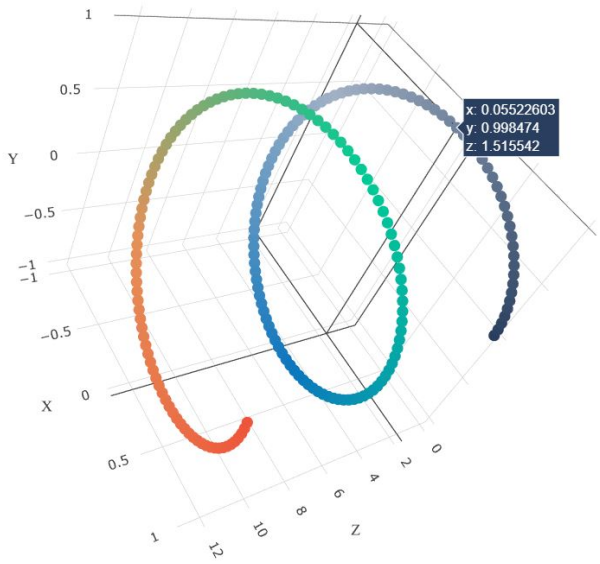
Assignment 8: DT

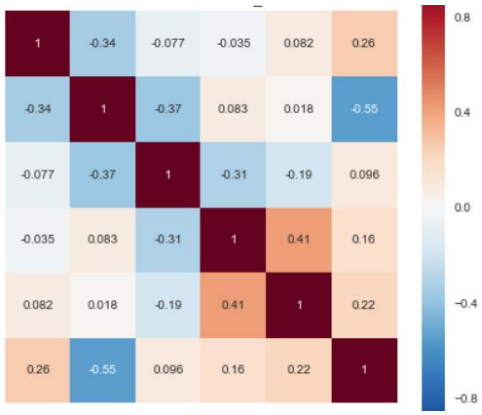
1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**
    - Set 1: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 2: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **The hyper paramter tuning (best `depth` in range [1, 5, 10, 50], and the best `min_samples_split` in range [5, 10, 100, 500])**
    - Find the best hyper parameter which will give the maximum AUC value
    - find the best hyper paramter using k-fold cross validation(use gridsearch cv or randomsearch cv)/simple cross validation data(you can write your own for loops refer sample solution)
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 **min_sample_split**, 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*

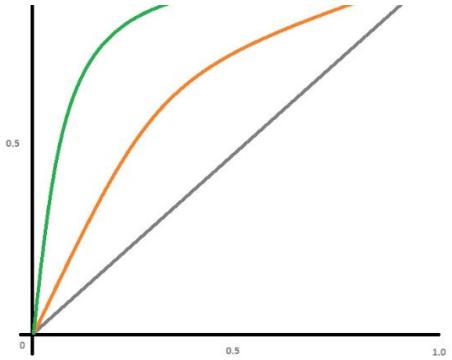
or

- 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 choose either of the plotting techniques out of 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](https://www.google.com/search?q=confusion+matrix) with predicted and original labels of test data points

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

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

4. **Task 2:** For this task consider set-1 features. Select all the features which are having non-zero feature importance.You can get the feature importance using 'feature_importances_` (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard the all other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3
   Note: when you want to find the feature importance make sure you don't use max_depth parameter keep it None.

5. You need to summarize the results at the end of the notebook, summarize it in the table format

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

In [0]:

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

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

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students w
ith the biggest enthusiasm \
for learning my students learn in many different ways using all of our senses and multiple intelli
gences i use a wide range\
of techniques to help all my students succeed students in my class come from a variety of differen
t backgrounds which makes\
for wonderful sharing of experiences and cultures including native americans our school is a carin
g community of successful \
learners which can be seen through collaborative student project based learning in and out of the
classroom kindergarteners \
in my class love to work with hands on materials and have many different opportunities to practice
a skill before it is\
mastered having the social skills to work cooperatively with friends is a crucial aspect of the ki
ndergarten curriculum\
montana is the perfect place to learn about agriculture and nutrition my students love to role pla
y in our pretend kitchen\
```

```
in the early childhood classroom i have had several kids ask me can we try cooking with real food
i will take their idea \
and create common core cooking lessons where we learn important math and writing concepts while co
oking delicious healthy \
food for snack time my students will have a grounded appreciation for the work that went into maki
ng the food and knowledge \
of where the ingredients came from as well as how it is healthy for their bodies this project woul
d expand our learning of \
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade apple
sauce make our own bread \
and mix up healthy plants from our classroom garden in the spring we will also create our own cook
books to be printed and \
shared with families students will gain math and literature skills as well as a life long enjoymen
t for healthy cooking \
nannan'
ss = sid.polarity_scores(for_sentiment)

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

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

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

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

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

1. Decision Tree

1.1 Loading Data

In [0]:

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

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

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

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

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

from tqdm import tqdm
import os
```

```
!pip install chart_studio

import chart_studio.plotly as 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 [0]:

```
dft = pd.read_csv('/content/drive/My Drive/Mass3/Assignments_DonorsChoose_2018/train_data.csv')
dfr = pd.read_csv('/content/drive/My Drive/Mass3/Assignments_DonorsChoose_2018/resources.csv')
```

In [0]:

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

```
Number of data points in train data (109248, 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 [0]:

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

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

Out[0]:

	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

In [0]:

```
# 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(dft.columns)]


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


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


dft.head(2)
```

Out[0]:

	Unnamed:	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Grades PreK-2	L

TEXT PROCESSING

In [0]:

```
# merge two column text dataframe:
dft["essay"] = dft["project_essay_1"].map(str) +\
                        dft["project_essay_2"].map(str) + \
                        dft["project_essay_3"].map(str) + \
                        dft["project_essay_4"].map(str)
```

In [0]:

```
dft.head(2)
```

Out[0]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_s
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27 00:46:53	Grades PreK-2	L

In [0]:

```
# https://stackoverflow.com/a/47091490/4084039
import re
def decontracted(phrase):
# specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
# general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [0]:

```
# 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', "d
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"]
```

Preprocessing of project_subject_categories

In [0]:

```
catogories = list(dft['project_subject_categories'].values)

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 placing 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())

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

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

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

Preprocessing of project_subject_subcategories

In [0]:

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

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
.e removing 'The')
        j = j.replace(' ','') # we are placing 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())

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

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

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

In [0]:

```
# we have to remove the grades from every row
print(dft['project_grade_category'][:20])
```

```
55660    Grades PreK-2
51140    Grades PreK-2
473      Grades PreK-2
41558       Grades 3-5
29891       Grades 3-5
23374    Grades PreK-2
49228    Grades PreK-2
7176     Grades PreK-2
35006       Grades 3-5
5145        Grades 3-5
48237      Grades 9-12
52282      Grades 9-12
46375       Grades 3-5
36468    Grades PreK-2
36358    Grades PreK-2
39438    Grades PreK-2
2521     Grades PreK-2
58794    Grades PreK-2
40180    Grades PreK-2
53562      Grades 9-12
Name: project_grade_category, dtype: object
```

In [0]:

```
d= list(dft['project_grade_category'].values)
# remove special characters from list of strings python:
# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/

grade_cat_list = []
for i in d:
# consider we have text like this:
    for j in i.split(' '): # # split by space
        j=j.replace('Grades','')# clean grades from the row
    grade_cat_list.append(j.strip())

dft['clean_grade'] = grade_cat_list
dft.drop(['project_grade_category'], axis=1, inplace=True)

my_counter = Counter()
for word in dft['clean_grade'].values:
     my_counter.update(word.split())
project_grade_category_dict= dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda
kv: kv[1]))
```

Preparing data for the models

Test - Train Split

In [0]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(dft, dft['project_is_approved'],stratify = dft[
'project_is_approved'], test_size=0.33)
X_train,X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [0]:

```
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, stratify= y_train,test_size = 0.3
3)
```

In [0]:

```
print(y_train.value_counts())
print(y_test.value_counts())
print(y_cv.value_counts())
```

```
1    15295
0     2750
Name: project_is_approved, dtype: int64
1    16782
0     3018
Name: project_is_approved, dtype: int64
1    7535
0    1354
Name: project_is_approved, dtype: int64
```

In [0]:

```
#droping the y labels
#https://stackoverflow.com/questions/13411544/delete-column-from-pandas-dataframe-by-column-name

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

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

X_cv.drop(["project_is_approved"], axis = 1, inplace = True)
```

Text preprocessing

In [0]:

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

```
100%|██████████| 18045/18045 [00:20<00:00, 760.92it/s]
```

In [0]:

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

```
100%|████████████████████████████████████████████████████████████████| 19800/19800 [00:
26<00:00, 749.84it/s]
```

In [0]:

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

```
100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:12<00:00, 736.00it/s]
```

In [0]:

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

```
100%|████████████████████████████████████████████████████████████████| 8889/8889
[00:00<00:00, 16760.57it/s]
```

In [0]:

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_train = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
```

```
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_train.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 18045/18045
[00:01<00:00, 16870.17it/s]
```

In [0]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 19800/19800
[00:01<00:00, 16517.69it/s]
```

Encoding numerical, Categorical features

vectorize categorical data

In [0]:

```
#project_subject_categories convert categorical to vectors

# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer1 = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False,binary=True
)
vectorizer1.fit(X_train['clean_categories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_cat = vectorizer1.transform(X_train['clean_categories'].values)
X_cv_cat = vectorizer1.transform(X_cv['clean_categories'].values)
X_test_cat = vectorizer1.transform(X_test['clean_categories'].values)
print(vectorizer1.get_feature_names())
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
```

In [0]:

```
f1=vectorizer1.get_feature_names()
print("After vectorizations")
print(X_train_cat.shape, y_train.shape)
print(X_cv_cat.shape, y_cv.shape)
print(X_test_cat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 9) (18045,)
(8889, 9) (8889,)
(19800, 9) (19800,)
====================================================================================================
```

In [0]:

```
##project_subject_subcategories convert categorical to vectors
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer2 = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary
=True)
vectorizer2.fit(X_train['clean_subcategories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat = vectorizer2.transform(X_train['clean_subcategories'].values)
X_cv_subcat = vectorizer2.transform(X_cv['clean_subcategories'].values)
X_test_subcat = vectorizer2.transform(X_test['clean_subcategories'].values)
print(vectorizer2.get_feature_names())
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'History_Geography', 'Music', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
```

In [0]:

```
print("After vectorizations")
print(X_train_subcat.shape, y_train.shape)
print(X_cv_subcat.shape, y_cv.shape)
print(X_test_subcat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 30) (18045,)
(8889, 30) (8889,)
(19800, 30) (19800,)
====================================================================================================
```

In [0]:

```
# school_state convert categorical to vectors
# now time to cont the each words
from collections import Counter
my_counter = Counter()
for word in dft['school_state'].values:
    my_counter.update(word.split())# count the words
school_state_dict = dict(my_counter)# store in dicionary
sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1]))
print(sorted_school_state_dict)
```

```
{'VT': 40, 'WY': 58, 'ND': 78, 'MT': 120, 'RI': 148, 'NH': 175, 'NE': 176, 'SD': 177, 'DE': 181,
'AK': 188, 'WV': 252, 'HI': 270, 'ME': 277, 'DC': 294, 'NM': 295, 'KS': 340, 'IA': 363, 'ID': 371,
'AR': 534, 'CO': 638, 'MN': 671, 'OR': 676, 'MS': 710, 'KY': 725, 'NV': 774, 'MD': 801, 'CT': 923,
'TN': 935, 'AL': 944, 'UT': 958, 'WI': 994, 'VA': 1124, 'AZ': 1172, 'NJ': 1235, 'OK': 1283, 'LA': 1
308, 'WA': 1309, 'MA': 1312, 'OH': 1399, 'MO': 1421, 'IN': 1431, 'PA': 1699, 'MI': 1760, 'SC': 2186
, 'GA': 2203, 'IL': 2371, 'NC': 2831, 'FL': 3444, 'TX': 4010, 'NY': 4039, 'CA': 8377}
```

In [0]:

```
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer3 = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercase=False, b
inary=True)
vectorizer3.fit(dft['school_state'].values)
# firstly convert fit the train data into the vector then it learn the vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer3.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer3.transform(X_cv['school_state'].values)
```

```
X_cv_school_state = vectorizer3.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer3.transform(X_test['school_state'].values)
print(vectorizer3.get_feature_names())
```

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

In [0]:

```
print("After vectorizations")
print(X_train_school_state .shape, y_train.shape)
print(X_cv_school_state .shape, y_cv.shape)
print(X_test_school_state .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 51) (18045,)
(8889, 51) (8889,)
(19800, 51) (19800,)
====================================================================================================
```

In [0]:

```
#project_grade_category categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
dft['clean_grade']=dft['clean_grade'].fillna("")# fill the null values with space
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer4 = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()),lowercase
=False, binary=True)
vectorizer4.fit(dft['clean_grade'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade_category = vectorizer4.transform(X_train['clean_grade'].values)
X_cv_project_grade_category = vectorizer4.transform(X_cv['clean_grade'].values)
X_test_project_grade_category = vectorizer4.transform(X_test['clean_grade'].values)
print(vectorizer4.get_feature_names())
```

```
['9-12', '6-8', '3-5', 'PreK-2']
```

In [0]:

```
print("After vectorizations")
print(X_train_project_grade_category .shape, y_train.shape)
print(X_cv_project_grade_category .shape, y_cv.shape)
print(X_test_project_grade_category .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 4) (18045,)
(8889, 4) (8889,)
(19800, 4) (19800,)
====================================================================================================
```

In [0]:

```
#teacher_prefix categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
dft['teacher_prefix']=dft['teacher_prefix'].fillna(" ")# filll the null valueswith space
my_counter = Counter()
for word in dft['teacher_prefix'].values:
    my_counter.update(word.split())
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
teacher_cat_dict = dict(my_counter)
sorted_teacher_prefix_dict = dict(sorted(teacher_cat_dict.items(), key=lambda kv: kv[1]))
```

In [0]:

```
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer5 = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=False,
binary=True)
vectorizer5.fit(dft['teacher_prefix'].values.astype('U'))
# firstly convert fit the train data into the vectorizer
# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer5.transform(X_train['teacher_prefix'].values.astype('U'))
X_cv_teacher_prefix= vectorizer5.transform(X_cv['teacher_prefix'].values.astype('U'))
X_test_teacher_prefix = vectorizer5.transform(X_test['teacher_prefix'].values.astype('U'))
print(vectorizer5.get_feature_names())
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
```

In [0]:

```
print("After vectorizations")
print(X_train_teacher_prefix .shape, y_train.shape)
print(X_cv_teacher_prefix .shape, y_cv.shape)
print(X_test_teacher_prefix .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(18045, 5) (18045,)
(8889, 5) (8889,)
(19800, 5) (19800,)
====================================================================================================
```

In [0]:

```
# compute average word2vec for each review.
def tf_idf_done(word_list):
    train_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this
list
    for sentence in tqdm(word_list): # 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():#.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in tfidf_words):
              #vec = model.wv[word]
              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()))
              vector += (vec * tf_idf) # calculating tfidf weighted w2v
              tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        train_title_tfidf_w2v_vectors.append(vector)
    print(len(train_title_tfidf_w2v_vectors))
    print(len(train_title_tfidf_w2v_vectors[0]))
    return train_title_tfidf_w2v_vectors
```

In [0]:

```
train_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_train)
test_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_test)
cv_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_cv)
```

```
100%|██████████| 18045/18045 [01:19<00:00, 225.72it/s]
```

```
18045
300
```

```
100%|██████████| 19800/19800 [01:
```

```
100%|██████████| 19800/19800 [01:27<00:00, 225.26it/s]

19800
300

100%|██████████| 8889/8889 [00:39<00:00, 222.26it/s]

8889
300
```

In [0]:

```
train_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_train)
test_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_test)
cv_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_cv)
```

```
100%|██████████| 18045/18045 [00:00<00:00, 19526.07it/s]

18045
300

100%|██████████| 19800/19800 [00:01<00:00, 17606.28it/s]

19800
300

100%|██████████| 8889/8889 [00:00<00:00, 17790.29it/s]

8889
300
```

Vectorizing Numerical features

In [0]:

```
price_data = dfr.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
dft = pd.merge(dft, price_data, on='id', how='left')
print(price_data.head(2))
# we also have to do this in tran,test and cv
# so also merge the resource data with the trian,cv and test
X_train = pd.merge(X_train, price_data, on = "id", how = "left")
#print(x_train.columns)
X_test = pd.merge(X_test, price_data, on = "id", how = "left")
X_cv = pd.merge(X_cv, price_data, on = "id", how = "left")
```

```
        id   price  quantity
0  p000001  459.56         7
1  p000002  515.89        21
```

In [0]:

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


price_scalar = StandardScaler()
```

```
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard
deviationof this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above mean and variance.
train_price_standar = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
test_price_standar = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_price_standar = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

In [0]:

```
# previous_year_projects
price_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # fi
nding the mean and standard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_prev_proj_standar
=price_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))
# Now standardize the data with above maen and variance.
test_prev_proj_standar
=price_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1
))
# Now standardize the data with above maen and variance.
cv_prev_proj_standar = price_scalar.transform(X_cv['teacher_number_of_previously_posted_projects']
.values.reshape(-1, 1))
```

In [0]:

```
price_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and
standarddeviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.
train_qnty_standar = price_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_qnty_standar = price_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
test_qnty_standar = price_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
```

merging

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_train = hstack((X_train_bow_title,X_train_bow,# all bows
                       X_train_teacher_prefix,X_train_cat,X_train_subcat
                      ,X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set1_train.shape, y_train.shape)
```

```
(18045, 6429) (18045,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_cv = hstack((X_cv_bow_title,X_cv_bow,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set1_cv.shape, y_cv.shape)
```

```
(8889, 6429) (8889,)
```

In [0]:

```
from scipy.sparse import hstack
```

```
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_test = hstack((X_test_bow_title,X_test_bow,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar))
print(X_set1_test.shape, y_test.shape)
```

```
(19800, 6429) (19800,)
```

In [0]:

```
xtr = X_set2_train.tocsr() # Here I have just applied kind of trail and logic. It was in coomatrix kada. Coomatrix is not accessible.
```

In [0]:

```
xtr
```

Out[0]:

```
<18045x6429 sparse matrix of type '<class 'numpy.float64'>'
 with 2359759 stored elements in Compressed Sparse Row format>
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_train = hstack((X_train_tf_essay,X_train_tf_title,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set2_train.shape, y_train.shape)
```

```
(18045, 6429) (18045,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_cv = hstack((X_cv_tf_essay,X_cv_tf_title,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set2_cv.shape, y_cv.shape)
```

```
(8889, 6429) (8889,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set2_test = hstack((X_test_tf_essay,X_test_tf_title,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar)).tocsr()
print(X_set2_test.shape, y_test.shape)
```

```
(19800, 6429) (19800,)
```

In [0]:

```
xte = X_set2_test.tocsr()    # We want in sparse type and so we are convertin it to sparse matrix r ather sparse type
type(xte)

#Instead of renamed everything just add an extension of .tocsr() wherever there is coomatrix type. Check below how am doing
```

Out[0]:

```
scipy.sparse.csr.csr_matrix
```

In [0]:

```
import numpy
s=numpy.array(train_avg_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(18045, 4)
(18045, 300)
```

In [0]:

```
from scipy.sparse import hstack
import numpy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set3_train = hstack((numpy.array(train_avg_w2v_vectors),numpy.array(train_avg_w2v_vectors_title)
,train_prev_proj_standar,train_price_standar,train_qnty_standar,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state))
print(X_set3_train.shape, y_train.shape)
```

```
(18045, 702) (18045,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set3_cv
=hstack((cv_avg_w2v_vectors,cv_avg_w2v_vectors_title,cv_prev_proj_standar,cv_price_standar,cv_qnty_
standar,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state))
print(X_set3_cv.shape, y_cv.shape)
```

```
(8889, 702) (8889,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set3_test
=hstack((test_avg_w2v_vectors,test_avg_w2v_vectors_title,test_prev_proj_standar,test_price_standar
,
                     test_qnty_standar,
                     X_test_teacher_prefix,X_test_cat,X_test_subcat,
                     X_test_project_grade_category,X_test_school_state))
print(X_set3_test.shape, y_test.shape)
```

```
(19800, 702) (19800,)
```

In [0]:

```
import numpy
s=numpy.array(train_tfidf_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(18045, 4)
(18045, 300)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
```

```
X_set4_train =hstack((train_tfidf_w2v_vectors,
train_title_tfidf_w2v_vectors,train_prev_proj_standar,
                      train_price_standar,train_qnty_standar,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state))

print(X_set4_train.shape, y_train.shape)
```

```
(18045, 702) (18045,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set4_cv =hstack((cv_tfidf_w2v_vectors,cv_title_tfidf_w2v_vectors,cv_prev_proj_standar,
                   cv_price_standar,cv_qnty_standar,
                   X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                   X_cv_project_grade_category,X_cv_school_state))


print(X_set4_cv.shape, y_cv.shape)
```

```
(8889, 702) (8889,)
```

In [0]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set4_test = hstack((test_title_tfidf_w2v_vectors,test_tfidf_w2v_vectors,test_prev_proj_standar,t
est_price_standar,test_qnty_standar,X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state))
print(X_set4_test.shape, y_test.shape)
```

```
(19800, 702) (19800,)
```

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

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

Decison trees on BOW

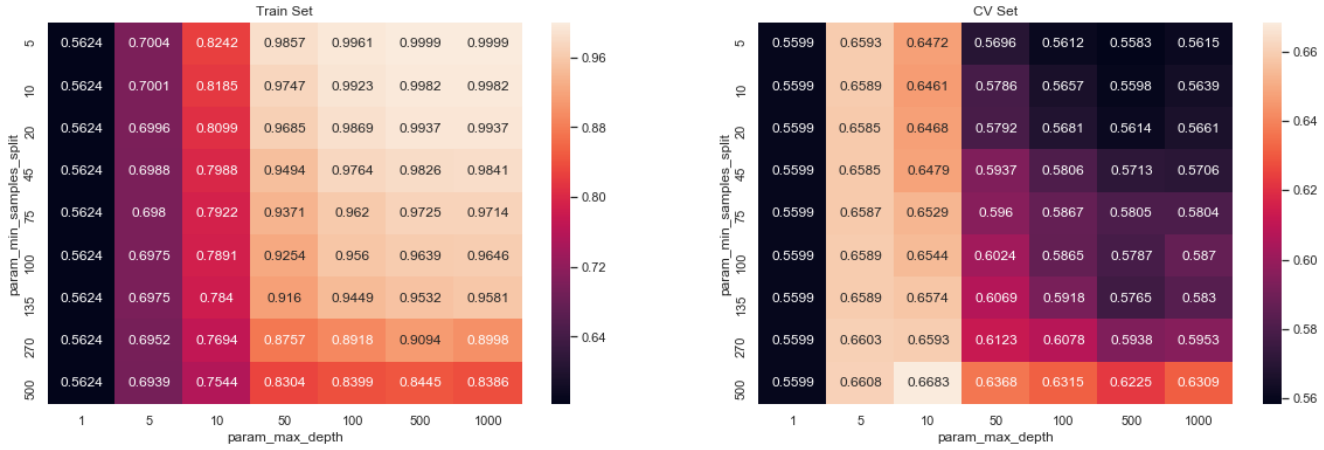
In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt1 = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf1 = GridSearchCV(dt1, parameters, cv=3, scoring='roc_auc',return_train_score=True)
se1 = clf1.fit(X_set1_train, y_train)
```

In [0]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf1.cv_results_).groupby(['param_min_samples_split', '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()
```



Best Estimator and Best tune parameters

In [0]:

```
print(clf1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf1.score(X_set1_train,y_train))
print(clf1.score(X_set1_test,y_test))
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7511722190852625
0.6719906398813649
```

In [0]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[10], 'min_samples_split':[500] } ]
```

In [0]:

```
clf1.get_params().keys()
```

Out[0]:

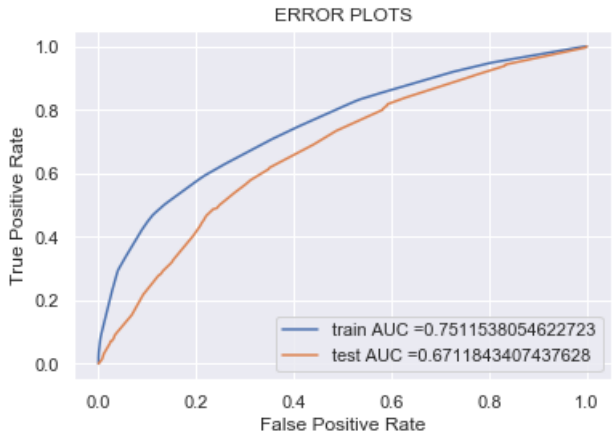
```
dict_keys(['cv', 'error_score', 'estimator__class_weight', 'estimator__criterion',
'estimator__max_depth', 'estimator__max_features', 'estimator__max_leaf_nodes',
'estimator__min_impurity_decrease', 'estimator__min_impurity_split',
'estimator__min_samples_leaf', 'estimator__min_samples_split',
'estimator__min_weight_fraction_leaf', 'estimator__presort', 'estimator__random_state',
'estimator__splitter', 'estimator', 'iid', 'n_jobs', 'param_grid', 'pre_dispatch', 'refit',
'return_train_score', 'scoring', 'verbose'])
```

Fitting Model to Hyper-Parameter Curve -> Best Max_depth-> 10 , Best Min_sample_split-> 100

In [0]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
```

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=500)
clf11.fit(X_set1_train, y_train)
# for visulation
clfV1.fit(X_set1_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set1_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set1_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

In [0]:

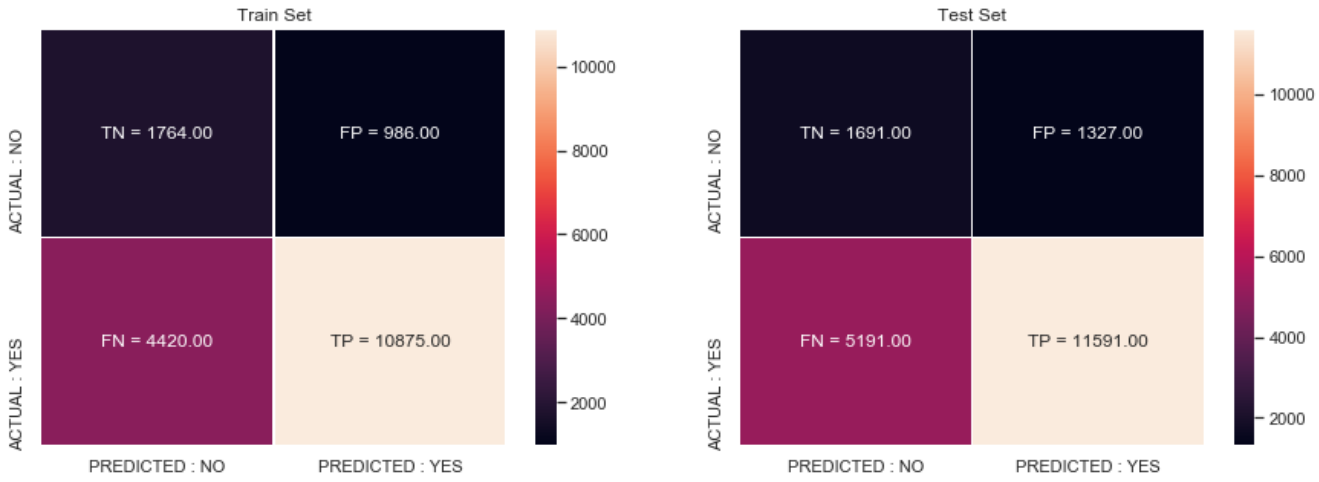
```
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", np.round(max(tpr*(1-fpr)),2) , "for threshold", np.ro
und(t,2))
    predictions = []
    global predictions1 # make it global
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1= predictions
    return predictions
```

In [0]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tp
r1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
```

```
sns.heatmap(conf_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.47 for threshold 0.44
the maximum value of tpr*(1-fpr) 0.4 for threshold 0.45
```



Visualizing Decision Tree

In [0]:

```
#Feature aggregation
f1=vectorizer1.get_feature_names()
f2=vectorizer2.get_feature_names()
f3=vectorizer3.get_feature_names()
f4=vectorizer4.get_feature_names()
f5=vectorizer5.get_feature_names()
fb=vectorizer6.get_feature_names()
ft=vectorizer7.get_feature_names()
fb1=vectorizer8.get_feature_names()
ft1=vectorizer9.get_feature_names()

feature_agg_bow = f1 + f2 + f3 + f4 + f5 + fb + ft
feature_agg_tfidf = f1 + f2 + f3 + f4 + f5 + fb1 + ft1
# p is price, q is quantity, t is teacher previous year projects
feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_previous_projects')
feature_agg_tfidf.append('teacher_previous_projects')
```

In [0]:

```
pip install pydotplus
```

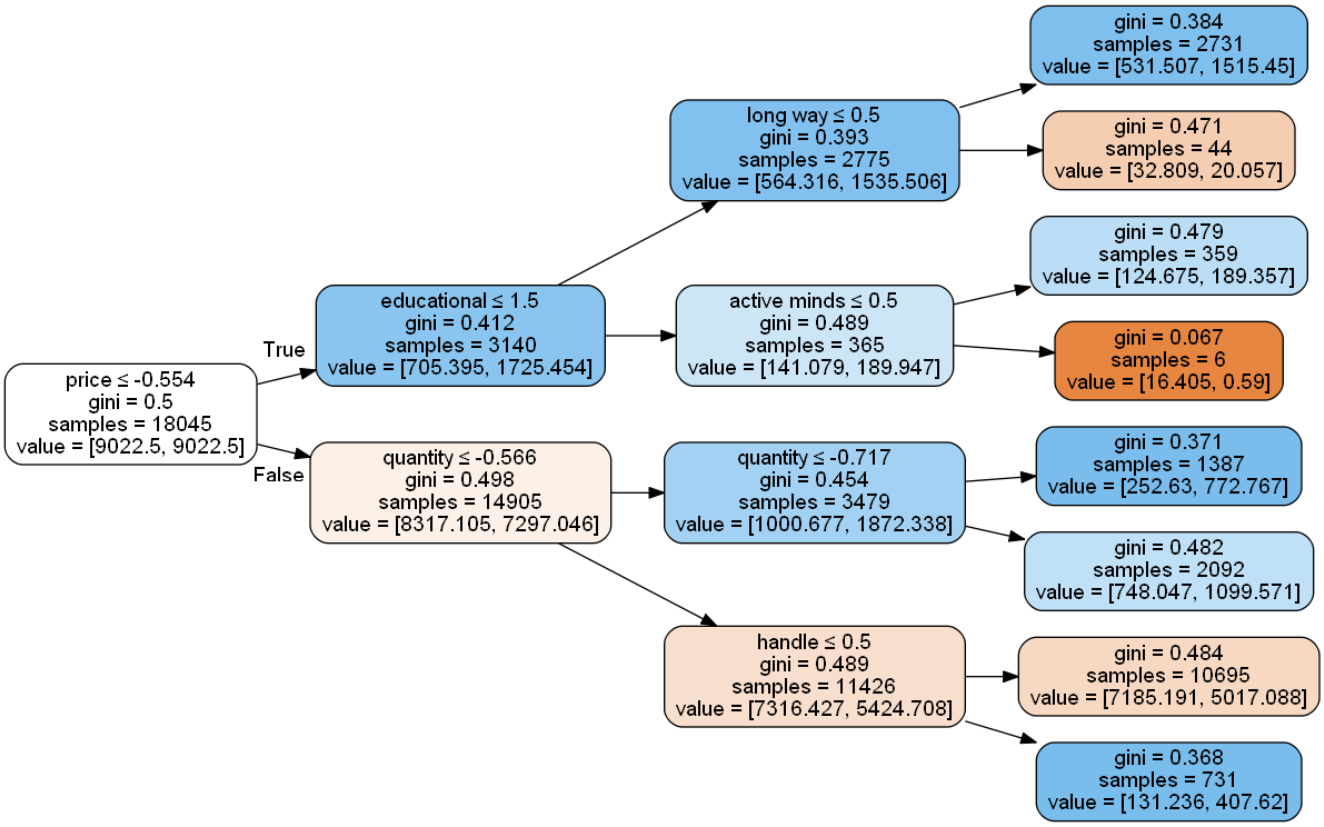
```
Requirement already satisfied: pydotplus in c:\users\hp\anaconda3\lib\site-packages (2.0.2)
Requirement already satisfied: pyparsing>=2.0.1 in c:\users\hp\anaconda3\lib\site-packages (from p
ydotplus) (2.3.1)
Note: you may need to restart the kernel to use updated packages.
```

In [0]:

```
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
```

```
export_graphviz(clfV1, out_file=dot_data, filled=True, rounded=True, special_characters=True, featu
re_names=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[0]:



Analysis on the False positives

In [0]:

```
#Get the False positives datapoints
X_test['essay'].values[1]
```

Out[0]:

```
"My classroom is filled with fun-loving special education students that are happy, active, and rea
dy to learn. Their ages range between 3-5 years. All of my students have special needs, including
autism, speech and language impairments, and intellectual disabilities, but we don't let that slow
us down! We are part of a low income school district on an elementary school campus. Many of my st
udents are nonverbal and need lots of visual and physical supports. We only get a few dollars a ye
ar for paper and crayons. We are in desperate need of enrichment supplies!I have a very busy group
of students in my preschool special education class. We are so excited, we just can't sit still. W
e need some special stools to help us move while sitting at the table. This way we can sit with ou
r friends but still keep moving. \\r\\nThe scooter boards will let us twist and shout when we need
a break from sitting. The science materials are hands-on to help us move and get kinesthetic input
when learning difficult topics. The ball toss will help us develop our gross motor skills and enco
urage our desire to move in an appropriate and fun way. Help us Move it, Move it!nannan"
```

In [0]:

```
#https://www.google.com/search?
q=geeks+for+geeks+false+positive&rlz=1C1SQJL_enIN849IN849&oq=geeks+for+geeks+false+positive&aqs=ch
.69i57j33l5.6431j0j7&sourceid=chrome&ie=UTF-8
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).

fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
```

```
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

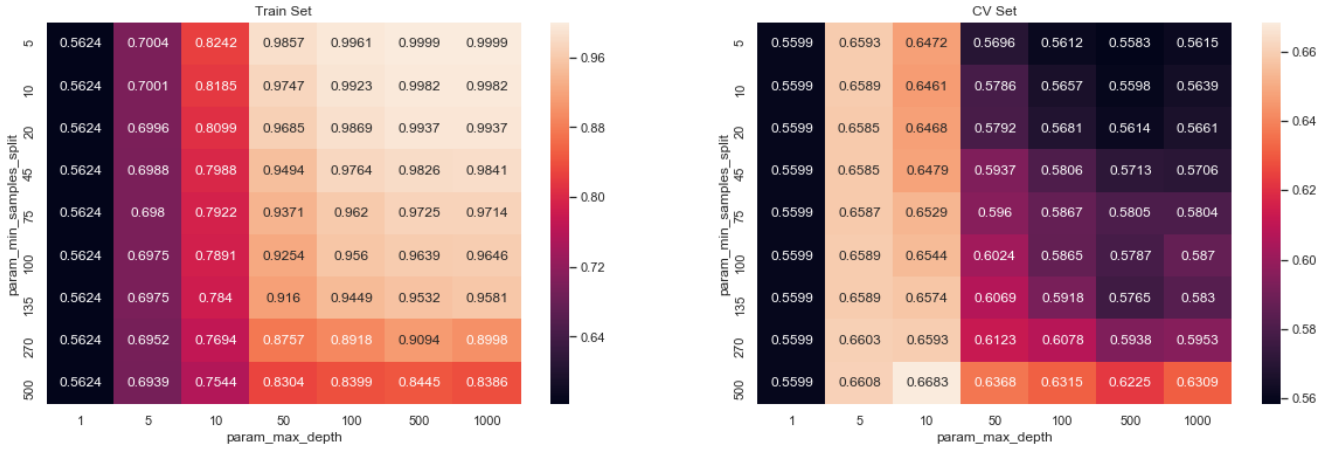
Decison trees on BOW

In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt1 = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf1 = GridSearchCV(dt1, parameters, cv=3, scoring='roc_auc',return_train_score=True)
se1 = clf1.fit(X_set1_train, y_train)
```

In [0]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf1.cv_results_).groupby(['param_min_samples_split', '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()
```



Best Estimator and Best tune parameters

In [0]:

```
print(clf1.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf1.score(X_set1_train,y_train))
print(clf1.score(X_set1_test,y_test))
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7511722190852625
0.6719906398813649
```

In [0]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[10], 'min_samples_split':[500] } ]
```

In [0]:

```
clf1.get_params().keys()
```

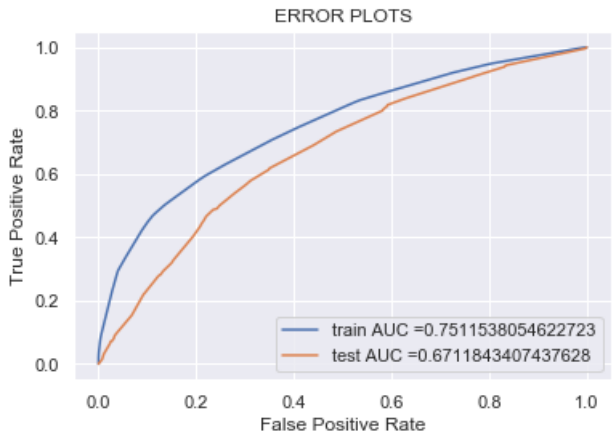
Out[0]:

```
dict_keys(['cv', 'error_score', 'estimator__class_weight', 'estimator__criterion',
'estimator__max_depth', 'estimator__max_features', 'estimator__max_leaf_nodes',
'estimator__min_impurity_decrease', 'estimator__min_impurity_split',
'estimator__min_samples_leaf', 'estimator__min_samples_split',
'estimator__min_weight_fraction_leaf', 'estimator__presort', 'estimator__random_state',
'estimator__splitter', 'estimator', 'iid', 'n_jobs', 'param_grid', 'pre_dispatch', 'refit',
'return_train_score', 'scoring', 'verbose'])
```

Fitting Model to Hyper-Parameter Curve -> Best Max_depth-> 10 , Best Min_sample_split-> 100

In [0]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=500)
clf11.fit(X_set1_train, y_train)
# for visulation
clfV1.fit(X_set1_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set1_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set1_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



Confusion Matrix

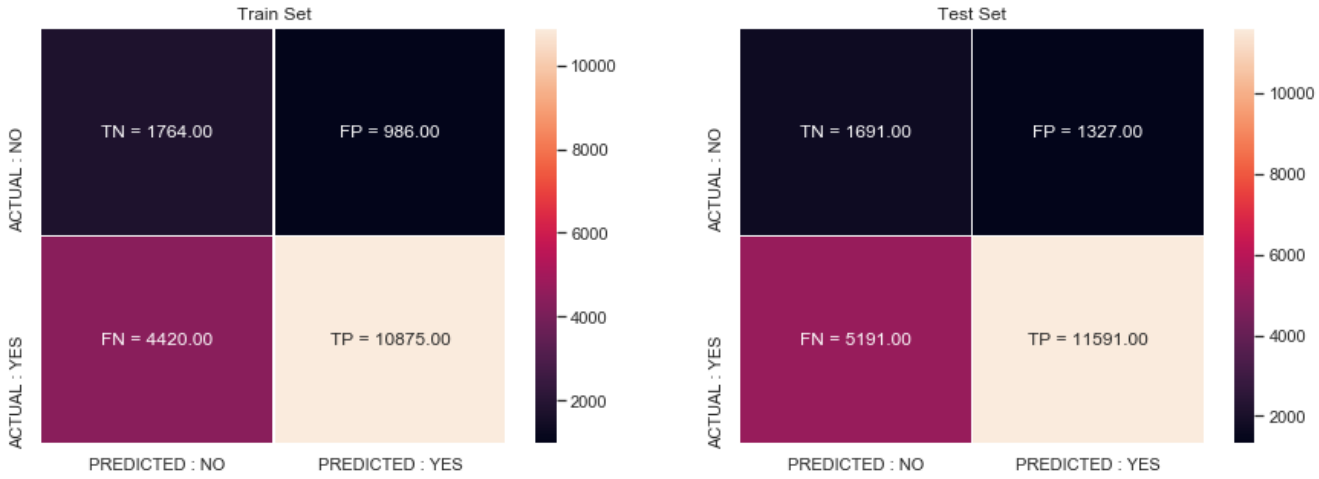
In [0]:

```
def predict(proba, threshould, fpr, tpr):
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", np.round(max(tpr*(1-fpr)),2) , "for threshold", np.ro
und(t,2))
    predictions = []
    global predictions1 # make it global
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1= predictions
    return predictions
```

In [0]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tp
r1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.47 for threshold 0.44
the maximum value of tpr*(1-fpr) 0.4 for threshold 0.45
```



Visualizing Decision Tree

In [0]:

```
#Feature aggregation
f1=vectorizer1.get_feature_names()
f2=vectorizer2.get_feature_names()
f3=vectorizer3.get_feature_names()
f4=vectorizer4.get_feature_names()
f5=vectorizer5.get_feature_names()
fb=vectorizer6.get_feature_names()
ft=vectorizer7.get_feature_names()
fb1=vectorizer8.get_feature_names()
ft1=vectorizer9.get_feature_names()
```

```
feature_agg_bow = f1 + f2 + f3 + f4 + f5 + fb + ft
feature_agg_tfidf = f1 + f2 + f3 + f4 + f5 + fb1 + ft1
# p is price, q is quantity, t is teacher previous year projects
feature_agg_bow.append('price')
feature_agg_tfidf.append('price')
feature_agg_bow.append('quantity')
feature_agg_tfidf.append('quantity')
feature_agg_bow.append('teacher_previous_projects')
feature_agg_tfidf.append('teacher_previous_projects')
```

In [0]:

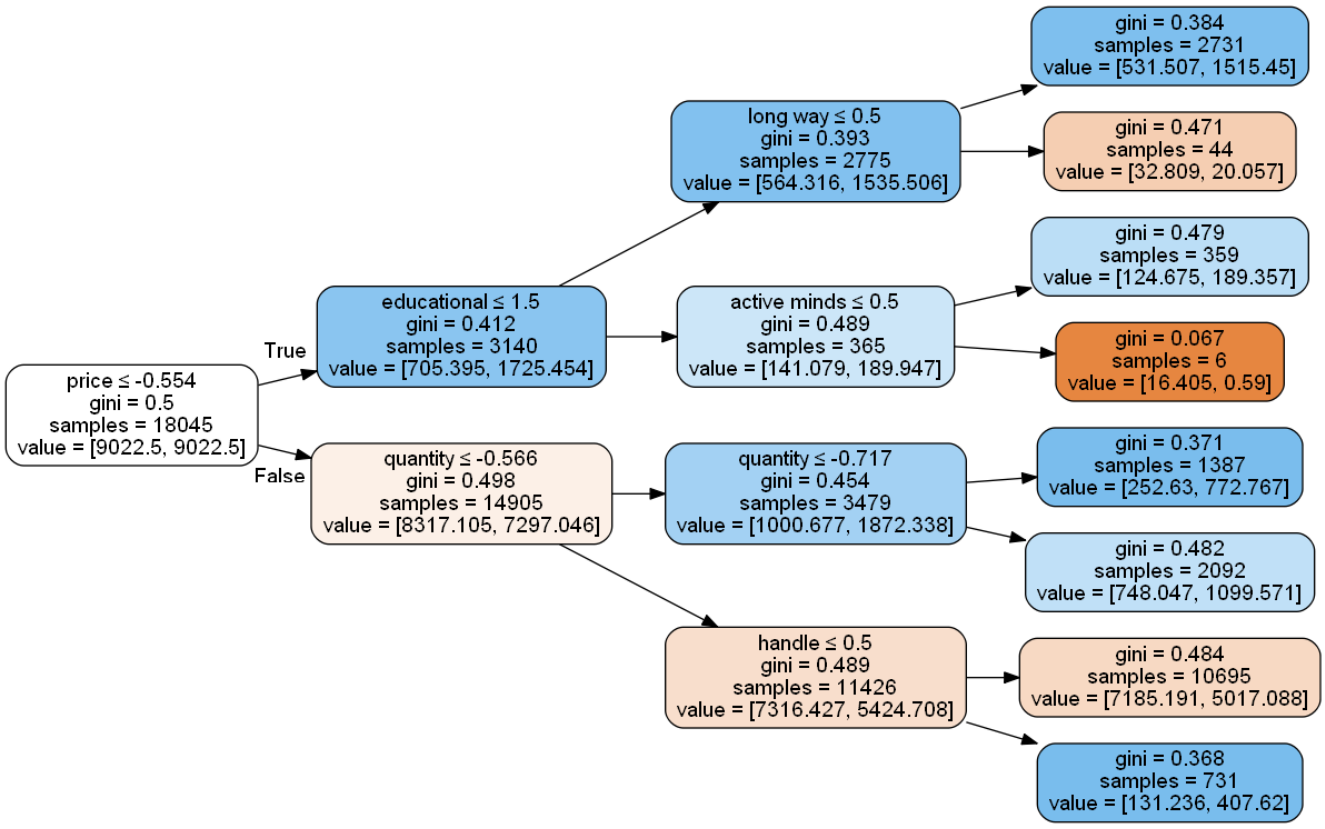
```
pip install pydotplus
```

```
Requirement already satisfied: pydotplus in c:\users\hp\anaconda3\lib\site-packages (2.0.2)
Requirement already satisfied: pyparsing>=2.0.1 in c:\users\hp\anaconda3\lib\site-packages (from p
ydotplus) (2.3.1)
Note: you may need to restart the kernel to use updated packages.
```

In [0]:

```
import warnings
warnings.filterwarnings("ignore")
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clfV1, out_file=dot_data, filled=True, rounded=True, special_characters=True, featu
re_names=feature_agg_bow,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[0]:



Analysis on the False positives

In [0]:

```
#Get the False positives datapoints
```

```
X_test['essay'].values[1]
```

Out[0]:

"My classroom is filled with fun-loving special education students that are happy, active, and rea
dy to learn. Their ages range between 3-5 years. All of my students have special needs, including
autism, speech and language impairments, and intellectual disabilities, but we don't let that slow
us down! We are part of a low income school district on an elementary school campus. Many of my st
udents are nonverbal and need lots of visual and physical supports. We only get a few dollars a ye
ar for paper and crayons. We are in desperate need of enrichment supplies!I have a very busy group
of students in my preschool special education class. We are so excited, we just can't sit still. W
e need some special stools to help us move while sitting at the table. This way we can sit with ou
r friends but still keep moving. \\r\\nThe scooter boards will let us twist and shout when we need
a break from sitting. The science materials are hands-on to help us move and get kinesthetic input
when learning difficult topics. The ball toss will help us develop our gross motor skills and enco
urage our desire to move in an appropriate and fun way. Help us Move it, Move it!nannan"

In [0]:

```
#https://www.google.com/search?
q=geeks+for+geeks+false+positive&rlz=1C1SQJL_enIN849IN849&oq=geeks+for+geeks+false+positive&aqs=ch
.69i57j33l5.6431j0j7&sourceid=chrome&ie=UTF-8
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1).
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

DataFrame of False Positives

In [0]:

```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)

# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)

  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))

X_test_falsePos1.head(1)
len(X_test_falsePos1)
```

Out[0]:

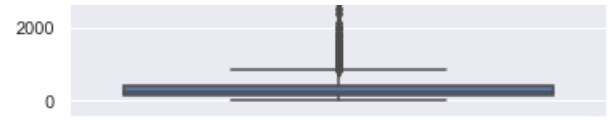
1327

In [0]:

```
##Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

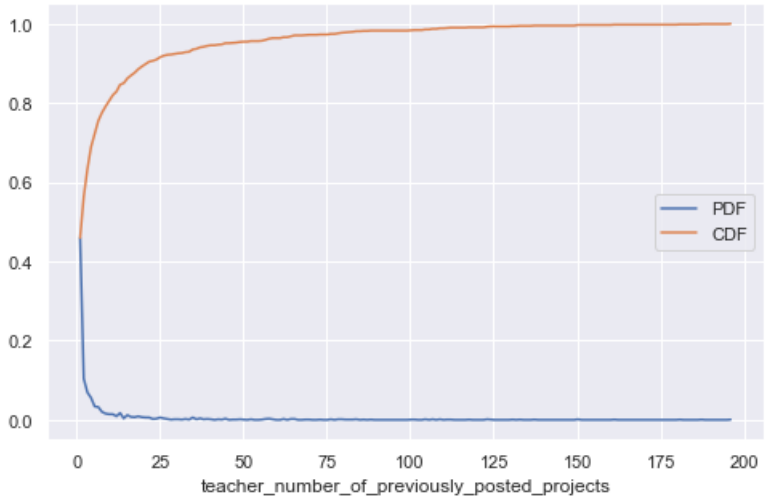
Out[0]:

<matplotlib.axes._subplots.AxesSubplot at 0x16d2c8e7588>



In [0]:

```
##PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



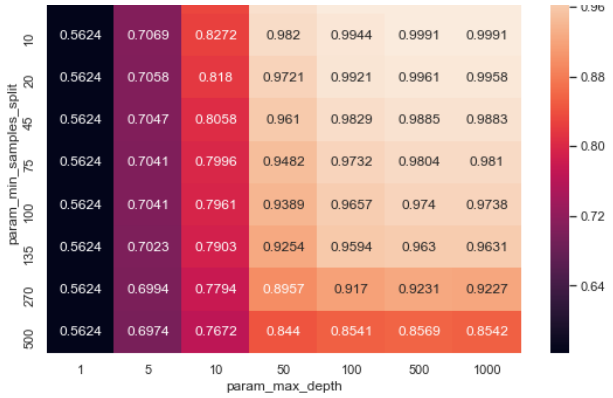
Applying Decision trees on TFIDF

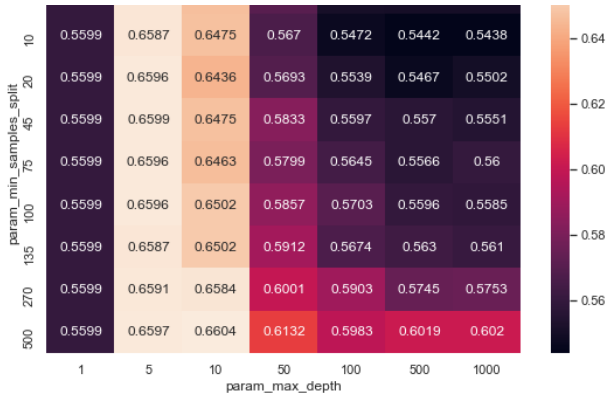
In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt2 = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf2 = GridSearchCV(dt2, parameters, cv=3, scoring='roc_auc',return_train_score=True)
se2 = clf2.fit(X_set2_train, y_train)
```

In [0]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf2.cv_results_).groupby(['param_min_samples_split', '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()
```





Confusion matrix

In [0]:

```
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tp
r1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.49 for threshold 0.39
the maximum value of tpr*(1-fpr) 0.39 for threshold 0.5
```

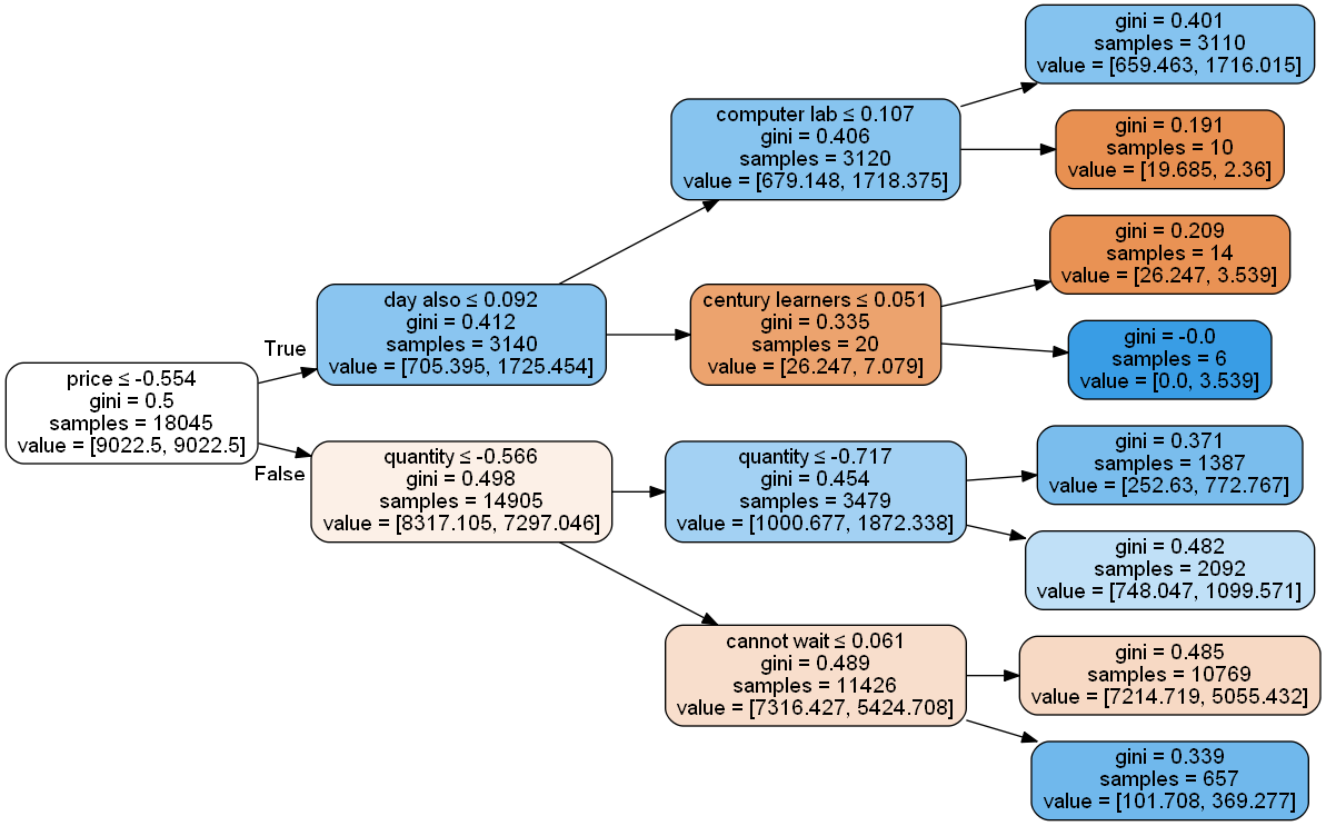
Visualizing Decision Tree

In [0]:

```
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(clfV1, out_file=dot_data, filled=True, rounded=True, special_characters=True, featu
re_names=feature_agg_bow,rotate=True)
```

```
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[0]:



In [0]:

```
#https://www.google.com/search?
q=geeks+for+geeks+false+positive&rlz=1C1SQJL_enIN849IN849&oq=geeks+for+geeks+false+positive&aqs=ch
.69i57j33l5.6431j0j7&sourceid=chrome&ie=UTF-8
#https://github.com/pskadasi/DecisionTrees_DonorsChoose/blob/master/Copy_of_8_DonorsChoose_DT_(1)..

fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

DataFrame of False Positives

In [0]:

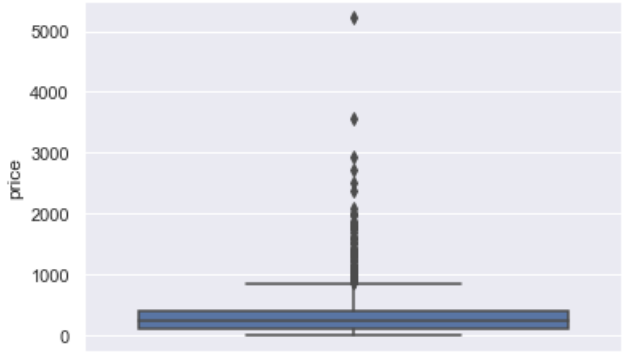
```
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
```

In [0]:

```
#Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

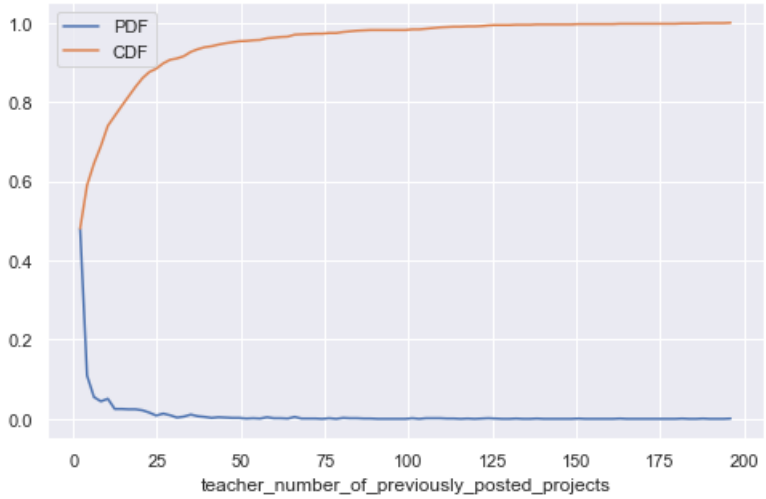
Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16bc09070b8>
```



In [0]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



In [0]:

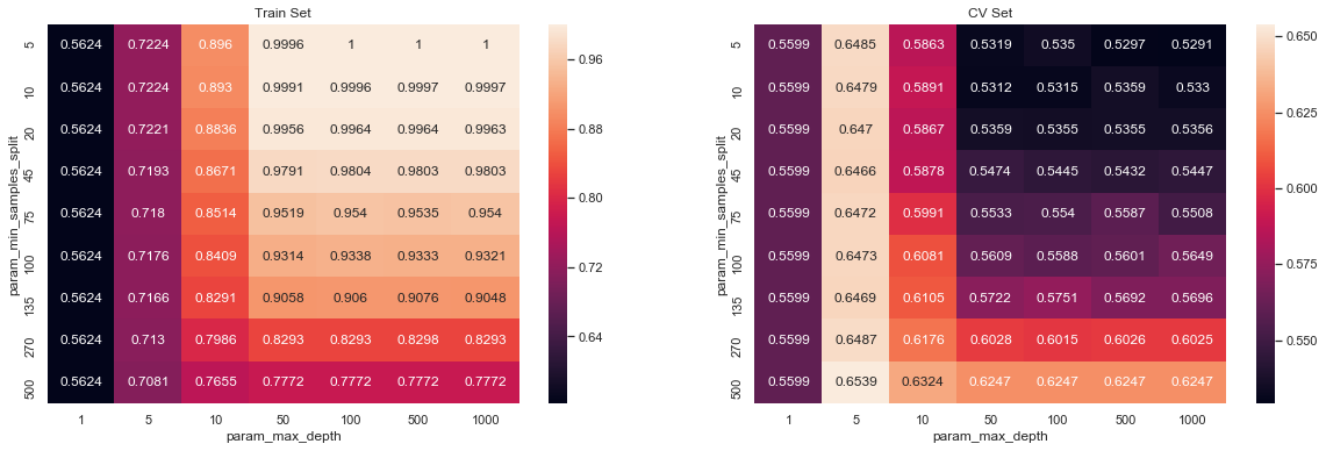
```

```

Applying Decision trees on AVG W2V

In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt3= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf3 = GridSearchCV(dt3, parameters, cv=3, scoring='roc_auc',n_jobs=4,return_train_score=True)
se3 = clf3.fit(X_set3_train, y_train)

import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf3.cv_results_).groupby(['param_min_samples_split', '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()
```



In [0]:

```
#Best Estimator and Best tune parameters
print(clf3.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf3.score(X_set3_train,y_train))
print(clf3.score(X_set3_test,y_test))
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6965402121905555
0.6437607521359746
```

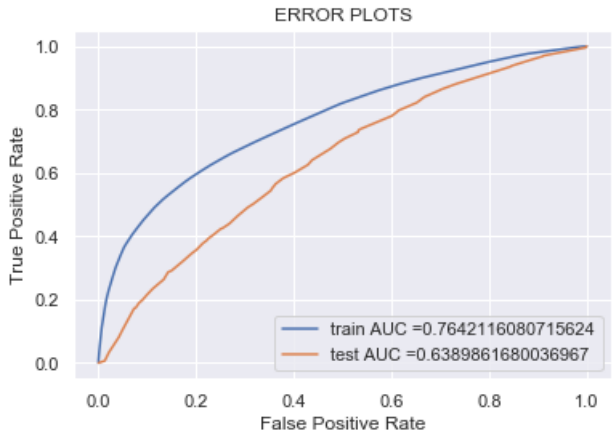
In [0]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth':[5], 'min_samples_split':[500] } ]
```

In [0]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=5,min_samples_split=500)
clf11.fit(X_set3_train, y_train)
# for visulation
clfV1.fit(X_set3_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set3_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set3_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
```

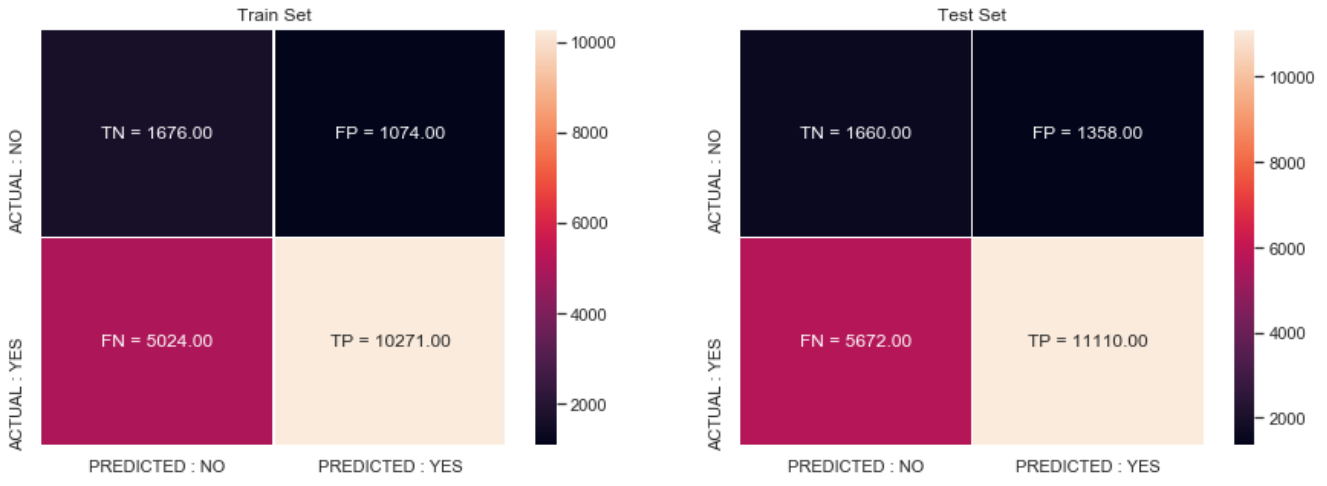
```
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [0]:

```
#confusion matrix test data
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tpr1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(), con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(), con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'], yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'], yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.41 for threshold 0.47
the maximum value of tpr*(1-fpr) 0.37 for threshold 0.47
```



In [0]:

```
##Analysis on the False positives
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
    fpi.append(i)
fp_essay1 = []
```

```
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [0]:

```
pip install wordcloud
```

```
Requirement already satisfied: wordcloud in c:\users\hp\anaconda3\lib\site-packages (1.5.0)
Requirement already satisfied: numpy>=1.6.1 in c:\users\hp\anaconda3\lib\site-packages (from
wordcloud) (1.16.2)
Requirement already satisfied: pillow in c:\users\hp\anaconda3\lib\site-packages (from wordcloud)
(5.4.1)
Note: you may need to restart the kernel to use updated packages.
```

In [0]:

```

```

In [0]:

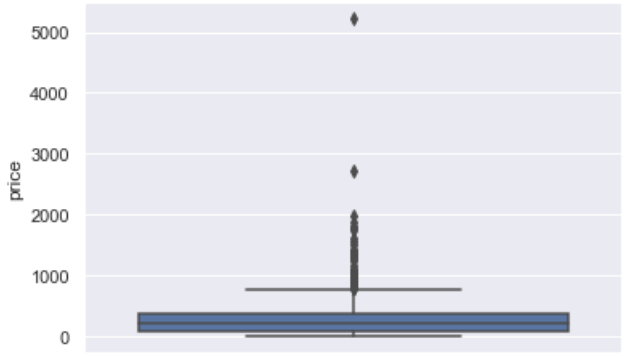
```
#DataFrame of False Positives
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
```

In [0]:

```
#Box Plot (FP 'price')
sns.boxplot(y='price', data=X_test_falsePos1)
```

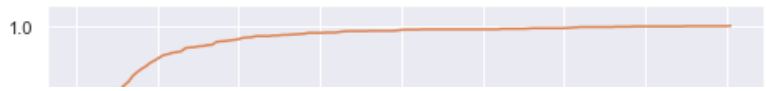
Out[0]:

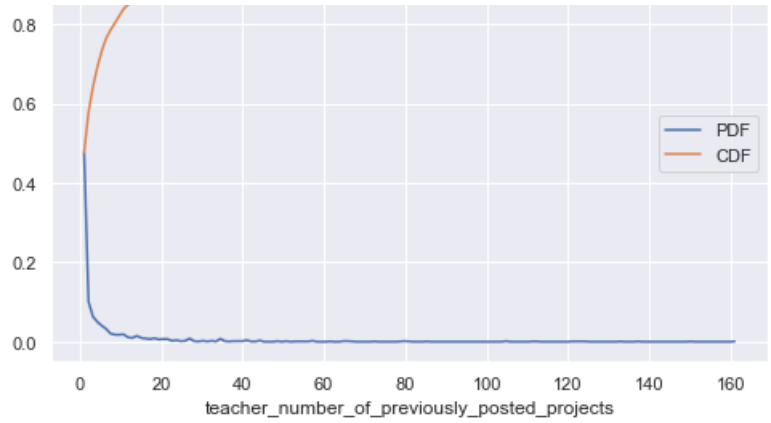
```
<matplotlib.axes._subplots.AxesSubplot at 0x16bb87b9240>
```



In [0]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```





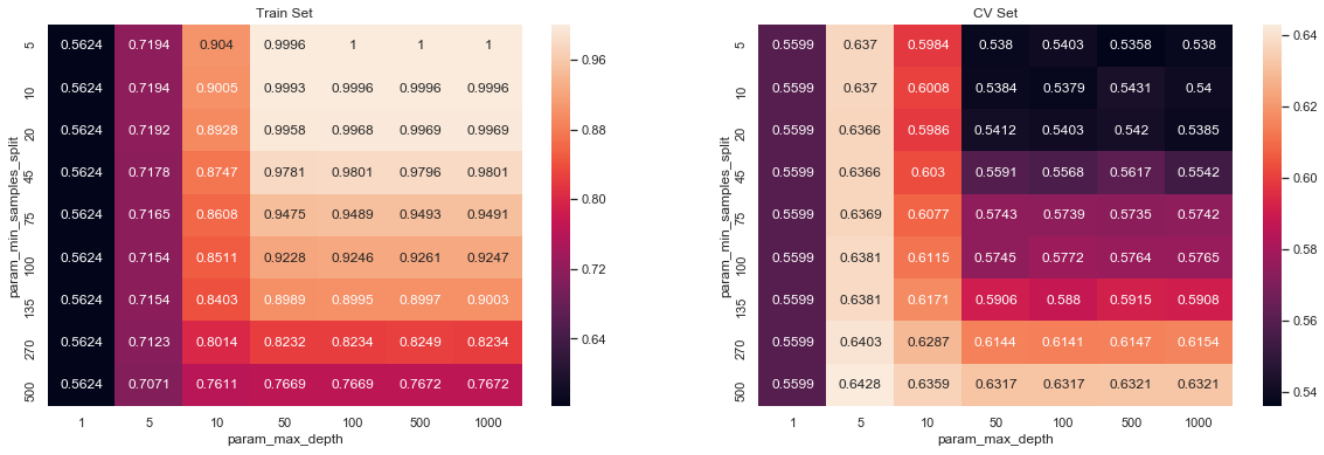
In [0]:

```
```

Applying Decision trees on td_idf W2V

In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt4= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf4 = GridSearchCV(dt4, parameters, cv=3, scoring='roc_auc',return_train_score=True)
set4= clf4.fit(X_set4_train, y_train)

import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf4.cv_results_).groupby(['param_min_samples_split', '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()
```



In [0]:

```
#Best Estimator and Best tune parameters
print(clf4.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf4.score(X_set4_train,y_train))
print(clf4.score(X_set4_test,y_test))
```

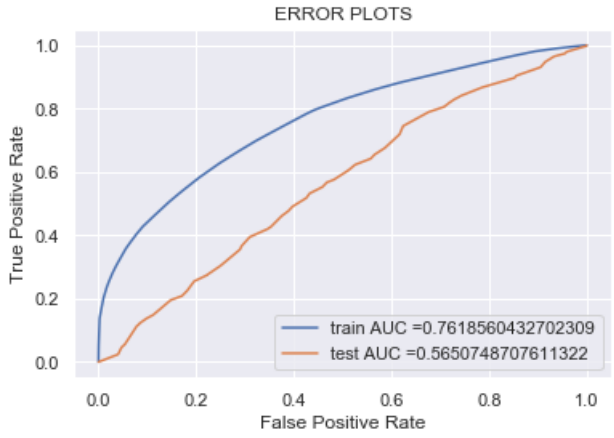
```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.6969748759249904
0.6138512151971972
```

In [0]:

```
best_tune_parameters= [{'max_depth': [5], 'min_samples_split':[500] }]
```

In [0]:

```
#Fitting Model to Hyper-Parameter Curve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=5,min_samples_split=500)
clf11.fit(X_set4_train, y_train)
# for visulation
clfV1.fit(X_set4_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
r_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set4_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set4_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

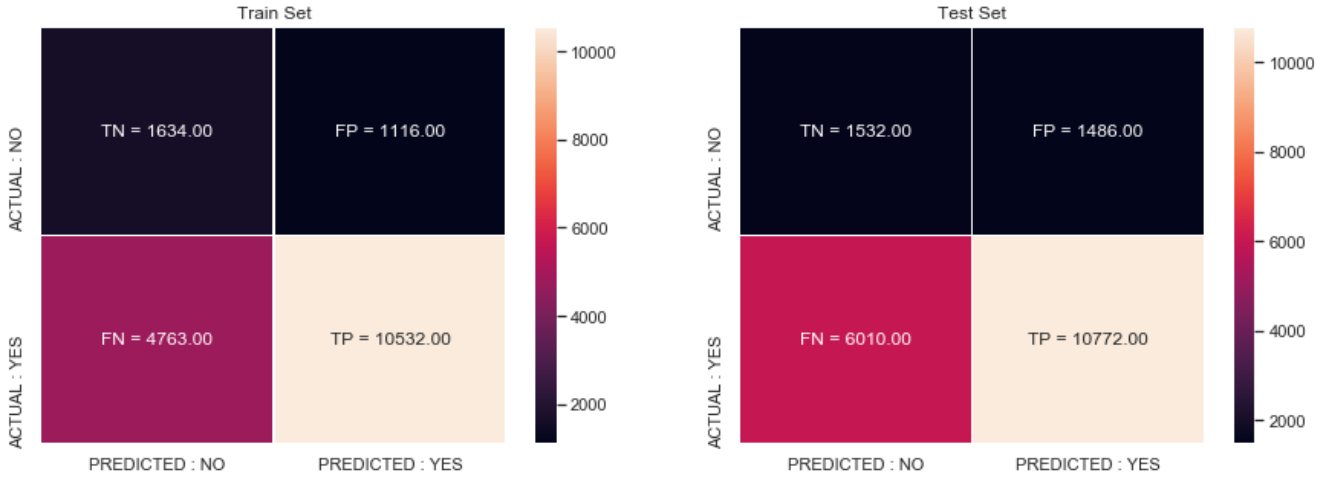


In [0]:

```
#CONFUSION MATRIX
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tp
r1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
```

```
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.42 for threshold 0.45
the maximum value of tpr*(1-fpr) 0.33 for threshold 0.5
```



In [0]:

```
#Analysis on the False positives
fpi = []
for i in range(len(y_test)) :
  if (y_test.values[i] == 0) & (predictions1[i] == 1) :
   fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [0]:

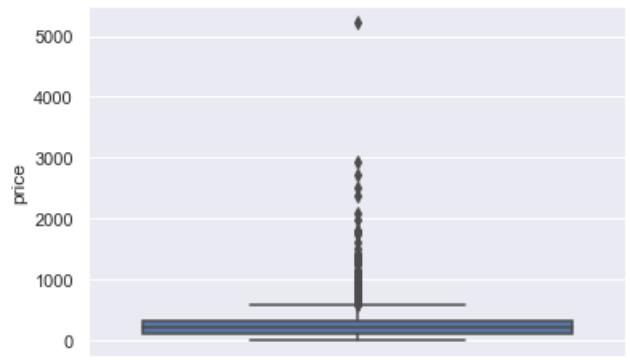
```

```

In [0]:

```
#Box Plot (FP 'price')
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
sns.boxplot(y='price', data=X_test_falsePos1)
```

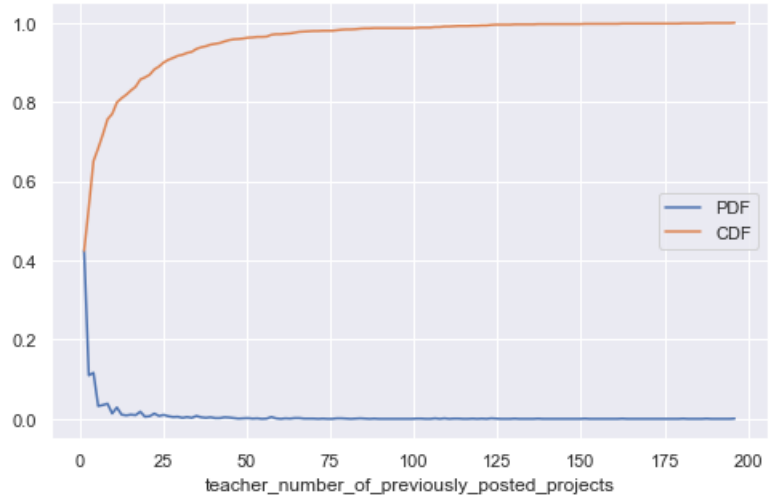
Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16d281599b0>
```



In [0]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```



Select 5k best features from features of Set 2 using feature_importances,discard all the other remaining features and then apply any of the model of your choice i.e.(Dession tree, Logistic Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

In [0]:

```
#https://stackoverflow.com/questions/47111434/randomforestregressor-and-feature-importances-error
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV
def selectKImportance(model, X, k=5):
    return X[:,model.best_estimator_.feature_importances_.argsort()[::-1][:k]]
```

In [0]:

```
# for tf-idf set 2
X_set5_train = selectKImportance(clf2, xtr,5000)
X_set5_test = selectKImportance(clf2, X_set2_test, 5000)

print(X_set5_train.shape)
print(X_set5_test.shape)
```

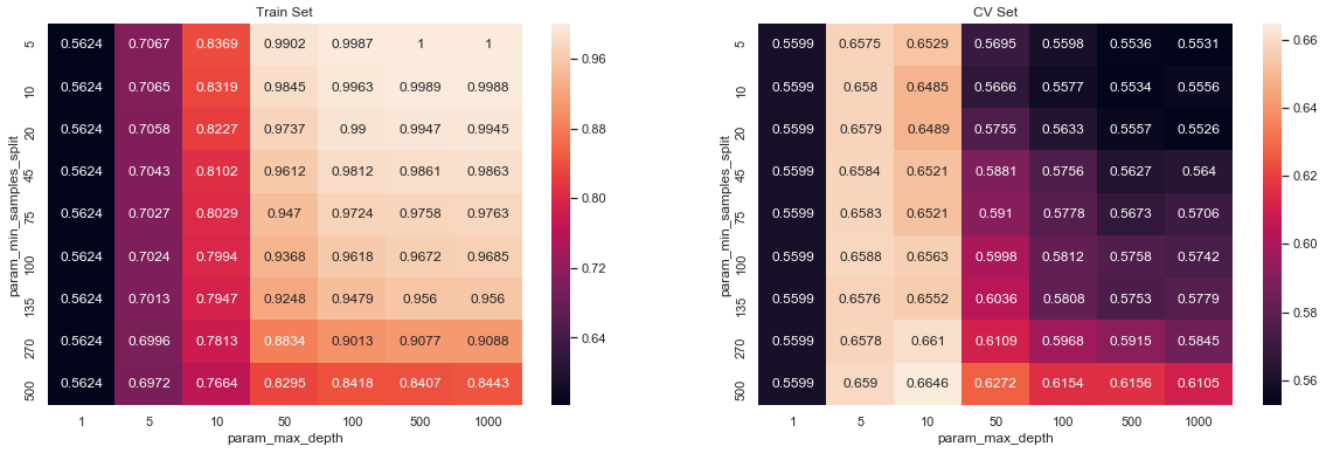
```
(18045, 5000)
(19800, 5000)
```

Decision tree on Important features

In [0]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
```

```
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
dt5= DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split': [5, 10, 20, 45, 75,
100, 135, 270, 500]}
clf5 = GridSearchCV(dt5, parameters, cv=3, scoring='roc_auc',return_train_score=True)
set5= clf5.fit(X_set5_train, y_train)


import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf5.cv_results_).groupby(['param_min_samples_split', '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()
```



In [0]:

```
#Best Estimator and Best tune parameters
print(clf5.best_estimator_)
#Mean cross-validated score of the best_estimator
print(clf5.score(X_set5_train,y_train))
print(clf5.score(X_set5_test,y_test))
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=10,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
0.7628998900413088
0.6659494725920092
```

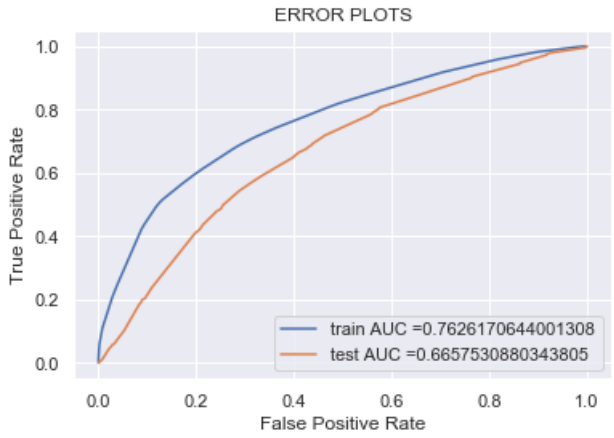
In [0]:

```
# Best tune parameters
best_tune_parameters=[{'max_depth': [10], 'min_samples_split':[500] } ]
```

In [0]:

```
# train with best hyperparameter
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc
clf11= GridSearchCV( DecisionTreeClassifier(class_weight = 'balanced'),best_tune_parameters)
clfV1=DecisionTreeClassifier (class_weight = 'balanced',max_depth=10,min_samples_split=500)
clf11.fit(X_set5_train, y_train)
# for visulation
clfV1.fit(X_set5_train, y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.
```

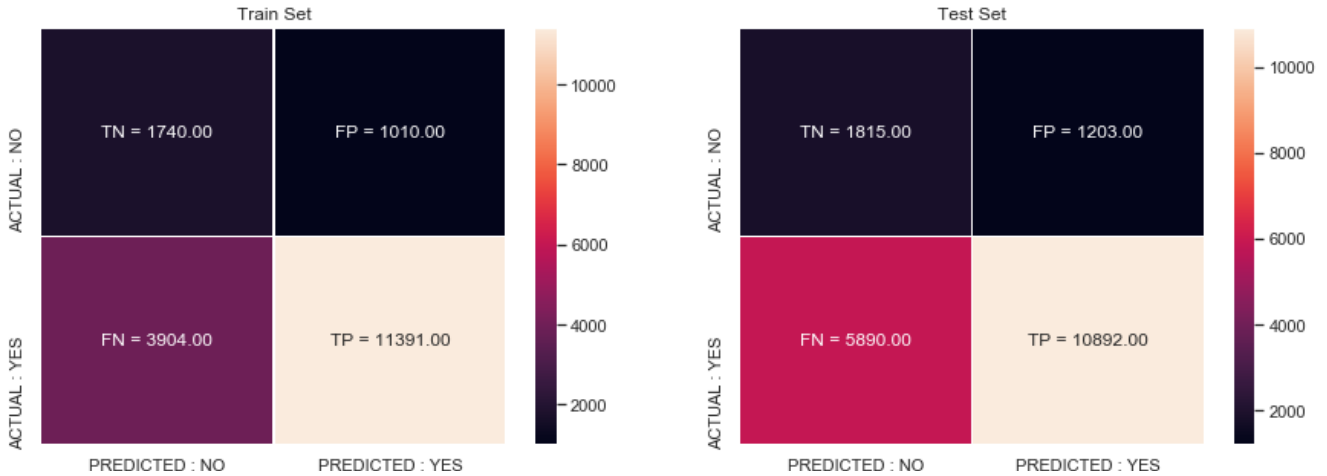
```
r_model.SGDClassifier.decision_function
y_train_pred1 = clf11.predict_proba(X_set5_train) [:,1]
y_test_pred1 = clf11.predict_proba(X_set5_test) [:,1]
train_fpr1, train_tpr1, tr_thresholds1 = roc_curve(y_train, y_train_pred1)
test_fpr1, test_tpr1, te_thresholds1 = roc_curve(y_test, y_test_pred1)
plt.plot(train_fpr1, train_tpr1, label="train AUC ="+str(auc(train_fpr1, train_tpr1)))
plt.plot(test_fpr1, test_tpr1, label="test AUC ="+str(auc(test_fpr1, test_tpr1)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [0]:

```
#CONFUSION MATRIX
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()
con_m_train = confusion_matrix(y_train, predict(y_train_pred1, tr_thresholds1, train_fpr1, train_tp
r1))
con_m_test = confusion_matrix(y_test, predict(y_test_pred1, te_thresholds1, test_fpr1, test_tpr1))
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)
sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED :
YES'],yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('Test Set')
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.49 for threshold 0.39
the maximum value of tpr*(1-fpr) 0.39 for threshold 0.5
```



In [0]:

```
#Analysis on the False positives

fpi = []
for i in range(len(y_test)) :
    if (y_test.values[i] == 0) & (predictions1[i] == 1) :
      fpi.append(i)
fp_essay1 = []
for i in fpi :
  fp_essay1.append(X_test['essay'].values[i])
```

In [0]:

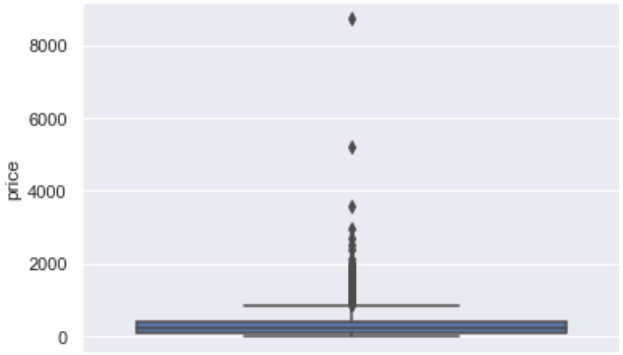
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging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

In [0]:

```
#Box Plot (FP 'price')
# first get the columns:
cols = X_test.columns
X_test_falsePos1 = pd.DataFrame(columns=cols)
# get the data of the false pisitives
for i in fpi : # (in fpi all the false positives data points indexes)
  X_test_falsePos1 = X_test_falsePos1.append(X_test.filter(items=[i], axis=0))
sns.boxplot(y='price', data=X_test_falsePos1)
```

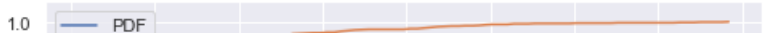
Out[0]:

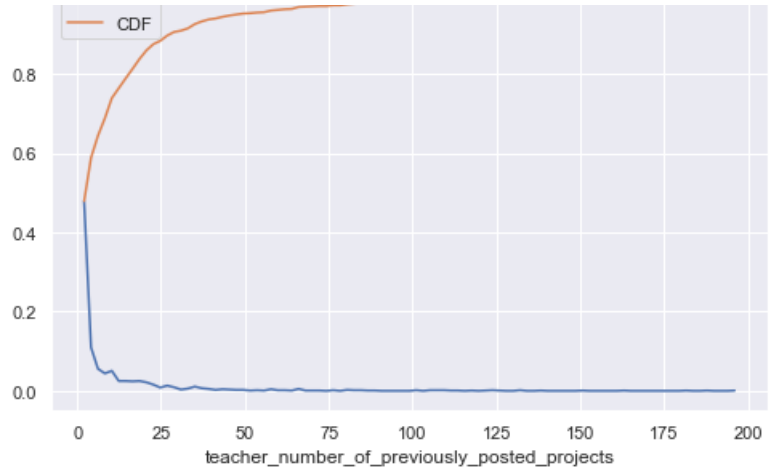
```
<matplotlib.axes._subplots.AxesSubplot at 0x16bc088ad68>
```



In [0]:

```
#PDF (FP ,teacher_number_of_previously_posted_projects)
plt.figure(figsize=(8,5))
counts, bin_edges = np.histogram(X_test_falsePos1['teacher_number_of_previously_posted_projects'],
bins='auto', density=True)
pdf = counts/sum(counts)
cdf = np.cumsum(pdf)
pdfP, = plt.plot(bin_edges[1:], pdf)
cdfP, = plt.plot(bin_edges[1:], cdf)
plt.legend([pdfP, cdfP], ["PDF", "CDF"])
plt.xlabel('teacher_number_of_previously_posted_projects')
plt.show()
```





Conclusions

2. Summary

In [0]:

```
# Please compare all your models using Prettytable library
#how to use pretty table http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= (" Vectorizer ", " Max_depth ", " Min_sample_split "," Test -AUC ")
tb.add_row([" BOW ", 10, 500, 67])
tb.add_row([" Tf - Idf", 10 , 500 ,66.5 ])
tb.add_row([" AVG-W2V", 5, 500,63.8 ])
tb.add_row(["A VG - Tf - Idf", 5 , 500 ,56.5])
tb.add_row(["Top 5000 Features", 10, 500 ,66.5 ])
print(tb.get_string(titles = "Decision trees- Observations"))
```

```
+-------------------+-------------+--------------------+-------------+
|     Vectorizer    |  Max_depth  |  Min_sample_split  |  Test -AUC  |
+-------------------+-------------+--------------------+-------------+
|        BOW        |      10     |        500         |      67     |
|      Tf - Idf     |      10     |        500         |     66.5    |
|       AVG-W2V     |      5      |        500         |     63.8    |
|  A VG - Tf - Idf  |      5      |        500         |     56.5    |
| Top 5000 Features |      10     |        500         |     66.5    |
+-------------------+-------------+--------------------+-------------+
```