8_DonorsChoose_DT_new.ipynb

July 5, 2019

[9]:
```
import dill
```

[60]:
```
dill.dump_session("8notebook_env_new.db")
#dill.load_session("8notebook_env_new.db")
```

1 DonorsChoose

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

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

How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible

```
<li>How to increase the consistency of project vetting across different volunteers to improve t
<li>How to focus volunteer time on the applications that need the most assistance</li>
</ul>
```

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

1.1 About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`

`project_title` | Title of the project. **Examples:**
Art Will Make You Happy!
First Grade Fun

`project_grade_category` | Grade level of students for which the project is targeted. One of the following enumerated values:

Grades PreK-2
Grades 3-5
Grades 6-8
Grades 9-12

`project_subject_categories` | One or more (comma-separated) subject categories for the project from the following enumerated list of values:

Applied Learning
Care & Hunger
Health & Sports
History & Civics
Literacy & Language
Math & Science
Music & The Arts
Special Needs
Warmth

Examples:

Music & The Arts
Literacy & Language, Math & Science

`school_state` | State where school is located (Two-letter U.S. postal code). **Example:** `WY`

`project_subject_subcategories` | One or more (comma-separated) subject subcategories for the project. **Examples:**

Literacy
Literature & Writing, Social Sciences

`project_resource_summary` | An explanation of the resources needed for the project. **Example:**

My students need hands on literacy materials to manage sensory needs!</code

`project_essay_1` | First application essay

`project_essay_2` | *Second application essay* `project_essay_3` | Third application essay *`project_essay_4`* | *Fourth application essay* `project_submitted_datetime` | Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`

`teacher_id` | A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`

`teacher_prefix` | Teacher's title. One of the following enumerated values:

nan
Dr.
Mr.
Mrs.
Ms.
Teacher.

`teacher_number_of_previously_posted_projects` | Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

Feature	Description

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

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

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

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

1.1.1 Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

project_essay_1: "Introduce us to your classroom"

project_essay_2: "Tell us more about your students"

project_essay_3: "Describe how your students will use the materials you're requesting"

project_essay_3: "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

project_essay_1: "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

project_essay_2: "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

[4]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
```

```
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

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

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

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

from tqdm import tqdm
import os

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

[8]:
```
# loading required libraries
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from collections import Counter
from sklearn import model_selection
```

1.2 1.1 Reading Data

[10]:
```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

[11]:
```
print("Number of data points in train data", project_data.shape)
print('-'*60)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
------------------------------------------------------------
```

```
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix'
'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']
```

[12]:
```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/
 ↪4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in␣
 ↪list(project_data.columns)]

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

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

project_data.head(2)
```

[12]:
```
       Unnamed: 0       id                         teacher_id teacher_prefix  \
55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.
76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df            Ms.

      school_state                Date project_grade_category  \
55660           CA 2016-04-27 00:27:36          Grades PreK-2
76127           UT 2016-04-27 00:31:25             Grades 3-5

      project_subject_categories           project_subject_subcategories  \
55660              Math & Science  Applied Sciences, Health & Life Science
76127               Special Needs                           Special Needs

                                  project_title  \
55660  Engineering STEAM into the Primary Classroom
76127                       Sensory Tools for Focus

                                        project_essay_1  \
55660  I have been fortunate enough to use the Fairy ...
76127  Imagine being 8-9 years old. You're in your th...
```

```
                                          project_essay_2  \
55660  My students come from a variety of backgrounds...
76127  Most of my students have autism, anxiety, anot...

                                          project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...

                                          project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...

                                 project_resource_summary  \
55660  My students need STEM kits to learn critical s...
76127  My students need Boogie Boards for quiet senso...

       teacher_number_of_previously_posted_projects  project_is_approved
55660                                            53                   1
76127                                             4                   1
```

[13]:
```
print("Number of data points in resource train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

[13]:
```
        id                                           description  quantity  \
0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
1  p069063         Bouncy Bands for Desks (Blue support pipes)         3

    price
0  149.00
1   14.95
```

1.3 1.2 preprocessing of `project_subject_categories`

[14]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.
 ↪com/a/47301924/4084039

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

```
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",␣
 ↪"Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on␣
 ↪space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to␣
 ↪replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with␣
 ↪''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the␣
 ↪trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.4 1.3 preprocessing of `project_subject_subcategories`

[15]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.
 ↪com/a/47301924/4084039

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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",␣
 ↪"Warmth", "Care & Hunger"]
```

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

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

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

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

1.5 1.3 Text preprocessing

[16]:
```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
project_data.drop(['project_essay_1','project_essay_2', 'project_essay_3',␣
 ↪'project_essay_4'], axis=1, inplace=True)
```

[17]:
```
project_data.drop(['project_resource_summary'], axis=1, inplace=True)
project_data.head(1)
```

[17]:
```
       Unnamed: 0       id                         teacher_id teacher_prefix  \
55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.

      school_state                 Date project_grade_category  \
55660           CA 2016-04-27 00:27:36          Grades PreK-2

                                  project_title  \
55660  Engineering STEAM into the Primary Classroom

       teacher_number_of_previously_posted_projects  project_is_approved  \
55660                                            53                    1
```

```
      clean_categories                clean_subcategories  \
55660     Math_Science  AppliedSciences Health_LifeScience

                                                      essay
55660  I have been fortunate enough to use the Fairy ...
```

[18]:
```
# 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
```

[19]:
```
sent = decontracted(project_data['essay'].values[20000])
# print(sent)
# print("="*50)
```

[20]:
```
# \r \n \t remove from string python: http://texthandler.com/info/
 ↪remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
# print(sent)
```

[21]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# print(sent)
```

[22]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you',␣
 ↪"you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he',␣
 ↪'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its',␣
 ↪'itself', 'they', 'them', 'their',\
```

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

1.4.1 Preprocessing of essays

[23]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|| 109248/109248 [01:21<00:00, 1341.33it/s]
```

[24]:
```
# after preprocesing we drop some coloums which we don't use from now on
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)

project_data.head(1)
```

[24]:
```
       Unnamed: 0       id                         teacher_id teacher_prefix  \
55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.

      school_state                Date project_grade_category  \
55660           CA 2016-04-27 00:27:36          Grades PreK-2

                                    project_title  \
55660  Engineering STEAM into the Primary Classroom

       teacher_number_of_previously_posted_projects  project_is_approved  \
55660                                            53                   1

      clean_categories                 clean_subcategories  \
55660     Math_Science  AppliedSciences Health_LifeScience

                                   preprocessed_essays
55660  fortunate enough use fairy tale stem kits clas...
```

1.4.2 Preprocessing of project_title

[25]:
```
# preprocessing project titles
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:03<00:00, 34950.51it/s]
```

[26]:
```
# droping coloums project_titles and project_resource_summary which we don't␣
 ↪want to use
project_data['preprocessed_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(1)
```

[26]:
```
       Unnamed: 0       id                         teacher_id teacher_prefix  \
55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.

      school_state                Date project_grade_category  \
55660           CA 2016-04-27 00:27:36          Grades PreK-2

       teacher_number_of_previously_posted_projects  project_is_approved  \
```

```
55660                                          53                    1

      clean_categories                 clean_subcategories  \
55660     Math_Science  AppliedSciences Health_LifeScience

                                     preprocessed_essays  \
55660  fortunate enough use fairy tale stem kits clas...

                        preprocessed_titles
55660  engineering steam primary classroom
```

1.5.1 preprocessing of project_grade_category

[27]:
```
# preprocessing of preoject_grade_category
from tqdm import tqdm
preprocessed_pgc = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_grade_category'].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_pgc.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:02<00:00, 37574.53it/s]
```

[28]:
```
project_data['preprocessed_pgc'] = preprocessed_pgc
project_data.drop(['project_grade_category'], axis=1, inplace=True)
```

1.5.2 preprocessing of teacher_prefix categorical feature

[29]:
```
# preprocessing of teacher prefix
from tqdm import tqdm
preprocessed_tp = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['teacher_prefix'].values):
    sent = decontracted(str(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_tp.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:01<00:00, 55789.29it/s]
```

[30]:
```
project_data['preprocessed_tp'] = preprocessed_tp
project_data.drop(['teacher_prefix'], axis=1, inplace=True)
```

[31]:
```
# Merging Project_data and price data dataframe
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
 ↪reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
project_data.head(2)
```

[31]:
```
   Unnamed: 0       id                         teacher_id school_state  \
0        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
1       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT

                 Date  teacher_number_of_previously_posted_projects  \
0 2016-04-27 00:27:36                                            53
1 2016-04-27 00:31:25                                             4

   project_is_approved clean_categories                clean_subcategories  \
0                    1     Math_Science  AppliedSciences Health_LifeScience
1                    1     SpecialNeeds                        SpecialNeeds

                                preprocessed_essays  \
0  fortunate enough use fairy tale stem kits clas...
1  imagine 8 9 years old third grade classroom se...

                  preprocessed_titles preprocessed_pgc preprocessed_tp  \
0  engineering steam primary classroom    grades_prek_2            mrs
1                  sensory tools focus       grades_3_5             ms

    price  quantity
0  725.05         4
1  213.03         8
```

[32]:
```
project_data['project_is_approved'].value_counts()
```

[32]:
```
1    92706
0    16542
Name: project_is_approved, dtype: int64
```

Since Number of data points for which are project is approved is much greater than the number of data points for which project is not approved so this is imbalence dataset.

1.6 1.5 Preparing data for models

[33]:
```
project_data.columns
```

[33]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'school_state', 'Date',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'preprocessed_essays',
       'preprocessed_titles', 'preprocessed_pgc', 'preprocessed_tp', 'price',
       'quantity'],
      dtype='object')
```

we are going to consider

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

- project_title : text data
- text : text data

- quantity : numerical
- teacher_number_of_previously_posted_projects : numerical
- price : numerical
```

2 Assignment 8: DT

Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets

Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)

Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)

Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)

Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

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

Find the best hyper parameter which will give the maximum AUC value

Find the best hyper paramter using k-fold cross validation or simple cross validation data

Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

```
</ul>
</li>
<br>
<li><strong>Graphviz</strong>
    <ul>
<li>Visualize your decision tree with Graphviz. It helps you to understand how a decision is be
<li>Since feature names are not obtained from word2vec related models, visualize only BOW & TF
```

```
<li>Make sure to print the words in each node of the decision tree instead of printing its inde
<li>Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated ir
    </ul>
</li>
<br>
<li>
<strong>Representation of results</strong>
    <ul>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='train_cv_auc.JPG' width=300px></li>
<li>Once after you found the best hyper parameter, you need to train your model with it, and fi
<img src='train_test_auc.JPG' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.c
<img src='confusion_matrix.png' width=300px></li>
<li>Once after you plot the confusion matrix with the test data, get all the `false positive da
    <ul>
        <li> Plot the WordCloud <a href='https://www.geeksforgeeks.org/generating-word-cloud-py
        <li> Plot the box plot with the `price` of these `false positive data points`</li>
        <li> Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `fal
    </ul>
    </ul>
</li>
<br>
<li><strong>[Task-2]</strong>
    <ul>
<li> Select 5k best features from features of <font color='red'>Set 2</font> using<a href='http
    </ul>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table for
    <img src='summary.JPG' width=400px>
</li>
    </ul>
```

Note: Data Leakage

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

2. Decision Tree

[34]:
```
project_data.head(1)
```

[34]:
```
   Unnamed: 0       id                         teacher_id school_state  \
0        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA

                 Date  teacher_number_of_previously_posted_projects  \
0 2016-04-27 00:27:36                                            53

   project_is_approved clean_categories                clean_subcategories  \
0                    1     Math_Science  AppliedSciences Health_LifeScience

                                preprocessed_essays  \
0  fortunate enough use fairy tale stem kits clas...

                  preprocessed_titles preprocessed_pgc preprocessed_tp  \
0  engineering steam primary classroom    grades_prek_2             mrs

    price  quantity
0  725.05         4
```

[35]:
```
y = project_data['project_is_approved'].values
X = project_data.drop(['project_is_approved'], axis=1)
```

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

[36]:
```
# train test split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.
 ↪2, stratify=y_train)
```

[37]:
```
print(X_train.shape)
print(y_train.shape)
print(X_cv.shape)
print(y_cv.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(69918, 14)
(69918,)
(17480, 14)
(17480,)
(21850, 14)
(21850,)
```

2.2 Make Data Model Ready: encoding numerical, categorical features

2.1 2.2.1 one hot encoding the categorical features: school_state

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

[38]:
```
# one hot encoding of school_state for training, cv and test data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on␣
 ↪train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
school_state_fn = vectorizer.get_feature_names()
print(school_state_fn)
```

```
After vectorizations
(69918, 51) (69918,)
(17480, 51) (17480,)
(21850, 51) (21850,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia',
'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms',
'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'or', 'pa',
'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
```

2.2 2.2.2 one hot encoding the categorical features: clean_categories

[39]:
```
# one hot encoding of clean_categories for training, cv and test data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values) # fit has to happen only on␣
 ↪train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_categories_ohe = vectorizer.transform(X_train['clean_categories'].
 ↪values)
X_cv_categories_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_categories_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_categories_ohe.shape, y_train.shape)
print(X_cv_categories_ohe.shape, y_cv.shape)
print(X_test_categories_ohe.shape, y_test.shape)
categories_fn = vectorizer.get_feature_names()
print(categories_fn)
```

```
After vectorizations
```

```
(69918, 9) (69918,)
(17480, 9) (17480,)
(21850, 9) (21850,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics',
'literacy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
```

2.3 2.2.3 one hot encoding the categorical features: clean_subcategories

[40]:
```
# one hot encoding of clean_subcategories for training, cv and test data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only␣
 ↪on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcategories_ohe = vectorizer.transform(X_train['clean_subcategories'].
 ↪values)
X_cv_subcategories_ohe = vectorizer.transform(X_cv['clean_subcategories'].
 ↪values)
X_test_subcategories_ohe = vectorizer.transform(X_test['clean_subcategories'].
 ↪values)

print("After vectorizations")
print(X_train_subcategories_ohe.shape, y_train.shape)
print(X_cv_subcategories_ohe.shape, y_cv.shape)
print(X_test_subcategories_ohe.shape, y_test.shape)
subcategories_fn = vectorizer.get_feature_names()
print(subcategories_fn)
```

```
After vectorizations
(69918, 30) (69918,)
(17480, 30) (17480,)
(21850, 30) (21850,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics',
'environmentalscience', 'esl', 'extracurricular', 'financialliteracy',
'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_wellness',
'history_geography', 'literacy', 'literature_writing', 'mathematics', 'music',
'nutritioneducation', 'other', 'parentinvolvement', 'performingarts',
'socialsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
```

2.4 2.2.4 one hot encoding the categorical features: teacher_prefix

[41]:
```
# one hot encoding of teacher_prefix for training, cv and test data
temp_tp_all = list(set(X_train['preprocessed_tp'].values))
temp_tp_all.remove('nan')

vectorizer = CountVectorizer()
```

```
#https://stackoverflow.com/questions/39303912/
 ↪tfidfvectorizer-in-scikit-learn-valueerror-np-nan-is-an-invalid-document
vectorizer.fit(temp_tp_all) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix_ohe = vectorizer.transform(X_train['preprocessed_tp'].
 ↪values)
X_cv_teacher_prefix_ohe = vectorizer.transform(X_cv['preprocessed_tp'].values)
X_test_teacher_prefix_ohe = vectorizer.transform(X_test['preprocessed_tp'].
 ↪values)

print("After vectorizations")
print(X_train_teacher_prefix_ohe.shape, y_train.shape)
print(X_cv_teacher_prefix_ohe.shape, y_cv.shape)
print(X_test_teacher_prefix_ohe.shape, y_test.shape)
teacher_prefix_fn = vectorizer.get_feature_names()
print(teacher_prefix_fn)
```

```
After vectorizations
(69918, 5) (69918,)
(17480, 5) (17480,)
(21850, 5) (21850,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
```

2.5 2.2.5 one hot encoding the categorical features: project_grade_category

[42]:
```
# one hot encoding of project_grade_category for training, cv and test data
vectorizer = CountVectorizer()
vectorizer.fit(X_train['preprocessed_pgc'].values) # fit has to happen only on␣
 ↪train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_pgc_ohe = vectorizer.transform(X_train['preprocessed_pgc'].values)
X_cv_pgc_ohe = vectorizer.transform(X_cv['preprocessed_pgc'].values)
X_test_pgc_ohe = vectorizer.transform(X_test['preprocessed_pgc'].values)

print("After vectorizations")
print(X_train_pgc_ohe.shape, y_train.shape)
print(X_cv_pgc_ohe.shape, y_cv.shape)
print(X_test_pgc_ohe.shape, y_test.shape)
pgc_fn = vectorizer.get_feature_names()
print(pgc_fn)
```

```
After vectorizations
(69918, 4) (69918,)
(17480, 4) (17480,)
```

```
(21850, 4) (21850,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
```

2.6 2.2.6 Normalizing the numerical features: Price

[43]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(-1,1))

X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
price_fn = ['price']
print(price_fn)
```

```
After vectorizations
(69918, 1) (69918,)
(17480, 1) (17480,)
(21850, 1) (21850,)
['price']
```

2.7 2.2.7 Normalizing the numerical features: teacher_number_of_previously_posted_projects

[44]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.
 ↪reshape(-1,1))
```

```
X_train_tnppp_norm = normalizer.
 ↪transform(X_train['teacher_number_of_previously_posted_projects'].values.
 ↪reshape(-1,1))
X_cv_tnppp_norm = normalizer.
 ↪transform(X_cv['teacher_number_of_previously_posted_projects'].values.
 ↪reshape(-1,1))
X_test_tnppp_norm = normalizer.
 ↪transform(X_test['teacher_number_of_previously_posted_projects'].values.
 ↪reshape(-1,1))

print("After vectorizations")
print(X_train_tnppp_norm.shape, y_train.shape)
print(X_cv_tnppp_norm.shape, y_cv.shape)
print(X_test_tnppp_norm.shape, y_test.shape)
tnppp_fn = ['teacher_number_of_previously_posted_projects']
print(tnppp_fn)
```

```
After vectorizations
(69918, 1) (69918,)
(17480, 1) (17480,)
(21850, 1) (21850,)
['teacher_number_of_previously_posted_projects']
```

2.8 2.2.8 Normalizing the numerical features: quantity

[45]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['quantity'].values.reshape(-1,1))

X_train_quantity_norm = normalizer.transform(X_train['quantity'].values.
 ↪reshape(-1,1))
X_cv_quantity_norm = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quantity_norm = normalizer.transform(X_test['quantity'].values.
 ↪reshape(-1,1))

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
quantity_fn = ['quantity']
print(quantity_fn)
```

```
After vectorizations
(69918, 1) (69918,)
(17480, 1) (17480,)
(21850, 1) (21850,)
['quantity']
```

2.3 Make Data Model Ready: encoding eassay, and project_title

[46]:
```
X_train.head(2)
```

[46]:

	Unnamed: 0	id	teacher_id	school_state	\
6411	125264	p013348	a8b17d20114df09ad0d20dd6c8dbed37	MO	
17902	70877	p119033	d0ba613d183f96a22a0ee277fa103487	TX	

	Date	teacher_number_of_previously_posted_projects	\
6411	2016-05-31 13:39:47	16	
17902	2016-07-25 22:18:02	0	

	clean_categories	clean_subcategories	\
6411	Literacy_Language Math_Science	Literature_Writing Mathematics	
17902	Literacy_Language	Literacy Literature_Writing	

	preprocessed_essays	preprocessed_titles	\
6411	awesome students lot students not stable homes...	desks success	
17902	live wonderful community involved much school ...	ipads pad	

```
      preprocessed_pgc preprocessed_tp   price  quantity
6411     grades_prek_2              ms   62.09         8
17902       grades_3_5             mrs  782.23        10
```

Bag of words for essays

[47]:
```
# We are considering only the words which appeared in at least 10␣
 ↪documents(rows or projects)
vectorizer = CountVectorizer(min_df=10, max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values) # fit has to happen only␣
 ↪on train data

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

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
essays_bog_fn = vectorizer.get_feature_names()
print(len(essays_bog_fn))
```

```
After vectorizations
(69918, 5000) (69918,)
(17480, 5000) (17480,)
(21850, 5000) (21850,)
5000
```

Bag of words for titles

[48]:
```
# We are considering only the words which appeared in at least 10␣
 ↪documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(X_train['preprocessed_titles'].values) # fit has to happen only␣
 ↪on train data

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

print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
```

```
title_bog_fn = vectorizer.get_feature_names()
print(len(title_bog_fn))
```

```
After vectorizations
(69918, 2440) (69918,)
(17480, 2440) (17480,)
(21850, 2440) (21850,)
2440
```

TFIDF vectorizer for essays

[49]:
```
# tfidf vectorizer on project essays
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,  max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer.transform(X_train['preprocessed_essays'].
 ↪values)
X_cv_essay_tfidf = vectorizer.transform(X_cv['preprocessed_essays'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['preprocessed_essays'].values)

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
essays_tfidf_fn = vectorizer.get_feature_names()
print(len(essays_tfidf_fn))
```

```
After vectorizations
(69918, 5000) (69918,)
(17480, 5000) (17480,)
(21850, 5000) (21850,)
5000
```

TFIDF vectorizer for titles

[50]:
```
# tfidf vectorizer on project titles
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['preprocessed_titles'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['preprocessed_titles'].
 ↪values)
X_cv_title_tfidf = vectorizer.transform(X_cv['preprocessed_titles'].values)
X_test_title_tfidf = vectorizer.transform(X_test['preprocessed_titles'].values)
```

```
print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_test_title_tfidf.shape, y_test.shape)
title_tfidf_fn = vectorizer.get_feature_names()
print(len(title_tfidf_fn))
```

```
After vectorizations
(69918, 2440) (69918,)
(17480, 2440) (17480,)
(21850, 2440) (21850,)
2440
```

Using Pretrained Models: Avg W2V for essays

[51]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/
 ↪how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

[52]:
```
def convert_avg_w2v(temp_list_essay):
    # average Word2Vec for preprocessed essays
    # compute average word2vec for each review.
    text_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this␣
 ↪list
    for sentence in tqdm(temp_list_essay): # for each review/sentence
        vector = np.zeros(300) # as word vectors are of zero length
        cnt_words = 0; # num of words with a valid vector in the sentence/
 ↪review
        for word in sentence.split(): # for each word in a review/sentence
            if word in glove_words:
                vector += model[word]
                cnt_words += 1
        if cnt_words != 0:
            vector /= cnt_words
        text_avg_w2v.append(vector)
    return text_avg_w2v
```

[53]:
```
X_train_essay_avgw2v = convert_avg_w2v(X_train['preprocessed_essays'].values)
X_cv_essay_avgw2v = convert_avg_w2v(X_cv['preprocessed_essays'].values)
X_test_essay_avgw2v = convert_avg_w2v(X_test['preprocessed_essays'].values)

print("After vectorizations")
print(len(X_train_essay_avgw2v), y_train.shape)
print(len(X_cv_essay_avgw2v), y_cv.shape)
```

```
print(len(X_test_essay_avgw2v), y_test.shape)
```

```
100%|| 69918/69918 [00:25<00:00, 2725.35it/s]
100%|| 17480/17480 [00:07<00:00, 2279.11it/s]

After vectorizations
69918 (69918,)
17480 (17480,)
21850 (21850,)
```

Using Pretrained Models: Avg W2V for titles

[54]:
```
# average Word2Vec for preprocessed titles
X_train_title_avgw2v = convert_avg_w2v(X_train['preprocessed_titles'].values)
X_cv_title_avgw2v = convert_avg_w2v(X_cv['preprocessed_titles'].values)
X_test_title_avgw2v = convert_avg_w2v(X_test['preprocessed_titles'].values)

print("After vectorizations")
print(len(X_train_title_avgw2v), y_train.shape)
print(len(X_cv_title_avgw2v), y_cv.shape)
print(len(X_test_title_avgw2v), y_test.shape)
print(len(X_train_title_avgw2v[0]))
print(len(X_cv_title_avgw2v[0]))
print(len(X_test_title_avgw2v[0]))
```

```
100%|| 69918/69918 [00:01<00:00, 51389.55it/s]
100%|| 17480/17480 [00:00<00:00, 51497.65it/s]

After vectorizations
69918 (69918,)
17480 (17480,)
21850 (21850,)
300
300
300
```

Using Pretrained Models: TFIDF weighted W2V for essays

[55]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_essays'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

[56]:
```
def convert_tfidf_w_w2v(temp_list_essay):
    # tfidf weighted Word2Vec
    # compute tfidf weighted word2vec for each review.
    text_tfidf_w_w2v = []; # the tfid weighted w2v for each sentence/review is␣
 ↪stored in this list
    for sentence in tqdm(temp_list_essay): # for each review/sentence
        vector = np.zeros(300) # as word vectors are of zero length
        tf_idf_weight =0; # num of words with a valid vector in the sentence/
 ↪review
        for word in sentence.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in tfidf_words):
                vec = model[word] # getting the vector for each word
                # here we are multiplying idf value(dictionary[word]) and the␣
 ↪tf value((sentence.count(word)/len(sentence.split())))
                tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.
 ↪split())) # getting the tfidf value for each word
                vector += (vec * tf_idf) # calculating tfidf weighted w2v
                tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        text_tfidf_w_w2v.append(vector)
    return text_tfidf_w_w2v
```

[57]:
```
X_train_essay_tww2v = convert_tfidf_w_w2v(X_train['preprocessed_essays'].values)
X_cv_essay_tww2v = convert_tfidf_w_w2v(X_cv['preprocessed_essays'].values)
X_test_essay_tww2v = convert_tfidf_w_w2v(X_test['preprocessed_essays'].values)

print("After vectorizations")
print(len(X_train_essay_tww2v), y_train.shape)
print(len(X_cv_essay_tww2v), y_cv.shape)
print(len(X_test_essay_tww2v), y_test.shape)
```

```
100%|| 69918/69918 [02:39<00:00, 439.53it/s]
100%|| 17480/17480 [00:39<00:00, 444.62it/s]

After vectorizations
69918 (69918,)
17480 (17480,)
21850 (21850,)
```

Using Pretrained Models: TFIDF weighted W2V for titles

[58]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_titles'].values)
# we are converting a dictionary with word as a key, and the idf as a value
```

```
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

[59]:
```
X_train_titles_tww2v = convert_tfidf_w_w2v(X_train['preprocessed_titles'].
 ↪values)
X_cv_titles_tww2v = convert_tfidf_w_w2v(X_cv['preprocessed_titles'].values)
X_test_titles_tww2v = convert_tfidf_w_w2v(X_test['preprocessed_titles'].values)

print("After vectorizations")
print(len(X_train_titles_tww2v), y_train.shape)
print(len(X_cv_titles_tww2v), y_cv.shape)
print(len(X_test_titles_tww2v), y_test.shape)
```

```
100%|| 69918/69918 [00:02<00:00, 24560.14it/s]
100%|| 17480/17480 [00:00<00:00, 24519.37it/s]

After vectorizations
69918 (69918,)
17480 (17480,)
21850 (21850,)
```

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

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

2.8.1 2.4.1 Applying Decision Trees on BOW, SET 1

[129]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow, X_train_title_bow, X_train_state_ohe,␣
 ↪X_train_categories_ohe, X_train_subcategories_ohe,␣
 ↪X_train_teacher_prefix_ohe, X_train_pgc_ohe, X_train_price_norm,␣
 ↪X_train_tnppp_norm)).tocsr()
X_cr = hstack((X_cv_essay_bow, X_cv_title_bow, X_cv_state_ohe,␣
 ↪X_cv_categories_ohe, X_cv_subcategories_ohe, X_cv_teacher_prefix_ohe,␣
 ↪X_cv_pgc_ohe, X_cv_price_norm, X_cv_tnppp_norm)).tocsr()
X_te = hstack((X_test_essay_bow, X_test_title_bow, X_test_state_ohe,␣
 ↪X_test_categories_ohe, X_test_subcategories_ohe, X_test_teacher_prefix_ohe,␣
 ↪X_test_pgc_ohe, X_test_price_norm, X_test_tnppp_norm)).tocsr()

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

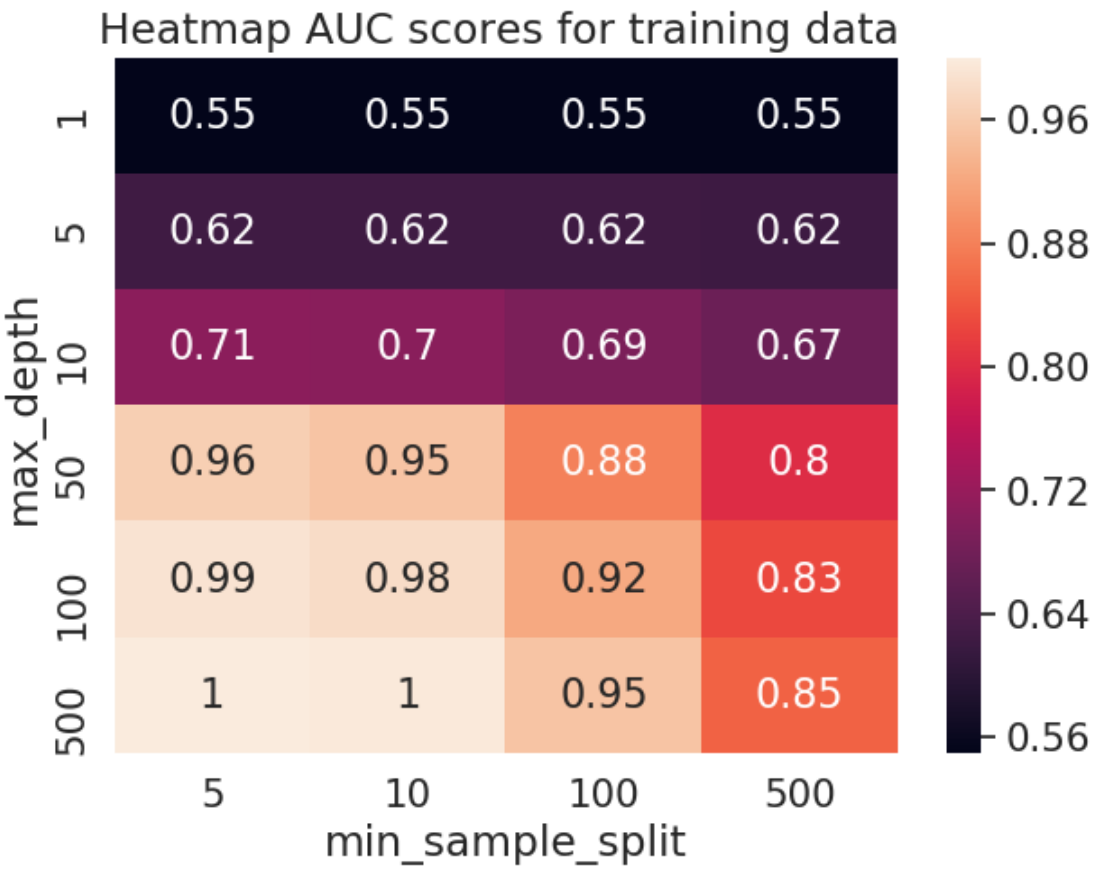
```
Final Data matrix
(69918, 7541) (69918,)
(17480, 7541) (17480,)
(21850, 7541) (21850,)
================================================================================
====================
```

[130]:
```
# importing required libraries
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
import numpy as np

# our hyperparameters to choose from
depth = [1, 5, 10, 50, 100, 500]
min_samples_split = [5, 10, 100, 500]
param_grid = dict(max_depth = depth, min_samples_split = min_samples_split)

clf_ = DecisionTreeClassifier(class_weight = 'balanced')

clf = GridSearchCV(clf_, param_grid, scoring = 'roc_auc', cv=3)

sc = clf.fit(X_tr, y_train)

# getting all the results
scores = clf.cv_results_
# getting train scores and cross validation scores
train_score = scores['mean_train_score']
cv_score = scores['mean_test_score']

# Reshape matrix for printing out in heatmap
train_score_reshaped = train_score.reshape(len(depth), len(min_samples_split))
cv_score_reshaped = cv_score.reshape(len(depth), len(min_samples_split))
```

[131]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(train_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7, 5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
```

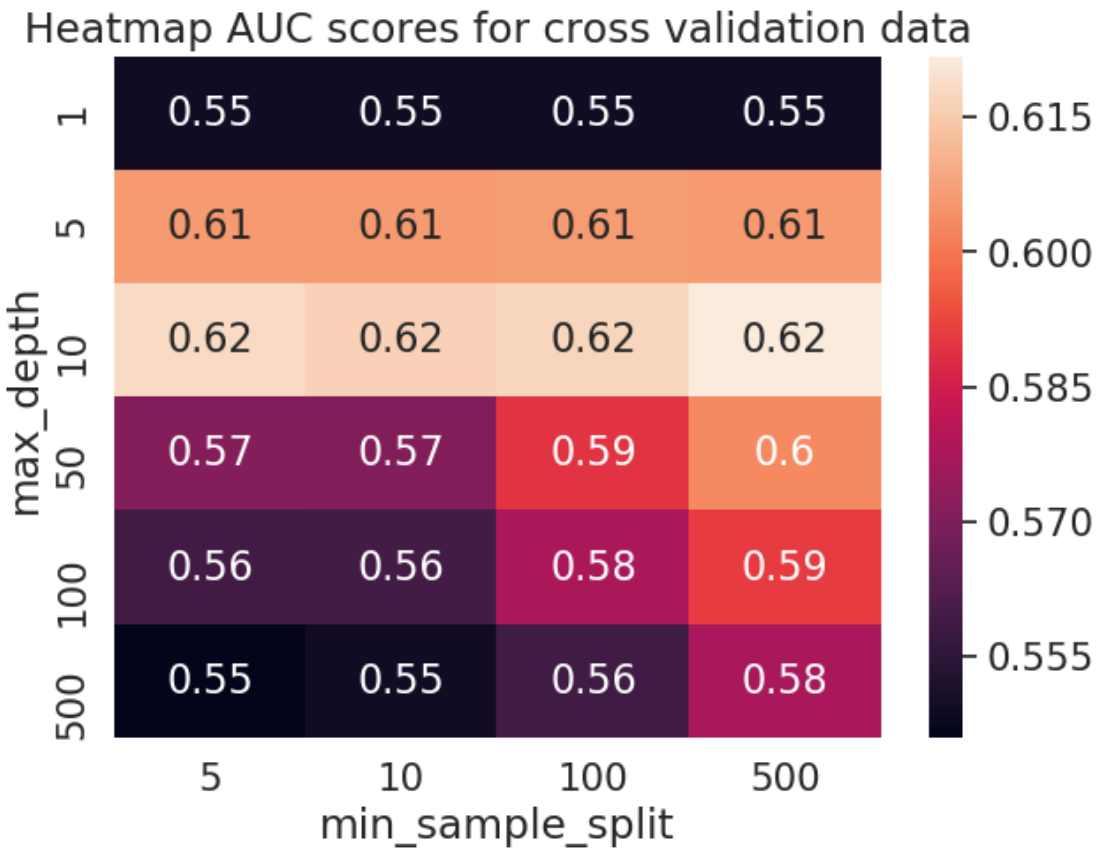
```
plt.title("Heatmap AUC scores for training data ")
```

[131]:
```
Text(0.5, 1, 'Heatmap AUC scores for training data ')
```



[132]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(cv_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7,5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for cross validation data")
```

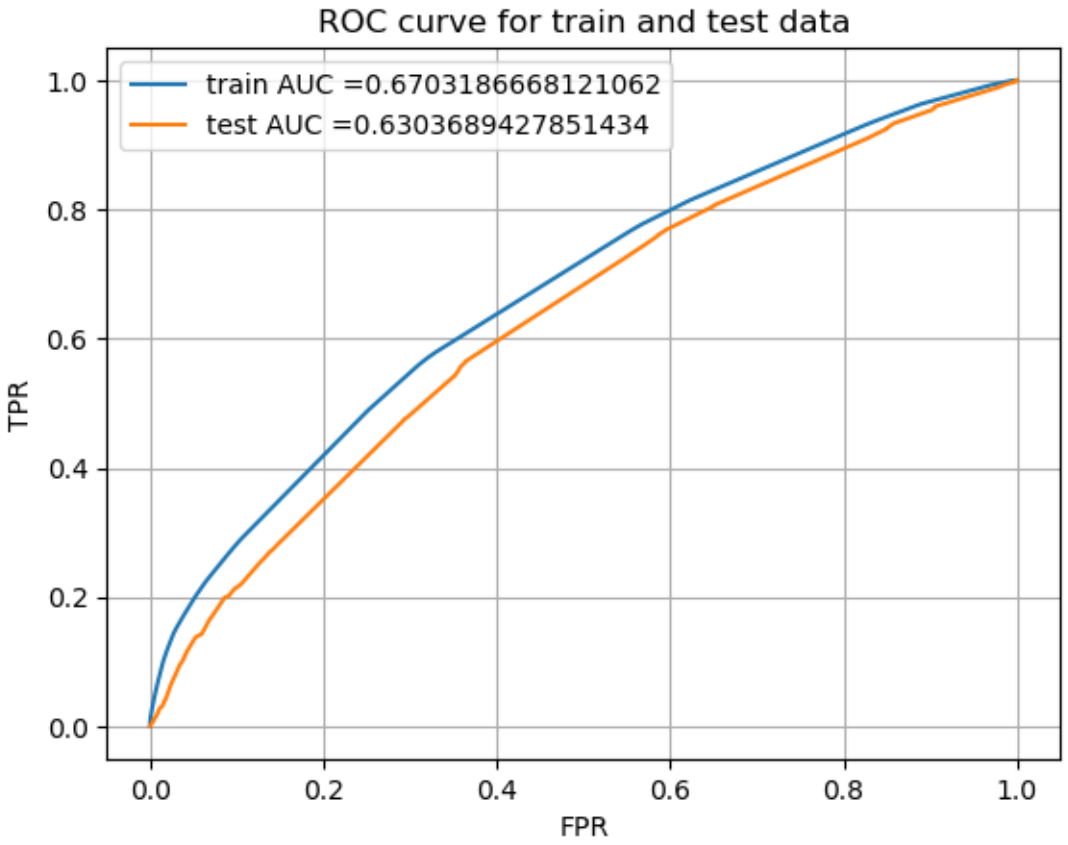
[132]:
```
Text(0.5, 1, 'Heatmap AUC scores for cross validation data')
```



we find best max_depth = 10 with min_sample_split = 500.

[107]:
```
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
from sklearn.metrics import roc_auc_score

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)

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


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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr,␣
 ↪train_tpr)))
```

```
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC curve for train and test data")
plt.grid()
plt.show()
```



Here train AUC is higher than the test auc that means this model is overfitting on the train data.

Drawing confusion matrix

[108]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
# this function returns actual prediction in form of 0 and 1 by accepting the␣
 ↪probability score on the data
def predict(proba, threshould, fpr, tpr):

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

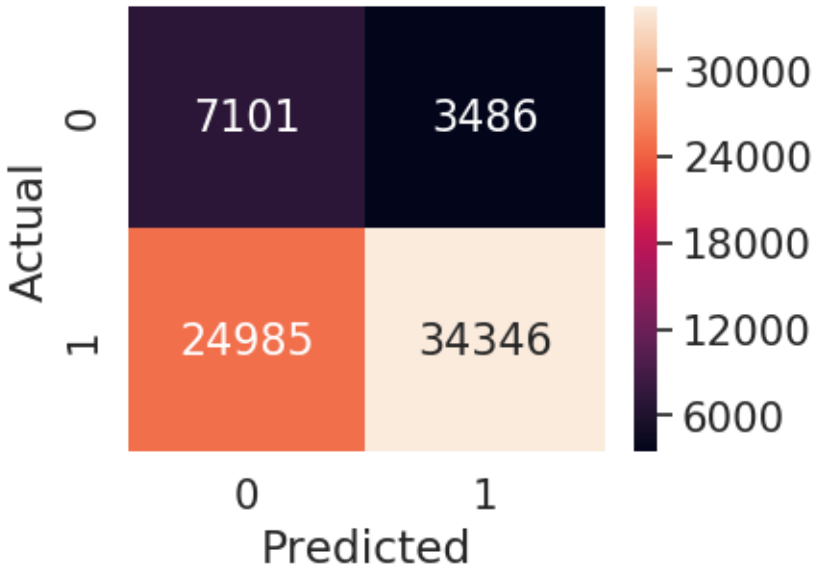
```
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very␣
 ↪high

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

[109]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
cmtr = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,␣
 ↪train_fpr, train_tpr))
print("Test confusion matrix")
cmte = confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr,␣
 ↪test_tpr))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.3882764917237512 for threshold 0.48
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3593175896494079 for threshold 0.48
```

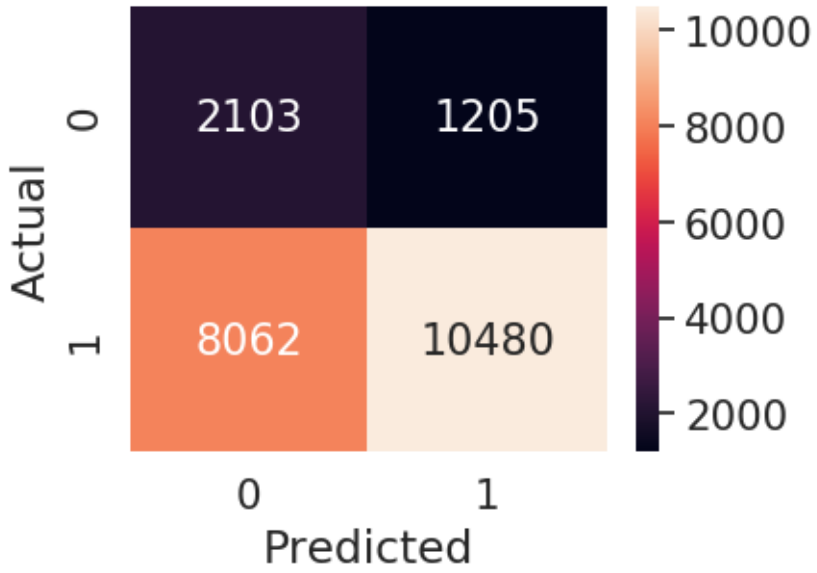
[110]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
array = cmtr
df_cm = pd.DataFrame(array, range(2), range(2))
plt.figure(figsize = (4,3))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
sn.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
```

[110]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f2029f1dfd0>
```



[111]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

array = cmte
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (4,3))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
sn.set(font_scale=1.4) #for label size
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[111]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f202dd820b8>
```



[112]:
```
# Store all feature names in a list all_features_bag in the same order in which␣
 ↪they appear in hstack function
all_features_bag = []

all_features_bag.extend(essays_bog_fn)
all_features_bag.extend(title_bog_fn)

all_features_bag.extend(school_state_fn)
all_features_bag.extend(categories_fn)
all_features_bag.extend(subcategories_fn)
all_features_bag.extend(teacher_prefix_fn)
all_features_bag.extend(pgc_fn)

all_features_bag.extend(price_fn)
all_features_bag.extend(tnppp_fn)
print(len(all_features_bag))
```

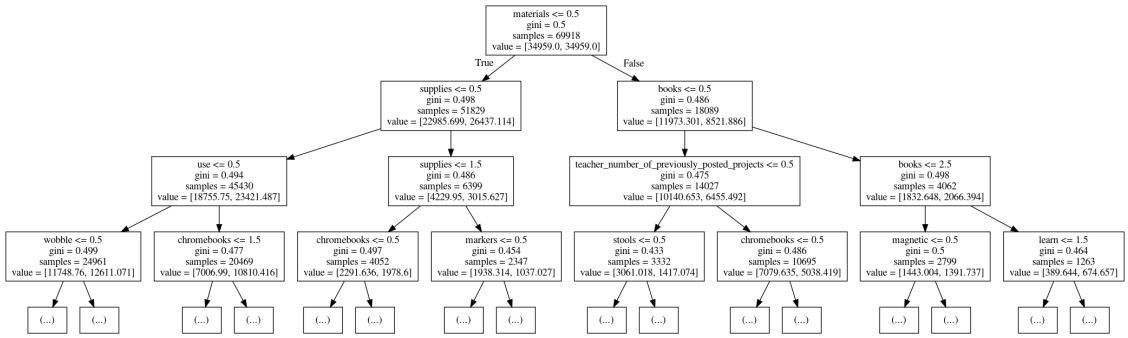
```
7541
```

2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

[115]:
```
#source https://chrisalbon.com/machine_learning/trees_and_forests/
 ↪visualize_a_decision_tree/
# importing required libraries
from IPython.display import Image
from sklearn import tree
import pydotplus
```

```
# Create DOT data
dot_data = tree.export_graphviz(clf, out_file=None, max_depth = 3,feature_names␣
 ↪= all_features_bag)

# Draw graph
graph = pydotplus.graph_from_dot_data(dot_data)

# Show graph
Image(graph.create_png())
```

[115]:



2.8.2 Selection and operations on false possitive data points

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

Plot the WordCloud <a href='https://www.geeksforgeeks.org/generating-word-cloud-python/' with the words of eassy text of these `false positive data points`>WordCloud

Plot the box plot with the `price` of these `false positive data points`

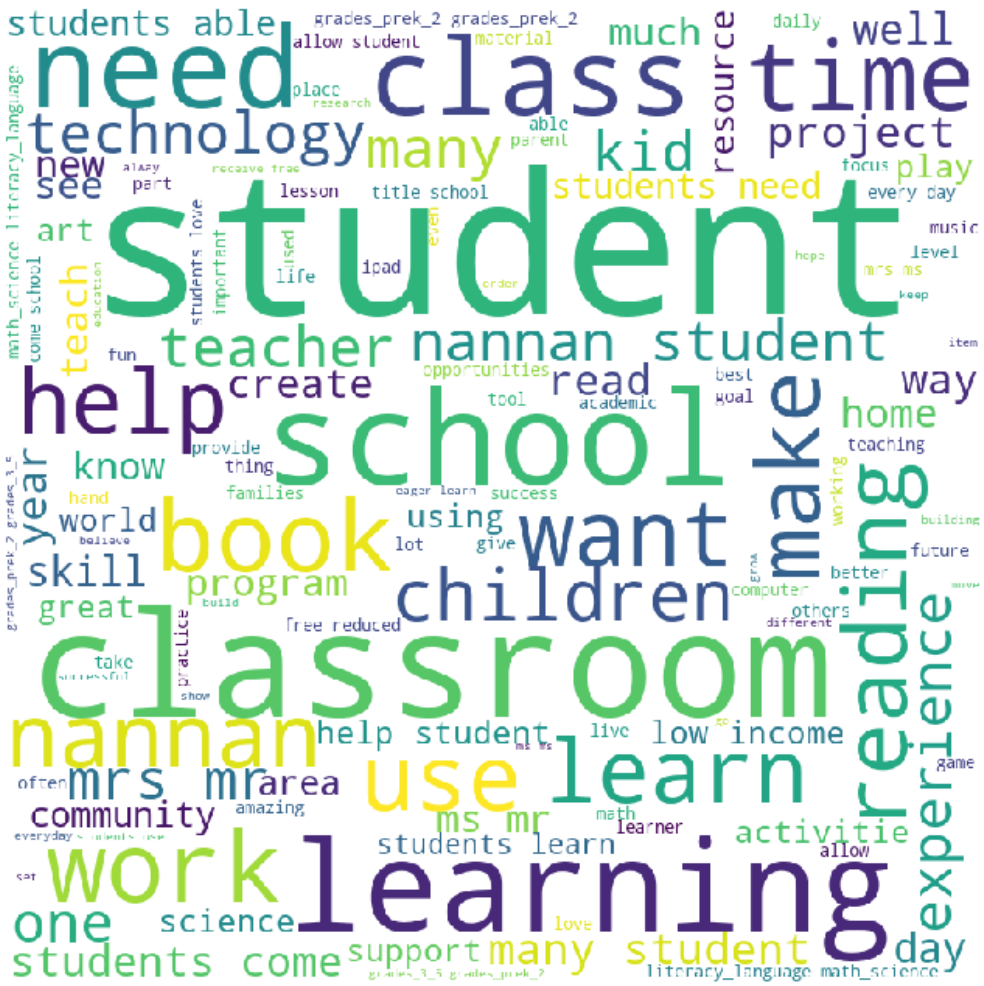
Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

[180]:
```
# Getting all indexes of false possitive data points for test data
index_of_false_positive_data_points_test = []
y_test_pred_class = predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)
for i in range(y_test.shape[0]):
    if y_test[i] == 0 and y_test_pred_class[i] == 1:
        index_of_false_positive_data_points_test.append(i)
    else:
        pass

print(len(index_of_false_positive_data_points_test))

# Selecting all the rows or data points from test data which gives false␣
 ↪possitive result.
X_test_false_positive = X_test.iloc[index_of_false_positive_data_points_test]
```

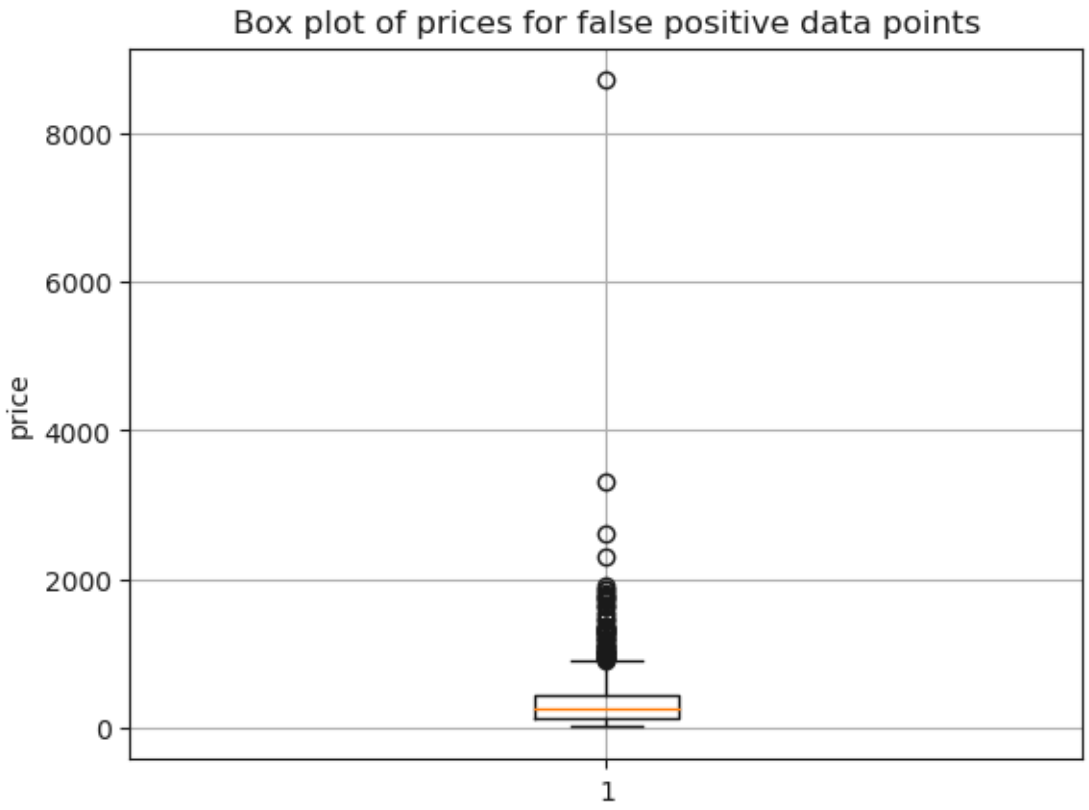
```
the maximum value of tpr*(1-fpr) 0.35379321849399187 for threshold 0.474
1901
```

[181]:
```
# ploting the wordcloud for all false positive data points for test data
# source https://www.geeksforgeeks.org/generating-word-cloud-python/

# importing all necessery modules
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd

column_select =␣
 ↪['school_state','clean_categories','clean_subcategories','preprocessed_essays',
                'preprocessed_titles','preprocessed_pgc','preprocessed_tp']

all_words_false_positive = ' '
stopwords = set(STOPWORDS)

# iterate through all the data
for col_name in column_select:
    for val in X_test_false_positive[col_name].values:

        # type cast each value to string
        val = str(val)

        #split the value
        tokens = val.split()

        #convert each tokens into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            all_words_false_positive = all_words_false_positive + words + ' '


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


# plot the WordCloud image
plt.figure(figsize = (7, 7), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
```

```
plt.show()
```

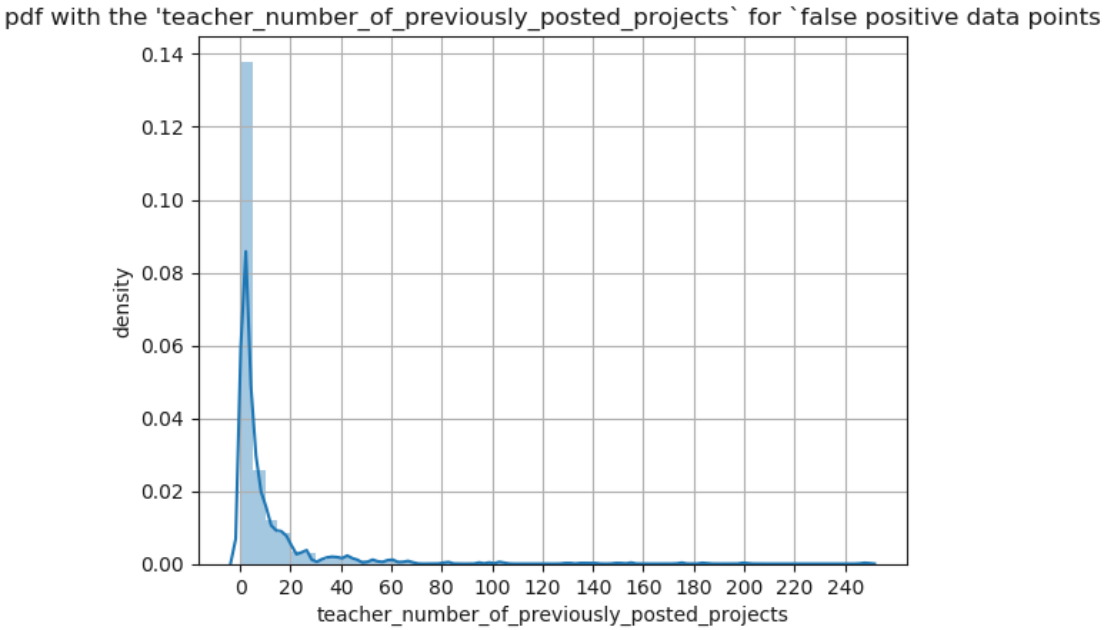


[182]:
```
# Plotting the box plot with the `price` of these `false positive data points`
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
plt.boxplot(X_test_false_possitive['price'].values)
plt.title("Box plot of prices for false positive data points")
plt.ylabel("price")
plt.grid()
plt.show()
```



Observations:
The range of prices for maximum projects is 0 to 1000
75% prices of this class belongs to less than 500
There are some project prices which are greater than 1000

[183]:
```
# Density Plot and Histogram of all arrival delays
import seaborn as sns
sns.
 ↪distplot(X_test_false_possitive['teacher_number_of_previously_posted_projects'].
 ↪values, hist = True)
plt.title("pdf with the 'teacher_number_of_previously_posted_projects` for␣
 ↪`false positive data points")
plt.xlabel("teacher_number_of_previously_posted_projects")
plt.ylabel("density")
plt.grid()
plt.xticks(np.arange(0, 250, step=20))
plt.show()
```



Observation: 1 - 5 projects are previously posted by maximum number of teachers 2 - For most projects in this class number_of_previously_posted_projects are between 0 to 20.

2.8.3 2.4.2 Applying DT on TFIDF , SET 2

[133]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tfidf, X_train_title_tfidf, X_train_state_ohe,␣
 ↪X_train_categories_ohe, X_train_subcategories_ohe,␣
 ↪X_train_teacher_prefix_ohe, X_train_pgc_ohe, X_train_price_norm,␣
 ↪X_train_tnppp_norm)).tocsr()
X_cr = hstack((X_cv_essay_tfidf, X_cv_title_tfidf, X_cv_state_ohe,␣
 ↪X_cv_categories_ohe, X_cv_subcategories_ohe, X_cv_teacher_prefix_ohe,␣
 ↪X_cv_pgc_ohe, X_cv_price_norm, X_cv_tnppp_norm)).tocsr()
X_te = hstack((X_test_essay_tfidf, X_test_title_tfidf, X_test_state_ohe,␣
 ↪X_test_categories_ohe, X_test_subcategories_ohe, X_test_teacher_prefix_ohe,␣
 ↪X_test_pgc_ohe, X_test_price_norm, X_test_tnppp_norm)).tocsr()

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

```
Final Data matrix
(69918, 7541) (69918,)
```

```
(17480, 7541) (17480,)
(21850, 7541) (21850,)
================================================================================
====================
```

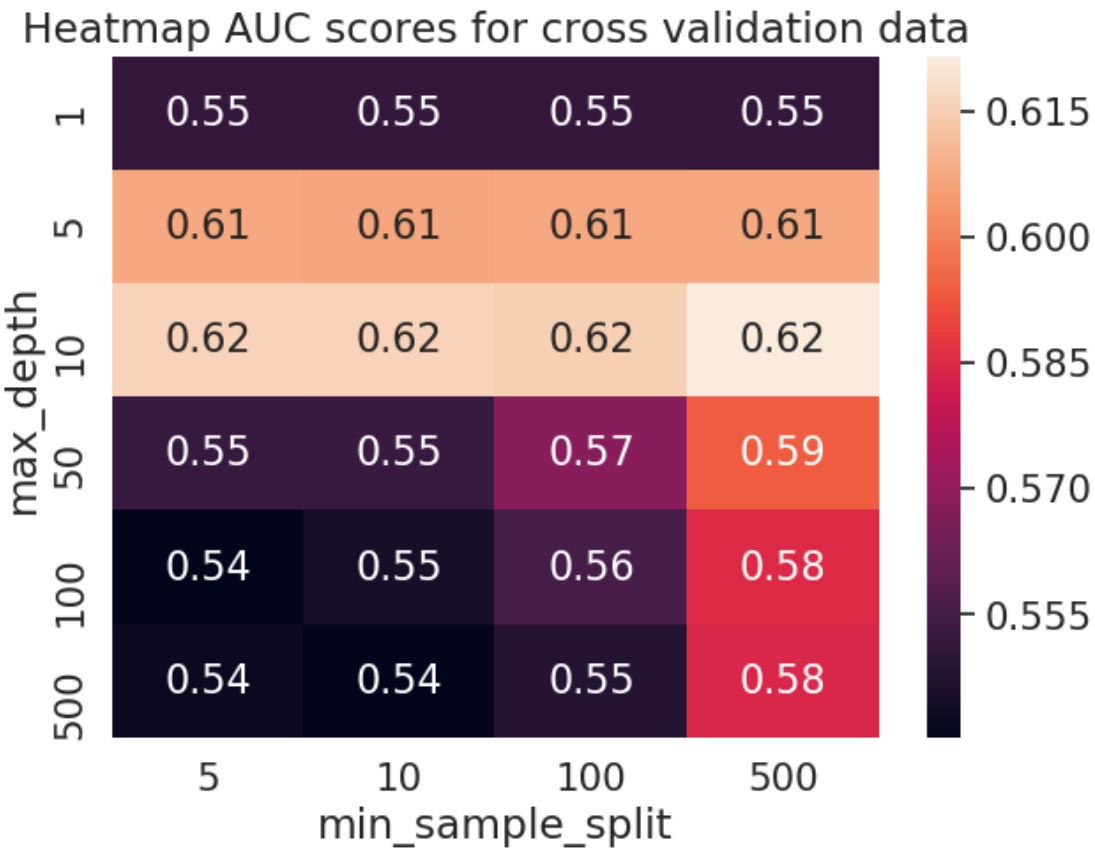
[134]:
```
# importing required libraries
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
import numpy as np

# our hyperparameters to choose from
depth = [1, 5, 10, 50, 100, 500]
min_samples_split = [5, 10, 100, 500]
param_grid = dict(max_depth = depth, min_samples_split = min_samples_split)

clf_ = DecisionTreeClassifier(class_weight = 'balanced')

clf = GridSearchCV(clf_, param_grid, scoring = 'roc_auc', cv=3, n_jobs = -1)

sc = clf.fit(X_tr, y_train)

# getting all the results
scores = clf.cv_results_
# getting train scores and cross validation scores
train_score = scores['mean_train_score']
cv_score = scores['mean_test_score']

# Reshape matrix for printing out in heatmap
train_score_reshaped = train_score.reshape(len(depth), len(min_samples_split))
cv_score_reshaped = cv_score.reshape(len(depth), len(min_samples_split))
```

[135]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(train_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7, 5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for training data ")
```

[135]: Text(0.5, 1, 'Heatmap AUC scores for training data ')

[136]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(cv_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7,5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for cross validation data")
```

[136]: Text(0.5, 1, 'Heatmap AUC scores for cross validation data')

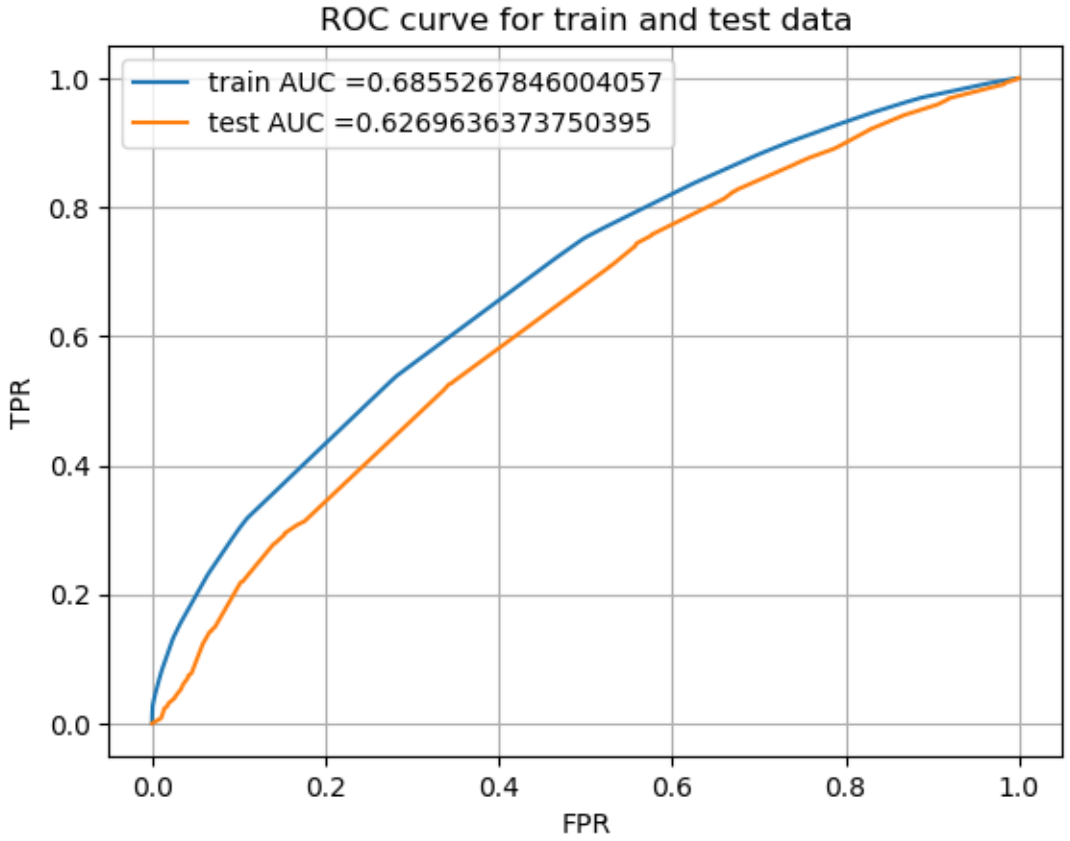


Hyperparameter tuning using gridsearchcv

we find best max_depth = 10 with min_sample_split = 500.

[121]:
```
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
from sklearn.metrics import roc_auc_score

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)

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


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

```
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr,␣
 ↪train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC curve for train and test data")
plt.grid()
plt.show()
```



Drawing confusion matrix

[122]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
# this function returns actual prediction in form of 0 and 1 by accepting the␣
 ↪probability score on the data
def predict(proba, threshould, fpr, tpr):

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

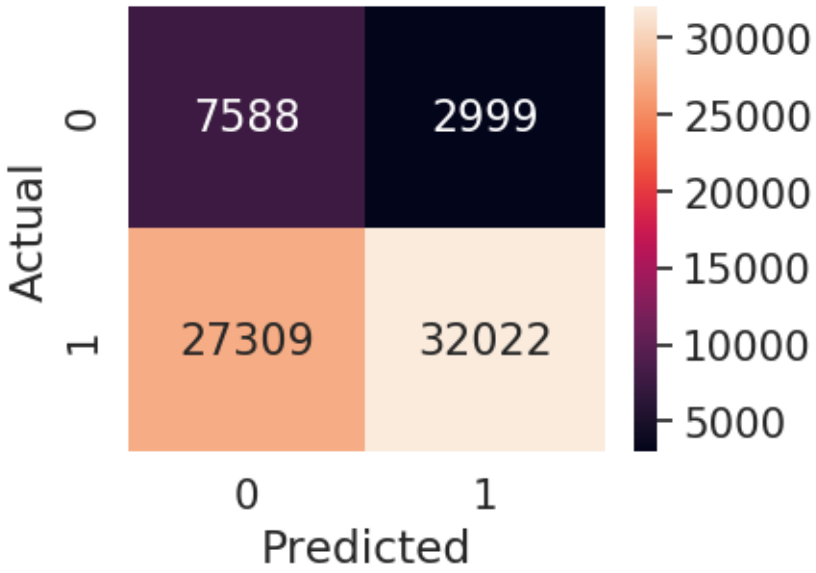
```
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very␣
 ↪high

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

[123]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
cmtr = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,␣
 ↪train_fpr, train_tpr))
print("Test confusion matrix")
cmte = confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr,␣
 ↪test_tpr))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.38683093196422624 for threshold 0.511
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3455734404470415 for threshold 0.552
```

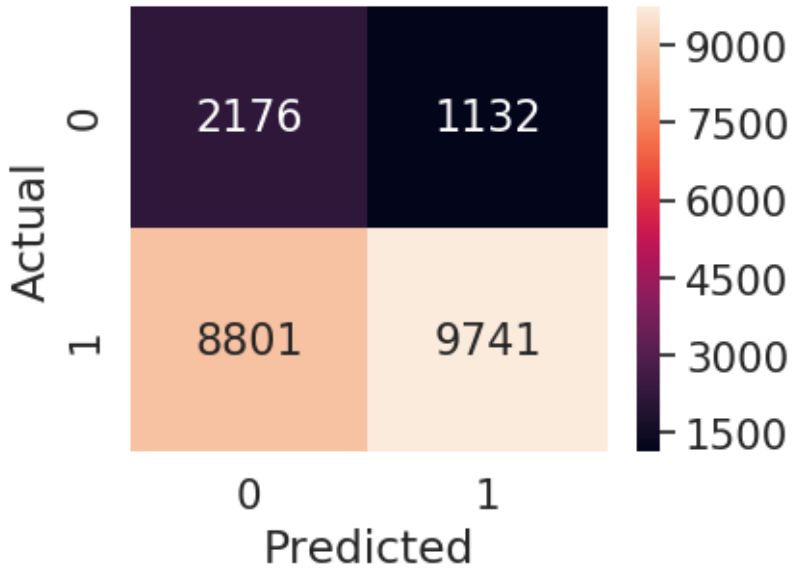
[124]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

array = cmtr
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (4,3))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
sn.set(font_scale=1.4) #for label size
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[124]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f201aa05fd0>
```



[125]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

array = cmte
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (4,3))
df_cm.index.name = 'Actual'
df_cm.columns.name = 'Predicted'
sn.set(font_scale=1.4) #for label size
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[125]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f201a8fdc88>
```



[126]:
```
# Store all feature names in a list all_features_bag in the same order in which␣
 ↪they appear in hstack function
all_features_bag = []

all_features_bag.extend(essays_tfidf_fn)
all_features_bag.extend(title_tfidf_fn)

all_features_bag.extend(school_state_fn)
all_features_bag.extend(categories_fn)
all_features_bag.extend(subcategories_fn)
all_features_bag.extend(teacher_prefix_fn)
all_features_bag.extend(pgc_fn)

all_features_bag.extend(price_fn)
all_features_bag.extend(tnppp_fn)
print(len(all_features_bag))
```

```
7541
```

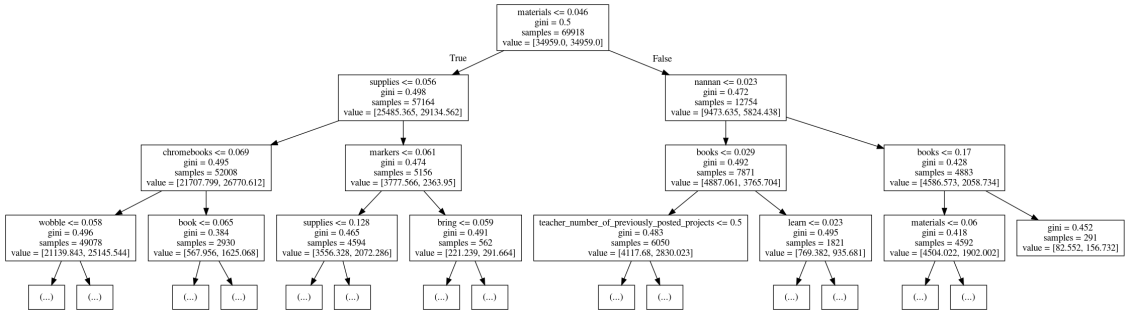
This model with TFIDF correctly classifies 61% of the data points which are belongs to class 0. But only 53% of the data points which belongs to class 1 are correctly classified.

2.4.2.1 Graphviz visualization of Decision Tree on TF-IDF, SET 2

[128]:
```
#source https://chrisalbon.com/machine_learning/trees_and_forests/
 ↪visualize_a_decision_tree/
# importing required libraries
from IPython.display import Image
from sklearn import tree
```

```
import pydotplus

# Create DOT data
dot_data = tree.export_graphviz(clf, out_file=None, max_depth = 3,feature_names␣
 ↪= all_features_bag)

# Draw graph
graph = pydotplus.graph_from_dot_data(dot_data)

# Show graph
Image(graph.create_png())
```

[128]:



2.8.4 Selection and operations on false possitive data points

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

Plot the WordCloud <a href='https://www.geeksforgeeks.org/generating-word-cloud-python/' with the words of eassy text of these `false positive data points`>WordCloud

Plot the box plot with the `price` of these `false positive data points`

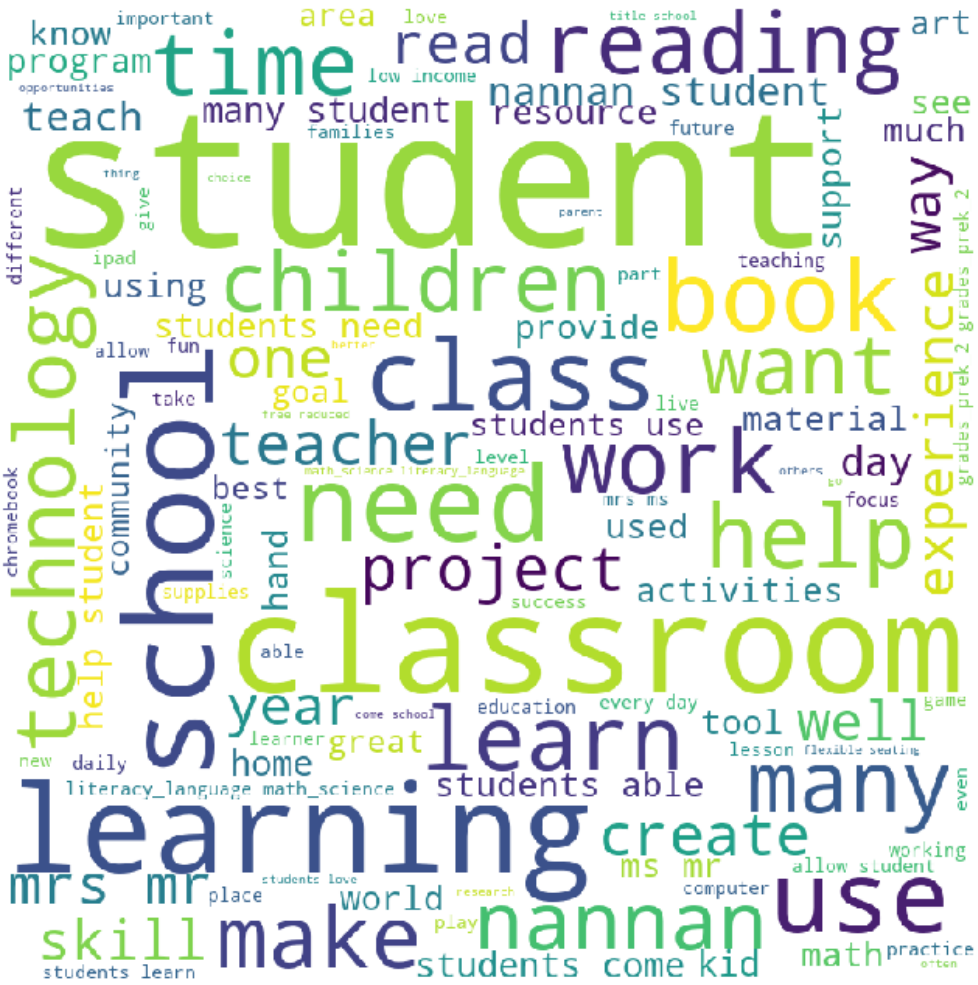
Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

[196]:
```
# Getting all indexes of false possitive data points for test data
index_of_false_positive_data_points_test = []
y_test_pred_class = predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)
for i in range(y_test.shape[0]):
    if y_test[i] == 0 and y_test_pred_class[i] == 1:
        index_of_false_positive_data_points_test.append(i)
    else:
        pass

print(len(index_of_false_positive_data_points_test))

# Selecting all the rows or data points from test data which gives false␣
 ↪possitive result.
X_test_false_positive = X_test.iloc[index_of_false_positive_data_points_test]
```

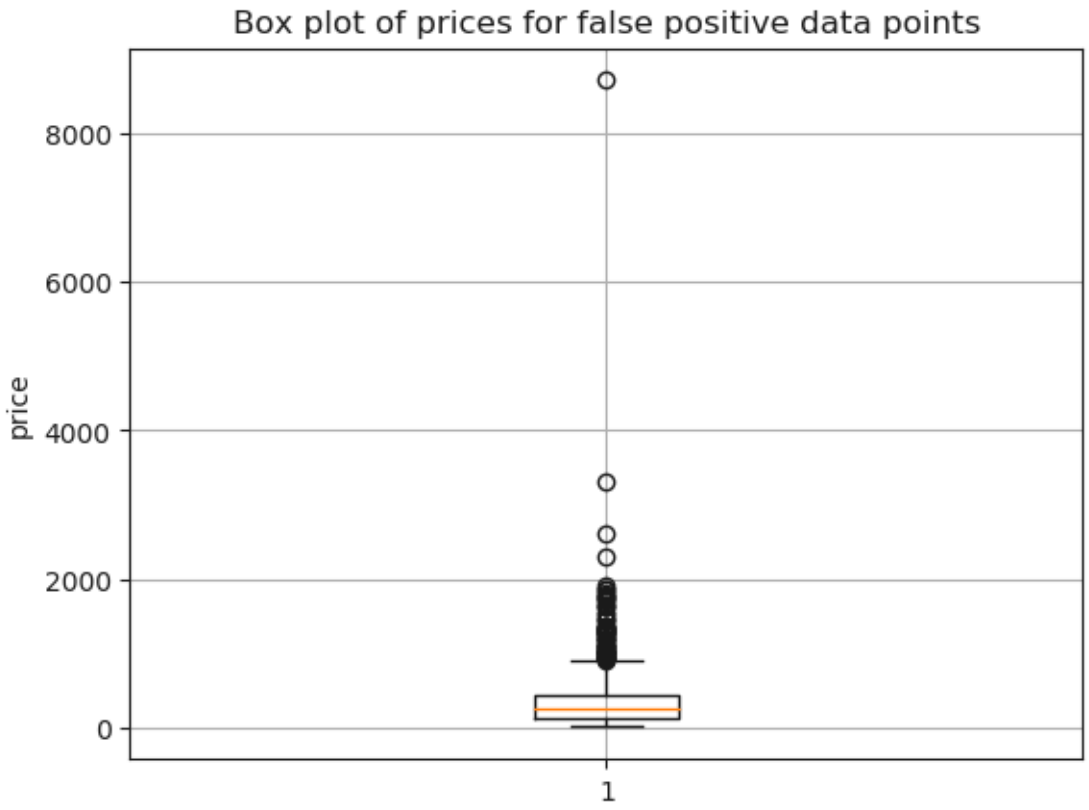
```
the maximum value of tpr*(1-fpr) 0.34029740253083396 for threshold 0.514
1228
```

[197]:
```
# ploting the wordcloud for all false positive data points for test data
# source https://www.geeksforgeeks.org/generating-word-cloud-python/

# importing all necessery modules
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd

column_select =␣
 ↪['school_state','clean_categories','clean_subcategories','preprocessed_essays',
                'preprocessed_titles','preprocessed_pgc','preprocessed_tp']

all_words_false_positive = ' '
stopwords = set(STOPWORDS)

# iterate through all the data
for col_name in column_select:
    for val in X_test_false_positive[col_name].values:

        # type cast each value to string
        val = str(val)

        #split the value
        tokens = val.split()

        #convert each tokens into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            all_words_false_positive = all_words_false_positive + words + ' '


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


# plot the WordCloud image
plt.figure(figsize = (7, 7), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
```

```
plt.show()
```

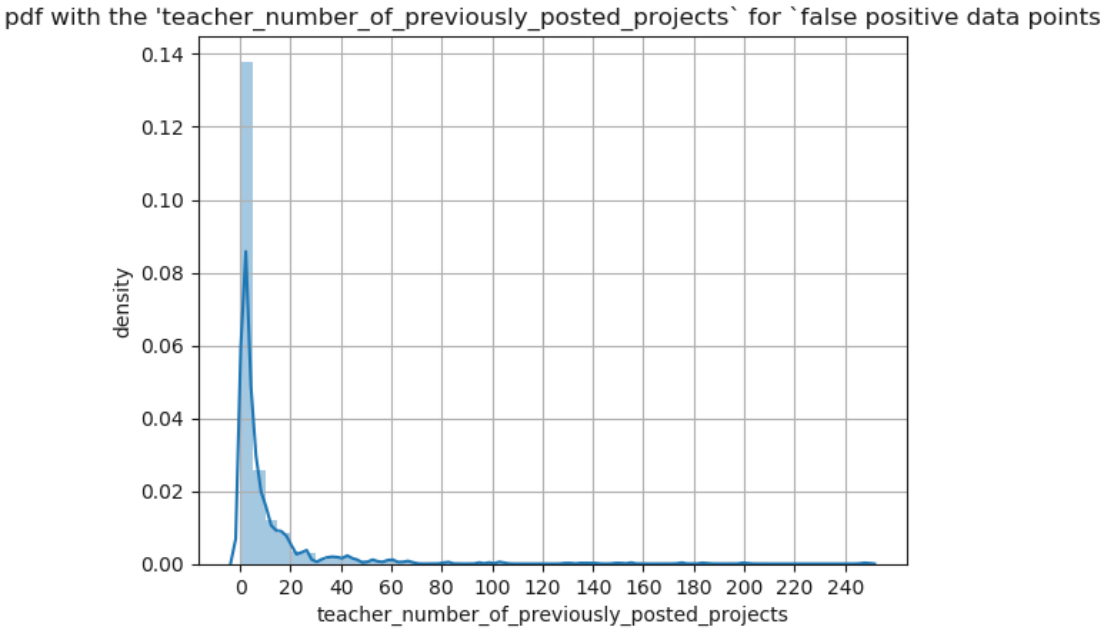


[198]:
```
# Plotting the box plot with the `price` of these `false positive data points`
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
plt.boxplot(X_test_false_possitive['price'].values)
plt.title("Box plot of prices for false positive data points")
plt.ylabel("price")
plt.grid()
plt.show()
```



Observations:
The range of prices for maximum projects is 0 to 1000
75% prices of this class belongs to less than 500
There are some project prices which are greater than 1000

[199]:
```
# Density Plot and Histogram of all arrival delays
import seaborn as sns
sns.
 ↪distplot(X_test_false_possitive['teacher_number_of_previously_posted_projects'].
 ↪values, hist = True)
plt.title("pdf with the 'teacher_number_of_previously_posted_projects` for␣
 ↪`false positive data points")
plt.xlabel("teacher_number_of_previously_posted_projects")
plt.ylabel("density")
plt.grid()
plt.xticks(np.arange(0, 250, step=20))
plt.show()
```



Observation: 1 - 5 projects are previously posted by maximum number of teachers 2 - For most projects in this class number_of_previously_posted_projects are between 0 to 20.

2.8.5 2.4.3 Applying DT on AVG W2V, SET 3

[137]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_avgw2v, X_train_title_avgw2v, X_train_state_ohe,␣
 ↪X_train_categories_ohe, X_train_subcategories_ohe,␣
 ↪X_train_teacher_prefix_ohe, X_train_pgc_ohe, X_train_price_norm,␣
 ↪X_train_tnppp_norm)).tocsr()
X_cr = hstack((X_cv_essay_avgw2v, X_cv_title_avgw2v, X_cv_state_ohe,␣
 ↪X_cv_categories_ohe, X_cv_subcategories_ohe, X_cv_teacher_prefix_ohe,␣
 ↪X_cv_pgc_ohe, X_cv_price_norm, X_cv_tnppp_norm)).tocsr()
X_te = hstack((X_test_essay_avgw2v, X_test_title_avgw2v, X_test_state_ohe,␣
 ↪X_test_categories_ohe, X_test_subcategories_ohe, X_test_teacher_prefix_ohe,␣
 ↪X_test_pgc_ohe, X_test_price_norm, X_test_tnppp_norm)).tocsr()

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

```
Final Data matrix
(69918, 701) (69918,)
```

```
(17480, 701) (17480,)
(21850, 701) (21850,)
================================================================================
====================
```

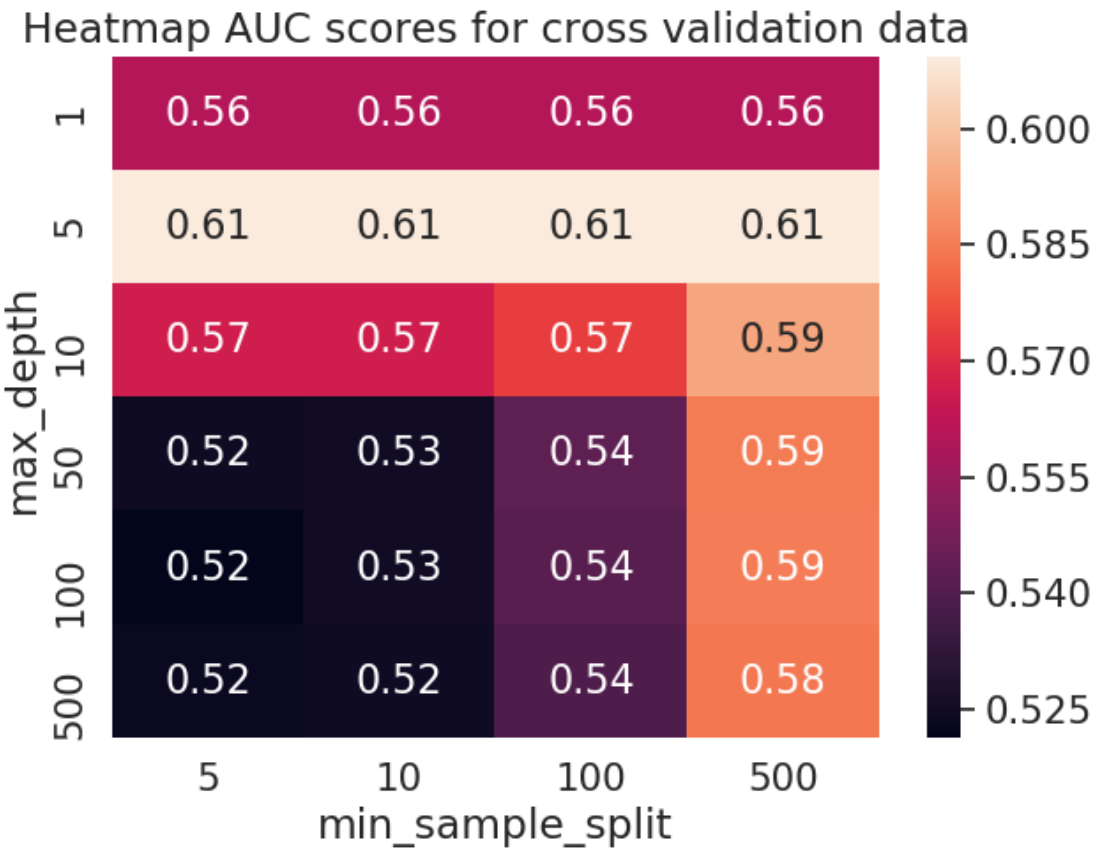
[138]:
```
# importing required libraries
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
import numpy as np

# our hyperparameters to choose from
depth = [1, 5, 10, 50, 100, 500]
min_samples_split = [5, 10, 100, 500]
param_grid = dict(max_depth = depth, min_samples_split = min_samples_split)

clf_ = DecisionTreeClassifier(class_weight = 'balanced')

clf = GridSearchCV(clf_, param_grid, scoring = 'roc_auc', cv=3, n_jobs=-1)

sc = clf.fit(X_tr, y_train)

# getting all the results
scores = clf.cv_results_
# getting train scores and cross validation scores
train_score = scores['mean_train_score']
cv_score = scores['mean_test_score']

# Reshape matrix for printing out in heatmap
train_score_reshaped = train_score.reshape(len(depth), len(min_samples_split))
cv_score_reshaped = cv_score.reshape(len(depth), len(min_samples_split))
```

[139]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(train_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7, 5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for training data ")
```

[139]: `Text(0.5, 1, 'Heatmap AUC scores for training data ')`

[140]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(cv_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7,5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for cross validation data")
```

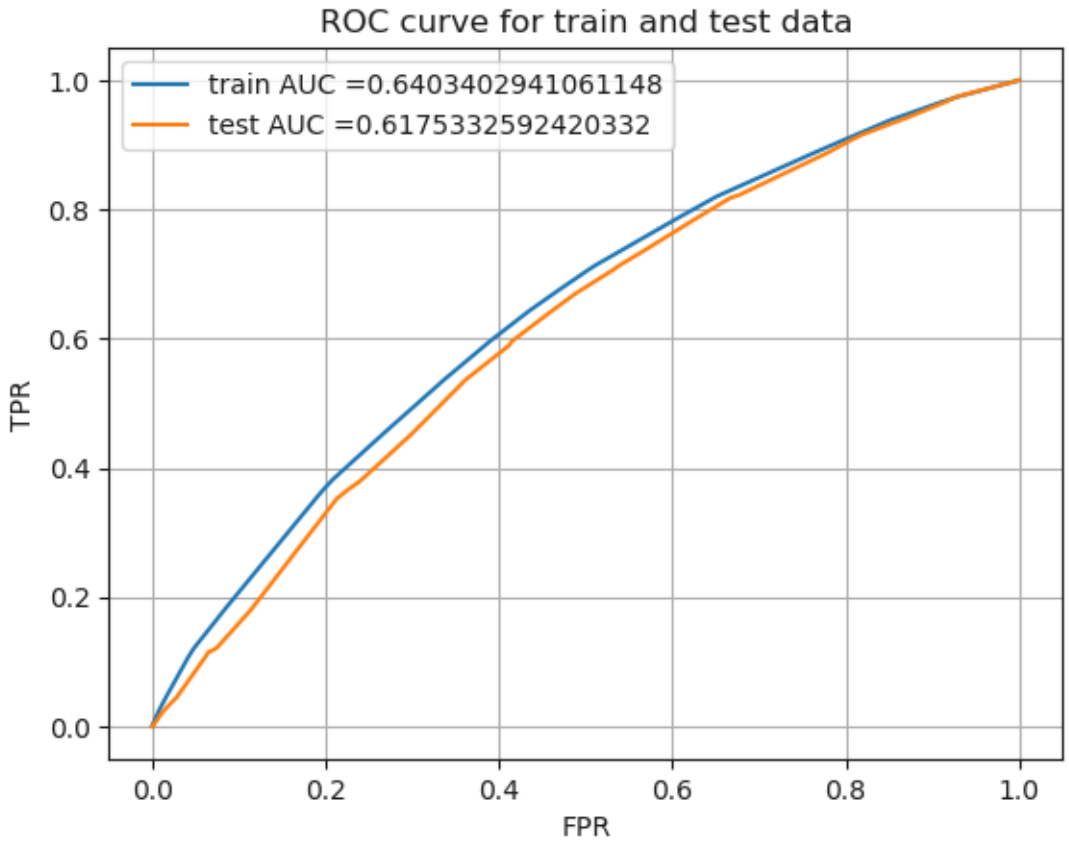
[140]: `Text(0.5, 1, 'Heatmap AUC scores for cross validation data')`



we choose max_depth = 5 and min_sample_split = 500 to train our final model

[202]:
```
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
from sklearn.metrics import roc_auc_score

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=5,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)

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


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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr,␣
 ↪train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
```

```
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC curve for train and test data")
plt.grid()
plt.show()
```



Here train AUC is slightly higher than the test auc, But this is considard as a good model.

Drawing confusion matrix

[203]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
# this function returns actual prediction in form of 0 and 1 by accepting the␣
 ↪probability score on the data
def predict(proba, threshould, fpr, tpr):

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

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

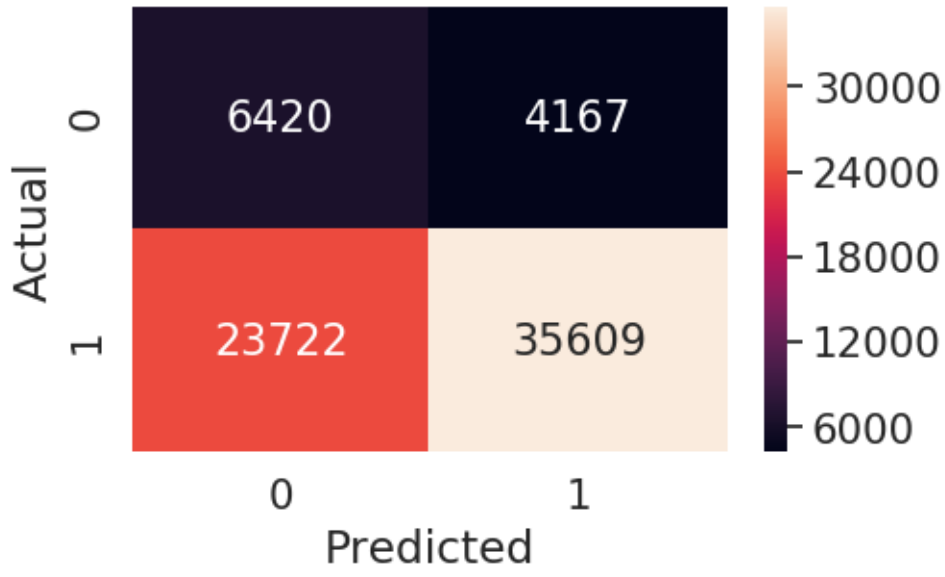
```
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for␣
 ↪threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

[204]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
cmtr = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,␣
 ↪train_fpr, train_tpr))
print("Test confusion matrix")
cmte = confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr,␣
 ↪test_tpr))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.36394874351809103 for threshold 0.521
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.34868965414248937 for threshold 0.521
```

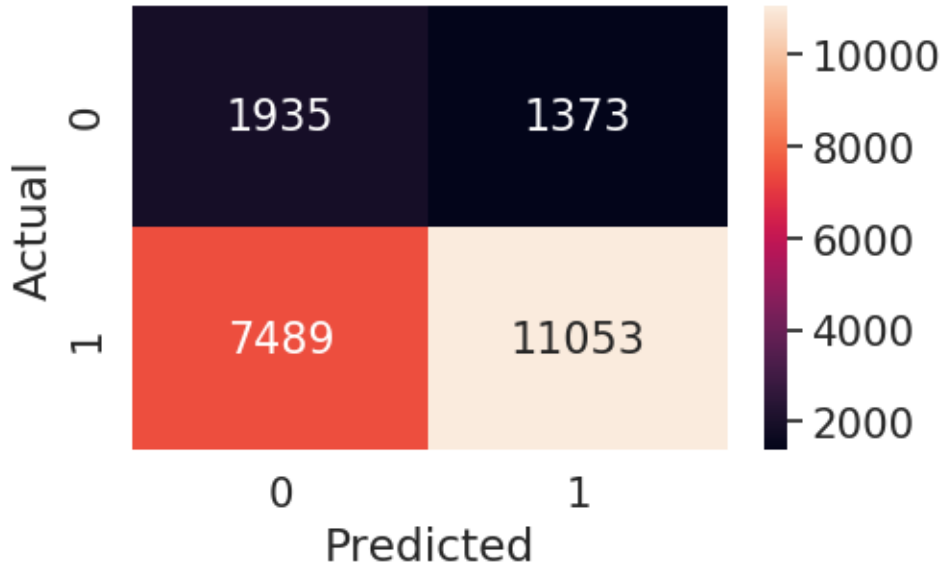
[205]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
array = cmtr
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (5,3))
sn.set(font_scale=1.4) #for label size
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[205]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f166a73ca58>
```



[206]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
array = cmte
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (5,3))
sn.set(font_scale=1.4) #for label size
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[206]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f162d6e80f0>
```



2.8.6 Selection and operations on false possitive data points

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

Plot the WordCloud <a href='https://www.geeksforgeeks.org/generating-word-cloud-python/' with the words of eassy text of these `false positive data points`>WordCloud

Plot the box plot with the `price` of these `false positive data points`

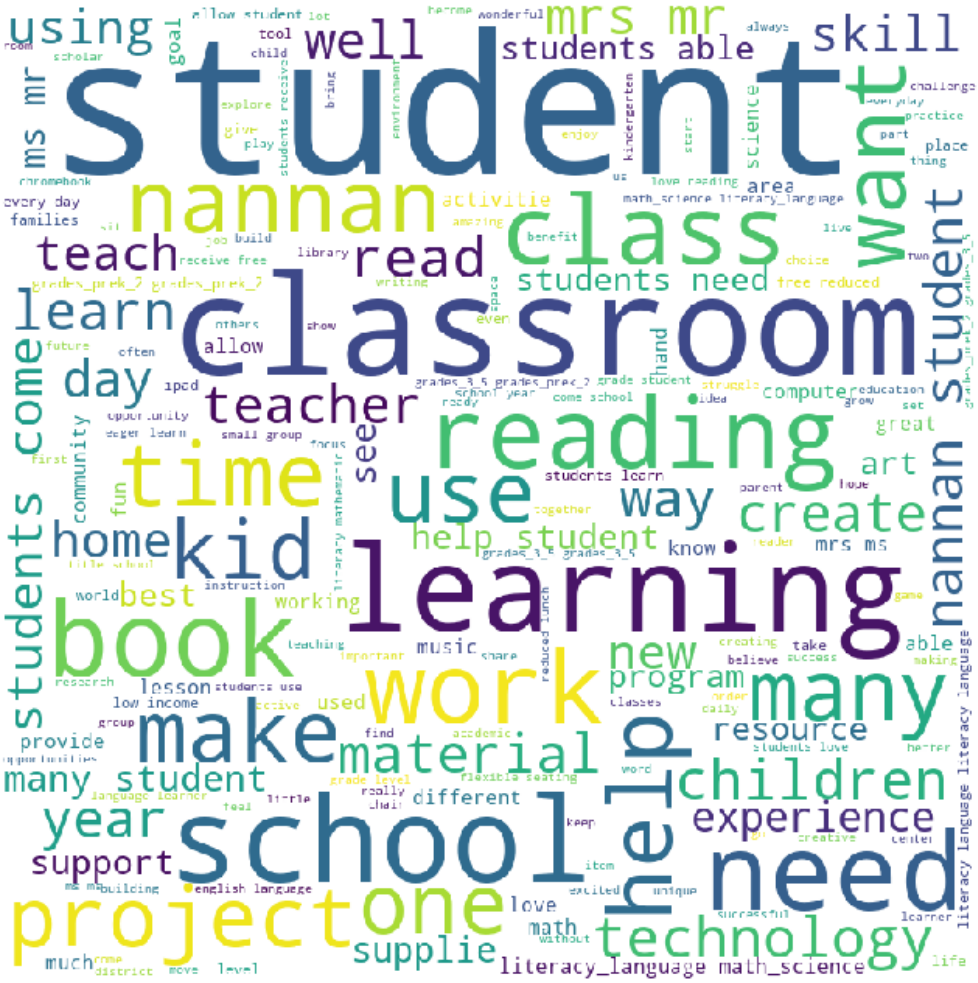
Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

[207]:
```
# Getting all indexes of false possitive data points for test data
index_of_false_positive_data_points_test = []
y_test_pred_class = predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)
for i in range(y_test.shape[0]):
    if y_test[i] == 0 and y_test_pred_class[i] == 1:
        index_of_false_positive_data_points_test.append(i)
    else:
        pass

print(len(index_of_false_positive_data_points_test))

# Selecting all the rows or data points from test data which gives false␣
 ↪possitive result.
X_test_false_positive = X_test.iloc[index_of_false_positive_data_points_test]
```

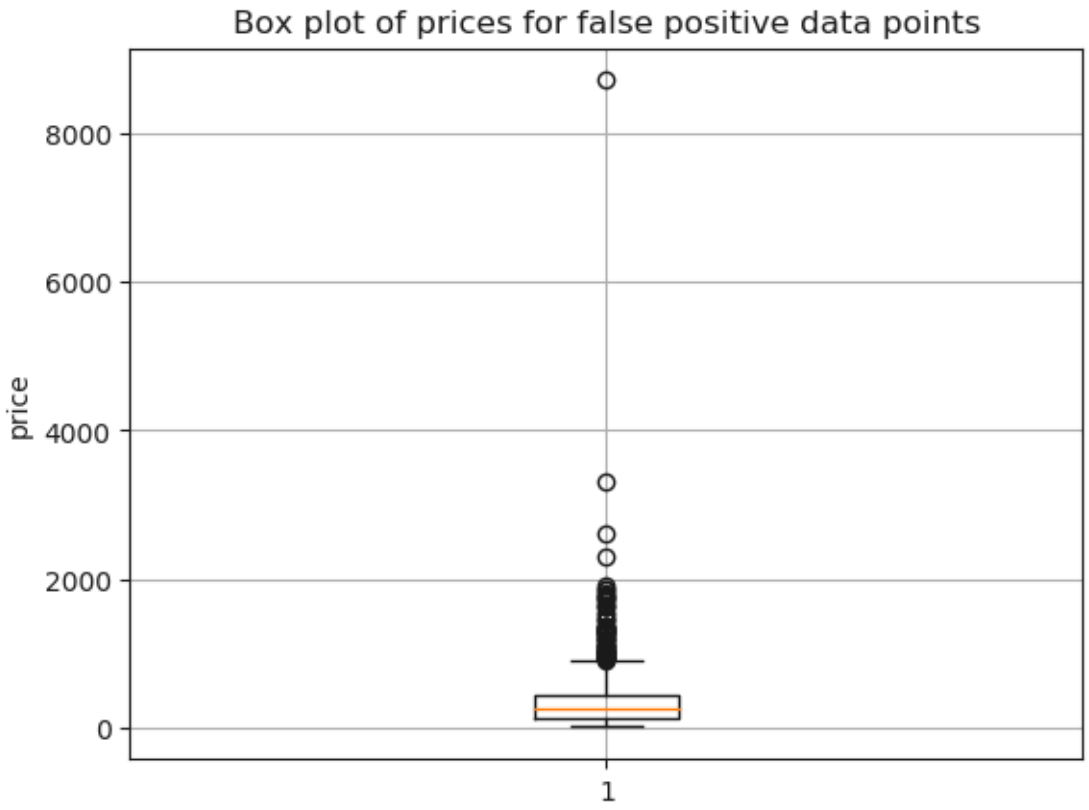
```
the maximum value of tpr*(1-fpr) 0.34868965414248937 for threshold 0.521
1373
```

[208]:
```
# ploting the wordcloud for all false positive data points for test data
# source https://www.geeksforgeeks.org/generating-word-cloud-python/

# importing all necessery modules
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd

column_select =␣
 ↪['school_state','clean_categories','clean_subcategories','preprocessed_essays',
                'preprocessed_titles','preprocessed_pgc','preprocessed_tp']

all_words_false_positive = ' '
stopwords = set(STOPWORDS)

# iterate through all the data
for col_name in column_select:
```

```
    for val in X_test_false_positive[col_name].values:

        # type cast each value to string
        val = str(val)

        #split the value
        tokens = val.split()

        #convert each tokens into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            all_words_false_positive = all_words_false_positive + words + ' '


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


# plot the WordCloud image
plt.figure(figsize = (7, 7), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

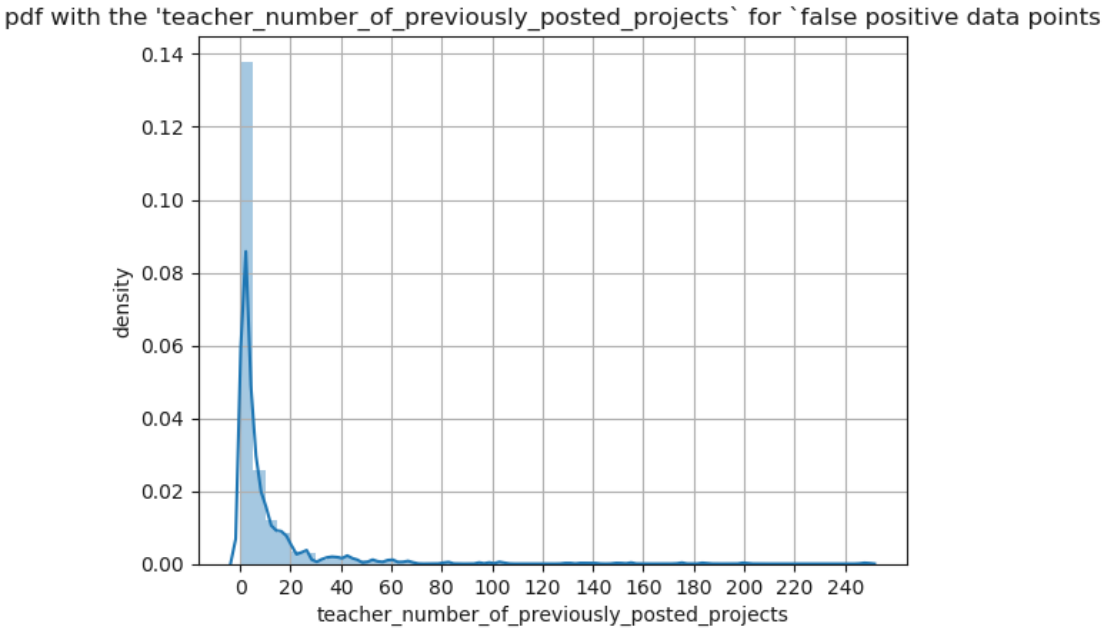


[209]:
```
# Plotting the box plot with the `price` of these `false positive data points`
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
plt.boxplot(X_test_false_possitive['price'].values)
plt.title("Box plot of prices for false positive data points")
plt.ylabel("price")
plt.grid()
plt.show()
```



Observations:
The range of prices for maximum projects is 0 to 1000
75% prices of this class belongs to less than 500
There are some project prices which are greater than 1000

[210]:
```
# Density Plot and Histogram of all arrival delays
import seaborn as sns
sns.
 ↪distplot(X_test_false_possitive['teacher_number_of_previously_posted_projects'].
 ↪values, hist = True)
plt.title("pdf with the 'teacher_number_of_previously_posted_projects` for␣
 ↪`false positive data points")
plt.xlabel("teacher_number_of_previously_posted_projects")
plt.ylabel("density")
plt.grid()
plt.xticks(np.arange(0, 250, step=20))
plt.show()
```



Observation: 1 - 5 projects are previously posted by maximum number of teachers 2 - For most projects in this class number_of_previously_posted_projects are between 0 to 20.

2.8.7 2.4.4 Applying DT on TFIDF W2V, SET 4

[141]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tww2v, X_train_title_avgw2v, X_train_state_ohe,␣
 ↪X_train_categories_ohe, X_train_subcategories_ohe,␣
 ↪X_train_teacher_prefix_ohe, X_train_pgc_ohe, X_train_price_norm,␣
 ↪X_train_tnppp_norm)).tocsr()
X_cr = hstack((X_cv_essay_tww2v, X_cv_title_avgw2v, X_cv_state_ohe,␣
 ↪X_cv_categories_ohe, X_cv_subcategories_ohe, X_cv_teacher_prefix_ohe,␣
 ↪X_cv_pgc_ohe, X_cv_price_norm, X_cv_tnppp_norm)).tocsr()
X_te = hstack((X_test_essay_tww2v, X_test_title_avgw2v, X_test_state_ohe,␣
 ↪X_test_categories_ohe, X_test_subcategories_ohe, X_test_teacher_prefix_ohe,␣
 ↪X_test_pgc_ohe, X_test_price_norm, X_test_tnppp_norm)).tocsr()

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

```
Final Data matrix
(69918, 701) (69918,)
```

```
(17480, 701) (17480,)
(21850, 701) (21850,)
================================================================================
====================
```

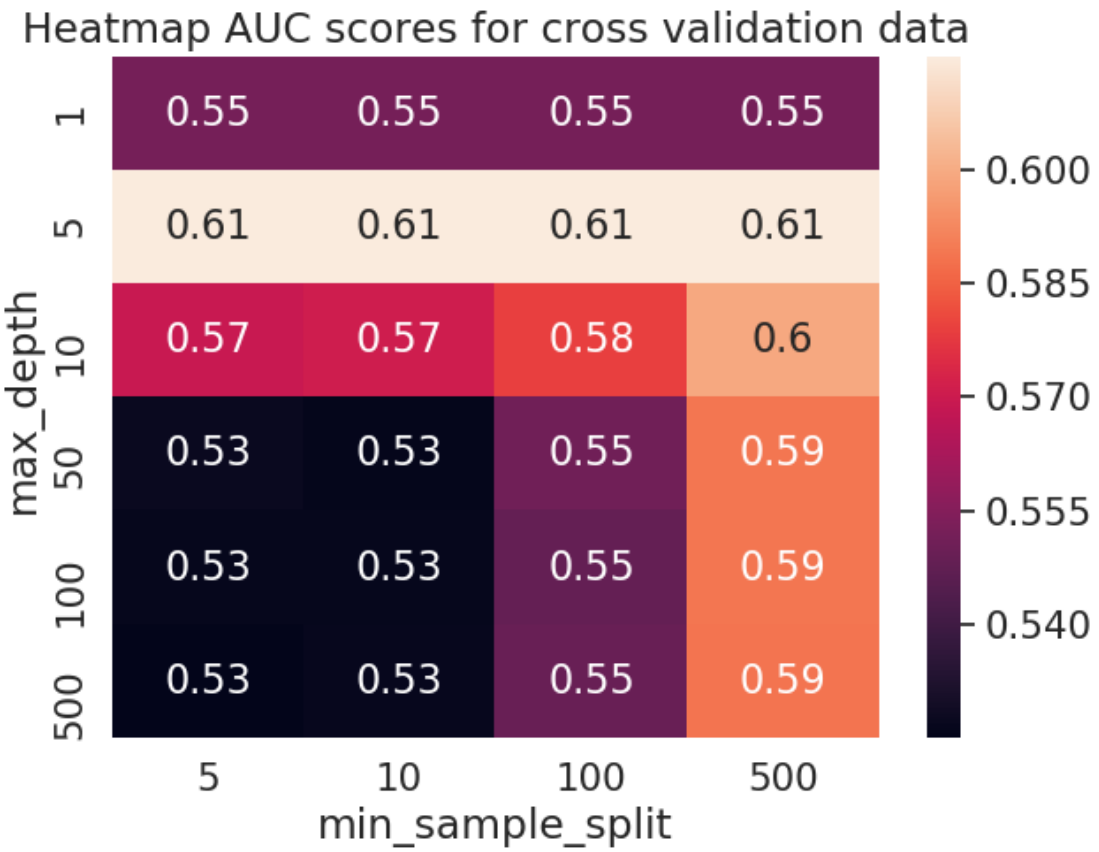
[142]:
```
# importing required libraries
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
import numpy as np

# our hyperparameters to choose from
depth = [1, 5, 10, 50, 100, 500]
min_samples_split = [5, 10, 100, 500]
param_grid = dict(max_depth = depth, min_samples_split = min_samples_split)

clf_ = DecisionTreeClassifier(class_weight = 'balanced')

clf = GridSearchCV(clf_, param_grid, scoring = 'roc_auc', cv=3)

sc = clf.fit(X_tr, y_train)

# getting all the results
scores = clf.cv_results_
# getting train scores and cross validation scores
train_score = scores['mean_train_score']
cv_score = scores['mean_test_score']

# Reshape matrix for printing out in heatmap
train_score_reshaped = train_score.reshape(len(depth), len(min_samples_split))
cv_score_reshaped = cv_score.reshape(len(depth), len(min_samples_split))
```

[143]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(train_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7, 5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for training data ")
```

[143]:
```
Text(0.5, 1, 'Heatmap AUC scores for training data ')
```

[144]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(cv_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7,5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for cross validation data")
```

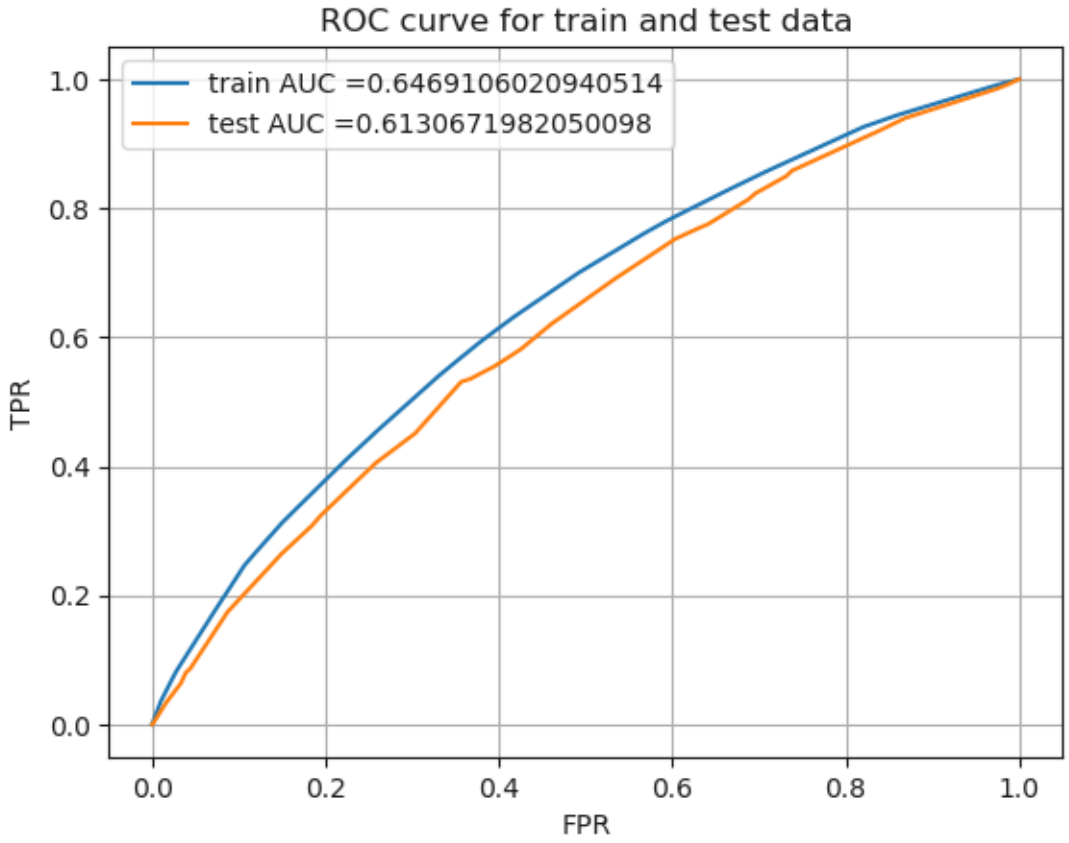
[144]:
```
Text(0.5, 1, 'Heatmap AUC scores for cross validation data')
```



Training our final model for max_depth = 5 and min_sample_split = 500

[118]:
```
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
from sklearn.metrics import roc_auc_score

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=5,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)

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


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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr,␣
 ↪train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
```

```
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC curve for train and test data")
plt.grid()
plt.show()
```



Drawing confusion matrix

[119]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
# this function returns actual prediction in form of 0 and 1 by accepting the␣
 ↪probability score on the data
def predict(proba, threshould, fpr, tpr):

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

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

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

Drawing confusion matrix https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_ma
By definition a confusion matrix is such that is equal to the number of observations known to be in group but predicted to be in group .

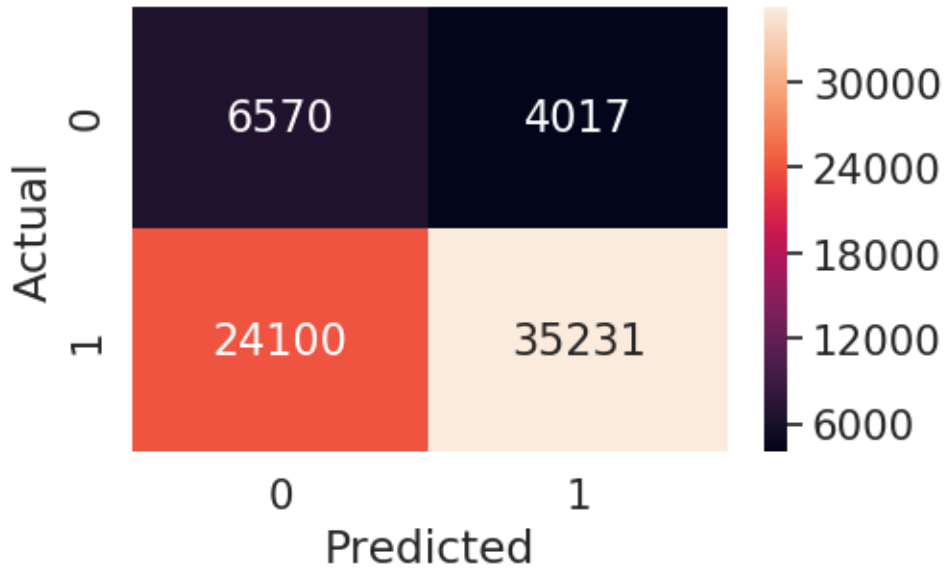
Thus in binary classification, the count of true negatives is C00, false negatives is C10, true positives is C01 and false positives is C01.

[120]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
cmtr = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,␣
↪train_fpr, train_tpr))
print("Test confusion matrix")
cmte = confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr,␣
↪test_tpr))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.3684985290723789 for threshold 0.521
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3416844297537132 for threshold 0.545
```

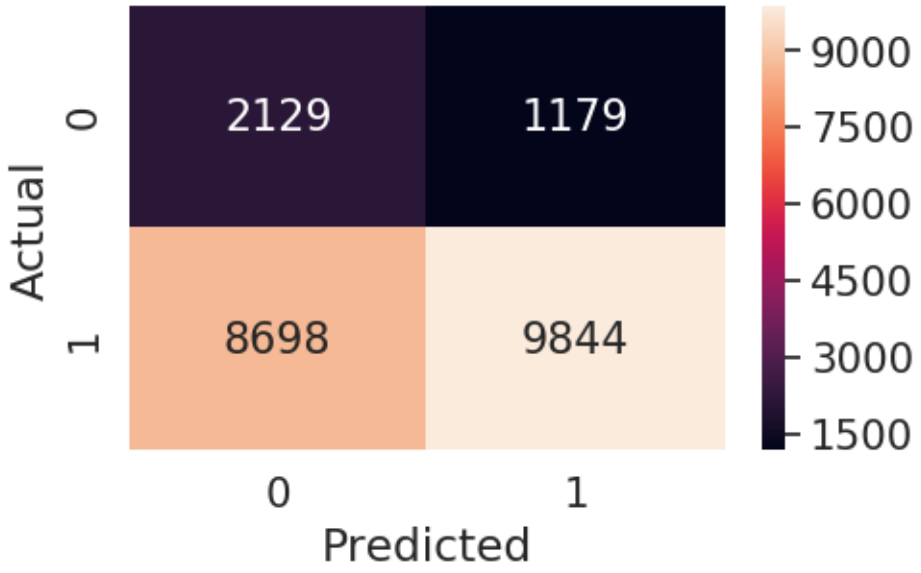
[121]:
```
# source https://stackoverflow.com/questions/35572000/
↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
array = cmtr
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (5,3))
sn.set(font_scale=1.4) #for label size
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[121]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f167c021588>
```



[122]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
array = cmte
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (5,3))
sn.set(font_scale=1.4) #for label size
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[122]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f166d2e4dd8>
```



2.8.8 Selection and operations on false possitive data points

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

Plot the WordCloud <a href='https://www.geeksforgeeks.org/generating-word-cloud-python/' with the words of eassy text of these `false positive data points`>WordCloud

Plot the box plot with the `price` of these `false positive data points`

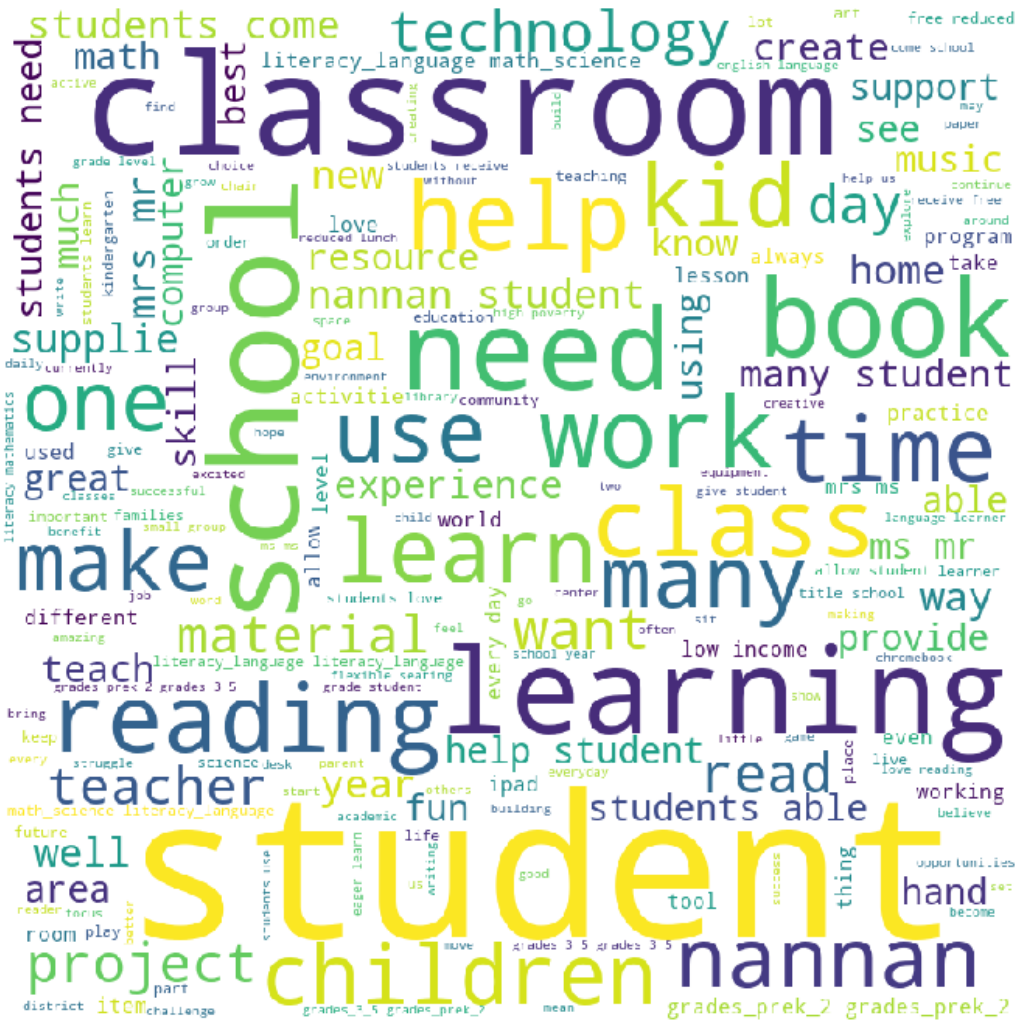
Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

[167]:
```
# Getting all indexes of false possitive data points for test data
index_of_false_positive_data_points_test = []
y_test_pred_class = predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)
for i in range(y_test.shape[0]):
    if y_test[i] == 0 and y_test_pred_class[i] == 1:
        index_of_false_positive_data_points_test.append(i)
    else:
        pass

print(len(index_of_false_positive_data_points_test))

# Selecting all the rows or data points from test data which gives false␣
 ↪possitive result.
X_test_false_positive = X_test.iloc[index_of_false_positive_data_points_test]
```

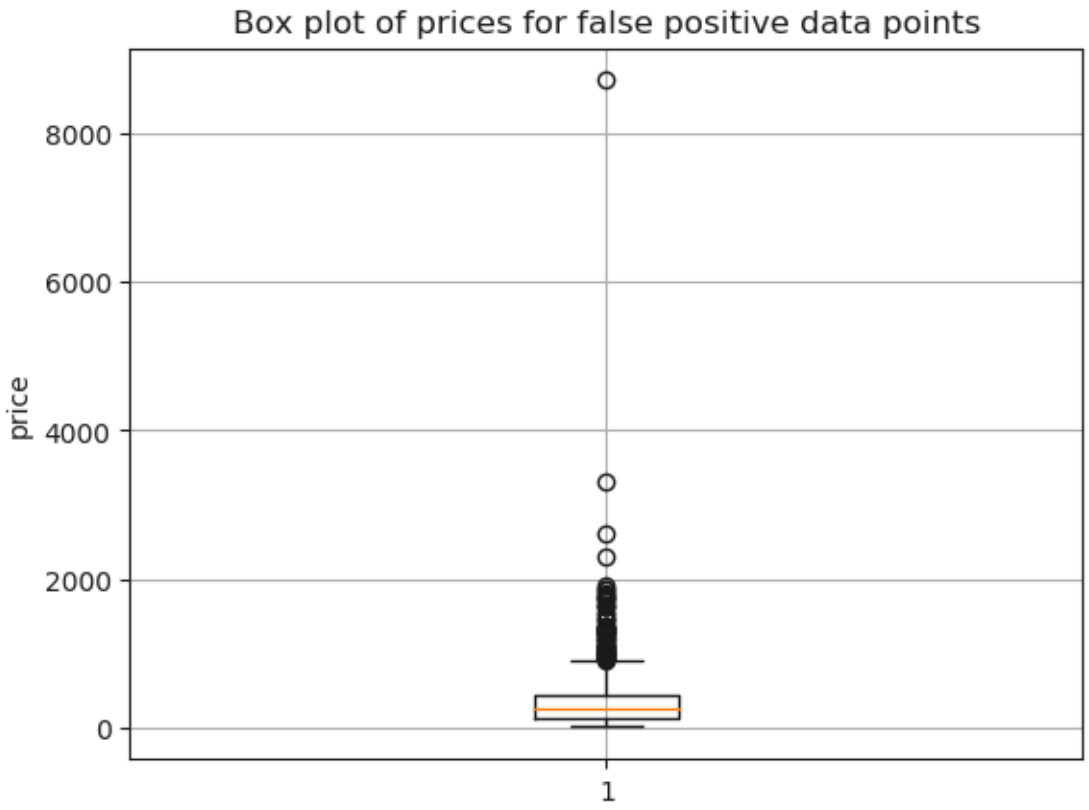
```
the maximum value of tpr*(1-fpr) 0.3416844297537132 for threshold 0.545
1179
```

[171]:
```
# ploting the wordcloud for all false positive data points for test data
# source https://www.geeksforgeeks.org/generating-word-cloud-python/

# importing all necessery modules
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd

column_select =␣
 ↪['school_state','clean_categories','clean_subcategories','preprocessed_essays',
                'preprocessed_titles','preprocessed_pgc','preprocessed_tp']

all_words_false_positive = ' '
stopwords = set(STOPWORDS)

# iterate through all the data
for col_name in column_select:
```

```
    for val in X_test_false_positive[col_name].values:

        # type cast each value to string
        val = str(val)

        #split the value
        tokens = val.split()

        #convert each tokens into lowercase
        for i in range(len(tokens)):
            tokens[i] = tokens[i].lower()

        for words in tokens:
            all_words_false_positive = all_words_false_positive + words + ' '


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


# plot the WordCloud image
plt.figure(figsize = (7, 7), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

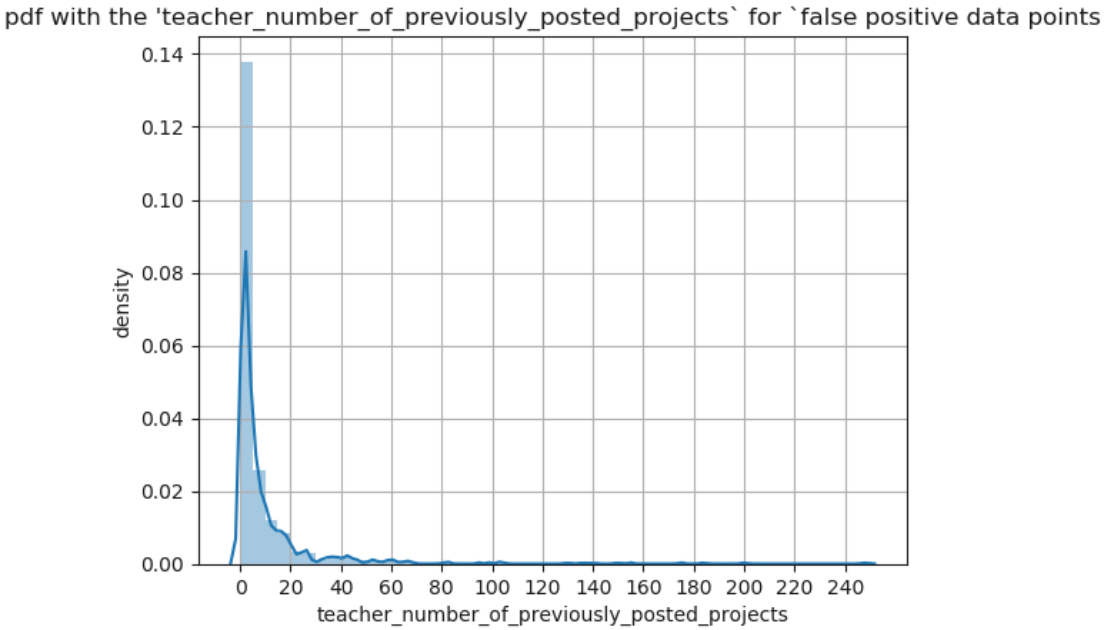


[169]:
```
# Plotting the box plot with the `price` of these `false positive data points`
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
plt.boxplot(X_test_false_possitive['price'].values)
plt.title("Box plot of prices for false positive data points")
plt.ylabel("price")
plt.grid()
plt.show()
```



Observations:
The range of prices for maximum projects is 0 to 1000
75% prices of this class belongs to less than 500
There are some project prices which are greater than 1000

[170]:
```
# Density Plot and Histogram of all arrival delays
import seaborn as sns
sns.
 ↪distplot(X_test_false_possitive['teacher_number_of_previously_posted_projects'].
 ↪values, hist = True)
plt.title("pdf with the 'teacher_number_of_previously_posted_projects` for␣
 ↪`false positive data points")
plt.xlabel("teacher_number_of_previously_posted_projects")
plt.ylabel("density")
plt.grid()
plt.xticks(np.arange(0, 250, step=20))
plt.show()
```



Observation: 1 - 5 projects are previously posted by maximum number of teachers 2 - For most projects in this class number_of_previously_posted_projects are between 0 to 20.

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

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

[145]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tfidf, X_train_title_tfidf, X_train_state_ohe,␣
 ↪X_train_categories_ohe, X_train_subcategories_ohe,␣
 ↪X_train_teacher_prefix_ohe, X_train_pgc_ohe, X_train_price_norm,␣
 ↪X_train_tnppp_norm)).tocsr()
X_cr = hstack((X_cv_essay_tfidf, X_cv_title_tfidf, X_cv_state_ohe,␣
 ↪X_cv_categories_ohe, X_cv_subcategories_ohe, X_cv_teacher_prefix_ohe,␣
 ↪X_cv_pgc_ohe, X_cv_price_norm, X_cv_tnppp_norm)).tocsr()
X_te = hstack((X_test_essay_tfidf, X_test_title_tfidf, X_test_state_ohe,␣
 ↪X_test_categories_ohe, X_test_subcategories_ohe, X_test_teacher_prefix_ohe,␣
 ↪X_test_pgc_ohe, X_test_price_norm, X_test_tnppp_norm)).tocsr()

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

```
Final Data matrix
```

```
(69918, 7541) (69918,)
(17480, 7541) (17480,)
(21850, 7541) (21850,)
==========================================================================
====================
```

[146]:
```
# Training our decision tree model for getting feature importances

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)
```

[146]:
```
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')
```

[147]:
```
# Getting features importances of all the columns
fi = clf.feature_importances_

# Selecting indexes of top 5k features
#https://stackoverflow.com/questions/6910641/
 ↪how-do-i-get-indices-of-n-maximum-values-in-a-numpy-array/
index_top_5k = np.argpartition(fi, -5000)[-5000:]

# Selecting data using index of top 5k features
# https://stackoverflow.com/questions/8386675/
 ↪extracting-specific-columns-in-numpy-array
X_tr = X_tr[ : , index_top_5k]
X_cr = X_cr[ : , index_top_5k]
X_te = X_te[ : , index_top_5k]

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*80)
```

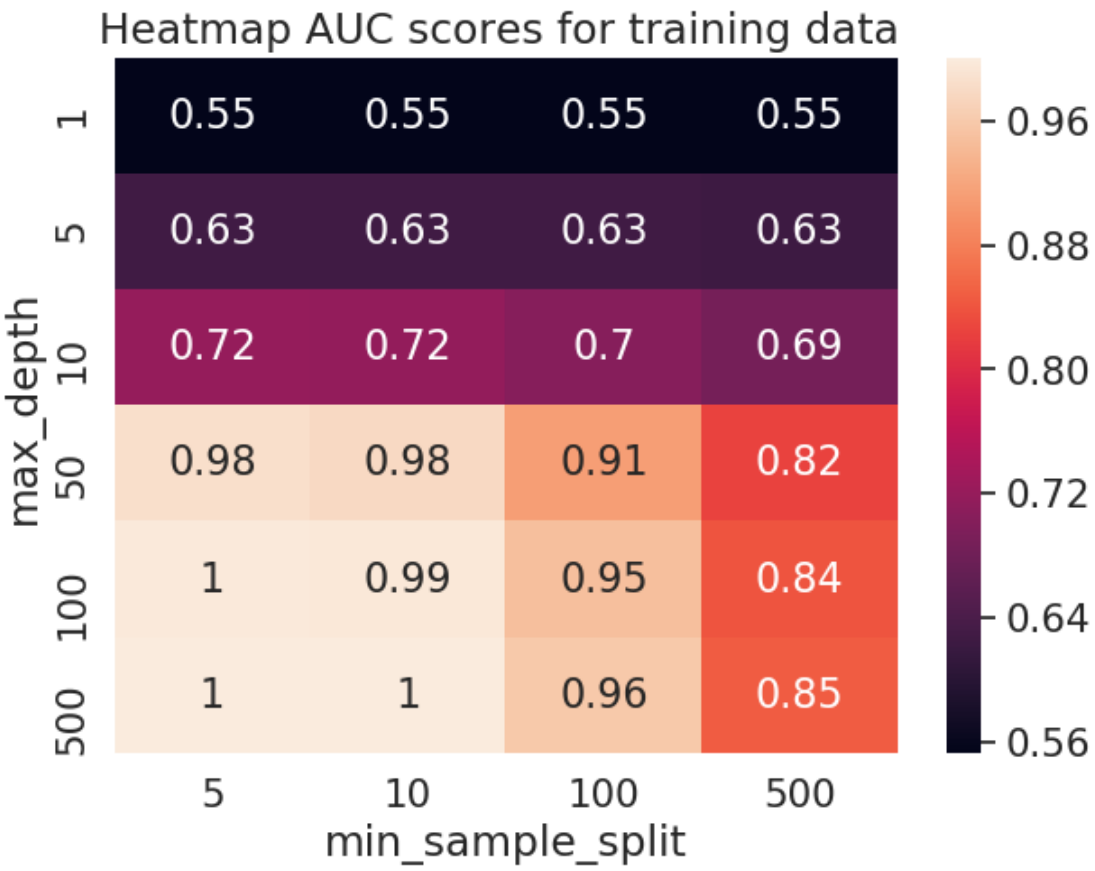
```
Final Data matrix
(69918, 5000) (69918,)
(17480, 5000) (17480,)
(21850, 5000) (21850,)
==========================================================================
```

Now we apply decision tree on this top 5k features

[148]:
```
# importing required libraries
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import roc_auc_score
from sklearn.tree import DecisionTreeClassifier
import seaborn as sns
import numpy as np

# our hyperparameters to choose from
depth = [1, 5, 10, 50, 100, 500]
min_samples_split = [5, 10, 100, 500]
param_grid = dict(max_depth = depth, min_samples_split = min_samples_split)

clf_ = DecisionTreeClassifier(class_weight = 'balanced')

clf = GridSearchCV(clf_, param_grid, scoring = 'roc_auc', cv=3, n_jobs=-1)

sc = clf.fit(X_tr, y_train)

# getting all the results
scores = clf.cv_results_
# getting train scores and cross validation scores
train_score = scores['mean_train_score']
cv_score = scores['mean_test_score']

# Reshape matrix for printing out in heatmap
train_score_reshaped = train_score.reshape(len(depth), len(min_samples_split))
cv_score_reshaped = cv_score.reshape(len(depth), len(min_samples_split))
```

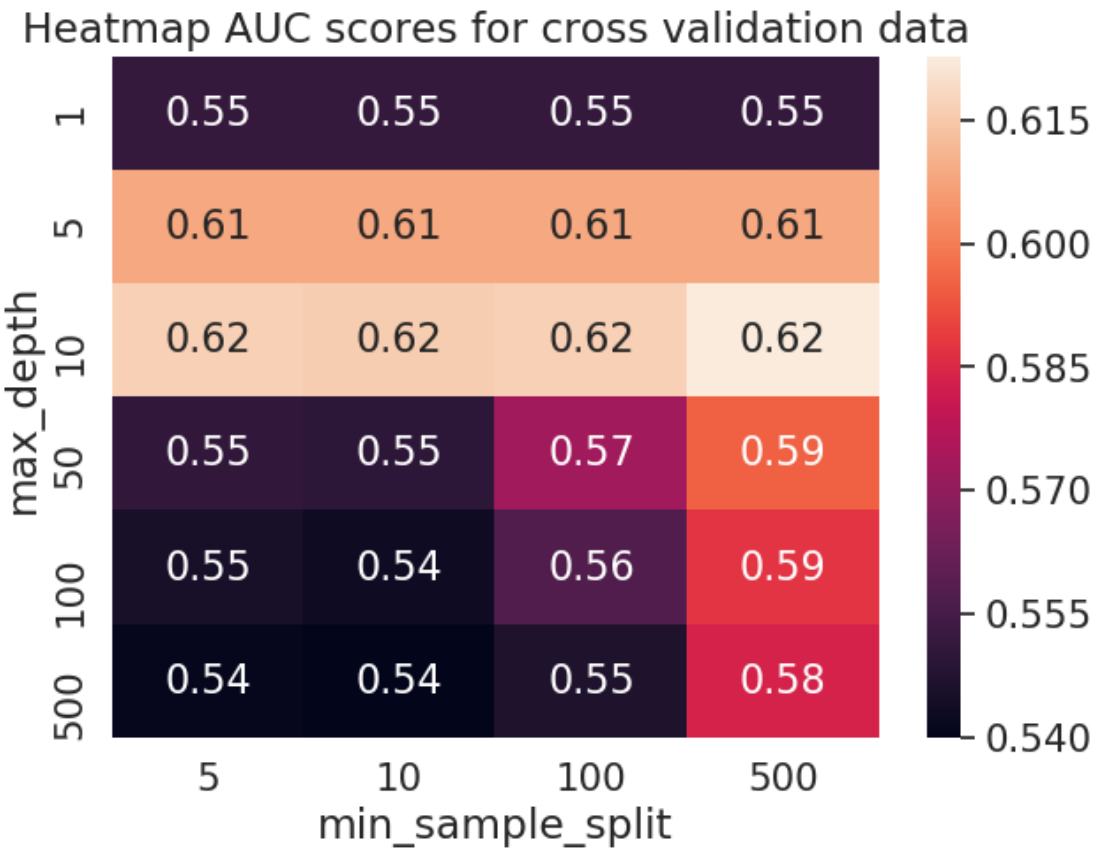
[149]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(train_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7, 5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for training data ")
```

[149]:
```
Text(0.5, 1, 'Heatmap AUC scores for training data ')
```



[150]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt

df_cm = pd.DataFrame(cv_score_reshaped, depth, min_samples_split)
plt.figure(figsize = (7,5))
sn.set(font_scale = 1.4) #for label size
df_cm.index.name = 'max_depth'
df_cm.columns.name = 'min_sample_split'
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='.2g')# font size
plt.title("Heatmap AUC scores for cross validation data")
```

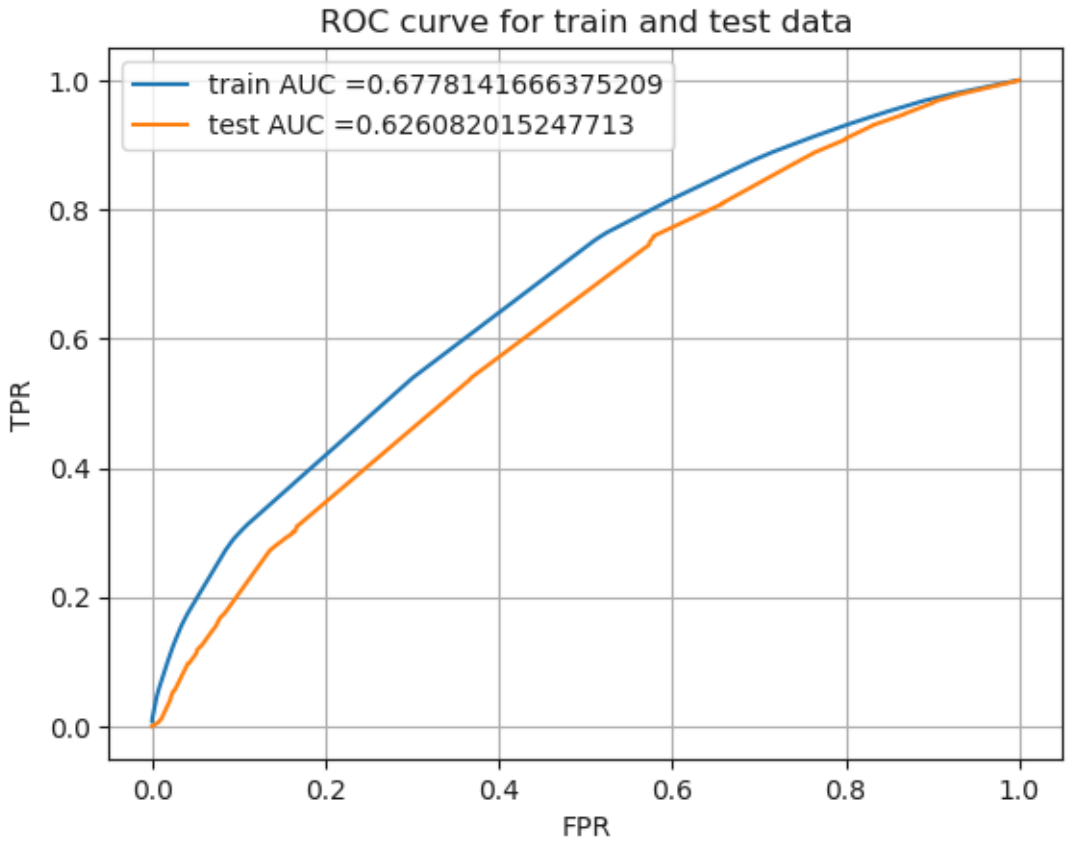
[150]:
```
Text(0.5, 1, 'Heatmap AUC scores for cross validation data')
```



Now we train our final model for max_depth = 10 and min_samples_split = 500

[230]:
```
import matplotlib.pyplot as plt
plt.rcParams.update(plt.rcParamsDefault)
from sklearn.metrics import roc_auc_score

clf = DecisionTreeClassifier(class_weight = 'balanced', max_depth=10,␣
 ↪min_samples_split = 500)

clf.fit(X_tr, y_train)

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


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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr,␣
 ↪train_tpr)))
```

```
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC curve for train and test data")
plt.grid()
plt.show()
```



Drawing confusion matrix

[231]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
# this function returns actual prediction in form of 0 and 1 by accepting the␣
 ↪probability score on the data
def predict(proba, threshould, fpr, tpr):

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

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

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

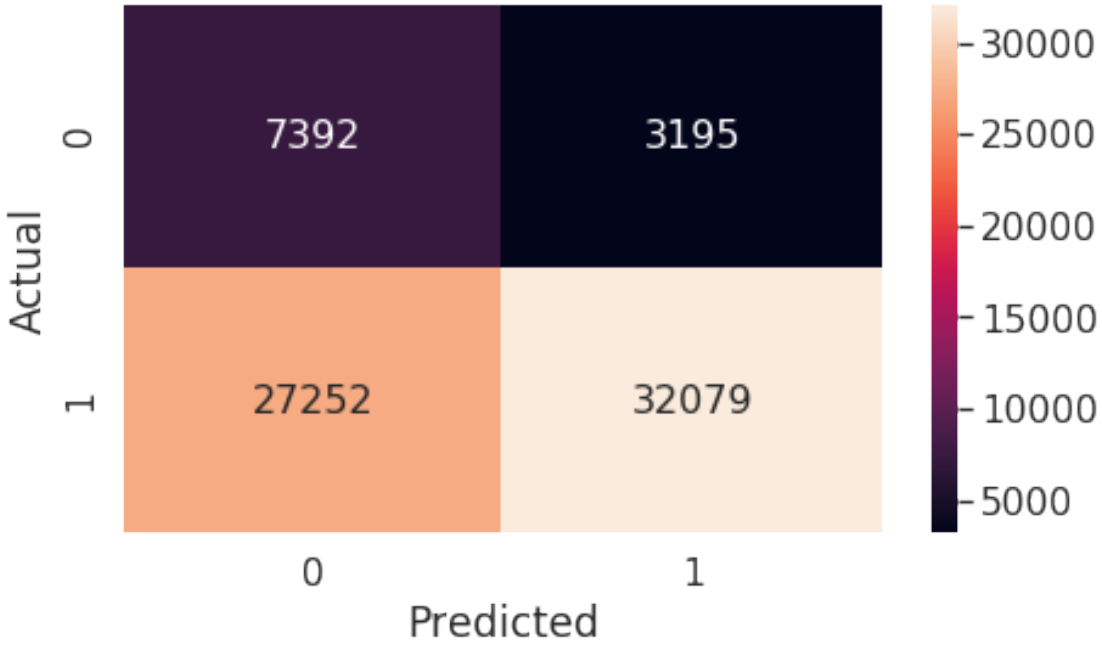
[232]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
cmtr = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,␣
 ↪train_fpr, train_tpr))
print("Test confusion matrix")
cmte = confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr,␣
 ↪test_tpr))
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.37750977235793726 for threshold 0.514
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3409304957782697 for threshold 0.514
```

[233]:
```
%matplotlib inline
```

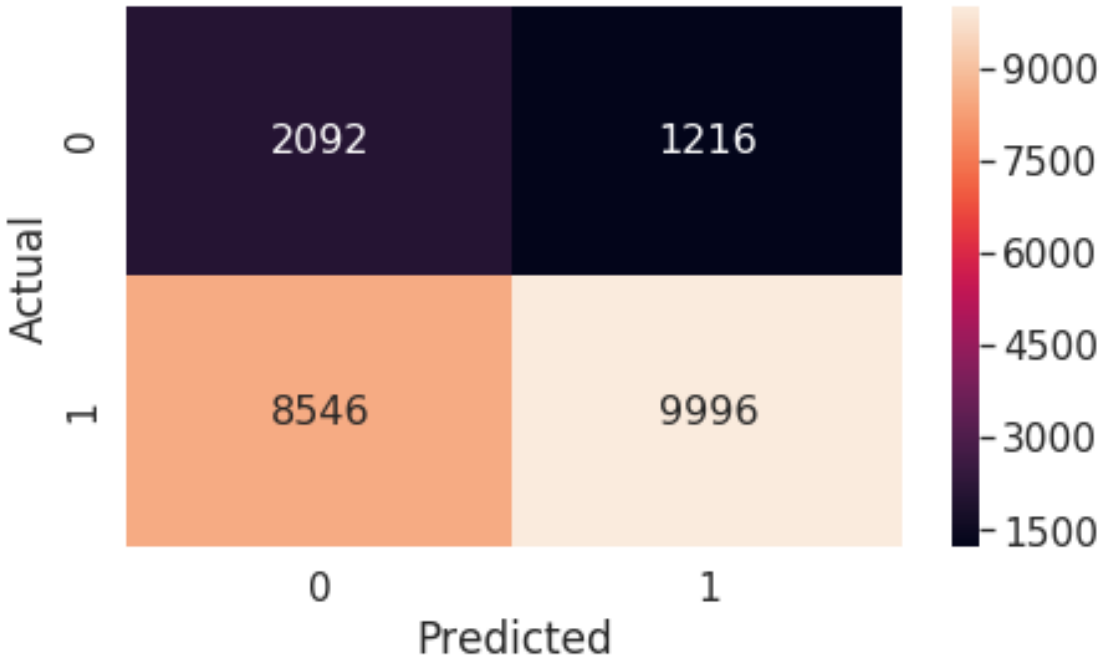
[234]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
import seaborn as sn
array = cmtr                    # Confusion matrix for train data
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (7,4))
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.set(font_scale=1.4) #for label size
sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g') # font size
```

[234]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1678503668>
```



[235]:
```
# source https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix
array = cmte      # Confusion matrix for test data
df_cm = pd.DataFrame(array, range(2),range(2))
plt.figure(figsize = (7,4))
sn.set(font_scale=1.4) #for label size
df_cm.index.name = "Actual"
df_cm.columns.name = "Predicted"
sn.heatmap(df_cm, annot = True, annot_kws={"size": 16}, fmt='g') # font size
```

[235]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f16707924a8>
```



3. Conclusions

[229]:
```
# compare models using Prettytable library
# source http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizor", "Model", "max_depth","min_sample_split", "AUC"]

x.add_row(["BOW", "decision tree", 10, 500, 0.63])
x.add_row(["TFIDF", "decision tree", 10, 500, 0.62])
x.add_row(["W2V", "decision tree", 5, 500, 0.61])
x.add_row(["TFIDFW2V", "decision tree", 5, 500, 0.61])

print(x)
```

```
+------------+---------------+-----------+------------------+------+
| Vectorizor |     Model     | max_depth | min_sample_split | AUC  |
+------------+---------------+-----------+------------------+------+
|    BOW     | decision tree |     10    |       500        | 0.63 |
|   TFIDF    | decision tree |     10    |       500        | 0.62 |
|    W2V     | decision tree |     5     |       500        | 0.61 |
|  TFIDFW2V  | decision tree |     5     |       500        | 0.61 |
+------------+---------------+-----------+------------------+------+
```

[ ]: