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*

Feature	Description
`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

import pickle

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv',nrows=50000)
resource_data = pd.read_csv('resources.csv')
```

In [3]:

```
project_data.shape
```

Out[3]:

```
(50000, 17)
```

In [4]:

```
project_data['project_is_approved'].value_counts()
```

Out[4]:

```
1    42286
0     7714
Name: project_is_approved, dtype: int64
```

In [5]:

```
resource_data.shape
```

Out[5]:

```
(1541272, 4)
```

In [6]:

```
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 (50000, 17)
```

```
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [7]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[7]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s
473	100660	p234804	cbc0e38f522143b86d372f8b43d4cff3	Mrs.	GA	2016-04-27 00:53:00	Grades PreK-2	
41558	33679	p137682	06f6e62e17de34fcf81020c77549e1d5	Mrs.	WA	2016-04-27 01:05:25	Grades 3-5	L

In [8]:

```
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[8]:

	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 [9]:

```
print(project_data['project_subject_categories'].head(5))
```

```
473                      Applied Learning
41558                  Literacy & Language
29891     Math & Science, History & Civics
23374                  Literacy & Language
49228                  Literacy & Language
Name: project_subject_categories, dtype: object
```

In [10]:

```
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 & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "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)
```

In [11]:

```
print(project_data['clean_categories'].head(5))
```

```
473                   AppliedLearning
41558               Literacy_Language
29891     Math_Science History_Civics
23374               Literacy_Language
49228               Literacy_Language
Name: clean_categories, dtype: object
```

1.3 preprocessing of `project_subject_subcategories`

In [12]:

```
print(project_data['project_subject_subcategories'].head(5))
```

```
473                 Early Development
41558                        Literacy
29891     Mathematics, Social Sciences
23374                  ESL, Literacy
49228                        Literacy
Name: project_subject_subcategories, dtype: object
```

In [13]:

```
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 & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
            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)
```

In [14]:

```
print(project_data['clean_subcategories'].head(5))
```

```
473                   EarlyDevelopment
41558                         Literacy
29891     Mathematics SocialSciences
23374                     ESL Literacy
49228                         Literacy
Name: clean_subcategories, dtype: object
```

1.5 preprocessing of `project_grade_category`

In [15]:

```
preproc = []
# tqdm is for printing the status bar
for sent in project_data['project_grade_category']:
    sent = sent.replace('Grades ', '')
    sent = sent.replace('PreK-2', 'PreKto2')
    sent = sent.replace('3-5', '3to5')
    sent = sent.replace('6-8', '6to8')
    sent = sent.replace('9-12', '9to12')
    preproc.append(sent)
project_data['project_grade_category']=preproc
```

In [16]:

```
print(project_data['project_grade_category'].head(5))
```

```
473      PreKto2
41558       3to5
29891       3to5
23374    PreKto2
49228    PreKto2
Name: project_grade_category, dtype: object
```

1.6 preprocessing of `teacher_prefix`

In [17]:

```
print(type(project_data['teacher_prefix']))
```

```
<class 'pandas.core.series.Series'>
```

In [18]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].astype(str)
preproc = []
# tqdm is for printing the status bar
for sent in project_data['teacher_prefix']:
    sent = sent.replace('Mr.', 'Mr')
    sent = sent.replace('Mrs.', 'Mrs')
    sent = sent.replace('Dr.', 'Dr')
    sent = sent.replace('Ms.', 'Ms')
    sent = sent.replace('nan','Mr')
    preproc.append(sent)
project_data['teacher_prefix']=preproc
```

In [19]:

```
project_data['teacher_prefix'].value_counts()
```

Out[19]:

```
Mrs        26140
Ms         17936
Mr          4861
Teacher     1061
Dr             2
Name: teacher_prefix, dtype: int64
```

In [20]:

```
print(project_data['teacher_prefix'].head(5))
```

```
473      Mrs
41558    Mrs
29891    Mrs
23374     Ms
49228     Ms
Name: teacher_prefix, dtype: object
```

1.3 Preprocessing of Essays

In [21]:

```
# 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 [22]:

```
# 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]:

```
# 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', 'between', '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', 'e
ach', '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', "couldn't", 'didn', "didn't", 'doesn', "do
esn'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 [24]:

```
# 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.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████| 50000/50000 [00:30<00:00, 1622.88it/s]
```

In [25]:

```
# after preprocesing
preprocessed_essays[2000]
```

Out[25]:

```
'teach elementary school 4th 5th grade building small town central illinois next year teaching thr
ee different classes students reading language writing spelling classroom students enjoy variety a
ctivities including hands collaborative learning order help make information real interesting givi
ng reason practice students wide variety students school 60 students receiving free lunch low inco
me percentage students often require additional help support help make learning valuable real worl
d teachers work hard collaborate order help students achieve highest level community supportive sc
hools lately lower levels state support many local businesses cut back individual assistance
classrooms order continue learning projects look support help us next year focusing great deal ela
english language arts time 5th grade improving writing across curriculum math science reading lang
uage social studies individual marker boards give students ability practice writing skills individ
ually giving ability check individual work practice also allow add creativity writing vocabulary p
ractice boards amazing tool classroom kids enjoy offer benefit working making errors learn fix imp
ortant step learning process nannan'
```

In [26]:

```
project_data['essay']=preprocessed_essays
```

1.4 Preprocessing of `project_title`

In [27]:

```
# similarly you can preprocess the titles also
preprocessed_titles = []
```

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

```
100%|██████████| 50000/50000 [00:01<00:00, 37286.08it/s]
```

In [28]:

```
project_data['project_title']=preprocessed_titles
```

1.5 Preparing data for models

In [29]:

```
project_data.columns
```

Out[29]:

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

we are going to consider

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

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

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

In [30]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f,encoding = "ISO-8859-1")
    glove_words =  set(model.keys())
```

Assignment 9: RF and GBDT

Response Coding: Example

> The response tabel is built only on train dataset. For a category which is not there in train data and present in test

> data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

1. **Apply both Random Forrest and GBDT on these feature sets**

   - Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
   - Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   - Set 3: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
   - Set 4: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)**

   - Find the best hyper parameter which will give the maximum AUC value
   - find the best hyper paramter using k-fold cross validation/simple cross validation data
   - use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

3. **Representation of results**

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

     with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

   or

   - 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

     seaborn heat maps with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
   - You can choose either of the plotting techniques: 3d plot or heat map
   - 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

4. **Conclusion**

   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

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

Decision Tree

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

In [31]:

```
train_data = project_data.iloc[:40000]
test_data = project_data.iloc[40000:]
```

In [32]:

```
train_data.shape
```

Out[32]:

```
(40000, 18)
```

In [33]:

```
test_data.shape
```

Out[33]:

```
(10000, 18)
```

In [34]:

```
y_train=train_data['project_is_approved']
```

In [35]:

```
y_test=test_data['project_is_approved']
```

In [36]:

```
X_train=train_data.copy()
```

In [37]:

```
X_test=test_data.copy()
```

In [38]:

```
X_train.drop(['project_is_approved'],axis=1,inplace=True)
```

In [39]:

```
X_test.drop(['project_is_approved'],axis=1,inplace=True)
```

In [40]:

```
print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
print("="*100)
```

```
(40000, 17) (40000,)
(10000, 17) (10000,)
====================================================================================================
```

2.3 Make Data Model Ready: encoding numerical and categorical features

Vectorizing Numerical features

In [41]:

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

In [42]:

```
price_data.head(5)
```

Out[42]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21
2	p000003	298.97	4
3	p000004	1113.69	98
4	p000005	485.99	8

In [43]:

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

In [44]:

```
X_train=X_train.fillna(0)
X_test=X_test.fillna(0)
```

Normalizing the numerical features: Price

In [45]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# 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.fit(X_train['price'].values.reshape(-1,1))
X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))
print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 1) (40000,)
(10000, 1) (10000,)
====================================================================================================
```

Normalizing the numerical features: Number of previously posted projects

In [46]:

```
normalizer = Normalizer()
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_train_project_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'
].values.reshape(-1,1))
X_test_project_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].
values.reshape(-1,1))
print("After vectorizations")
print(X_train_project_norm.shape, y_train.shape)
print(X_test_project_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 1) (40000,)
(10000, 1) (10000,)
====================================================================================================
```

Vectorizing Categorical features using Response Coding

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

Vectorizing Categorical features: project grade category

In [47]:

```
cat = train_data['project_grade_category'].unique()
count=0
freqP = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['project_grade_category'] == i and row['project_is_approved']==1:
            count=count+1
    freqP.append(count)
    count=0
```

In [48]:

```
cat = train_data['project_grade_category'].unique()
count=0
freqN = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['project_grade_category'] == i and row['project_is_approved']==0:
            count=count+1
    freqN.append(count)
    count=0
```

In [49]:

```
encodedP = []
for i in range(len(cat)) :
    encodedP.append(freqP[i]/(freqP[i] + freqN[i]))
encodedN = []
encodedN[:] = [1 - x for x in encodedP]
encodedPVAL = dict(zip(cat, encodedP))
encodedNVAL = dict(zip(cat, encodedN))
```

In [50]:

```
grade_pos_encode_train = X_train['project_grade_category'].map(encodedPVAL)
grade_neg_encode_train = X_train['project_grade_category'].map(encodedNVAL)
```

In [51]:

```
grade_pos_encode_test=X_test['project_grade_category'].map(encodedPVAL)
grade_neg_encode_test=X_test['project_grade_category'].map(encodedNVAL)
```

Vectorizing Categorical features: teacher prefix

In [52]:

```
train_data['teacher_prefix'].value_counts()
```

Out[52]:

```
Mrs        20980
Ms         14283
Mr          3886
```

```
Teacher      850
Dr             1
Name: teacher_prefix, dtype: int64
```

In [53]:

```
%%time
cat = train_data['teacher_prefix'].unique()
count=0
freqP = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['teacher_prefix'] == i and row['project_is_approved']==1:
            count=count+1
    freqP.append(count)
    count=0
```

```
CPU times: user 11.2 s, sys: 11.3 ms, total: 11.3 s
Wall time: 11.3 s
```

In [54]:

```
%%time
cat = train_data['teacher_prefix'].unique()
count=0
freqN = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['teacher_prefix'] == i and row['project_is_approved']==0:
            count=count+1
    freqN.append(count)
    count=0
```

```
CPU times: user 11.2 s, sys: 0 ns, total: 11.2 s
Wall time: 11.2 s
```

In [55]:

```
encodedP = []
for i in range(len(cat)) :
    encodedP.append(freqP[i]/(freqP[i] + freqN[i]))
encodedN = []
encodedN[:] = [1 - x for x in encodedP]
encodedPVAL = dict(zip(cat, encodedP))
encodedNVAL = dict(zip(cat, encodedN))
```

In [56]:

```
teacher_pos_encode_train = X_train['teacher_prefix'].map(encodedPVAL)
teacher_neg_encode_train = X_train['teacher_prefix'].map(encodedNVAL)
```

In [57]:

```
teacher_pos_encode_test=X_test['teacher_prefix'].map(encodedPVAL)
teacher_neg_encode_test=X_test['teacher_prefix'].map(encodedNVAL)
```

Vectorizing Categorical features: school state

In [58]:

```
%%time
cat = train_data['school_state'].unique()
count=0
freqP = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['school_state'] == i and row['project_is_approved']==1:
            count=count+1
    freqP.append(count)
    freqP.append(count)
    count=0
```

```
CPU times: user 1min 51s, sys: 14.4 ms, total: 1min 51s
Wall time: 1min 51s
```

In [59]:

```
%%time
cat = train_data['school_state'].unique()
count=0
freqN = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['school_state'] == i and row['project_is_approved']==0:
            count=count+1
    freqN.append(count)
    count=0
```

```
CPU times: user 1min 51s, sys: 7.57 ms, total: 1min 51s
Wall time: 1min 51s
```

In [60]:

```
encodedP = []
for i in range(len(cat)) :
    encodedP.append(freqP[i]/(freqP[i] + freqN[i]))
encodedN = []
encodedN[:] = [1 - x for x in encodedP]
encodedPVAL = dict(zip(cat, encodedP))
encodedNVAL = dict(zip(cat, encodedN))
```

In [61]:

```
state_pos_encode_train = X_train['school_state'].map(encodedPVAL)
state_neg_encode_train = X_train['school_state'].map(encodedNVAL)
```

In [62]:

```
state_pos_encode_test=X_test['school_state'].map(encodedPVAL)
state_neg_encode_test=X_test['school_state'].map(encodedNVAL)
```

Vectorizing Categorical features: clean categories

In [63]:

```
%%time
cat = train_data['clean_categories'].unique()
count=0
freqP = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['clean_categories'] == i and row['project_is_approved']==1:
            count=count+1
    freqP.append(count)
    count=0
```

```
CPU times: user 1min 49s, sys: 7.82 ms, total: 1min 49s
Wall time: 1min 49s
```

In [64]:

```
%%time
cat = train_data['clean_categories'].unique()
count=0
freqN = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['clean_categories'] == i and row['project_is_approved']==0:
            count=count+1
    freqN.append(count)
    count=0
```

```
CPU times: user 1min 48s, sys: 11.9 ms, total: 1min 48s
Wall time: 1min 48s
```

In [65]:

```
encodedP = []
for i in range(len(cat)) :
    encodedP.append(freqP[i]/(freqP[i] + freqN[i]))
encodedN = []
encodedN[:] = [1 - x for x in encodedP]
encodedPVAL = dict(zip(cat, encodedP))
encodedNVAL = dict(zip(cat, encodedN))
```

In [66]:

```
cat_pos_encode_train = X_train['clean_categories'].map(encodedPVAL)
cat_neg_encode_train = X_train['clean_categories'].map(encodedNVAL)
```

In [67]:

```
cat_pos_encode_test=X_test['clean_categories'].map(encodedPVAL)
cat_neg_encode_test=X_test['clean_categories'].map(encodedNVAL)
```

Vectorizing Categorical features: clean subcategories

In [71]:

```
%%time
cat = train_data['clean_subcategories'].unique()
count=0
freqP = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['clean_subcategories'] == i and row['project_is_approved']==1:
            count=count+1
    freqP.append(count)
    count=0
```

```
CPU times: user 13min 27s, sys: 59.7 ms, total: 13min 27s
Wall time: 13min 27s
```

In [72]:

```
%%time
cat = train_data['clean_subcategories'].unique()
count=0
freqN = []
for i in cat:
    for index,row in train_data.iterrows():
        if row['clean_subcategories'] == i and row['project_is_approved']==0:
            count=count+1
    freqN.append(count)
    count=0
```

```
CPU times: user 13min 28s, sys: 47.9 ms, total: 13min 28s
Wall time: 13min 28s
```

In [73]:

```
encodedP = []
for i in range(len(cat)) :
    encodedP.append(freqP[i]/(freqP[i] + freqN[i]))
encodedN = []
```

```
encodedN[:] = [1 - x for x in encodedP]
encodedPVAL = dict(zip(cat, encodedP))
encodedNVAL = dict(zip(cat, encodedN))
```

In [74]:

```
sub_pos_encode_train = X_train['clean_subcategories'].map(encodedPVAL)
sub_neg_encode_train = X_train['clean_subcategories'].map(encodedNVAL)
```

In [75]:

```
sub_pos_encode_test=X_test['clean_subcategories'].map(encodedPVAL)
sub_neg_encode_test=X_test['clean_subcategories'].map(encodedNVAL)
```

2.2 Make Data Model Ready: encoding eassay, and project_title

Encoding of Text Data

In [76]:

```
from sklearn.feature_extraction.text import CountVectorizer
```

BOW of Essay

In [77]:

```
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [78]:

```
vectorizer.fit(X_train['essay'].values) # fit has to happen only on train data
```

Out[78]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
        tokenizer=None, vocabulary=None)
```

In [79]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['essay'].values)
```

In [80]:

```
X_test_essay_bow = vectorizer.transform(X_test['essay'].values)
```

In [81]:

```
print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 5000) (40000,)
(10000, 5000) (10000,)
===================================================================================================
```

BOW of Title

In [82]:

```
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [83]:

```
vectorizer.fit(X_train['project_title'].values) # fit has to happen only on train data
```

Out[83]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
        tokenizer=None, vocabulary=None)
```

In [84]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['project_title'].values)
```

In [85]:

```
X_test_title_bow = vectorizer.transform(X_test['project_title'].values)
```

In [86]:

```
print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_test_title_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 3436) (40000,)
(10000, 3436) (10000,)
===================================================================================================
```

TFIDF of Essay

In [87]:

```
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [88]:

```
vectorizer.fit(X_train['essay'].values) # fit has to happen only on train data
```

Out[88]:

```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), norm='l2', preprocessor=None, smooth_idf=True,
        stop_words=None, strip_accents=None, sublinear_tf=False,
        token_pattern='(?u)\\b\\w\\w+\\b', tokenizer=None, use_idf=True,
        vocabulary=None)
```

In [89]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer.transform(X_train['essay'].values)
```

In [90]:

```
X_test_essay_tfidf = vectorizer.transform(X_test['essay'].values)
```

In [91]:

```
print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 5000) (40000,)
(10000, 5000) (10000,)
====================================================================================================
```

TFIDF of Title

In [92]:

```
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [93]:

```
vectorizer.fit(X_train['project_title'].values) # fit has to happen only on train data
```

Out[93]:

```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), norm='l2', preprocessor=None, smooth_idf=True,
        stop_words=None, strip_accents=None, sublinear_tf=False,
        token_pattern='(?u)\\b\\w\\w+\\b', tokenizer=None, use_idf=True,
        vocabulary=None)
```

In [94]:

```
# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['project_title'].values)
```

In [95]:

```
X_test_title_tfidf = vectorizer.transform(X_test['project_title'].values)
```

In [96]:

```
print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_test_title_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(40000, 3436) (40000,)
(10000, 3436) (10000,)
====================================================================================================
```

Avg W2V of Essay

In [97]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_essay_train = []; # the avg-w2v for each sentence/review is stored in this list
```

```
avg_w2v_essay_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_train.append(vector)
print(len(avg_w2v_essay_train))
print(len(avg_w2v_essay_train[0]))
print(type(avg_w2v_essay_train))
```

```
100%|██████████| 40000/40000 [00:11<00:00, 3617.32it/s]
```

```
40000
300
<class 'list'>
```

In [98]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_essay_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_test.append(vector)
print(len(avg_w2v_essay_test))
print(len(avg_w2v_essay_test[0]))
print(type(avg_w2v_essay_test))
```

```
100%|██████████| 10000/10000 [00:02<00:00, 3721.72it/s]
```

```
10000
300
<class 'list'>
```

Avg W2V of Title

In [99]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_title_train.append(vector)

print(len(avg_w2v_title_train))
print(len(avg_w2v_title_train[0]))
print(type(avg_w2v_title_train))
```

```
100%|██████████| 40000/40000 [00:00<00:00, 66368.51it/s]
```

```
40000
300
<class 'list'>
```

In [100]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_title_test.append(vector)

print(len(avg_w2v_title_test))
print(len(avg_w2v_title_test[0]))
print(type(avg_w2v_title_test))
```

```
100%|██████████| 10000/10000 [00:00<00:00, 65199.31it/s]
```

```
10000
300
<class 'list'>
```

TFIDF-W2V of Essay

In [101]:

```
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
tfidf_model.fit(X_train['essay'].values)
# 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 [102]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_train_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_train_essay.append(vector)

print(len(tfidf_w2v_train_essay))
print(len(tfidf_w2v_train_essay[0]))
```

```
100%|██████████| 40000/40000 [01:00<00:00, 661.20it/s]
```

```
100%|██████████| 40000/40000 [01:00<00:00, 661.20it/s]
```

```
40000
300
```

In [103]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_test_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_test_essay.append(vector)

print(len(tfidf_w2v_test_essay))
print(len(tfidf_w2v_test_essay[0]))
```

```
100%|██████████| 10000/10000 [00:14<00:00, 667.47it/s]
```

```
10000
300
```

TFIDF-W2V of Title

In [104]:

```
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
tfidf_model.fit(X_train['project_title'].values)
# 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 [105]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_train_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_train_title.append(vector)

print(len(tfidf_w2v_train_title))
print(len(tfidf_w2v_train_title[0]))
```

```
100%|██████████| 40000/40000 [00:01<00:00, 34423.90it/s]
```

```
40000
300
```

In [106]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_test_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_test_title.append(vector)

print(len(tfidf_w2v_test_title))
print(len(tfidf_w2v_test_title[0]))
```

```
100%|██████████| 10000/10000 [00:00<00:00, 31824.82it/s]
```

```
10000
300
```

Applying DT on BOW, SET 1

Creating Data Matrix

In [107]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr =
hstack((X_train_essay_bow,X_train_title_bow,grade_pos_encode_train.reshape(40000,1),grade_neg_encoc
e_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),teacher_neg_encode_train.reshape
(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_train.reshape(40000,1),cat_pos_e
ncode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),sub_pos_encode_train.reshape(40
000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_train_project_norm))
X_te =
hstack((X_test_essay_bow,X_test_title_bow,grade_pos_encode_test.reshape(10000,1),grade_neg_encode_t
est.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teacher_neg_encode_test.reshape(10000
,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.reshape(10000,1),cat_pos_encode_te
st.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_encode_test.reshape(10000,1),sub_n
eg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_norm))

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

```
Final Data matrix
(40000, 8448) (40000,)
(10000, 8448) (10000,)
```

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

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

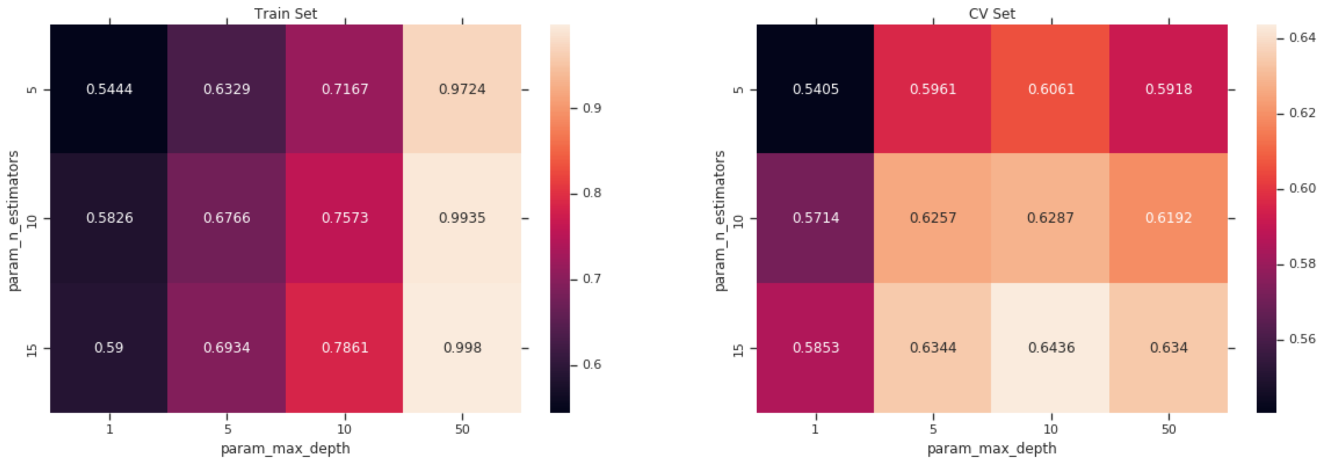
In [108]:

```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
ens=RandomForestClassifier(class_weight='balanced')
parameters = {'max_depth': [1,5,10,50], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 1min 1s, sys: 3.73 s, total: 1min 5s
Wall time: 1min 6s
```

In [109]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train The Model

In [110]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [111]:

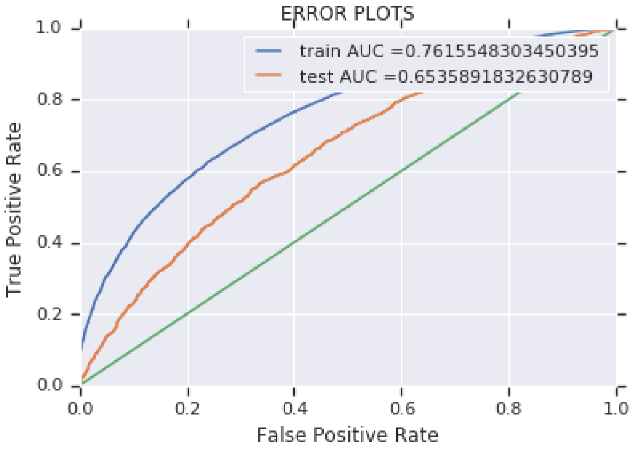
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [112]:

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

from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_curve, auc


classifier = RandomForestClassifier(max_depth = 10, n_estimators = 15,class_weight='balanced')

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [113]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [114]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

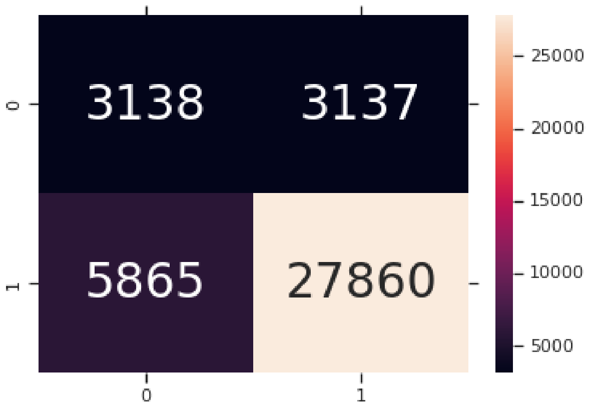
In [115]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.477
```

Out[115]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f20558a3ac8>
```



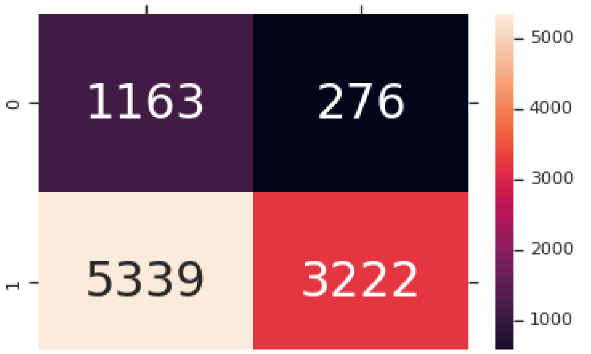
In [116]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,t
est_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499998792691048 for threshold 0.533
```

Out[116]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f20800c81d0>
```



Applying DT on TFIDF, SET 2

Creating Data Matrix

In [117]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr =
hstack((X_train_essay_tfidf,X_train_title_tfidf,grade_pos_encode_train.reshape(40000,1),grade_neg_e
ncode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),teacher_neg_encode_train.res
hape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_train.reshape(40000,1),cat_
pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),sub_pos_encode_train.reshap
e(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_train_project_norm))
X_te =
hstack((X_test_essay_tfidf,X_test_title_tfidf,grade_pos_encode_test.reshape(10000,1),grade_neg_enco
de_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teacher_neg_encode_test.reshape(
10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.reshape(10000,1),cat_pos_enco
de_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_encode_test.reshape(10000,1),
sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_norm))

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

```
Final Data matrix
(40000, 8448) (40000,)
(10000, 8448) (10000,)
===================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

In [118]:

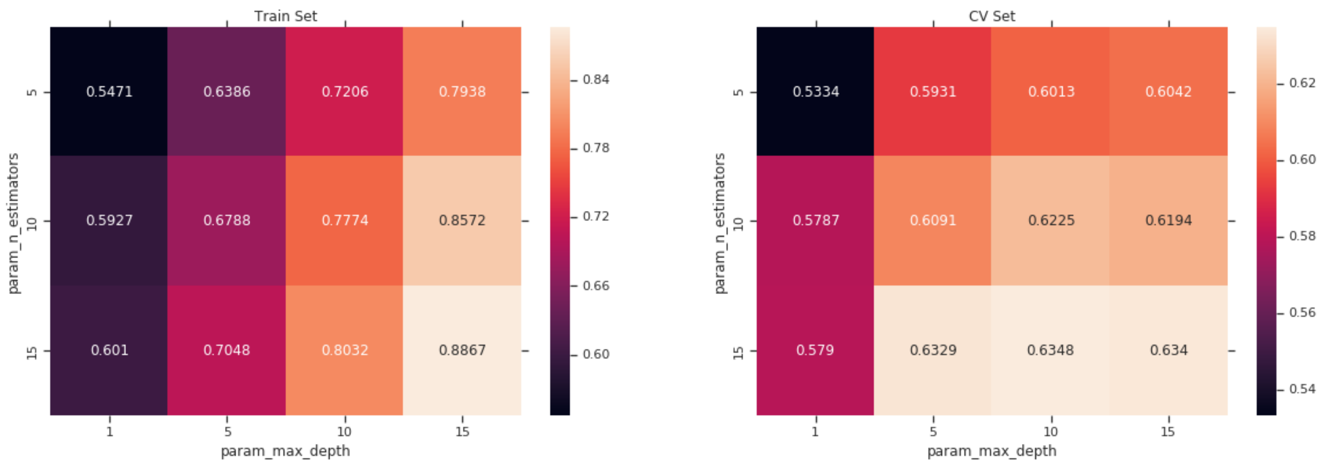
```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
ens=RandomForestClassifier(class_weight='balanced')
parameters = {'max_depth': [1,5,10,15], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 35.1 s, sys: 2.84 s, total: 37.9 s
Wall time: 37.9 s
```

In [119]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
```

```
plt.show()
```



Train The Model

In [120]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [121]:

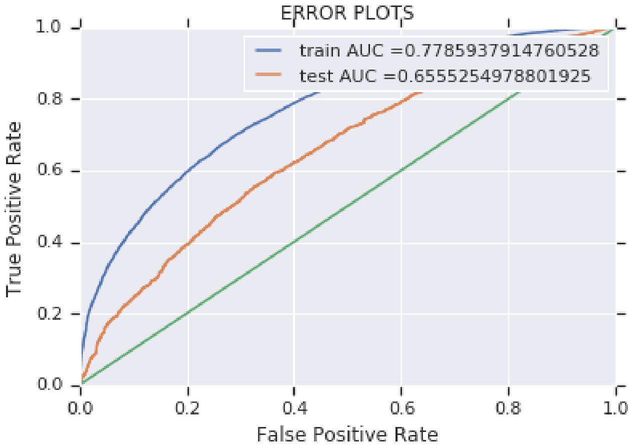
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [152]:

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

from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_curve, auc


classifier = RandomForestClassifier(max_depth = 10, n_estimators = 15,class_weight='balanced')

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [153]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [154]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

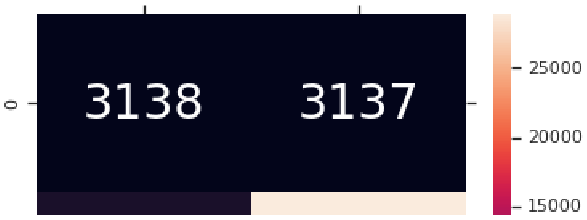
In [155]:

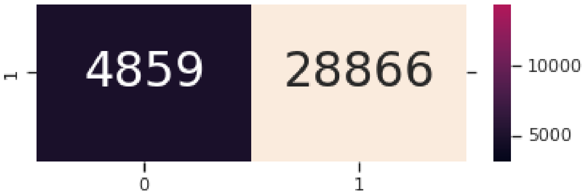
```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.482
```

Out[155]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f208c6c1208>
```





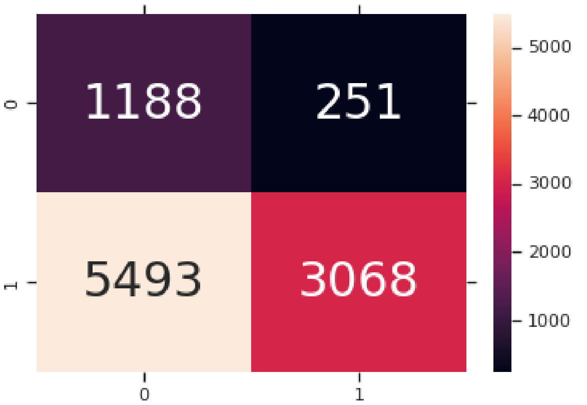
In [156]:

```
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,test_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999987926910483 for threshold 0.538
```

Out[156]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f2064e5ab00>
```



Applying DT on AVG W2V, SET 3

Creating Data Matrix

In [157]:

```
from scipy.sparse import csr_matrix
```

In [158]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((csr_matrix(avg_w2v_essay_train),csr_matrix(avg_w2v_title_train),grade_pos_encode_train.reshape(40000,1),grade_neg_encode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),teacher_neg_encode_train.reshape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_train.reshape(40000,1),cat_pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),sub_pos_encode_train.reshape(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_train_project_norm))
X_te = hstack((csr_matrix(avg_w2v_essay_test),csr_matrix(avg_w2v_title_test),grade_pos_encode_test.reshape(10000,1),grade_neg_encode_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teacher_neg_encode_test.reshape(10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.reshape(10000,1),cat_pos_encode_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_encode_test.reshape(10000,1),sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_norm))

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

```
Final Data matrix
(40000, 612) (40000,)
(10000, 612) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

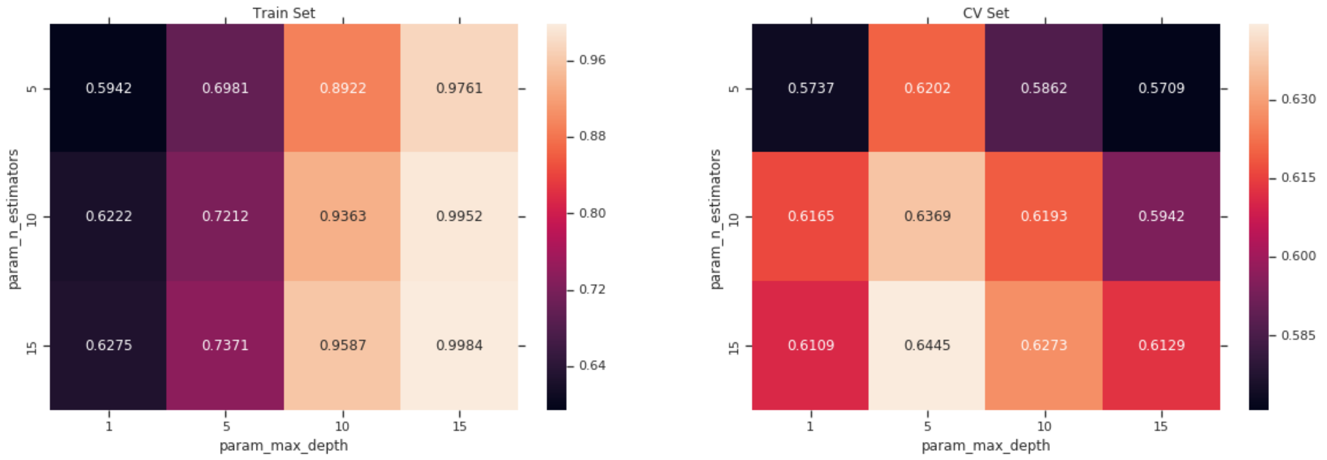
In [159]:

```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
ens=RandomForestClassifier(class_weight='balanced')
parameters = {'max_depth': [1,5,10,15], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 6min 21s, sys: 16.6 s, total: 6min 37s
Wall time: 6min 37s
```

In [160]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train The Model

In [161]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [162]:

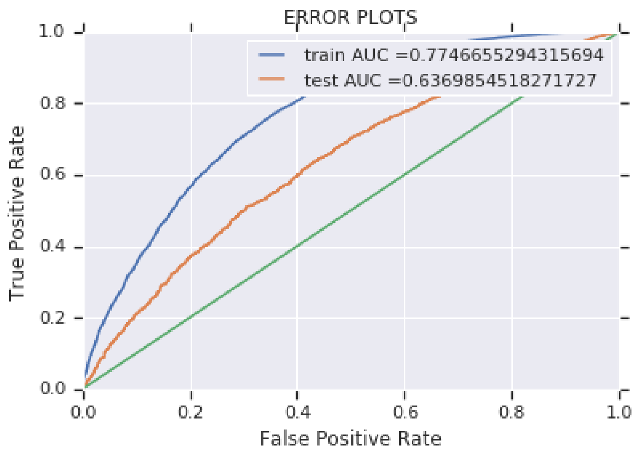
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [167]:

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

from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_curve, auc


classifier = RandomForestClassifier(max_depth = , n_estimators = 15)

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [168]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [169]:

In [169]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

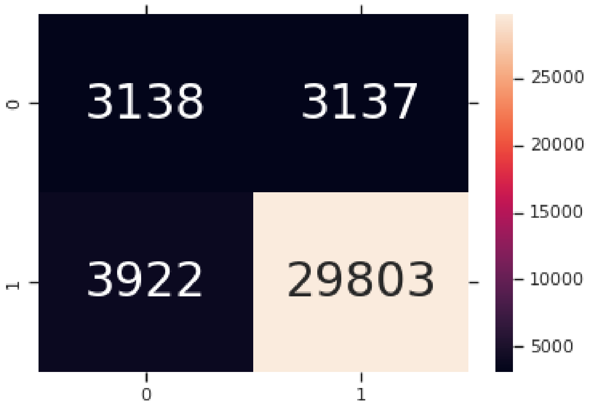
In [170]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.807
```

Out[170]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f2077966dd8>
```



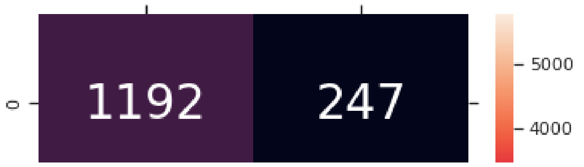
In [171]:

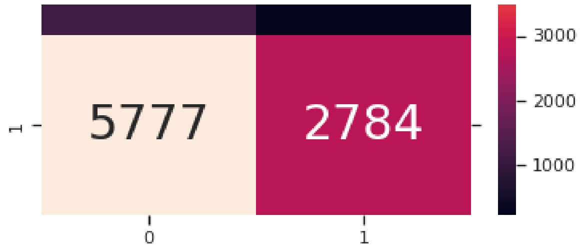
```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,t
est_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499998792691048 for threshold 0.87
```

Out[171]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f20813a7198>
```





Applying DT on TFIDF W2V, SET 4

Creating Data Matrix

In [172]:

```
from scipy.sparse import csr_matrix
```

In [173]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr =
hstack((csr_matrix(tfidf_w2v_train_essay),csr_matrix(tfidf_w2v_train_title),grade_pos_encode_train
.reshape(40000,1),grade_neg_encode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1
),teacher_neg_encode_train.reshape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encoc
e_train.reshape(40000,1),cat_pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,
1),sub_pos_encode_train.reshape(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,
X_train_project_norm))
X_te =
hstack((csr_matrix(tfidf_w2v_test_essay),csr_matrix(tfidf_w2v_test_title),grade_pos_encode_test.re
shape(10000,1),grade_neg_encode_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teac
her_neg_encode_test.reshape(10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.
reshape(10000,1),cat_pos_encode_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_
encode_test.reshape(10000,1),sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_
norm))

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

```
Final Data matrix
(40000, 612) (40000,)
(10000, 612) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

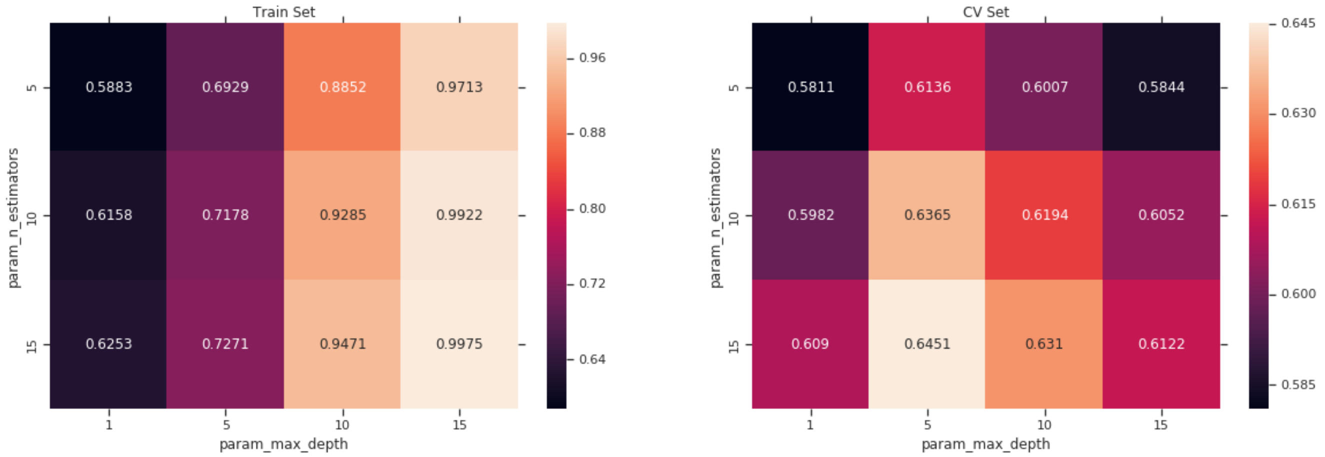
In [174]:

```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
ens=RandomForestClassifier(class_weight='balanced')
parameters = {'max_depth': [1,5,10,15], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 6min 24s, sys: 12.4 s, total: 6min 36s
Wall time: 6min 36s
```

In [175]:

```python
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators', 
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train The Model

In [176]:

```python
X_te.data = np.nan_to_num(X_te.data)
```

In [177]:

```python
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

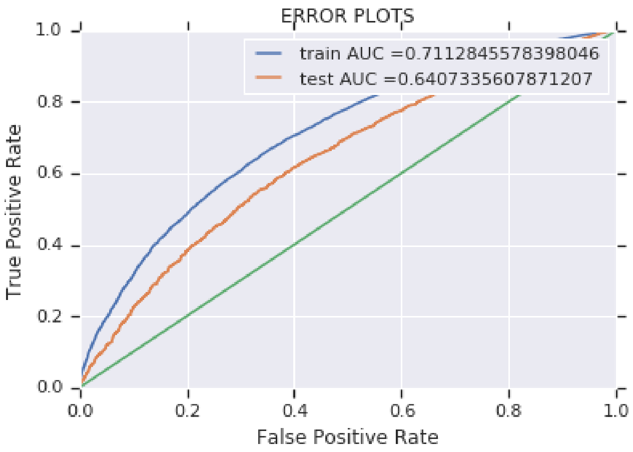
In [188]:

```python
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_curve, auc


classifier = RandomForestClassifier(max_depth = 5, n_estimators = 15,class_weight='balanced')

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [189]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [190]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

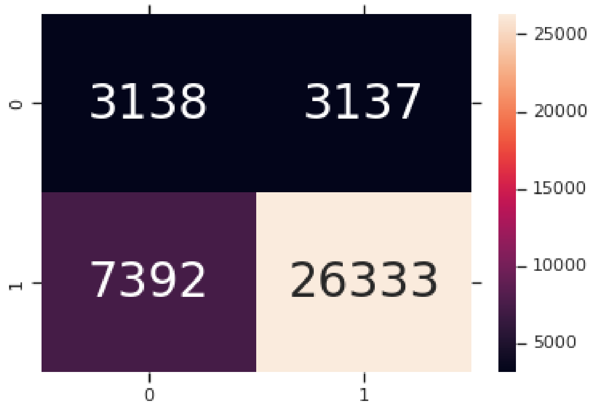
In [191]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.47
```

Out[191]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f20695a7278>
```



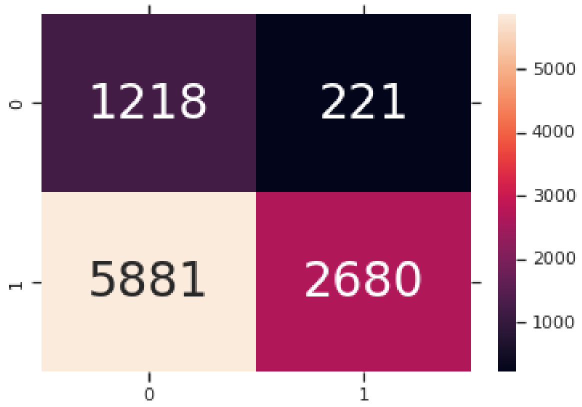
In [192]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,test_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499998792691048 for threshold 0.558
```

Out[192]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f205d2f6828>
```



Applying GBDT

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

2.5.1 Applying XGBOOST on BOW, SET 1

Creating Data Matrix

In [214]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
```

```
from scipy.sparse import hstack
X_tr =
hstack((X_train_essay_bow,X_train_title_bow,grade_pos_encode_train.reshape(40000,1),grade_neg_encod
e_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),teacher_neg_encode_train.reshape
(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_train.reshape(40000,1),cat_pos_e
ncode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),sub_pos_encode_train.reshape(40
000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_train_project_norm))
X_te =
hstack((X_test_essay_bow,X_test_title_bow,grade_pos_encode_test.reshape(10000,1),grade_neg_encode_t
est.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teacher_neg_encode_test.reshape(10000
,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.reshape(10000,1),cat_pos_encode_te
st.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_encode_test.reshape(10000,1),sub_n
eg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_norm))

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

```
Final Data matrix
(40000, 8448) (40000,)
(10000, 8448) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

In [215]:

```
from xgboost import XGBClassifier
```

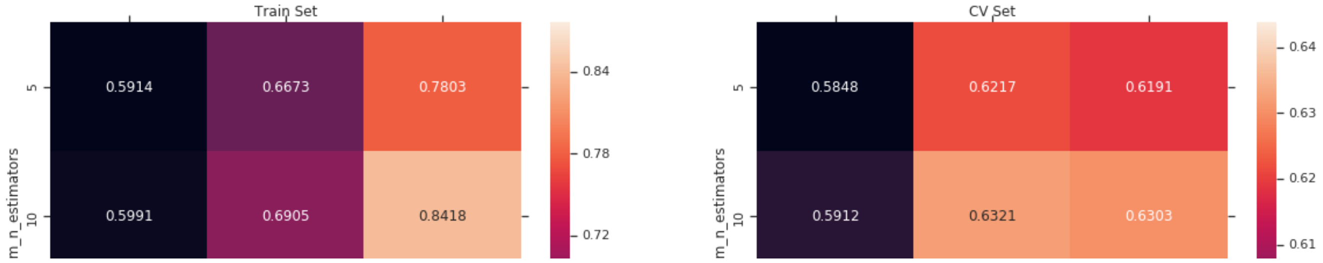
In [216]:

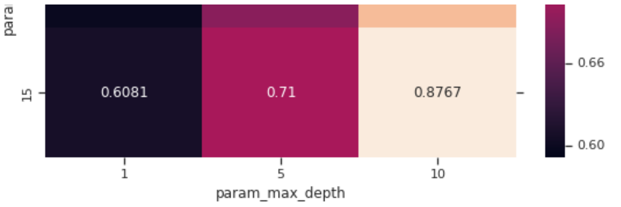
```
%%time
from sklearn.model_selection import GridSearchCV
ens=XGBClassifier()
parameters = {'max_depth': [1,5,10], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

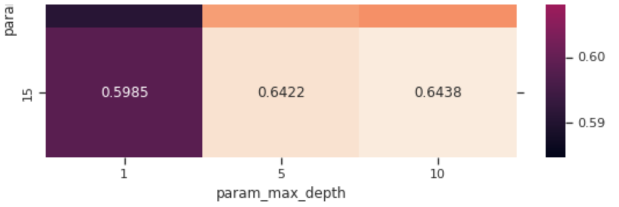
```
CPU times: user 2min 37s, sys: 1.72 s, total: 2min 39s
Wall time: 2min 39s
```

In [217]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```







Train The Model

In [218]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [219]:

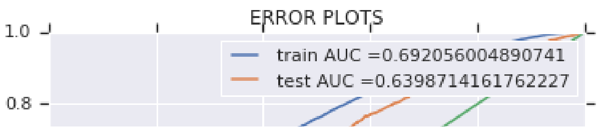
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

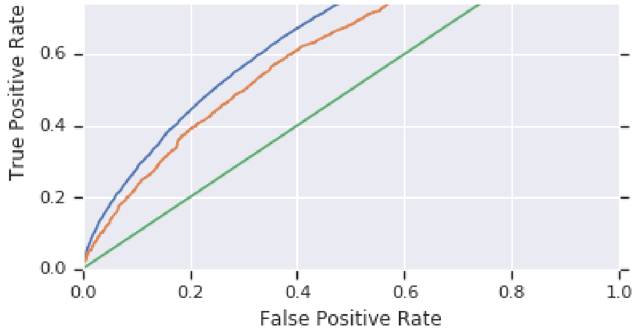
In [222]:

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


classifier = XGBClassifier(max_depth = 5, n_estimators = 15)

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [223]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```





Confusion Matrix

In [224]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

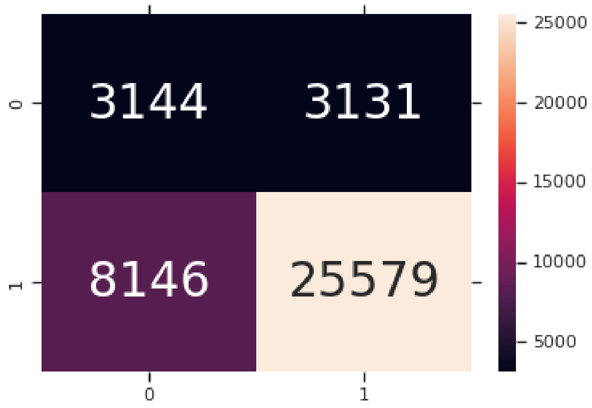
In [225]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999892700115872 for threshold 0.751
```

Out[225]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f0574b7b9b0>
```



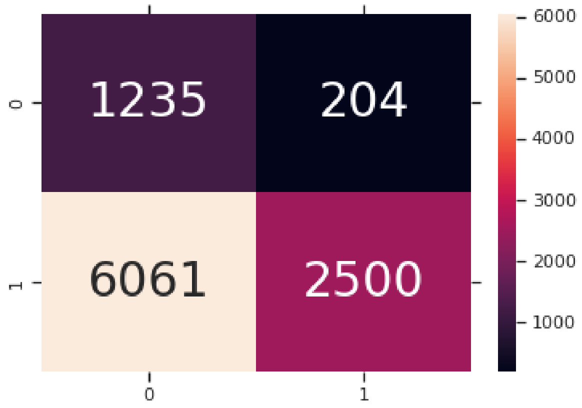
In [226]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,t
est_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999987926910483 for threshold 0.801
```

Out[226]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f05659f0390>
```



2.5.2 Applying XGBOOST on TFIDF, SET 2

Creating Data Matrix

In [227]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr =
hstack((X_train_essay_tfidf,X_train_title_tfidf,grade_pos_encode_train.reshape(40000,1),grade_neg_e
ncode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),teacher_neg_encode_train.res
hape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_train.reshape(40000,1),cat_
pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),sub_pos_encode_train.reshap
e(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_train_project_norm))
X_te =
hstack((X_test_essay_tfidf,X_test_title_tfidf,grade_pos_encode_test.reshape(10000,1),grade_neg_enco
de_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teacher_neg_encode_test.reshape(
10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.reshape(10000,1),cat_pos_enco
de_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_encode_test.reshape(10000,1),
sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_norm))

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

```
Final Data matrix
(40000, 8448) (40000,)
(10000, 8448) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

In [228]:

```
from xgboost import XGBClassifier
```

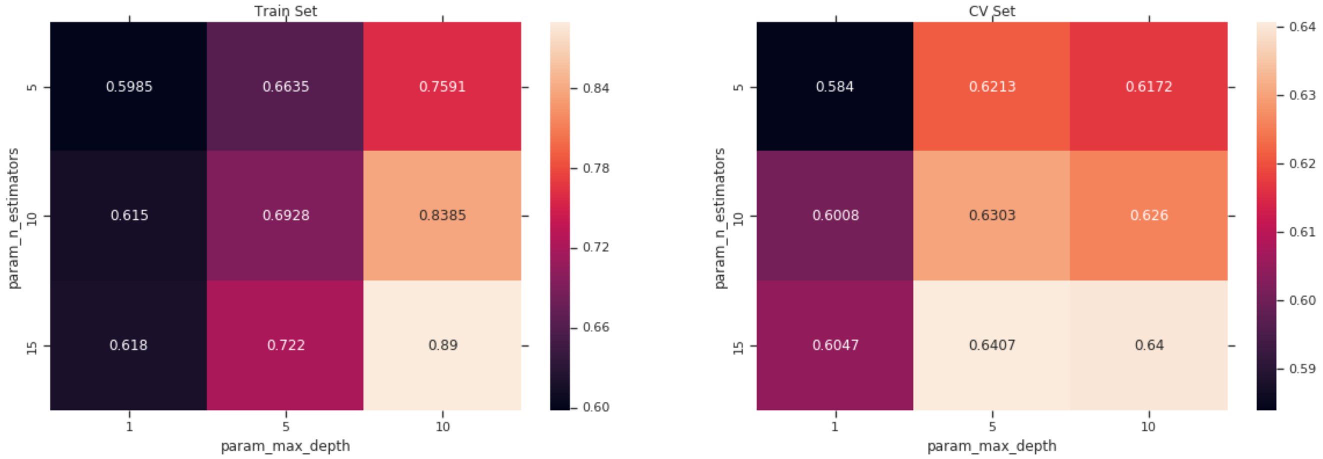
In [229]:

```
%%time
from sklearn.model_selection import GridSearchCV
ens=XGBClassifier()
parameters = {'max_depth': [1,5,10], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 4min 46s, sys: 1.37 s, total: 4min 47s
Wall time: 4min 47s
```

In [230]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train The Model

In [231]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [232]:

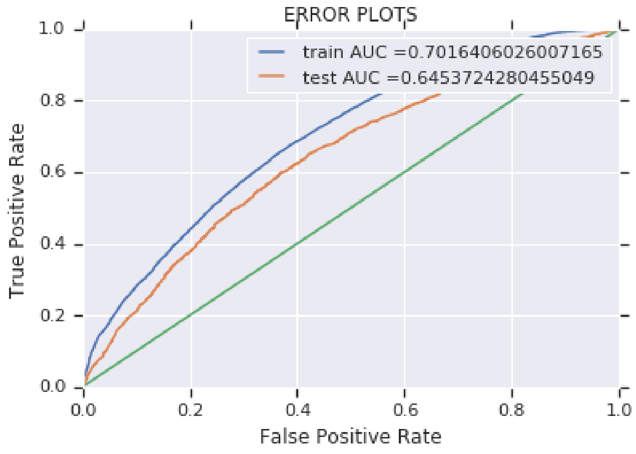
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [233]:

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


classifier = XGBClassifier(max_depth = 5, n_estimators = 15)

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [234]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [235]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

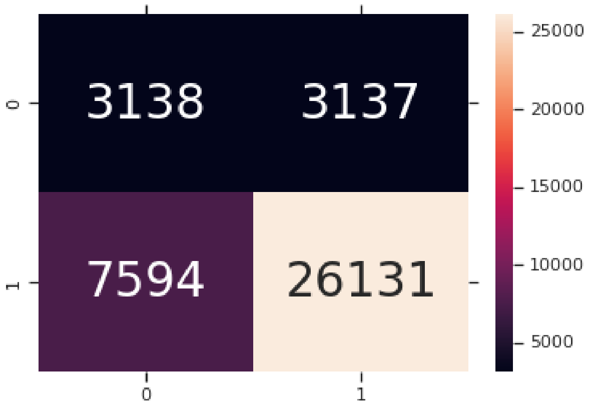
In [236]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.753
```

Out[236]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f0560f57dd8>
```



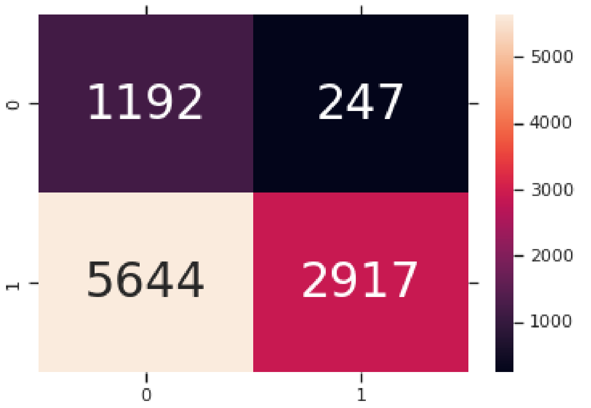
In [237]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,t
est_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999987926910483 for threshold 0.798
```

Out[237]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f057174cc88>
```



2.5.3 Applying XGBOOST on AVG W2V, SET 3

Creating Data Matrix

In [105]:

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

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
from scipy.sparse import csr_matrix
X_tr =
hstack((csr_matrix(avg_w2v_essay_train),csr_matrix(avg_w2v_title_train),grade_pos_encode_train.res
hape(40000,1),grade_neg_encode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1),te
acher_neg_encode_train.reshape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encode_tr
ain.reshape(40000,1),cat_pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,1),s
ub_pos_encode_train.reshape(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,X_tra
in_project_norm))
X_te = hstack((csr_matrix(avg_w2v_essay_test),csr_matrix(avg_w2v_title_test),grade_pos_encode_test
.reshape(10000,1),grade_neg_encode_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),
teacher_neg_encode_test.reshape(10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_te
st.reshape(10000,1),cat_pos_encode_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_p
os_encode_test.reshape(10000,1),sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_proje
ct_norm))

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

```
Final Data matrix
(40000, 612) (40000,)
(10000, 612) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

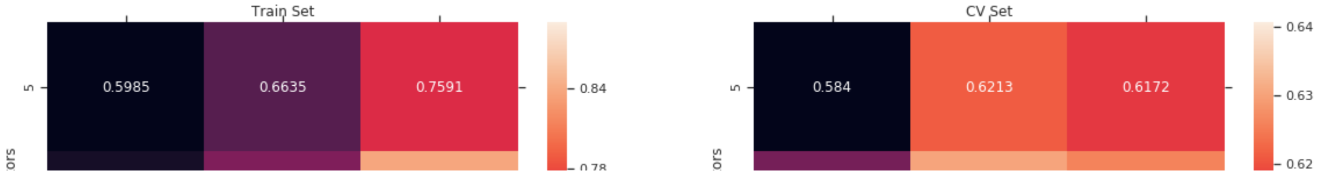
In [107]:

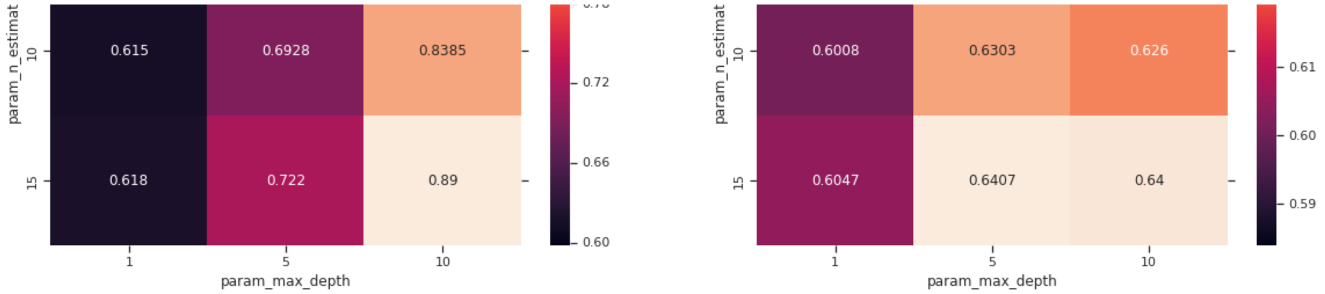
```
%%time
from xgboost import XGBClassifier
from sklearn.model_selection import GridSearchCV
ens=XGBClassifier()
parameters = {'max_depth': [1,5,10], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 17min 12s, sys: 30.7 s, total: 17min 43s
Wall time: 17min 42s
```

In [230]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```





Train The Model

In [231]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [232]:

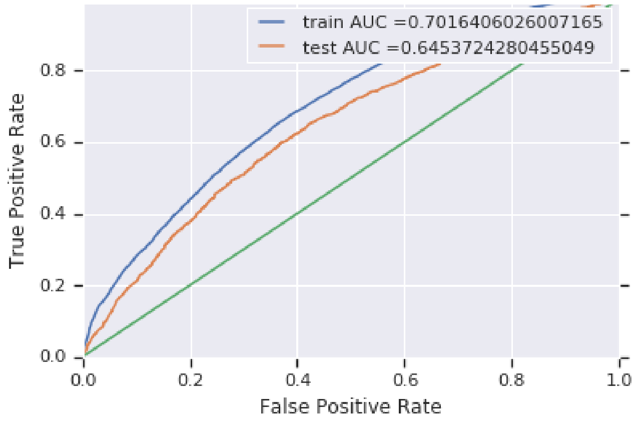
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [233]:

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


classifier = XGBClassifier(max_depth = 5, n_estimators = 15)

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [234]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [235]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

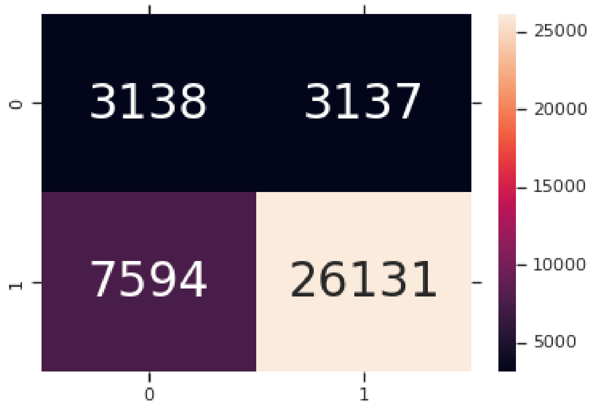
In [236]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999365089445 for threshold 0.753
```

Out[236]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f0560f57dd8>
```



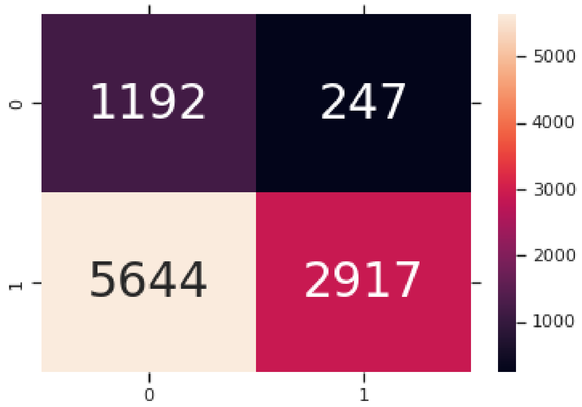
In [237]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,t
est_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999987926910483 for threshold 0.798
```

Out[237]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f057174cc88>
```



2.5.4 Applying XGBOOST on TFIDF W2V, SET 4

Creating Data Matrix

In [108]:

```
from scipy.sparse import csr_matrix
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr =
hstack((csr_matrix(tfidf_w2v_train_essay),csr_matrix(tfidf_w2v_train_title),grade_pos_encode_train
.reshape(40000,1),grade_neg_encode_train.reshape(40000,1),teacher_pos_encode_train.reshape(40000,1
),teacher_neg_encode_train.reshape(40000,1),state_pos_encode_train.reshape(40000,1),state_neg_encoc
e_train.reshape(40000,1),cat_pos_encode_train.reshape(40000,1),cat_neg_encode_train.reshape(40000,
1),sub_pos_encode_train.reshape(40000,1),sub_neg_encode_train.reshape(40000,1),X_train_price_norm,
X_train_project_norm))
X_te =
hstack((csr_matrix(tfidf_w2v_test_essay),csr_matrix(tfidf_w2v_test_title),grade_pos_encode_test.re
shape(10000,1),grade_neg_encode_test.reshape(10000,1),teacher_pos_encode_test.reshape(10000,1),teac
her_neg_encode_test.reshape(10000,1),state_pos_encode_test.reshape(10000,1),state_neg_encode_test.
reshape(10000,1),cat_pos_encode_test.reshape(10000,1),cat_neg_encode_test.reshape(10000,1),sub_pos_
encode_test.reshape(10000,1),sub_neg_encode_test.reshape(10000,1),X_test_price_norm,X_test_project_
norm))

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

```
Final Data matrix
(40000, 612) (40000,)
(10000, 612) (10000,)
====================================================================================================
```

Hyperparameter Tuning: Simple for loop (if you are having memory limitations use this)

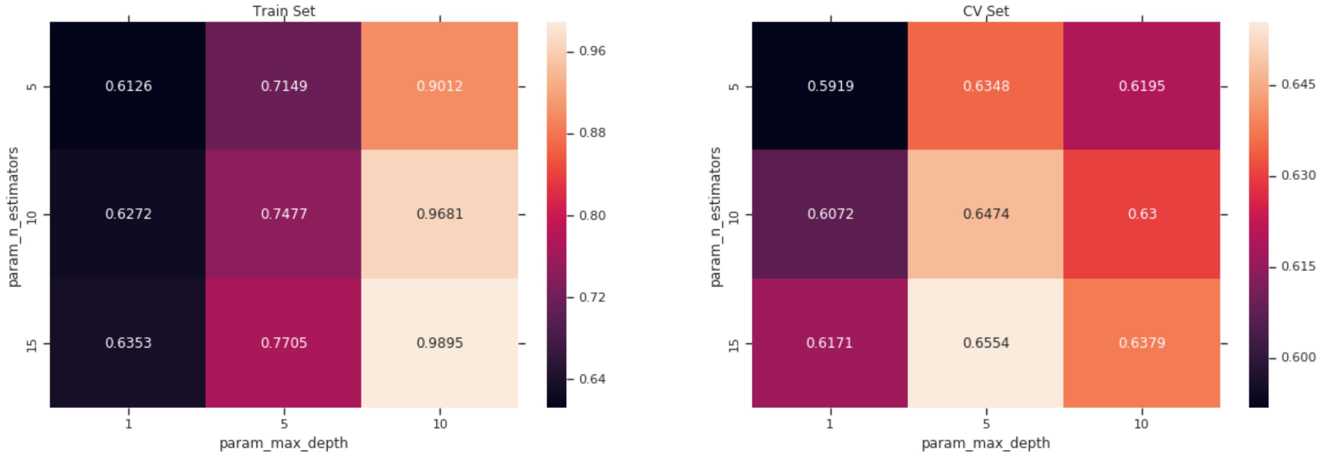
In [109]:

```
%%time
from xgboost import XGBClassifier
from sklearn.model_selection import GridSearchCV
ens=XGBClassifier()
parameters = {'max_depth': [1,5,10], 'n_estimators': [5, 10,15]}

classifier = GridSearchCV(ens, parameters, cv=3, scoring='roc_auc')
select = classifier.fit(X_tr, y_train)
```

```
CPU times: user 17min 3s, sys: 31.1 s, total: 17min 34s
Wall time: 17min 33s
```

In [110]:

```
import seaborn as sns; sns.set()

max_scores1 = pd.DataFrame(classifier.cv_results_).groupby(['param_n_estimators',
'param_max_depth']).max().unstack()[['mean_test_score', 'mean_train_score']]

fig, ax = plt.subplots(1,2, figsize=(20,6))

sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('CV Set')

plt.show()
```



Train The Model

In [111]:

```
X_te.data = np.nan_to_num(X_te.data)
```

In [112]:

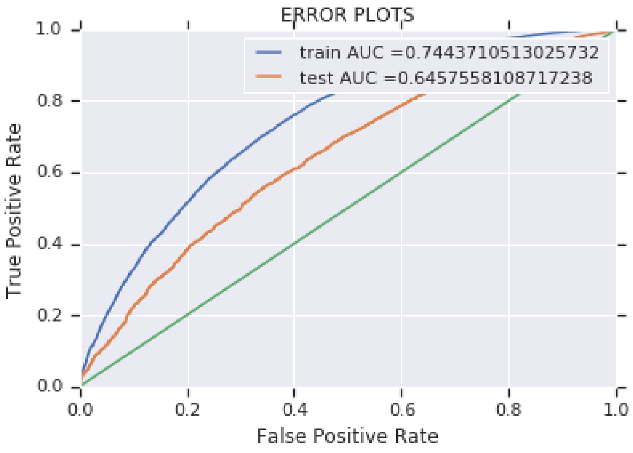
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [113]:

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


classifier = XGBClassifier(max_depth = 5, n_estimators = 15)

classifier.fit(X_tr, y_train)
#clfV1.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 = classifier.predict_proba(X_tr)
y_test_pred = classifier.predict_proba(X_te)
```

In [114]:

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred[:,1])
x=[0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0]
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.plot(x,x)
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [115]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):
    global predictions1
    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)
    predictions1=predictions
    return predictions
```

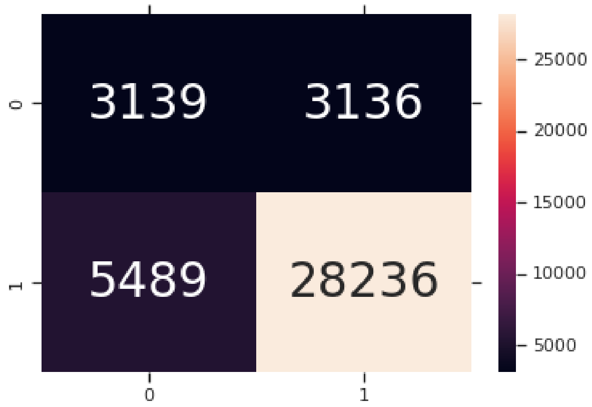
In [116]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred[:,1],tr_thresholds,train_fpr,train_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999994285804988 for threshold 0.738
```

Out[116]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f43f7d32978>
```



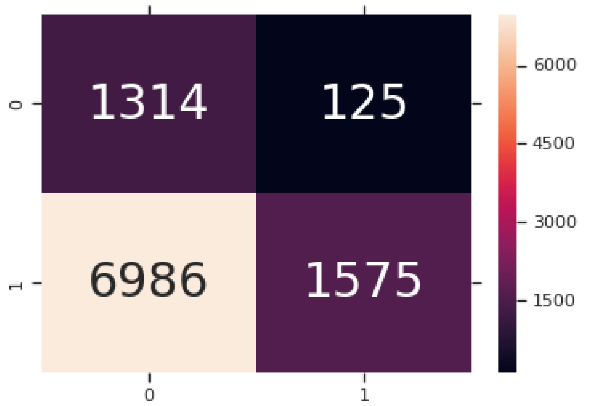
In [119]:

```
#conf_matr_df_train_2[1][0]
print("Test confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred[:,1],tr_thresholds,test_fpr,test_fpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999987926910483 for threshold 0.813
```

Out[119]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f43da1f69b0>
```



3. Conclusions

In [195]:

```
# http://zetcode.com/python/prettytable/
```

```
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x=PrettyTable()
x.field_names=["Vectorizer","Model","AUC"]
x.add_row(["BOW","RF",0.66])
x.add_row(["TFIDF","RF",0.66])
x.add_row(["AVG W2V","RF",0.64])
x.add_row(["TFIDF W2V","RF",0.64])
x.add_row(["BOW","GBDT",0.64])
x.add_row(["TFIDF","GBDT",0.65])
x.add_row(["AVG W2V","GBDT",0.65])
x.add_row(["TFIDF W2V","GBDT",0.65])
print(x)
```

```
+------------+-------+------+
| Vectorizer | Model | AUC  |
+------------+-------+------+
|    BOW     |   RF  | 0.66 |
|   TFIDF    |   RF  | 0.66 |
|  AVG W2V   |   RF  | 0.64 |
| TFIDF W2V  |   RF  | 0.64 |
|    BOW     |  GBDT | 0.64 |
|   TFIDF    |  GBDT | 0.65 |
|  AVG W2V   |  GBDT | 0.65 |
| TFIDF W2V  |  GBDT | 0.65 |
+------------+-------+------+
```

In [ ]: