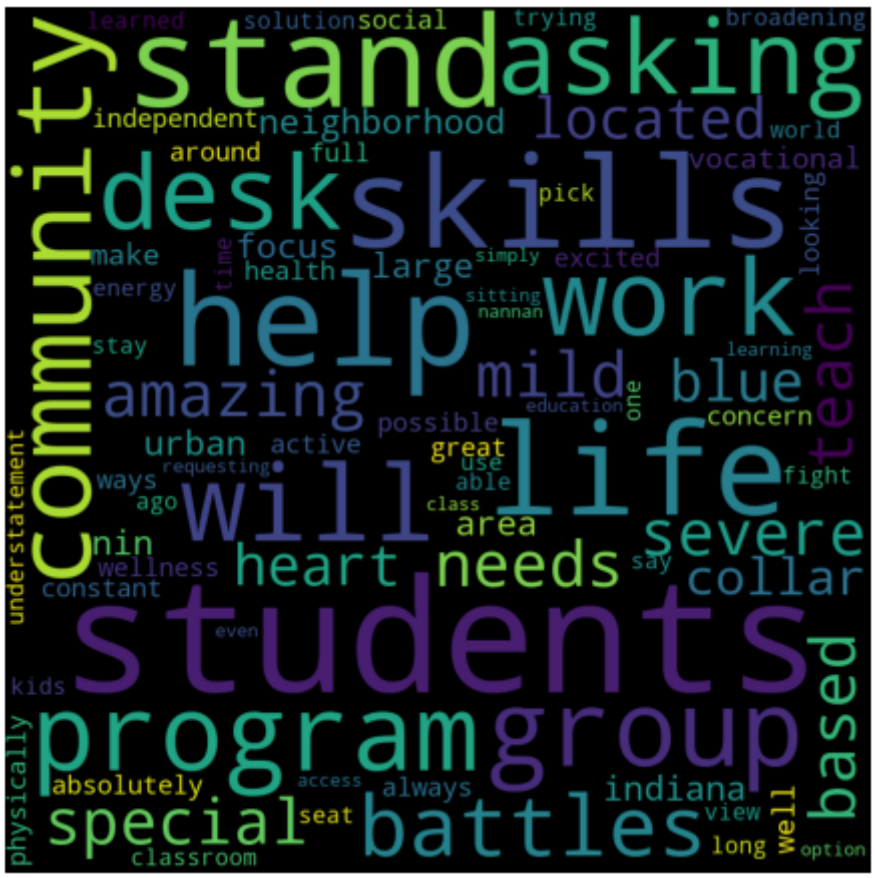
In [0]:

```
# for all those data points which are 'false positive' we extract their essay for word cloud:
fp_essay=[]
for i in fp:
  fp_essay.append(X_test['essay'].values[1])
```

Word Cloud

In [90]:

```
# https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).ipynb
from wordcloud import WordCloud, STOPWORDS

comment_words = ' '
stopwords = set(STOPWORDS)

for val in fp_essay :
  val = str(val) # converts all type of values into string
  tokens = val.split() # splits the sentences into individual words

for i in range(len(tokens)):
  tokens[i] = tokens[i].lower() #lowercases the words

for words in tokens : #seperates the words by a blank space
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='black', stopwords = stopwords, min_font_size = 10).generate(comment_words)


plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [0]:

```
cols = X_test.columns
X_test_false_bow = pd.DataFrame(columns=cols)
```

In [0]:

```
for i in fp :
  X_test_false_bow = X_test_false_bow.append(X_test.filter(items=[i], axis=0)) # filtering by index of false positives
```

In [93]:

```
len(fp)
```

Out[93]:

1876

In [94]:

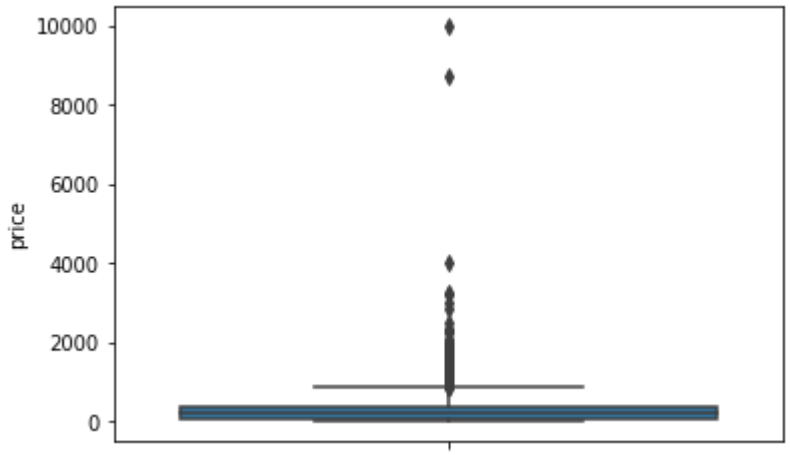
```
X_test_false_bow.shape
```

Out[94]:

(1876, 19)

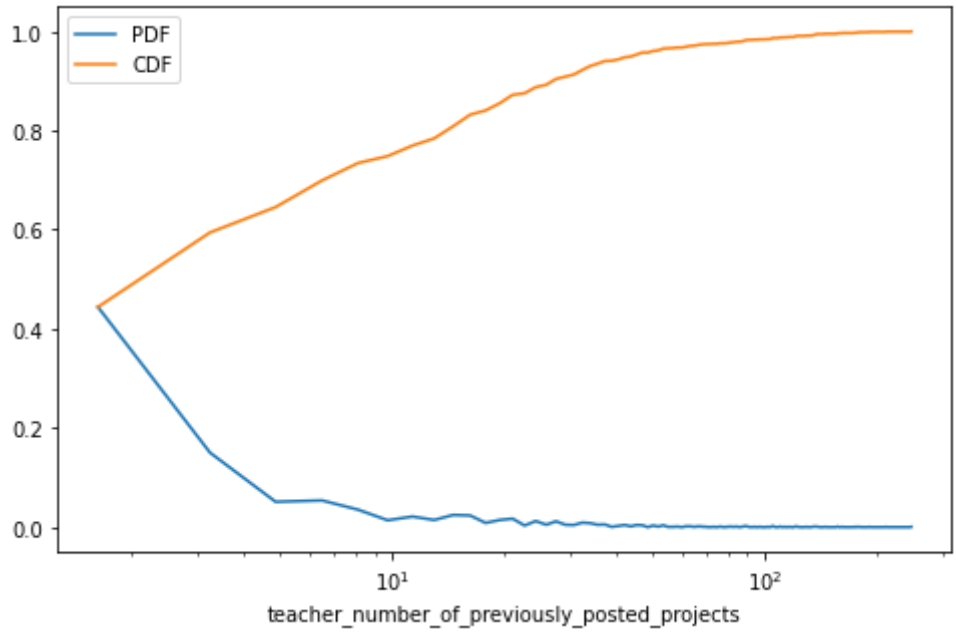
In [95]:

```
ax = sns.boxplot(y='price', data=X_test_false_bow)
```



In [96]:

```
plt.figure(figsize=(8,5))

counts, bin_edges = np.histogram(X_test_false_bow['teacher_number_of_previously_
posted_projects'], bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xscale('log')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



In [0]:

```

```

TFIDF W2V (SET 2):

In [97]:

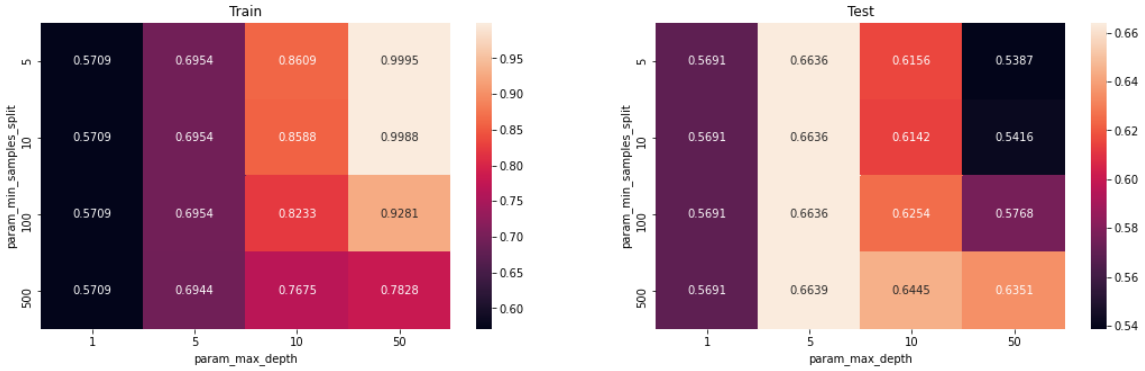
```
# https://scikit-learn.org/stable/modules/tree.html
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV

dt= DecisionTreeClassifier(class_weight= 'balanced',max_depth=4,min_samples_spli
t=500)
param= {'max_depth':[1,5,10,50], 'min_samples_split':[5,10,100,500]}

clf= GridSearchCV(dt, param, scoring= 'roc_auc', cv=3, return_train_score= True,
n_jobs=-1)
clf.fit(X_set2_train, Y_train)
```

Out[97]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
                                              class_weight='balance
d',
                                              criterion='gini', max_
depth=4,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=
0.0,
                                              min_impurity_split=Non
e,
                                              min_samples_leaf=1,
                                              min_samples_split=500,
                                              min_weight_fraction_le
af=0.0,
                                              presort='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score
=True,
             scoring='roc_auc', verbose=0)
```

In [98]:

```
#confusion matrix
# cv_results_ is A dict with keys as column headers and values as columns, that
 can be imported into a pandas DataFrame
scores= pd.DataFrame(clf.cv_results_).groupby(['param_min_samples_split','param_
max_depth']).max().unstack()[['mean_test_score','mean_train_score']]
#grouping by param_min_samples and param_max_depth and corrresponding to them, m
ax mean score obtained by gridsearch

fig, ax= plt.subplots(1,2, figsize=(18,5)) #18width,5 height of each plot
ax[0].set_title('Train') #title for first plot
ax[1].set_title('Test') #title for second plot

sns.heatmap(scores.mean_train_score,annot=True,fmt='.4g', ax=ax[0])
sns.heatmap(scores.mean_test_score,annot=True,fmt='.4g', ax=ax[1])

plt.show()
```



In [99]:

```
clf.best_params_ #best parameters as per gridsearch
```

Out[99]:

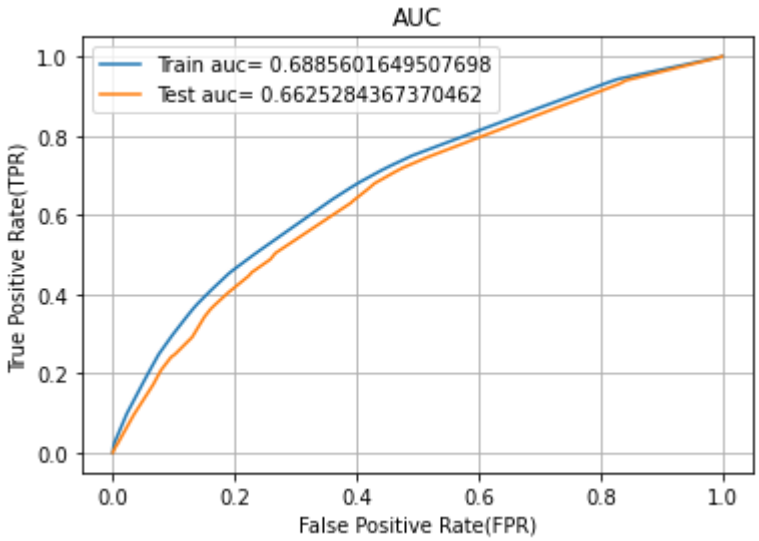
```
{'max_depth': 5, 'min_samples_split': 500}
```

In [0]:

```
def pred_proba(clf, data): #function to predict y
    y_pred = []
    y_pred = clf.predict_proba(data)[:,1]
    return y_pred
```

In [101]:

```
from sklearn.metrics import roc_curve, auc
dectree= DecisionTreeClassifier( class_weight= 'balanced', max_depth= clf.best_p
arams_['max_depth'], min_samples_split= clf.best_params_['min_samples_split'] )
dectree.fit(X_set2_train, Y_train)

Y_train_pred= pred_proba(dectree,X_set2_train)
Y_test_pred= pred_proba(dectree, X_set2_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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



Confusion Matrix:

Train:

In [0]:

```
#finding best threshold which gives minimum fpr:
def find_best_threshold(threshold, fpr, tpr):
    t = threshold[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold",
np.round(t,3))
    return t

#predicting with best thresholds:
def predict_with_best_t(proba, threshold):
    predictions = []
    global predictions_tf_w2v
    for i in proba:
        if i>=threshold:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions_tf_w2v=predictions
    return predictions
```

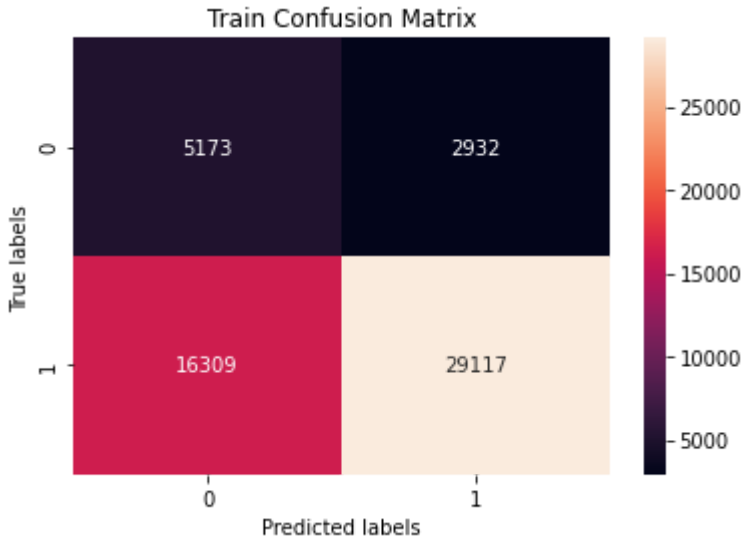
In [103]:

```
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(Y_train, predict_with_best_t(Y_train_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.40910198723860886 for threshold
0.504
Train confusion matrix
[[ 5173  2932]
 [16309 29117]]
```

In [104]:

```
#heatmap
ax=plt.subplot()
sns.heatmap(confusion_matrix(Y_train, predict_with_best_t(Y_train_pred, best_t
)),ax=ax, annot=True,fmt='g');

ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Train Confusion Matrix');
```



Test:

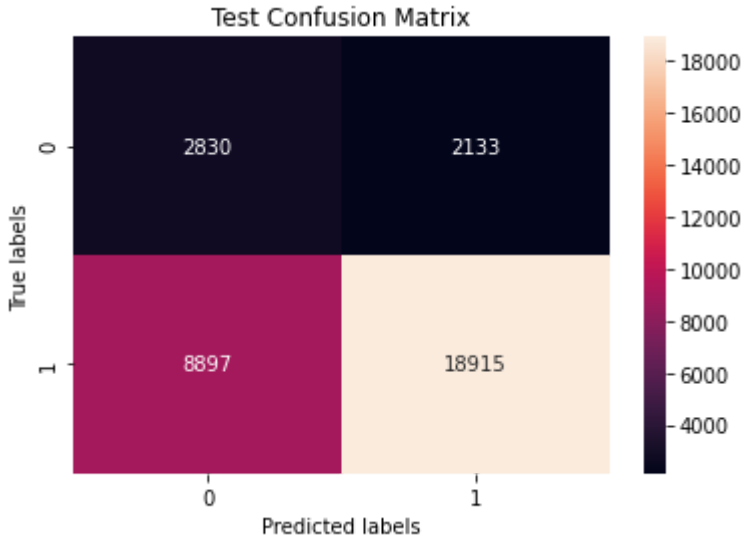
In [105]:

```
best_t = find_best_threshold(tr_thresholds, test_fpr, test_tpr)
print("Train confusion matrix")
print(confusion_matrix(Y_test, predict_with_best_t(Y_test_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.3878075726723214 for threshold 0.
483
Train confusion matrix
[[ 2830  2133]
 [ 8897 18915]]
```

In [106]:

```
#heatmap
ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, predict_with_best_t(Y_test_pred, best_t)),a
nnot=True,ax=ax,fmt='g');
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Test Confusion Matrix');
```



Getting the false positives

In [0]:

```
# finding the index of all the false positives that is 'actual negatives', wrong
ly classified as 'positives':
fp= []

for i in range(len(Y_test)):
  if (Y_test[i]==0) & (predictions_tf_w2v[i]==1):
    fp.append(i)
```

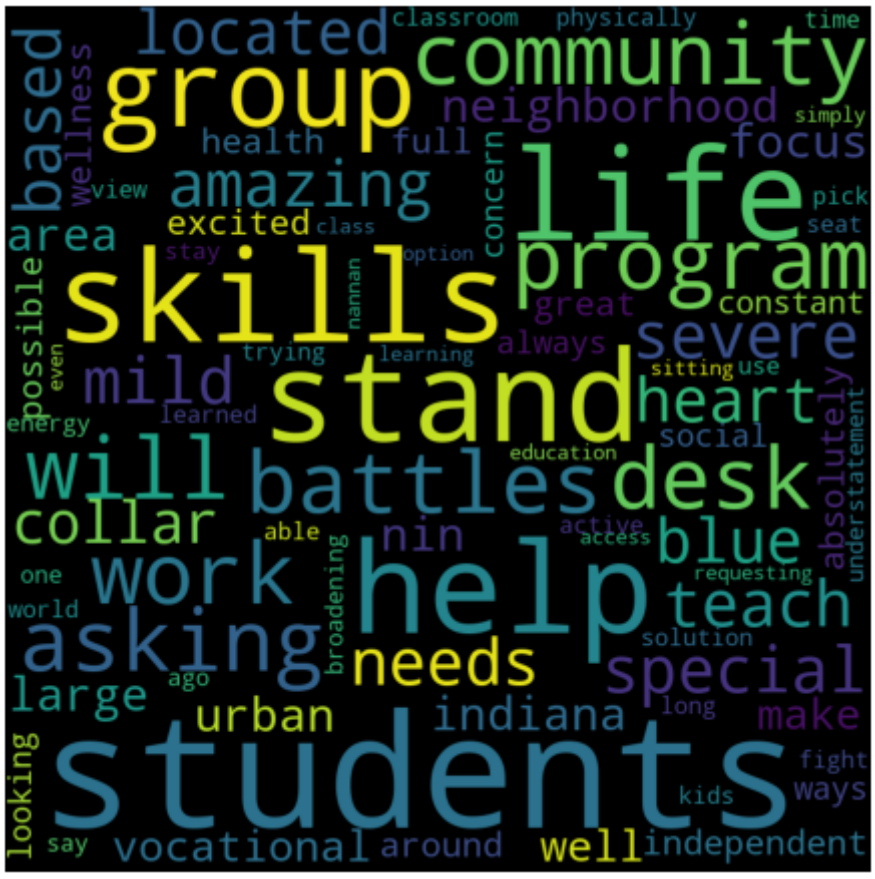
In [0]:

```
# for all those data points which are 'false positive' we extract their essay fo
r word cloud:
fp_essay=[]
for i in fp:
  fp_essay.append(X_test['essay'].values[1])
```

Word Cloud:

In [109]:

```
# https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).ipynb
from wordcloud import WordCloud, STOPWORDS

comment_words = ' '
stopwords = set(STOPWORDS)

for val in fp_essay :
  val = str(val) # converts all type of values into string
  tokens = val.split() # splits the sentences into individual words

for i in range(len(tokens)):
  tokens[i] = tokens[i].lower() #lowercases the words

for words in tokens : #seperates the words by a blank space
  comment_words = comment_words + words + ' '

wordcloud = WordCloud(width = 800, height = 800, background_color ='black', stopwords = stopwords, min_font_size = 10).generate(comment_words)


plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [0]:

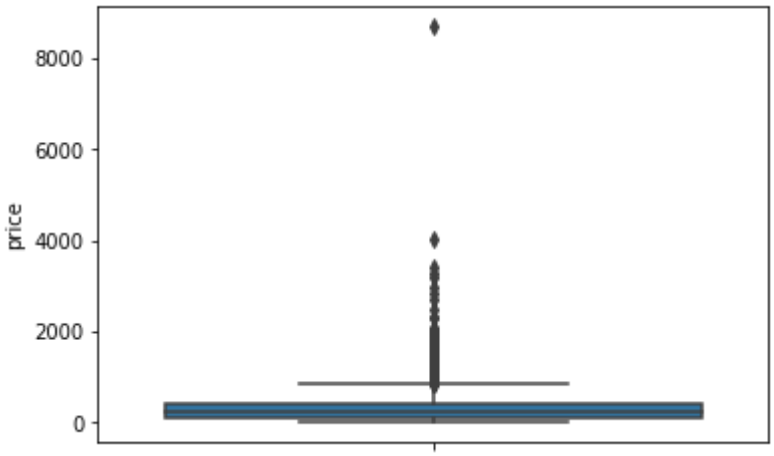
```
cols = X_test.columns
X_test_false_bow = pd.DataFrame(columns=cols)
```

In [0]:

```
for i in fp :
  X_test_false_bow = X_test_false_bow.append(X_test.filter(items=[i], axis=0)) # filtering by index of false positives
```

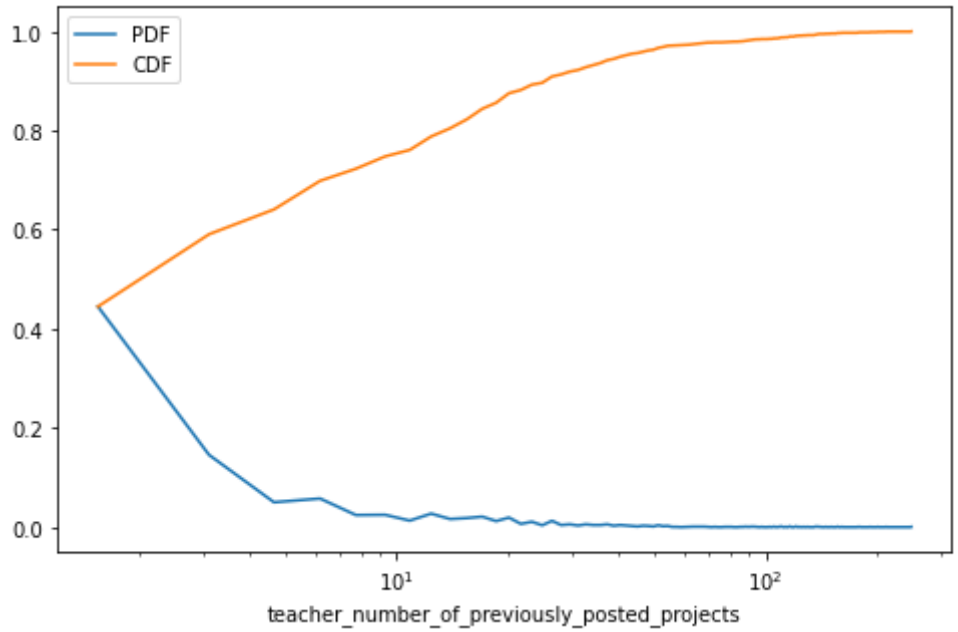
In [112]:

```
ax = sns.boxplot(y='price', data=X_test_false_bow)
```



In [113]:

```
plt.figure(figsize=(8,5))

counts, bin_edges = np.histogram(X_test_false_bow['teacher_number_of_previously_
posted_projects'], bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xscale('log')
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Top 5000 features from SET 2:

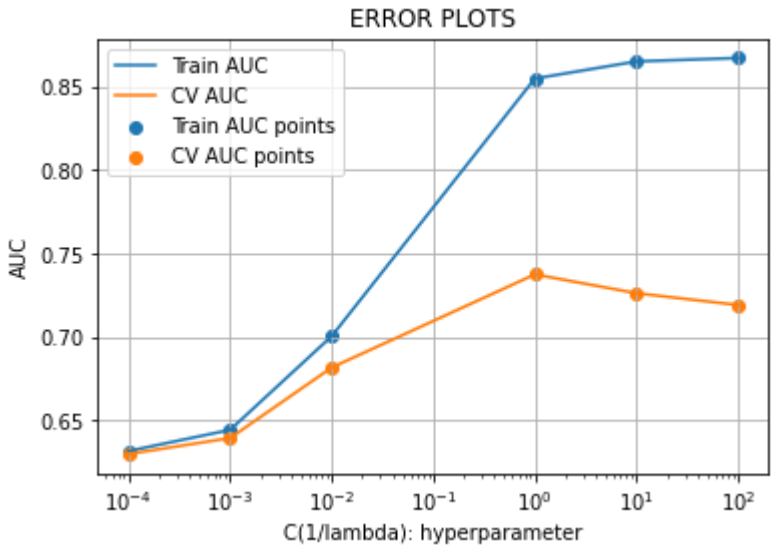
In [0]:

```
from sklearn.datasets import load_digits
from sklearn.feature_selection import SelectKBest, chi2, f_classif

best_k = SelectKBest(f_classif, k=5000).fit(X_set1_train, Y_train)
X_set3_train= best_k.transform(X_set1_train)
X_set3_test= best_k.transform(X_set1_test)
```

Applying Logistic Regression on 'Top 5000 features' SET-3

In [115]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import learning_curve, GridSearchCV

"""
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, confid
ence 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.

"""

clf = LogisticRegression(class_weight='balanced');
parameters ={'C':[10**-4, 10**-3,10**-2,1,10,100]}
cl = GridSearchCV(clf, parameters, cv=3, scoring='roc_auc',return_train_score=Tr
ue)
cl.fit(X_set3_train, Y_train);

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

plt.plot(parameters['C'], train_auc, label='Train AUC')
plt.plot(parameters['C'], cv_auc, label='CV AUC')

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

plt.legend()
plt.xlabel("C(1/lambda): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



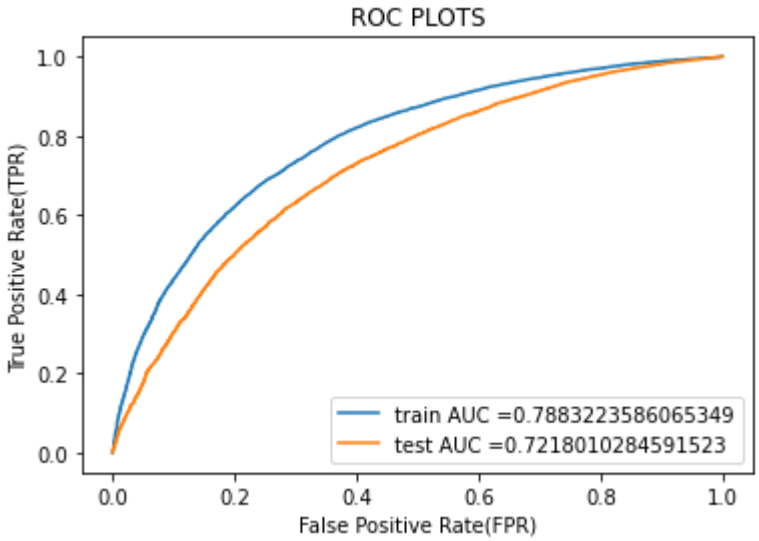
In [116]:

```
# finding best C: hyperparameter
C= [10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10, 100]
score_t_cv=[x for x in cv_auc]
opt_t_cv=C[score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:"+' '+str(max(score_t_cv)))
print("Corresponding k value of cv is:",opt_t_cv,'\n')
best_C=opt_t_cv
print(best_C)
```

```
Maximum AUC score of cv is: 0.7373198231251351
Corresponding k value of cv is: 0.1

0.1
```

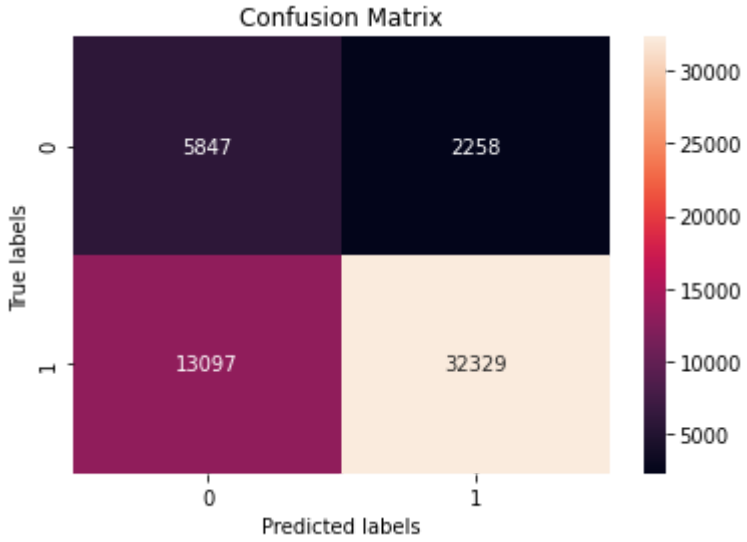
In [117]:

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


neigh = LogisticRegression(C=best_C,class_weight='balanced');
neigh.fit(X_set3_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

train_fpr, train_tpr, thresholds = roc_curve(Y_train, neigh.predict_proba(X_set3_train)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(Y_test, neigh.predict_proba(X_set3_test)[:,1])

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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
```



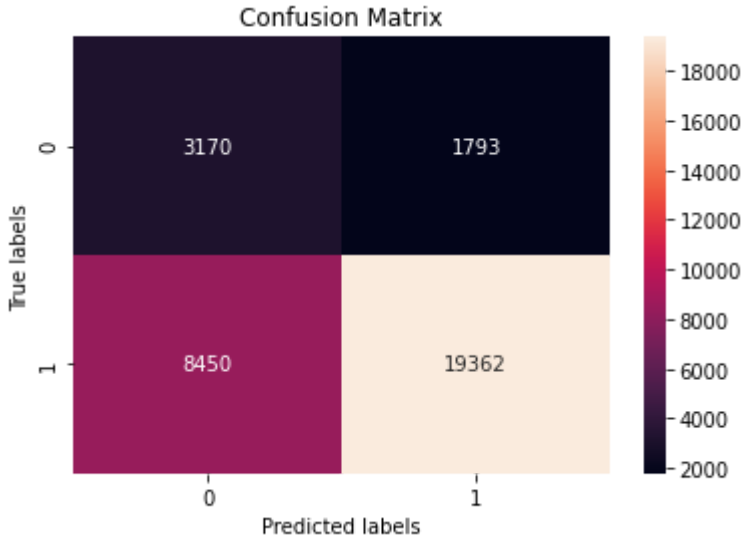
In [118]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, neigh.predict(X_set3_train )), annot=True,
ax = ax,fmt='g'); #annot=True to annotate cells

# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
#ax.xaxis.set_ticklabels(['business', 'health']); ax.yaxis.set_ticklabels(['heal
th', 'business']);
```



In [119]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, neigh.predict(X_set3_test )), annot=True, a
x = ax,fmt='g'); #annot=True to annotate cells

# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
#ax.xaxis.set_ticklabels(['business', 'health']); ax.yaxis.set_ticklabels(['heal
th', 'business']);
```



Conclusion

In [11]:

```
# https://ptable.readthedocs.io/en/latest/tutorial.html
from prettytable import PrettyTable
x = PrettyTable()

x.field_names = ["Vectorizer","Model","Hyper Parameter","min_samples split","AU
C"]

x.add_row(["TFIDF","Decision Tree","10 (max depth)",500,0.68])
x.add_row(["TFIDF W2V","Decision Tree","5 (max depth)",500,0.65])
x.add_row(["TOP 5000 feat","Logistic Regression","0.1 (C)", "Nan",0.72])

x.padding_width =0
print (x)
```

```
+-------------+-------------------+---------------+-----------------
+----+
|  Vectorizer |       Model       |Hyper Parameter|min_samples split
|AUC |
+-------------+-------------------+---------------+-----------------
+----+
|    TFIDF    |   Decision Tree   | 10 (max depth)|       500
|0.68|
|  TFIDF W2V  |   Decision Tree   | 5 (max depth) |       500
|0.65|
|TOP 5000 feat|Logistic Regression|    0.1 (C)    |       Nan
|0.72|
+-------------+-------------------+---------------+-----------------
+----+
```