DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`

Feature	Description
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

Label	Description

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.

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
%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
import chart_studio.plotly
# from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
from scipy.sparse import hstack,vstack
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from sklearn import model_selection
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import RandomizedSearchCV
#from sklearn.impute import SimpleImputer
from sklearn.datasets import load_digits
#from sklearn.feature_selection import SelectKBest, chi2
#from sklearn.model_selection import GridSearchCV
from sklearn.feature_selection import SelectKBest,f_classif
from prettytable import PrettyTable
from sklearn.naive_bayes import MultinomialNB
from sklearn.preprocessing import Normalizer
from sklearn.metrics import confusion_matrix
#import math
```

```
#from sklearn.linear_model import LogisticRegression
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
#from sklearn.linear_model import SGDClassifier
from sklearn.tree import DecisionTreeClassifier
nltk.download('vader_lexicon')
import pdb
from sklearn.decomposition import TruncatedSVD

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

1.1 Reading Data

```
Project_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/train_data.csv')
Resource_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/resources.csv')
print(Project_data.shape)
print(Resource_data.shape)
```

```
(109248, 17)
(1541272, 4)
```

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(Project_data.columns)]
#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
Project_data['Date'] = pd.to_datetime(Project_data['project_submitted_datetime'])
Project_data.drop('project_submitted_datetime', axis=1, inplace=True)
Project_data.sort_values(by=['Date'], inplace=True)
# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
Project_data = Project_data[cols]
Project_data.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_categories	project_subject_subcategories	project_title
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Math & Science	Applied Sciences, Health & Life Science	Engineering STEAM into the Primary Classroom
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Special Needs	Special Needs	Sensory Tools for Focus

1.2 preprocessing of `project_subject_categories`

```
y = Project_data['project_is_approved'].values
Project_data.drop(['project_is_approved'], axis=1, inplace=True)
lpd = len(Project_data)
```

```
ys = np.zeros(lpd, dtype=np.int32)
X = Project_data
```

```
#Spliting the Dataset into three Train and Test
X_Train, X_Test, Y_Train, Y_Test = train_test_split(X, y, test_size=0.33, random_state=0, stratify=ys)
print('Shape of the X_Train data is {0} and Y_Train data is: {1}'.format(X_Train.shape,Y_Train.shape[0]))
print('Shape of the X_Test data is  {0} and Y_Test data is : {1}'.format(X_Test.shape,Y_Test.shape[0]))
```

```
Shape of the X_Train data is (73196, 16) and Y_Train data is: 73196
Shape of the X_Test data is  (36052, 16) and Y_Test data is : 36052
```

```
# 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

#************************************************************Train Data**********************************************************************
catogories = list(X_Train['project_subject_categories'].values)
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & 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())

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

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

cat_dict = dict(my_counter)
sorted_cat_dict_Train = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
print(len(sorted_cat_dict_Train))

#************************************************************Test Data**********************************************************************
catogories = list(X_Test['project_subject_categories'].values)
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & 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())

X_Test['clean_categories'] = cat_list
```

```
X_Test.drop(['project_subject_categories'], axis=1, inplace=True)

```

```
9
```

1.3 preprocessing of `project_subject_subcategories`

```
# 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
#************************************************************Train Data**********************************************************************************
sub_catogories = list(X_Train['project_subject_subcategories'].values)
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())

X_Train['clean_subcategories'] = sub_cat_list
X_Train.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 X_Train['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict_Train = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
print(len(sorted_sub_cat_dict_Train))

#************************************************************Test Data**********************************************************************************
sub_catogories = list(X_Test['project_subject_subcategories'].values)
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())

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

```
30
```

1.3 Text preprocessing

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

X_Test["essay"] = X_Test["project_essay_1"].map(str) +\
                        X_Test["project_essay_2"].map(str) + \
                        X_Test["project_essay_3"].map(str) + \
                        X_Test["project_essay_4"].map(str)
```

```
# 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
```

```
# 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"]
```

```
# Combining all the above stundents
# tqdm is for printing the status bar

#--------------------------------PreProcessing of Essays in Train data set-------------------------------------------
preprocessed_essays_Train = []
for sentance in tqdm(X_Train['essay'].values):
```

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

#----------------------------------PreProcessing of Essays in Test data set-------------------------------------------------
preprocessed_essays_Test = []
for sentance in tqdm(X_Test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_Test.append(sent.lower().strip())
# pdb.set_trace()
```

```
100%|██████████| 73196/73196 [00:40<00:00, 1798.75it/s]
100%|██████████| 36052/36052 [00:20<00:00, 1789.34it/s]
```

```
word_count_essay_Train = []
for a in tqdm(X_Train["essay"]) :
    b = len(a.split())
    word_count_essay_Train.append(b)

X_Train["word_count_essay_Train"] = word_count_essay_Train

word_count_essay_Test = []
for a in tqdm(X_Test["essay"]) :
    b = len(a.split())
    word_count_essay_Test.append(b)

X_Test["word_count_essay_Test"] = word_count_essay_Test
```

```
100%|██████████| 73196/73196 [00:01<00:00, 68071.92it/s]
100%|██████████| 36052/36052 [00:00<00:00, 67627.98it/s]
```

1.4 Preprocessing of `project_title`

```
# Combining all the above stundents
# tqdm is for printing the status bar

#----------------------------------PreProcessing of Project Title in Train data set---------------------------------------
preprocessed_titles_Train = []
for sentance in tqdm(X_Train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
```

```
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_Train.append(sent.lower().strip())
# pdb.set_trace()

#----------------------------------PreProcessing of Project Title in Test data set----------------------------------------
preprocessed_titles_Test = []
for sentance in tqdm(X_Test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_Test.append(sent.lower().strip())
# pdb.set_trace()
```

```
100%|██████████| 73196/73196 [00:01<00:00, 41760.61it/s]
100%|██████████| 36052/36052 [00:00<00:00, 41939.72it/s]
```

```
word_count_title_Train = []
for a in tqdm(X_Train["project_title"]) :
    b = len(a.split())
    word_count_title_Train.append(b)

X_Train["word_count_title_Train"] = word_count_title_Train


word_count_title_Test = []
for a in tqdm(X_Test["project_title"]) :
    b = len(a.split())
    word_count_title_Test.append(b)

X_Test["word_count_title_Test"] = word_count_title_Test
```

```
100%|██████████| 73196/73196 [00:00<00:00, 849627.99it/s]
100%|██████████| 36052/36052 [00:00<00:00, 874862.87it/s]
```

1.5 Preparing data for models

1.5.1 Vectorizing Categorical data

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

```
#-------------------------Vectorizing categorical data for Train and Test-----------------------------------------------

# we use count vectorizer to convert the values into one hot encoding
vectorizer_cat = CountVectorizer(vocabulary=list(sorted_cat_dict_Train.keys()), lowercase=False, binary=True)
vectorizer_cat.fit(X_Train['clean_categories'].values)
categories_one_hot_Train = vectorizer_cat.transform(X_Train['clean_categories'].values)
categories_one_hot_Test = vectorizer_cat.transform(X_Test['clean_categories'].values)
print(vectorizer_cat.get_feature_names())
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(categories_one_hot_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(categories_one_hot_Test.shape))
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
----------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 9)
Shape of Test dataset matrix after one hot encoding is: (36052, 9)
```

```
#-------------------------Vectorizing Sub categorical data for Train and Test-----------------------------------------------

# we use count vectorizer to convert the values into one hot encoding
vectorizer_sub_cat = CountVectorizer(vocabulary=list(sorted_sub_cat_dict_Train.keys()), lowercase=False, binary=True)
vectorizer_sub_cat.fit(X_Train['clean_categories'].values)
sub_categories_one_hot_Train = vectorizer_sub_cat.transform(X_Train['clean_subcategories'].values)
sub_categories_one_hot_Test = vectorizer_sub_cat.transform(X_Test['clean_subcategories'].values)
print(vectorizer_sub_cat.get_feature_names())
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(sub_categories_one_hot_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(sub_categories_one_hot_Test.shape))
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Civics_Government', 'Extracurricular', 'ForeignLanguages', 'Warmth', 'Care_Hunger', 'NutritionEducation', 'SocialScienc
----------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 30)
Shape of Test dataset matrix after one hot encoding is: (36052, 30)
```

School State

```
#-------------------------Vectorizing categorical data of School state for Train dataset-----------------------------------

school_catogories_Train = list(X_Train['school_state'].values)
school_list_Train = []
for sent in school_catogories_Train:
    school_list_Train.append(sent.lower().strip())
X_Train['school_categories'] = school_list_Train
X_Train.drop(['school_state'], axis=1, inplace=True)

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
school_dict_Train = dict(my_counter_school_Train)
sorted_school_dict_Train = dict(sorted(school_dict_Train.items(), key=lambda kv: kv[1]))

vectorizer_school = CountVectorizer(vocabulary=list(sorted_school_dict_Train.keys()), lowercase=False, binary=True)
vectorizer_school.fit(X_Train['school_categories'].values)
#print(vectorizer.get_feature_names())

school_one_hot_Train = vectorizer_school.transform(X_Train['school_categories'].values)

#-------------------------Vectorizing categorical data of School state for Test dataset------------------------------------

school_catogories_Test = list(X_Test['school_state'].values)
school_list_Test = []
for sent in school_catogories_Test:
    school_list_Test.append(sent.lower().strip())
X_Test['school_categories'] = school_list_Test
X_Test.drop(['school_state'], axis=1, inplace=True)
```

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
school_dict_Test = dict(my_counter_school_Test)
sorted_school_dict_Test = dict(sorted(school_dict_Test.items(), key=lambda kv: kv[1]))
school_one_hot_Test = vectorizer_school.transform(X_Test['school_categories'].values)
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(school_one_hot_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(school_one_hot_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 51)
Shape of Test dataset matrix after one hot encoding is: (36052, 51)
```

Prefix

```
#-------------------------Vectorizing categorical data of Teacher Prefix for Train dataset-----------------------------------

# 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
prefix_catogories_Train = list(X_Train['teacher_prefix'].values)
prefix_list_Train = []
for sent in prefix_catogories_Train:
    sent = re.sub('[^A-Za-z0-9]+', ' ', str(sent))
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split())
    prefix_list_Train.append(sent.lower().strip())
X_Train['prefix_catogories'] = prefix_list_Train
X_Train.drop(['teacher_prefix'], axis=1, inplace=True)

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
prefix_dict_Train = dict(my_counter_prefix_Train)
sorted_prefix_dict_Train = dict(sorted(prefix_dict_Train.items(), key=lambda kv: kv[1]))


vectorizer_prefix = CountVectorizer(vocabulary=list(sorted_prefix_dict_Train.keys()), lowercase=False, binary=True)
vectorizer_prefix.fit(X_Train['prefix_catogories'].values)
#print(vectorizer.get_feature_names())

prefix_one_hot_Train = vectorizer_prefix.transform(X_Train['prefix_catogories'].values)
#print("Shape of matrix after one hot encodig ",prefix_one_hot.shape)

#-------------------------Vectorizing categorical data of Teacher Prefix for Test dataset-----------------------------------

prefix_catogories_Test = list(X_Test['teacher_prefix'].values)
prefix_list_Test = []
for sent in prefix_catogories_Test:
```

```
    sent = re.sub('[^A-Za-z0-9]+', ' ', str(sent))
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split())
    prefix_list_Test.append(sent.lower().strip())
X_Test['prefix_catogories'] = prefix_list_Test
X_Test.drop(['teacher_prefix'], axis=1, inplace=True)

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
prefix_dict_Test = dict(my_counter_prefix_Test)
sorted_prefix_dict_Test = dict(sorted(prefix_dict_Test.items(), key=lambda kv: kv[1]))
prefix_one_hot_Test = vectorizer_prefix.transform(X_Test['prefix_catogories'].values)
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(prefix_one_hot_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(prefix_one_hot_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 6)
Shape of Test dataset matrix after one hot encoding is: (36052, 6)
```

project_grade_category

```
#-------------------------Vectorizing categorical data of Project Grade for Train dataset-----------------------------------

# 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
grade_catogories_Train = list(X_Train['project_grade_category'].values)
grade_list_Train = []
for sent in grade_catogories_Train:
    sent = sent.replace('-','_')
    sent = sent.replace(' ','_')
    # sent = re.sub('[^A-Za-z0-9]+', ' ', str(sent))
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split())
    grade_list_Train.append(sent.lower().strip())

# temp = temp.replace('-','_')
X_Train['new_grade_category'] = grade_list_Train
X_Train.drop(['project_grade_category'], axis=1, inplace=True)

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
grade_dict_Train = dict(my_counter_grade_Train)
sorted_grade_dict_Train = dict(sorted(grade_dict_Train.items(), key=lambda kv: kv[1]))

vectorizer_grade = CountVectorizer(vocabulary=list(sorted_grade_dict_Train.keys()), lowercase=False, binary=True)
vectorizer_grade.fit(X_Train['new_grade_category'].values)
#print(vectorizer.get_feature_names())
```

```
grade_one_hot_Train = vectorizer_grade.transform(X_Train['new_grade_category'].values)

#-------------------------Vectorizing categorical data of Project Grade for Train dataset----------------------------------

grade_catogories_Test = list(X_Test['project_grade_category'].values)
grade_list_Test = []
for sent in grade_catogories_Test:
    sent = sent.replace('-','_')
    sent = sent.replace(' ','_')
    # sent = re.sub('[^A-Za-z0-9]+', ' ', str(sent))
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split())
    grade_list_Test.append(sent.lower().strip())

# temp = temp.replace('-','_')
X_Test['new_grade_category'] = grade_list_Test
X_Test.drop(['project_grade_category'], axis=1, inplace=True)

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

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
grade_dict_Test = dict(my_counter_grade_Test)
sorted_grade_dict_Test = dict(sorted(grade_dict_Test.items(), key=lambda kv: kv[1]))

grade_one_hot_Test = vectorizer_grade.transform(X_Test['new_grade_category'].values)
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(grade_one_hot_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(grade_one_hot_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 4)
Shape of Test dataset matrix after one hot encoding is: (36052, 4)
```

1.5.2 Vectorizing Numerical features

```
price_data = Resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
X_Train = pd.merge(X_Train, price_data, on='id', how='left')
X_Test = pd.merge(X_Test, price_data, on='id', how='left')
```

```
price_norm = Normalizer(norm='l2', copy=False)
price_norm.fit(X_Train['price'].values.reshape(1,-1))

p=price_norm.transform(X_Train['price'].values.reshape(1,-1))
price_norm.transform(X_Test['price'].values.reshape(1,-1))
price_norm_Train = (X_Train['price'].values.reshape(-1,1))
price_norm_Test = (X_Test['price'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized price dataset matrix after one hot encoding is: {0}'.format(price_norm_Train.shape))
print('Shape of Test normalized price dataset matrix after one hot encoding is: {0}'.format(price_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized price dataset matrix after one hot encoding is: (73196, 1)
Shape of Test normalized price dataset matrix after one hot encoding is: (36052, 1)
```

```
quantity_norm = Normalizer(norm='l2', copy=False)
quantity_norm.fit(X_Train['quantity'].values.reshape(1,-1))

quantity_norm.transform(X_Train['quantity'].values.reshape(1,-1))
quantity_norm.transform(X_Test['quantity'].values.reshape(1,-1))
quantity_norm_Train = quantity_norm.transform(X_Train['quantity'].values.reshape(-1,1))
quantity_norm_Test = quantity_norm.transform(X_Test['quantity'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized quantity dataset matrix after one hot encoding is: {0}'.format(quantity_norm_Train.shape))
print('Shape of Test normalized quantity dataset matrix after one hot encoding is: {0}'.format(quantity_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized quantity dataset matrix after one hot encoding is: (73196, 1)
Shape of Test normalized quantity dataset matrix after one hot encoding is: (36052, 1)
```

```
teacher_prev_post_norm = Normalizer(norm='l2', copy=False)
teacher_prev_post_norm.fit(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

teacher_prev_post_norm.transform(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
teacher_prev_post_norm.transform(X_Test['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
teacher_prev_post_norm_Train = teacher_prev_post_norm.transform(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
teacher_prev_post_norm_Test = teacher_prev_post_norm.transform(X_Test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized previously posted project dataset matrix after one hot encoding is: {0}'.format(teacher_prev_post_norm_Train.shape))
print('Shape of Test normalized previously posted project dataset matrix after one hot encoding is: {0}'.format(teacher_prev_post_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized previously posted project dataset matrix after one hot encoding is: (73196, 1)
Shape of Test normalized previously posted project dataset matrix after one hot encoding is: (36052, 1)
```

```
title_norm = Normalizer(norm='l2', copy=False)
title_norm.fit(X_Train['word_count_title_Train'].values.reshape(1,-1))
title_norm.transform(X_Train['word_count_title_Train'].values.reshape(1,-1))
title_norm.transform(X_Test['word_count_title_Test'].values.reshape(1,-1))
word_count_title_Train = title_norm.transform(X_Train['word_count_title_Train'].values.reshape(-1,1))
word_count_title_Test = title_norm.transform(X_Test['word_count_title_Test'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_title_Train.shape))
print('Shape of Test normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_title_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized title dataset matrix after one hot encoding is: (73196, 1)
Shape of Test normalized title dataset matrix after one hot encoding is: (36052, 1)
```

```
essay_norm = Normalizer(norm='l2', copy=False)
essay_norm.fit(X_Train['word_count_essay_Train'].values.reshape(1,-1))
essay_norm.transform(X_Train['word_count_essay_Train'].values.reshape(1,-1))
essay_norm.transform(X_Test['word_count_essay_Test'].values.reshape(1,-1))
word_count_essay_Train = essay_norm.transform(X_Train['word_count_essay_Train'].values.reshape(-1,1))
word_count_essay_Test = essay_norm.transform(X_Test['word_count_essay_Test'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_essay_Train.shape))
print('Shape of Test normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_essay_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized title dataset matrix after one hot encoding is: (73196, 1)
Shape of Test normalized title dataset matrix after one hot encoding is: (36052, 1)
```

1.5.3 Vectorizing Text data

1.5.2.2 TFIDF vectorizer

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essays_tfidf = TfidfVectorizer(min_df=10)
text_tfidf_Train = vectorizer_essays_tfidf.fit_transform(preprocessed_essays_Train)
text_tfidf_Test = vectorizer_essays_tfidf.transform(preprocessed_essays_Test)
print("-"*120)
print("Applying TFIDF for Text Data")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(text_tfidf_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(text_tfidf_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying TFIDF for Text Data
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 14144)
Shape of Test dataset matrix after one hot encoding is: (36052, 14144)
```

TFIDF vectorizer for Project Title

```
vectorizer_titles_tfidf = TfidfVectorizer(min_df=10)
title_tfidf_Train = vectorizer_titles_tfidf.fit_transform(preprocessed_titles_Train)
title_tfidf_Test = vectorizer_titles_tfidf.transform(preprocessed_titles_Test)
print("-"*120)
print("Applying TFIDF for Project Title")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(title_tfidf_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(title_tfidf_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying TFIDF for Project Title
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (73196, 2631)
Shape of Test dataset matrix after one hot encoding is: (36052, 2631)
```

```
# 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())
with open('/content/drive/My Drive/Colab Notebooks/glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

```
tfidf_model_essays = TfidfVectorizer()
tfidf_model_essays.fit(preprocessed_essays_Train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model_essays.get_feature_names(), list(tfidf_model_essays.idf_)))
tfidf_words_essays = set(tfidf_model_essays.get_feature_names())
```

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Train): # 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_essays):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_Train.append(vector)
#-------------------------------------------------------------------------------------------
tfidf_w2v_vectors_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Test): # 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_essays):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_Test.append(vector)

print(len(tfidf_w2v_vectors_Test))
print(len(tfidf_w2v_vectors_Test[0]))

```

```
100%|██████████| 73196/73196 [02:04<00:00, 585.70it/s]
100%|██████████| 36052/36052 [01:01<00:00, 582.80it/s]36052
300
```

Using Pretrained Models: TFIDF weighted W2V on project_title

```
# Similarly you can vectorize for title also
tfidf_model_title = TfidfVectorizer()
tfidf_model_title.fit(preprocessed_titles_Train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model_title.get_feature_names(), list(tfidf_model_title.idf_)))
tfidf_words_title = set(tfidf_model_title.get_feature_names())

# compute tfidf word2vec for each title.
tfidf_w2v_vectors_title_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Train): # for each review/sentence
    vector_title = 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_title):
            vec = model[word] # getting the vector for each word
```

```
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector_title += (vector_title * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector_title /= tf_idf_weight
    tfidf_w2v_vectors_title_Train.append(vector_title)

#-----------------------------------------------------------------------------------------------------------------------------------


tfidf_w2v_vectors_title_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Test): # for each review/sentence
    vector_title = 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_title):
            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_title += (vector_title * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector_title /= tf_idf_weight
    tfidf_w2v_vectors_title_Test.append(vector_title)

print(len(tfidf_w2v_vectors_title_Test))
print(len(tfidf_w2v_vectors_title_Test[0]))

```

```
100%|██████████| 73196/73196 [00:02<00:00, 31772.34it/s]
100%|██████████| 36052/36052 [00:01<00:00, 31641.90it/s]36052
300
```

Calculating the sentiment score's of each of the essay

```

sid = SentimentIntensityAnalyzer()

essays = X_Train['essay']
essays_sentiment_TR_P = []
essays_sentiment_TR_N = []
essays_sentiment_TR_NE = []
essays_sentiment_TR_C = []
for essay in tqdm(essays):
    res = sid.polarity_scores(essay)
    essays_sentiment_TR_P.append(res['pos'])
    essays_sentiment_TR_N.append(res['neg'])
    essays_sentiment_TR_NE.append(res['neu'])
    essays_sentiment_TR_C.append(res['compound'])
X_Train['sentiment_essay_TR_P'] = essays_sentiment_TR_P
X_Train['sentiment_essay_TR_N'] = essays_sentiment_TR_N
X_Train['sentiment_essay_TR_NE'] = essays_sentiment_TR_NE
X_Train['sentiment_essay_TR_C'] = essays_sentiment_TR_C


```

```
essays = X_Test['essay']
essays_sentiment_TS_P = []
essays_sentiment_TS_N = []
essays_sentiment_TS_NE = []
essays_sentiment_TS_C = []
for essay in tqdm(essays):
    res = sid.polarity_scores(essay)
    essays_sentiment_TS_P.append(res['pos'])
    essays_sentiment_TS_N.append(res['neg'])
    essays_sentiment_TS_NE.append(res['neu'])
    essays_sentiment_TS_C.append(res['compound'])
X_Test['sentiment_essay_TS_P'] = essays_sentiment_TS_P
X_Test['sentiment_essay_TS_N'] = essays_sentiment_TS_N
X_Test['sentiment_essay_TS_NE'] = essays_sentiment_TS_NE
X_Test['sentiment_essay_TS_C'] = essays_sentiment_TS_C

sentiment_norm_P = Normalizer(norm='l2', copy=False)
sentiment_norm_N = Normalizer(norm='l2', copy=False)
sentiment_norm_NE = Normalizer(norm='l2', copy=False)
sentiment_norm_C = Normalizer(norm='l2', copy=False)


sentiment_norm_P.fit(X_Train['sentiment_essay_TR_P'].values.reshape(1,-1))
sentiment_norm_N.fit(X_Train['sentiment_essay_TR_N'].values.reshape(1,-1))
sentiment_norm_NE.fit(X_Train['sentiment_essay_TR_NE'].values.reshape(1,-1))
sentiment_norm_C.fit(X_Train['sentiment_essay_TR_C'].values.reshape(1,-1))

sentiment_Train_P = sentiment_norm_P.transform(X_Train['sentiment_essay_TR_P'].values.reshape(1,-1))
sentiment_Test_P = sentiment_norm_P.transform(X_Test['sentiment_essay_TS_P'].values.reshape(1,-1))
sentiment_Train_N = sentiment_norm_N.transform(X_Train['sentiment_essay_TR_N'].values.reshape(1,-1))
sentiment_Test_N = sentiment_norm_N.transform(X_Test['sentiment_essay_TS_N'].values.reshape(1,-1))
sentiment_Train_NE = sentiment_norm_NE.transform(X_Train['sentiment_essay_TR_NE'].values.reshape(1,-1))
sentiment_Test_NE = sentiment_norm_NE.transform(X_Test['sentiment_essay_TS_NE'].values.reshape(1,-1))
sentiment_Train_C = sentiment_norm_C.transform(X_Train['sentiment_essay_TR_C'].values.reshape(1,-1))
sentiment_Test_C = sentiment_norm_C.transform(X_Test['sentiment_essay_TS_C'].values.reshape(1,-1))

sentiment_Train_P = (X_Train['sentiment_essay_TR_P'].values.reshape(-1,1))
sentiment_Test_P = (X_Test['sentiment_essay_TS_P'].values.reshape(-1,1))
sentiment_Train_N = (X_Train['sentiment_essay_TR_N'].values.reshape(-1,1))
sentiment_Test_N = (X_Test['sentiment_essay_TS_N'].values.reshape(-1,1))
sentiment_Train_NE = (X_Train['sentiment_essay_TR_NE'].values.reshape(-1,1))
sentiment_Test_NE = (X_Test['sentiment_essay_TS_NE'].values.reshape(-1,1))
sentiment_Train_C = (X_Train['sentiment_essay_TR_C'].values.reshape(-1,1))
sentiment_Test_C = (X_Test['sentiment_essay_TS_C'].values.reshape(-1,1))


print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_P.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_P.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_N.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_N.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_NE.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_NE.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_C.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_C.shape)
```

```
100%|██████████| 73196/73196 [03:08<00:00, 387.92it/s]
100%|██████████| 36052/36052 [01:33<00:00, 385.50it/s]Shape of sentiment Train matrix after one hot encodig  (73196, 1)
Shape of sentiment Test matrix after one hot encodig  (36052, 1)
Shape of sentiment Train matrix after one hot encodig  (73196, 1)
Shape of sentiment Test matrix after one hot encodig  (36052, 1)
Shape of sentiment Train matrix after one hot encodig  (73196, 1)
Shape of sentiment Test matrix after one hot encodig  (36052, 1)
Shape of sentiment Train matrix after one hot encodig  (73196, 1)
Shape of sentiment Test matrix after one hot encodig  (36052, 1)
```

Assignment 8: DT

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

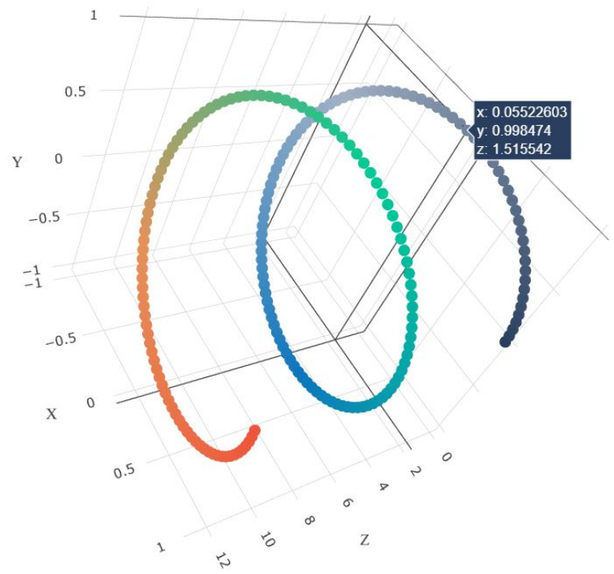
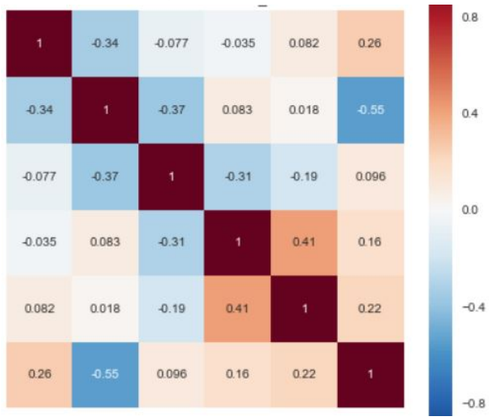
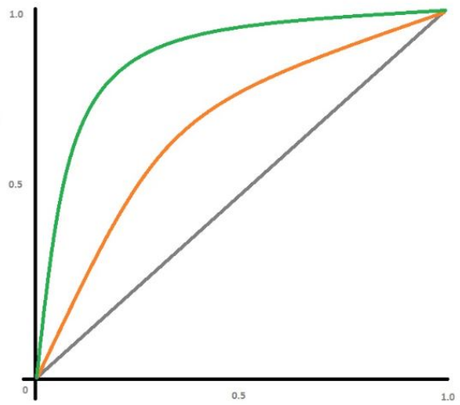


figure with X-axis as **min_sample_split**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

or

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

[seaborn heat maps](#) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
- You choose either of the plotting techniques out of 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test. 

- Along with plotting ROC curve, you need to print the [confusion matrix](#) with predicted and original labels of test data points

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

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

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

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

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

1.5.4 Merging all the above features

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

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
TFIDF_Train = hstack((categories_one_hot_Train,sub_categories_one_hot_Train,school_one_hot_Train,grade_one_hot_Train,prefix_one_hot_Train,text_tfidf_Train,t
print(TFIDF_Train.shape)
TFIDF_W2V_Train = hstack((categories_one_hot_Train,sub_categories_one_hot_Train,school_one_hot_Train,grade_one_hot_Train,prefix_one_hot_Train,tfidf_w2v_vect
print(TFIDF_W2V_Train.shape)
```

```
(73196, 16884)
(73196, 709)
```

```
TFIDF_Test = hstack((categories_one_hot_Test,sub_categories_one_hot_Test,school_one_hot_Test,grade_one_hot_Test,prefix_one_hot_Test,text_tfidf_Test,title_tf
print(TFIDF_Test.shape)
TFIDF_W2V_Test = hstack((categories_one_hot_Test,sub_categories_one_hot_Test,school_one_hot_Test,grade_one_hot_Test,prefix_one_hot_Test,tfidf_w2v_vectors_Te
print(TFIDF_W2V_Test.shape)
```

```
(36052, 16884)
(36052, 709)
```

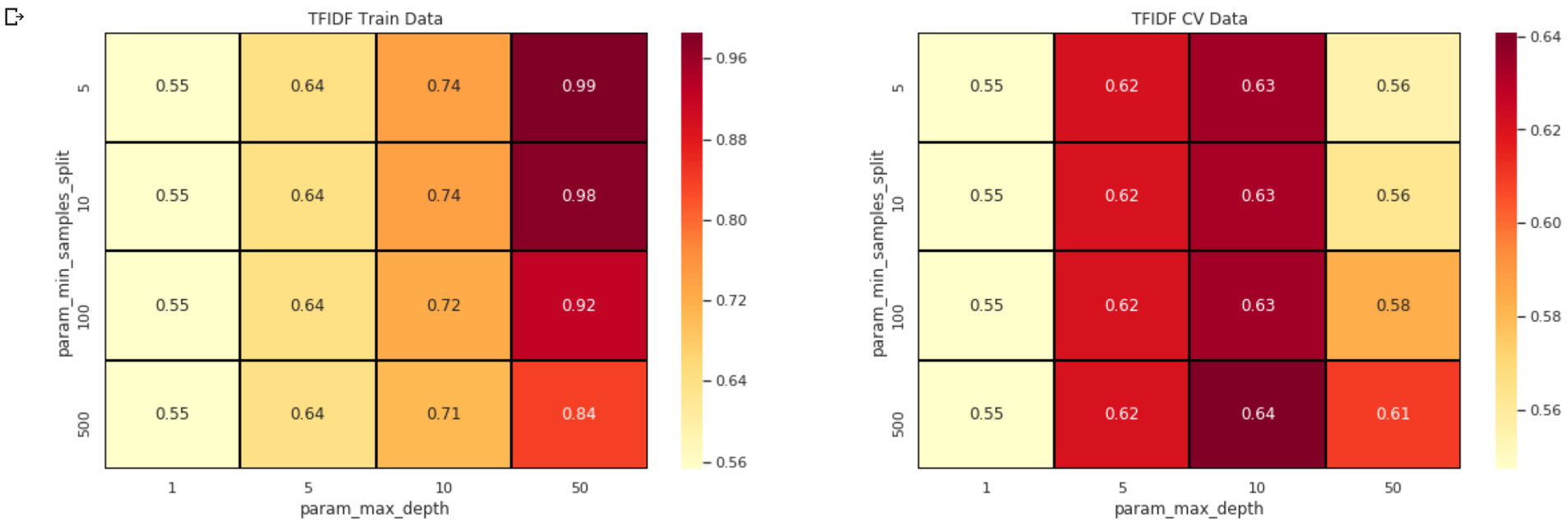
Applying Decision Tree on TFIDF, SET 1

```
%%time
Dec_Tree = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50], 'min_samples_split': [5, 10, 100, 500]}
Dec_Tree_C = RandomizedSearchCV(Dec_Tree, parameters, cv=3, scoring='roc_auc',return_train_score=True,n_iter=30)
Dec_Tree_C.fit(TFIDF_Train, Y_Train)
print(Dec_Tree_C.best_estimator_)
#print(Dec_Tree_C.cv_results_)
```

```
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')
CPU times: user 14min 51s, sys: 30.3 ms, total: 14min 52s
Wall time: 14min 52s
```

TFIDF Heatmap

```
sns.set()
Dec_Tree_CV = pd.DataFrame(Dec_Tree_C.cv_results_).groupby(['param_min_samples_split', 'param_max_depth']).max().unstack()[['mean_test_score','mean_train_sc
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(Dec_Tree_CV.mean_train_score, annot = True,cbar=True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[0])
sns.heatmap(Dec_Tree_CV.mean_test_score, annot = True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[1])
ax[0].set_title('TFIDF Train Data')
ax[1].set_title('TFIDF CV Data')
plt.show()
```




```
#Fitting Model to Hyper-Parameter Curve
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

TFIDF_MD=(Dec_Tree_C.best_params_['max_depth'])
TFIDF_MSS=(Dec_Tree_C.best_params_['min_samples_split'])
Dec_Tree_C_OP=DecisionTreeClassifier(class_weight = 'balanced',max_depth=TFIDF_MD,min_samples_split=TFIDF_MSS)
Dec_Tree_C_OP.fit(TFIDF_Train, Y_Train)

Y_Train_PR = Dec_Tree_C_OP.predict_proba(TFIDF_Train) [:,1]
Y_Test_PR = Dec_Tree_C_OP.predict_proba(TFIDF_Test) [:,1]

fpr_Train, tpr_Train, thresholds_Train = roc_curve(Y_Train, Y_Train_PR)
fpr_Test, tpr_Test, thresholds_Test = roc_curve(Y_Test, Y_Test_PR)

TFIDF_AUC = auc(fpr_Test, tpr_Test)
plt.plot([0,1],[0,1],'k-',color='blue')
plt.plot(fpr_Train, tpr_Train, label="Train AUC")
plt.plot(fpr_Test, tpr_Test, label="Test AUC")
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ROC Curve")
plt.show()
print("-"*120)
print("Optimal value of AUC Train =",auc(fpr_Train, tpr_Train))
print("Optimal value of AUC Test =",auc(fpr_Test, tpr_Test))
pred1 = Dec_Tree_C_OP.predict(TFIDF_Train)
```

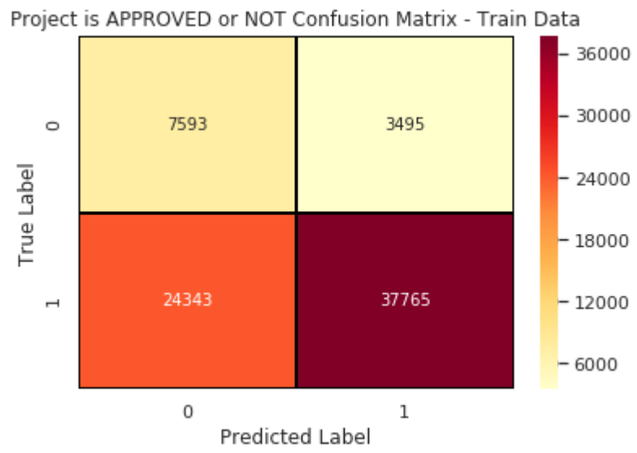
```
28 pred2 = Dec_Tree_C_OP.predict(TFIDF_Test)
```


```
------------------------------------------------------------------------------------------------------------------------
Optimal value of AUC Train = 0.7007161862927224
Optimal value of AUC Test = 0.6218123067835468
```

Confusion Matrix

```
1 #https://seaborn.pydata.org/generated/seaborn.heatmap.html
2 #https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
3 #https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
4 %matplotlib inline
5 Train = confusion_matrix(Y_Train, pred1)
6 sns.heatmap(Train,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
7 plt.ylabel('True Label')
8 plt.xlabel('Predicted Label')
9 plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Train Data')
```



OBSERVATION:

True Negative = 7593; False Negative = 24343; True Positive = 37765; False Positive = 3495

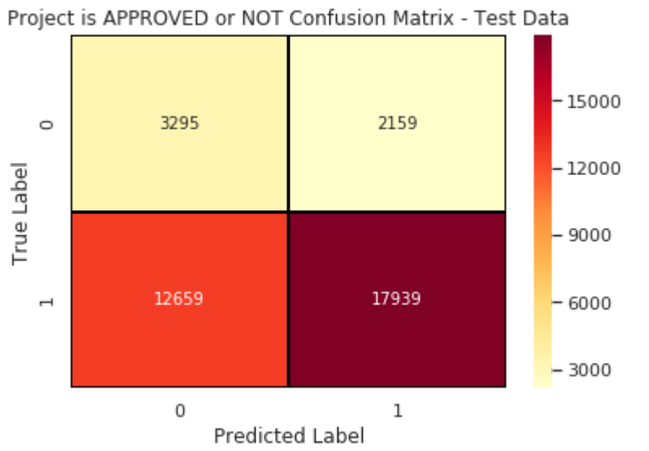
Accuracy (Overall, how often is the classifier correct) = 0.62

Precision(When it predicts yes, how often is it correct) =0.92

Misclassification (Overall, how often is it wrong) =0.39

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
#https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
Test = confusion_matrix(Y_Test, pred2)
sns.heatmap(Test,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Test Data')
```



OBSERVATION:

True Negative = 3295; False Negative = 12659; True Positive = 17939; False Positive = 2159

Accuracy (Overall, how often is the classifier correct) = 0.59

Precision(When it predicts yes, how often is it correct) =0.90

Misclassification (Overall, how often is it wrong) =0.42

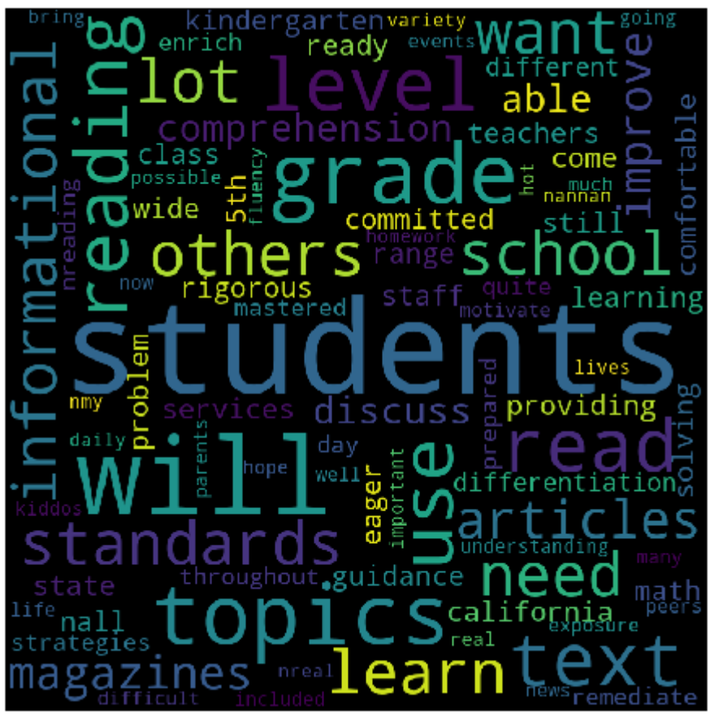
WordCloud

```
#https://www.geeksforgeeks.org/generating-word-cloud-python/
fpi = []
for i in range(len(Y_Test)) :
  if (Y_Test[i] == 0) & (pred2[i] == 1) :
    fpi.append(i)

X_Test_ES = pd.DataFrame(X_Test['essay'])

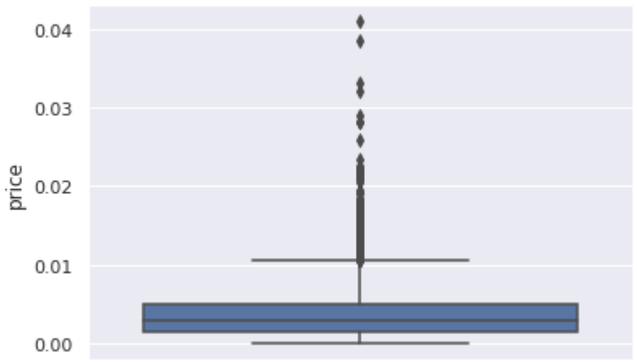
fp_essay1 = []
for i in fpi :
  #pdb.set_trace()
  fp_essay1.append(X_Test_ES['essay'][i])
# Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
```

```
22 for words in tokens :
23   comment_words = comment_words + words + ' '
24
25 wordcloud = WordCloud(width = 800, height = 800, background_color ='black', stopwords = stopwords,
26 min_font_size = 10).generate(comment_words)
27
28 plt.figure(figsize = (6, 6), facecolor = None)
29 plt.imshow(wordcloud)
30 plt.axis("off")
31 plt.tight_layout(pad = 0)
32 plt.show()
```



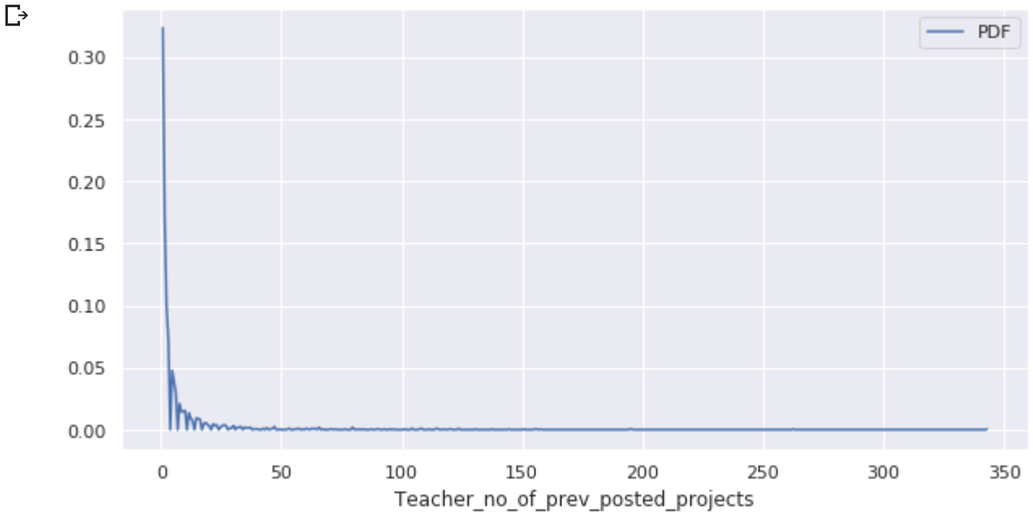

```
1 cols = X_Test.columns
2 X_Test_fp = pd.DataFrame(columns=cols)
3 for i in fpi :
4   X_Test_fp = X_Test_fp.append(X_Test.filter(items=[i], axis=0))
5 sns.boxplot(y='price', data=X_Test_fp)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4679451748>
```




```
1 #PDF (FP ,teacher_number_of_previously_posted_projects)
2 plt.figure(figsize=(10,5))
```

```
counts, bin_edges = np.histogram(X_Test_fp['teacher_number_of_previously_posted_projects'],bins='auto', density=True)
pdf = counts/sum(counts)
pdfP, = plt.plot(bin_edges[1:], pdf)
plt.legend([pdfP], ["PDF"])
plt.xlabel('Teacher_no_of_prev_posted_projects')
plt.show()
```




```
#Feature aggregation
feat_1=vectorizer_cat.get_feature_names()
feat_2=vectorizer_sub_cat.get_feature_names()
feat_3=vectorizer_school.get_feature_names()
feat_4=vectorizer_prefix.get_feature_names()
feat_5=vectorizer_grade.get_feature_names()
feat_ES=vectorizer_essays_tfidf.get_feature_names()
feat_TT=vectorizer_titles_tfidf.get_feature_names()

feat_net_tfidf = feat_1 + feat_2 + feat_3 + feat_4 + feat_5 + feat_ES + feat_TT
# p is price, q is quantity, t is teacher previous year projects
feat_net_tfidf.append('price')
feat_net_tfidf.append('quantity')
feat_net_tfidf.append('prev_proposed_projects')
feat_net_tfidf.append("title_word_count")
feat_net_tfidf.append("essay_word_count")
feat_net_tfidf.append('sentiment_Test_P')
feat_net_tfidf.append('sentiment_Test_N')
feat_net_tfidf.append('sentiment_Test_NE')
feat_net_tfidf.append('sentiment_Test_C')

print(len(feat_net_tfidf))
```

```
16884
```

```
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
Dec_Tree_C_OP=DecisionTreeClassifier(class_weight = 'balanced',max_depth=TFIDF_MD,min_samples_split=TFIDF_MSS)
Dec_Tree_C_OP.fit(TFIDF_Train, Y_Train)
dot_data = tree.export_graphviz(Dec_Tree_C_OP, out_file=None, feature_names=feat_net_tfidf)
graph = graphviz.Source(dot_data)
graph.format = 'png'
graph.render("Tfidf decision tree",view = True)
dot_data = StringIO()
```

```
export_graphviz(Dec_Tree_C_OP, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature_names=feat_net_tfidf,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

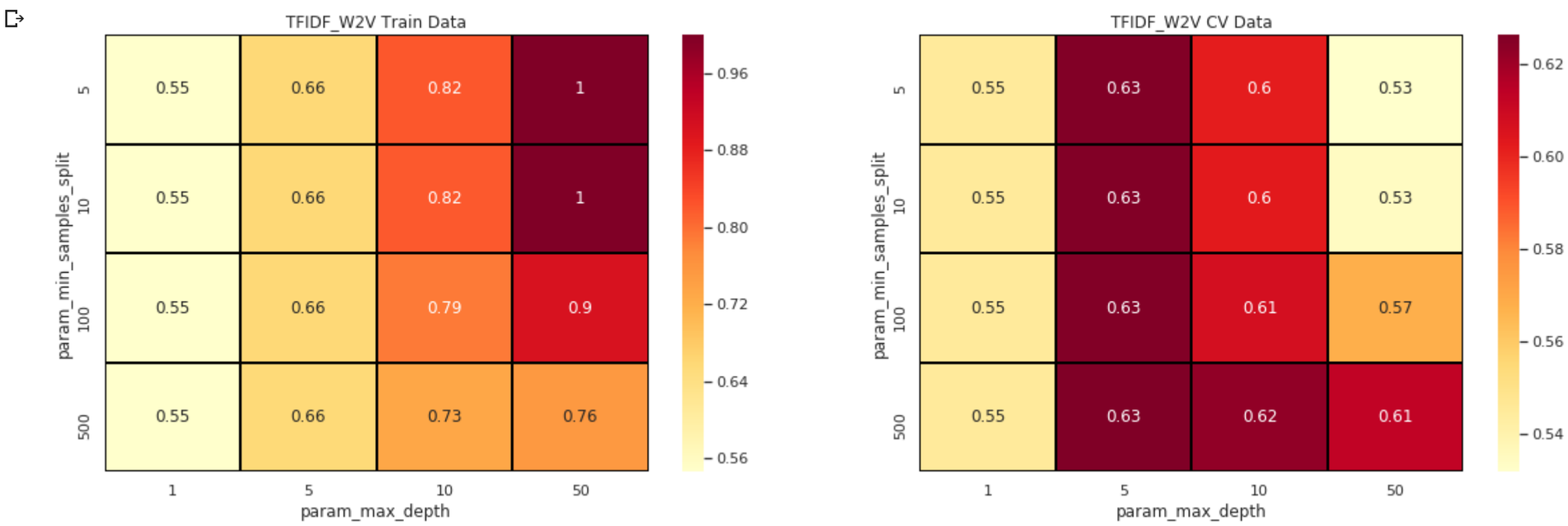
Applying Decision Tree on TFIDF_W2V, SET 2

```
%%time
Dec_Tree = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50], 'min_samples_split': [5, 10, 100, 500]}
Dec_Tree_C = RandomizedSearchCV(Dec_Tree, parameters, cv=3, scoring='roc_auc',return_train_score=True,n_iter=30)
Dec_Tree_C.fit(TFIDF_W2V_Train, Y_Train)
print(Dec_Tree_C.best_estimator_)
#print(Dec_Tree_C.cv_results_)
```

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini', max_depth=5,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=500,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
CPU times: user 25min 46s, sys: 409 ms, total: 25min 46s
Wall time: 25min 46s
```

TFIDF W2V Heatmap

```
sns.set()
Dec_Tree_CV = pd.DataFrame(Dec_Tree_C.cv_results_).groupby(['param_min_samples_split', 'param_max_depth']).max().unstack()[['mean_test_score','mean_train_sc
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(Dec_Tree_CV.mean_train_score, annot = True,cbar=True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[0])
sns.heatmap(Dec_Tree_CV.mean_test_score, annot = True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[1])
ax[0].set_title('TFIDF_W2V Train Data')
ax[1].set_title('TFIDF_W2V CV Data')
plt.show()
```




```
#Fitting Model to Hyper-Parameter Curve
```

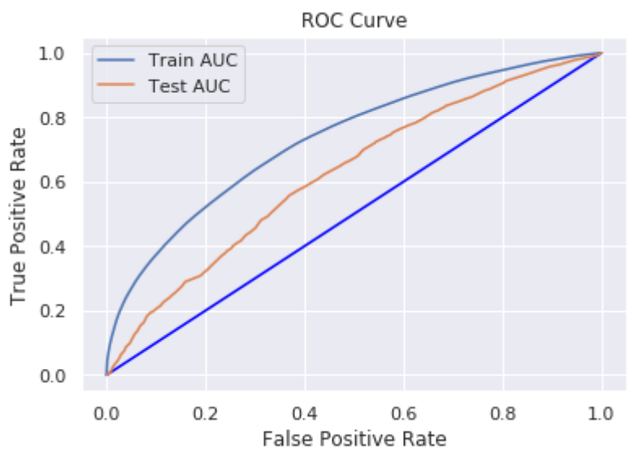
```
#Fitting Model to Hyper-Parameter Curve
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

TFIDF_W2V_MD=(Dec_Tree_C.best_params_['max_depth'])
TFIDF_W2V_MSS=(Dec_Tree_C.best_params_['min_samples_split'])
Dec_Tree_C_OP=DecisionTreeClassifier(class_weight = 'balanced',max_depth=TFIDF_MD,min_samples_split=TFIDF_MSS)
Dec_Tree_C_OP.fit(TFIDF_W2V_Train, Y_Train)

Y_Train_PR = Dec_Tree_C_OP.predict_proba(TFIDF_W2V_Train) [:,1]
Y_Test_PR = Dec_Tree_C_OP.predict_proba(TFIDF_W2V_Test) [:,1]

fpr_Train, tpr_Train, thresholds_Train = roc_curve(Y_Train, Y_Train_PR)
fpr_Test, tpr_Test, thresholds_Test = roc_curve(Y_Test, Y_Test_PR)

TFIDF_W2V_AUC = auc(fpr_Test, tpr_Test)
plt.plot([0,1],[0,1],'k-',color='blue')
plt.plot(fpr_Train, tpr_Train, label="Train AUC")
plt.plot(fpr_Test, tpr_Test, label="Test AUC")
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ROC Curve")
plt.show()
print("-"*120)
print("Optimal value of AUC Train =",auc(fpr_Train, tpr_Train))
print("Optimal value of AUC Test =",auc(fpr_Test, tpr_Test))
pred3 = Dec_Tree_C_OP.predict(TFIDF_W2V_Train)
pred4 = Dec_Tree_C_OP.predict(TFIDF_W2V_Test)
```



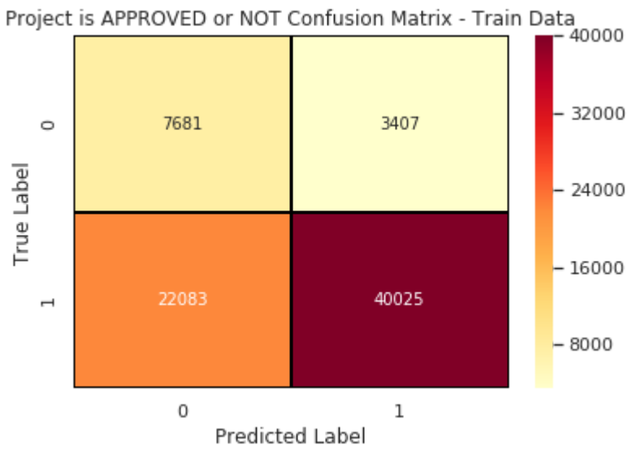

```
------------------------------------------------------------------------------------------------------------------------
Optimal value of AUC Train = 0.7335238586109045
Optimal value of AUC Test = 0.6240460475988554
```

Confusion Matrix

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
#https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
%matplotlib inline
Train = confusion_matrix(Y_Train, pred3)
sns.heatmap(Train,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
```

```
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Train Data')
```



OBSERVATION:

True Negative = 7681; False Negative = 22083; True Positive = 40025; False Positive = 3407

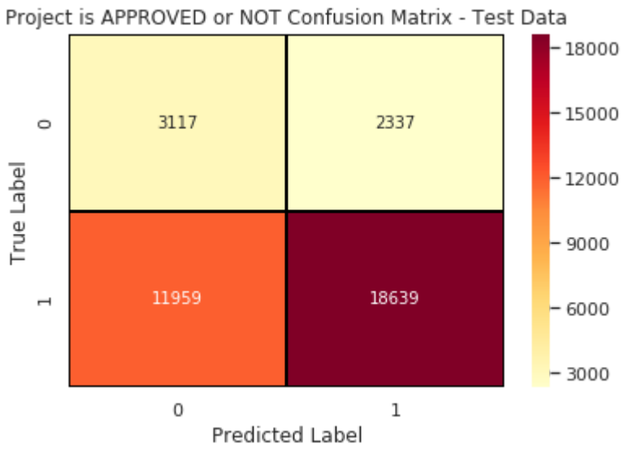
Accuracy (Overall, how often is the classifier correct) = 0.66

Precision(When it predicts yes, how often is it correct) =0.93

Misclassification (Overall, how often is it wrong) =0.35

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
#https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
Test = confusion_matrix(Y_Test, pred4)
sns.heatmap(Test,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Test Data')
```



OBSERVATION:

True Negative = 3117; False Negative = 11959; True Positive = 18639; False Positive = 2337

Accuracy (Overall, how often is the classifier correct) = 0.61

Precision(When it predicts yes, how often is it correct) =0.89

WordCloud

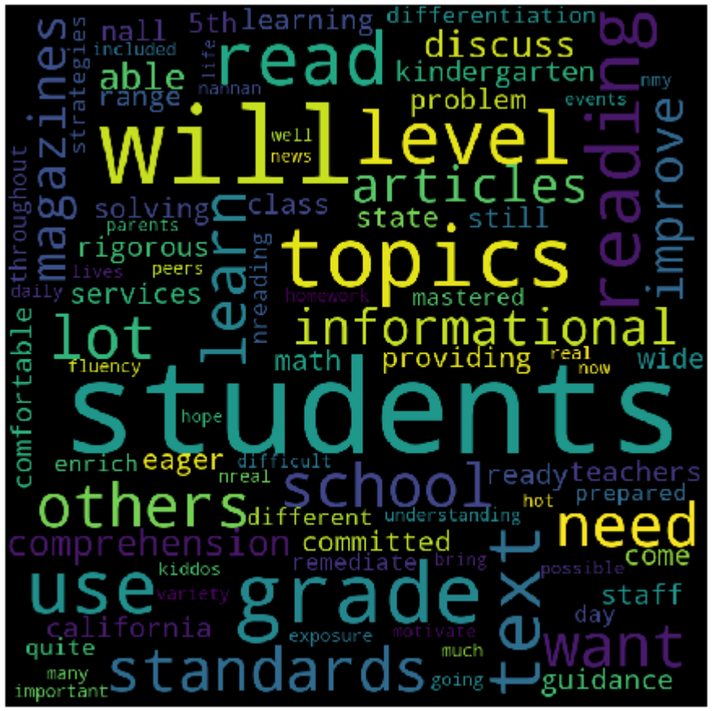
```
#https://www.geeksforgeeks.org/generating-word-cloud-python/
fpi = []
for i in range(len(Y_Test)) :
  if (Y_Test[i] == 0) & (pred2[i] == 1) :
    fpi.append(i)

X_Test_ES = pd.DataFrame(X_Test['essay'])

fp_essay1 = []
for i in fpi :
  #pdb.set_trace()
  fp_essay1.append(X_Test_ES['essay'][i])
# Word cloud of essay
from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
stopwords = set(STOPWORDS)
for val in fp_essay1 :
  val = str(val)
  tokens = val.split()
for i in range(len(tokens)):
  tokens[i] = tokens[i].lower()
for words in tokens :
  comment_words = comment_words + words + ' '

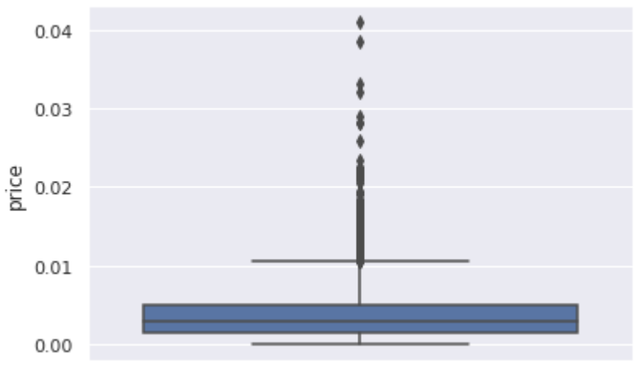
wordcloud = WordCloud(width = 800, height = 800, background_color ='black', stopwords = stopwords,
min_font_size = 10).generate(comment_words)

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

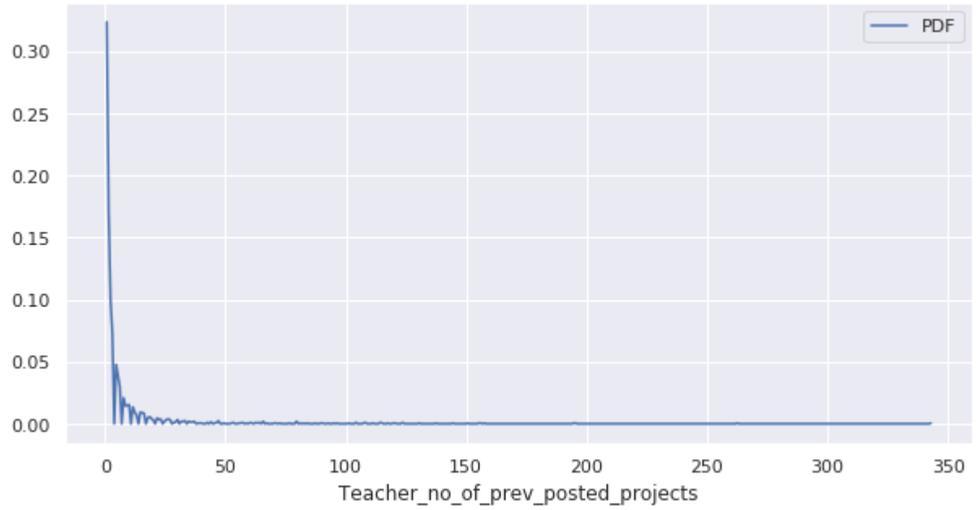



```
1 cols = X_Test.columns
2 X_Test_fp = pd.DataFrame(columns=cols)
3 for i in fpi :
4   X_Test_fp = X_Test_fp.append(X_Test.filter(items=[i], axis=0))
5 sns.boxplot(y='price', data=X_Test_fp)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f46c816ccf8>
```




```
1 #PDF (FP ,teacher_number_of_previously_posted_projects)
2 plt.figure(figsize=(10,5))
3 counts, bin_edges = np.histogram(X_Test_fp['teacher_number_of_previously_posted_projects'],bins='auto', density=True)
4 pdf = counts/sum(counts)
5 pdfP, = plt.plot(bin_edges[1:], pdf)
6 plt.legend([pdfP], ["PDF"])
7 plt.xlabel('Teacher_no_of_prev_posted_projects')
8 plt.show()
```



[Task-2]Applying Decision Tree on Non-zero features importance of Set-1

```
#https://www.geeksforgeeks.org/numpy-nonzero-in-python/
# Coverting the Non-zero important features into a new dataset

Dec_Tree_C1=DecisionTreeClassifier(class_weight = 'balanced',max_depth=None,min_samples_split=TFIDF_MSS)
Dec_Tree_C1.fit(TFIDF_Train, Y_Train)
Fe_Im=Dec_Tree_C1.feature_importances_
NZFI = np.nonzero(Fe_Im)
df = pd.DataFrame(TFIDF_Train.toarray())

ls=[]
NZFI_TR= pd.DataFrame()
NZFI1_TR=list(NZFI)
for i in NZFI1_TR:
    ls.append(i)
for j in ls:
  for k in j:
      m=int(k)
      fn=feat_net_tfidf[m]
      t_ls=list(df[m])
      NZFI_TR[fn] = t_ls

df_ts = pd.DataFrame(TFIDF_Test.toarray())
ls_ts=[]
NZFI_TS= pd.DataFrame()

NZFI1_TS=list(NZFI1_TR)
for i in NZFI1_TS:
    ls_ts.append(i)
for j in ls_ts:
  for k in j:
      m=int(k)
      fn=feat_net_tfidf[m]
      t_ls_ts=list(df_ts[m])
      NZFI_TS[fn] = t_ls_ts
print("-"*120)
print("Shape of the Non Zero features important Train Dataset:",NZFI_TR.shape)
```

```
print("Shape of the Non Zero features important Test Dataset:",NZFI_TS.shape)

```

```
----------------------------------------------------------------------------------------------------------------------
Shape of the Non Zero features important Train Dataset: (73196, 1077)
Shape of the Non Zero features important Test Dataset: (36052, 1077)
```

```
# Non-zero important features of Set-1
for j in ls:
  for k in j:
      m=int(k)
      fn=feat_net_tfidf[m]
      print(fn)
```

Literacy_Language
PerformingArts
wv
ar
mn
ga
ny
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grades_6_8
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14
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17
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3rd
4th
54
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80
83
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acceptance
accomplish
account
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acquire
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allowing
alphabet
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basketball
bathroom
batteries
beach
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beating
beautiful
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brave
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bundle
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capable
cardio
cards
care
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carpet
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centers
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charts
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check
child
choice
chorus
chromebook
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classroom
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cleaning
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clever
close
closer
clothes
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compassionate
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concerts
conditions
confidence
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foreign
forever
fossils

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fractions
freshman
frog
frost
frustration
fueled
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struggle
struggles
students
subscriptions
suburb
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supportive
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books
bookworms
carpet
centers
chromebooks
classic
classroom
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discovery
dramatic
drumming
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explore
first
fit
flood
great

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grow
health
hidden
imaginative
ipads
keeps
kindergarten
kindle
leaders
learners
library
love
manipulatives
move
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needed
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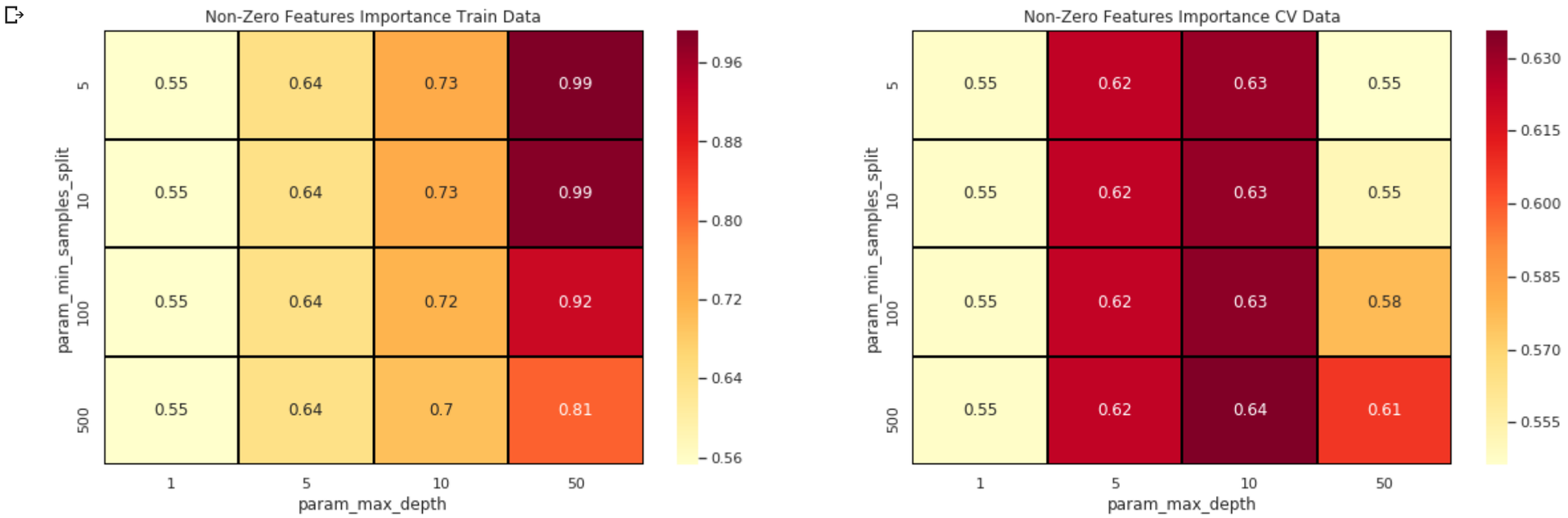
organization
place
playground
preschool
printer
readers
recess
scientist
see
sit
space
special
stand
super
teach
teaching
time
under
up
us
want
we
wiggle
without
writing
price
prev_proposed_projects
sentiment_Test_P
sentiment_Test_N
sentiment_Test_NE
sentiment_Test_C
```

```
%%time
Dec_Tree = DecisionTreeClassifier(class_weight = 'balanced')
parameters = {'max_depth': [1, 5, 10, 50], 'min_samples_split': [5, 10, 100, 500]}
Dec_Tree_C = RandomizedSearchCV(Dec_Tree, parameters, cv=3, scoring='roc_auc',return_train_score=True,n_iter=30)
Dec_Tree_C.fit(NZFI_TR, Y_Train)
print(Dec_Tree_C.best_estimator_)
#print(Dec_Tree_C.cv_results_)
```

```
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')
CPU times: user 6min 9s, sys: 71.7 ms, total: 6min 9s
Wall time: 6min 9s
```

Non-zero features importance Heatmap

```
sns.set()
Dec_Tree_CV = pd.DataFrame(Dec_Tree_C.cv_results_).groupby(['param_min_samples_split', 'param_max_depth']).max().unstack()[['mean_test_score','mean_train_sc
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(Dec_Tree_CV.mean_train_score, annot = True,cbar=True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[0])
sns.heatmap(Dec_Tree_CV.mean_test_score, annot = True, fmt='.2g', cmap='YlOrRd', linewidths=1,linecolor='black', ax=ax[1])
ax[0].set_title('Non-Zero Features Importance Train Data')
ax[1].set_title('Non-Zero Features Importance CV Data')
plt.show()
```

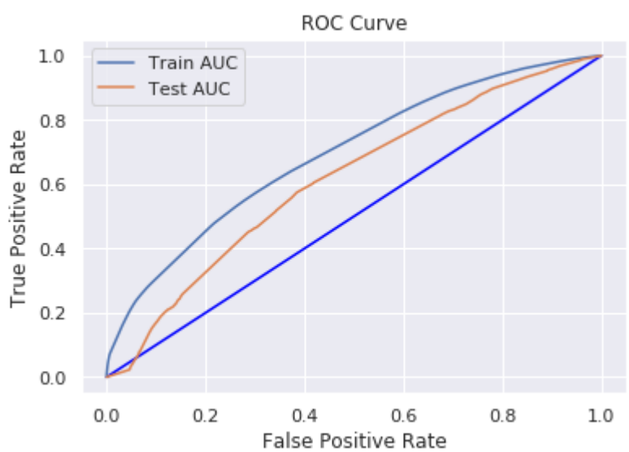



```
#Fitting Model to Hyper-Parameter Curve
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

NZIF_MD=(Dec_Tree_C.best_params_['max_depth'])
NZIF_MSS=(Dec_Tree_C.best_params_['min_samples_split'])
Dec_Tree_C_OP=DecisionTreeClassifier(class_weight = 'balanced',max_depth=TFIDF_MD,min_samples_split=TFIDF_MSS)
# for visulation
Dec_Tree_C_OP.fit(NZFI_TR, Y_Train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn.linear_model.SGDClassifier.decision_function
Y_Train_PR = Dec_Tree_C_OP.predict_proba(NZFI_TR) [:,1]
Y_Test_PR = Dec_Tree_C_OP.predict_proba(NZFI_TS) [:,1]

fpr_Train, tpr_Train, thresholds_Train = roc_curve(Y_Train, Y_Train_PR)
fpr_Test, tpr_Test, thresholds_Test = roc_curve(Y_Test, Y_Test_PR)
```

```
NZIF_AUC = auc(fpr_Test, tpr_Test)
plt.plot([0,1],[0,1],'k-',color='blue')
plt.plot(fpr_Train, tpr_Train, label="Train AUC")
plt.plot(fpr_Test, tpr_Test, label="Test AUC")
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ROC Curve")
plt.show()
print("-"*120)
print("Optimal value of AUC Train =",auc(fpr_Train, tpr_Train))
print("Optimal value of AUC Test =",auc(fpr_Test, tpr_Test))
pred5 = Dec_Tree_C_OP.predict(NZFI_TR)
pred6 = Dec_Tree_C_OP.predict(NZFI_TS)
```

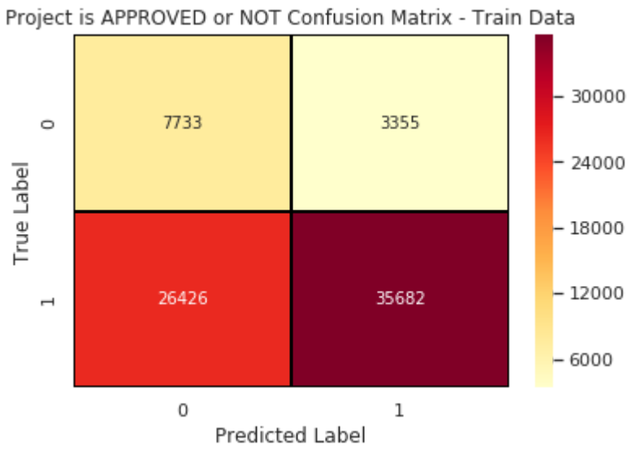



```
------------------------------------------------------------------------------------------------------------------------
Optimal value of AUC Train = 0.6938484698394856
Optimal value of AUC Test = 0.6155285512428185
```

Confusion Matrix

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
#https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
%matplotlib inline
Train = confusion_matrix(Y_Train, pred5)
sns.heatmap(Train,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Train Data')
```



OBSERVATION:

True Negative = 7733; False Negative = 26426; True Positive = 35682; False Positive = 3355

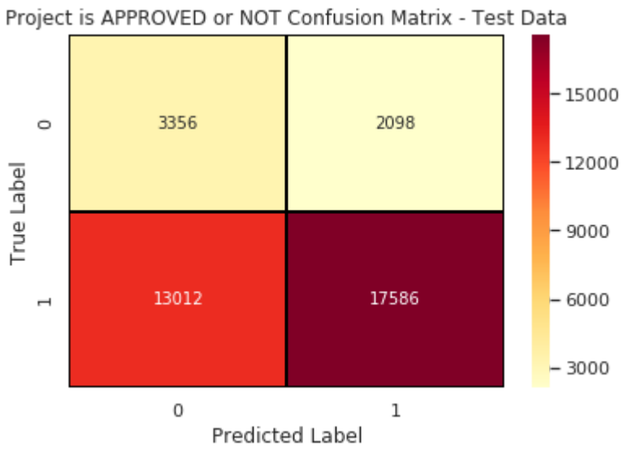
Accuracy (Overall, how often is the classifier correct) = 0.60

Precision(When it predicts yes, how often is it correct) =0.92

Misclassification (Overall, how often is it wrong) =0.41

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
#https://stackoverflow.com/questions/19233771/sklearn-plot-confusion-matrix-with-labels
Test = confusion_matrix(Y_Test, pred6)
sns.heatmap(Test,annot=True,cbar=True,fmt='d', cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
Text(0.5, 1, 'Project is APPROVED or NOT Confusion Matrix - Test Data')
```



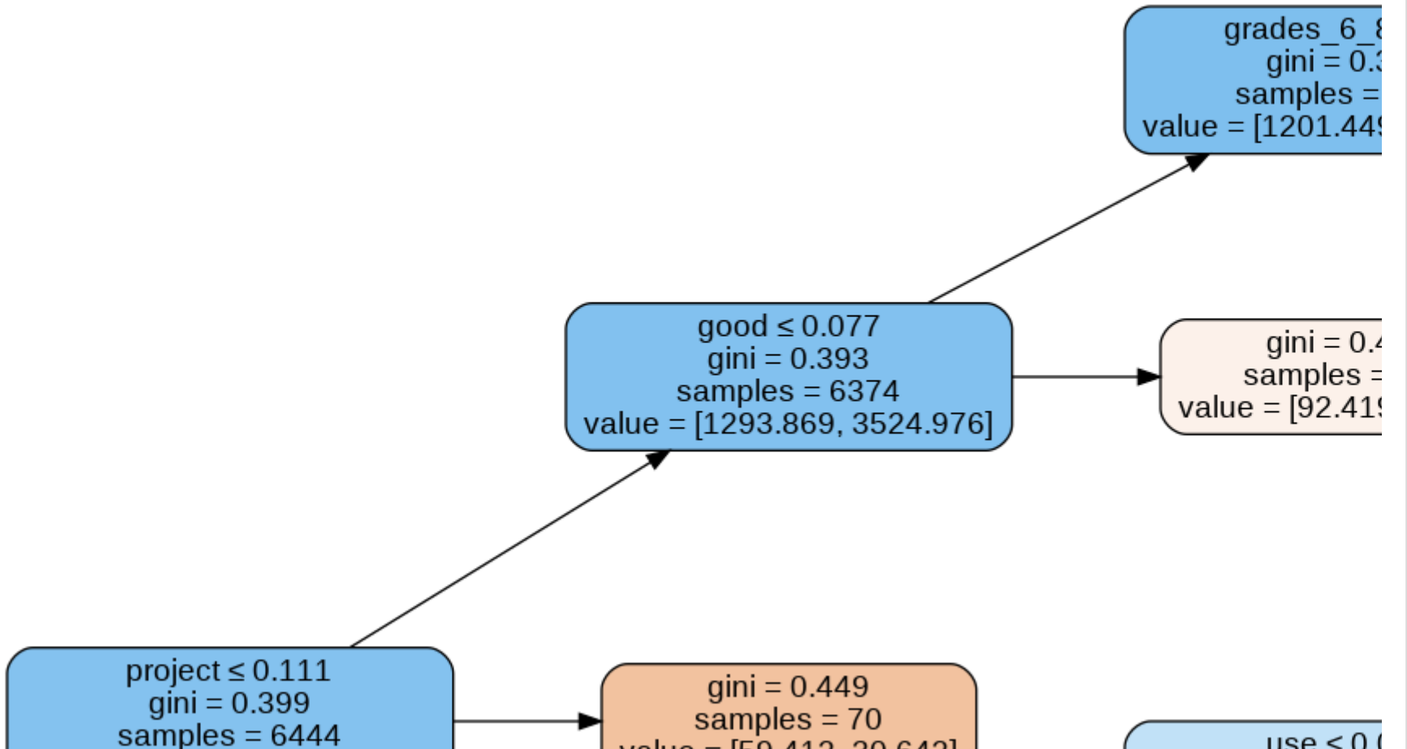
OBSERVATION:

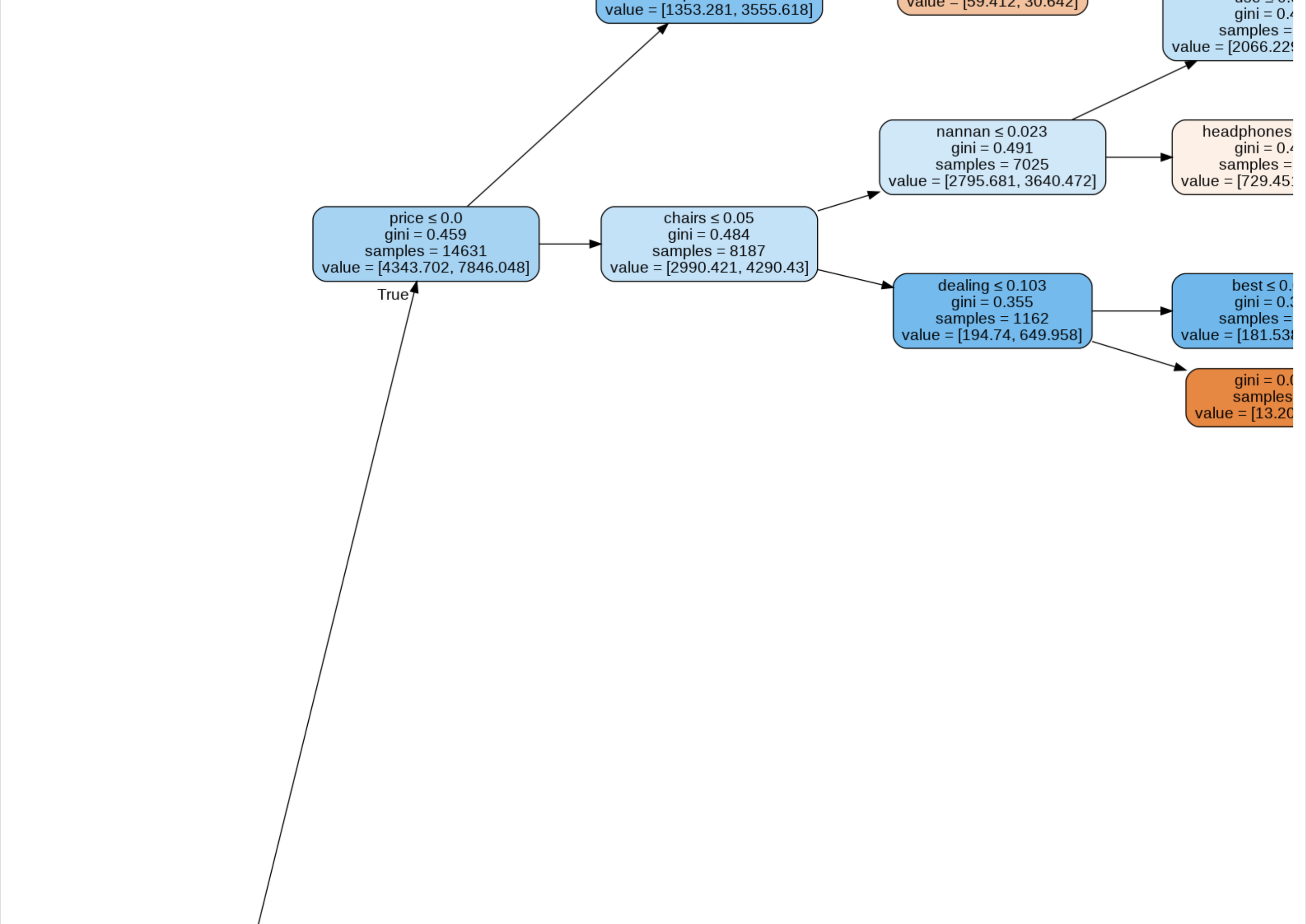
True Negative = 3356; False Negative = 13012; True Positive = 17586; False Positive = 2098

Accuracy (Overall, how often is the classifier correct) = 0.59

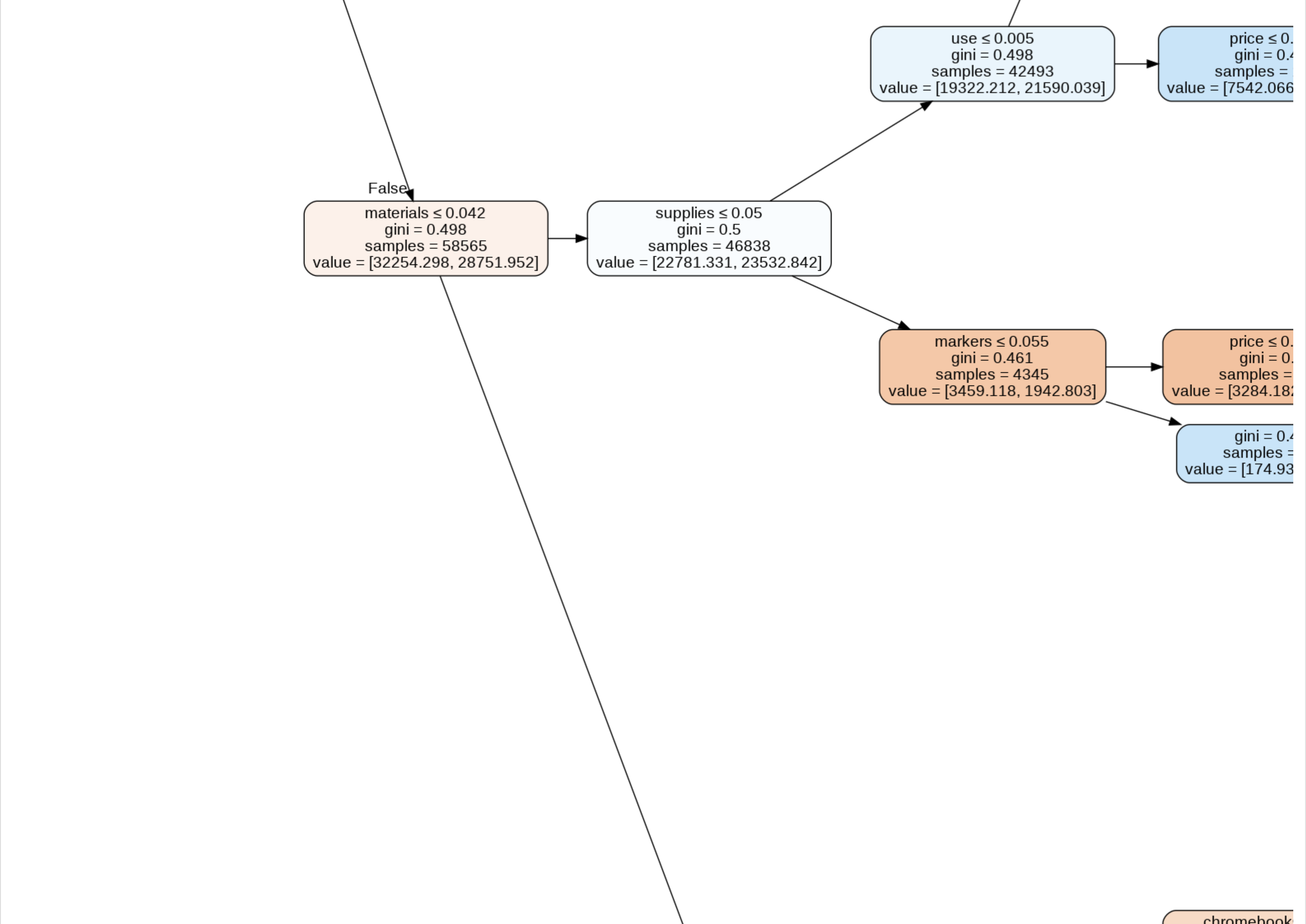
Precision(When it predicts yes, how often is it correct) =0.90

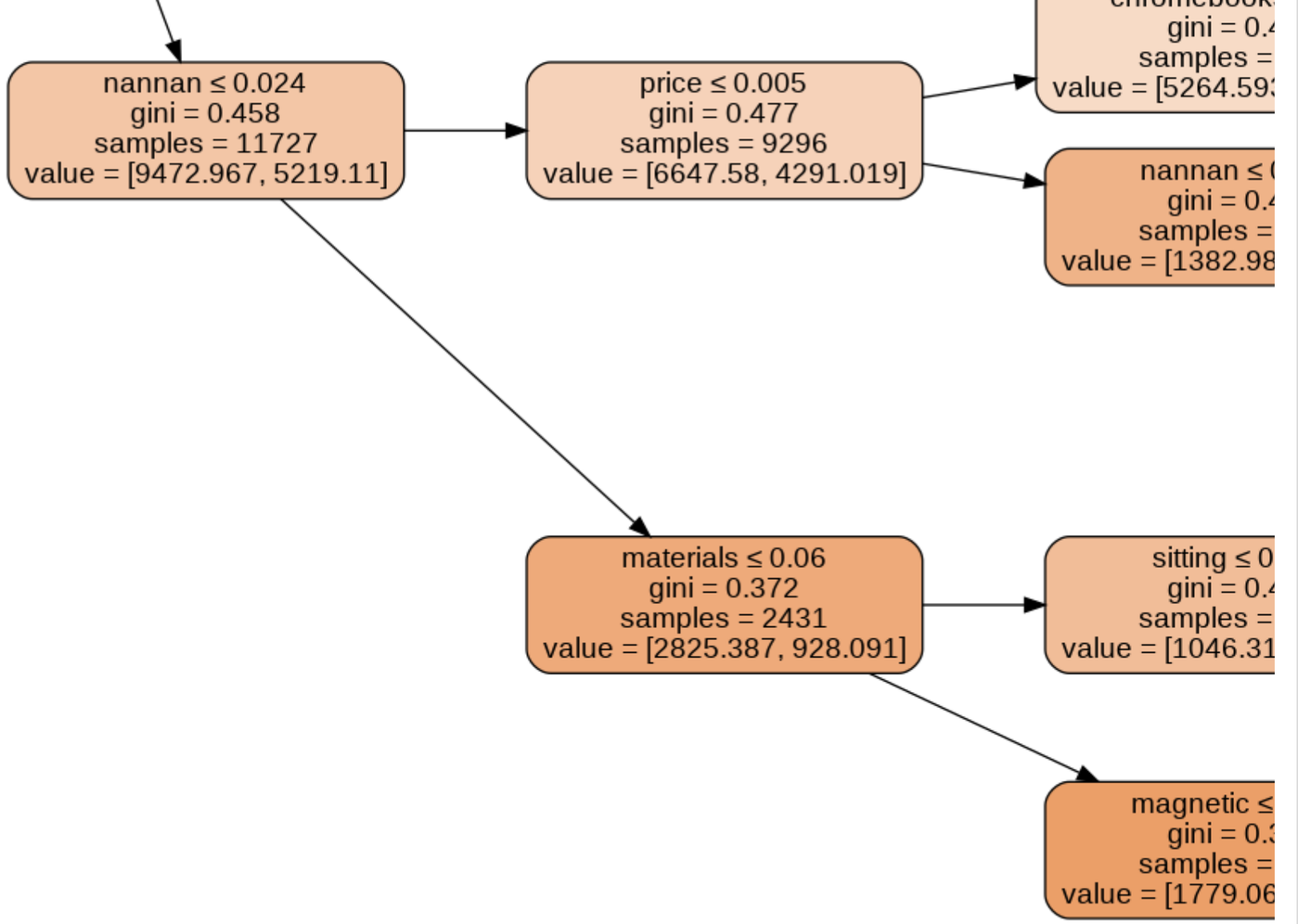
```
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
Dec_Tree_C_OP=DecisionTreeClassifier(class_weight = 'balanced',max_depth=TFIDF_MD,min_samples_split=TFIDF_MSS)
Dec_Tree_C_OP.fit(NZFI_TR, Y_Train)
graph.format = 'png'
dot_data = StringIO()
export_graphviz(Dec_Tree_C_OP, out_file=dot_data, filled=True, rounded=True, special_characters=True, feature_names=NZFI_TR.columns,rotate=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```


grades_6_8
gini = 0.3
samples =
value = [1201.449
good ≤ 0.077
gini = 0.393
samples = 6374
value = [1293.869, 3524.976]
gini = 0.4
samples =
value = [92.419
project ≤ 0.111
gini = 0.399
samples = 6444
gini = 0.449
samples = 70


value = [1353.281, 3555.618]
value = [59.412, 30.642]
gini = 0.4
samples =
value = [2066.22
nannan ≤ 0.023
gini = 0.491
samples = 7025
value = [2795.681, 3640.472]
headphones
gini = 0.4
samples =
value = [729.45
price ≤ 0.0
gini = 0.459
samples = 14631
value = [4343.702, 7846.048]
chairs ≤ 0.05
gini = 0.484
samples = 8187
value = [2990.421, 4290.43]
dealing ≤ 0.103
gini = 0.355
samples = 1162
value = [194.74, 649.958]
best ≤ 0.
gini = 0.3
samples =
value = [181.53
gini = 0.0
samples
value = [13.20
True


price ≤ 0.001
gini = 0.5
samples = 73196
value = [36598.0, 36598.0]
stools ≤ 0
gini = 0
samples =
value = [11780.14


use ≤ 0.005
gini = 0.498
samples = 42493
value = [19322.212, 21590.039]
price ≤ 0.
gini = 0.4
samples =
value = [7542.066
False
materials ≤ 0.042
gini = 0.498
samples = 58565
value = [32254.298, 28751.952]
supplies ≤ 0.05
gini = 0.5
samples = 46838
value = [22781.331, 23532.842]
markers ≤ 0.055
gini = 0.461
samples = 4345
value = [3459.118, 1942.803]
price ≤ 0.
gini = 0.
samples =
value = [3284.182
gini = 0.4
samples =
value = [174.93



3. Conclusions

```
# Please compare all your models using Prettytable library

pt = PrettyTable()
pt.field_names= ("S.No","Vectorizer", "Model", "Max Depth","Min Samples Split", "AUC")
pt.add_row(["1","TFIDF", "DecisionTree",TFIDF_MD, TFIDF_MSS, TFIDF_AUC])
pt.add_row(["2","TFIDF_W2V", "DecisionTree", TFIDF_W2V_MD,TFIDF_W2V_MSS,TFIDF_W2V_AUC])
pt.add_row(["3","[Task-2]-Non Zero Features Importance", "DecisionTree",NZIF_MD,NZIF_MSS, NZIF_AUC])
print(pt)
```

S.No	Vectorizer	Model	Max Depth	Min Samples Split	AUC
1	TFIDF	DecisionTree	10	500	0.6218123067835468
2	TFIDF_W2V	DecisionTree	5	500	0.6240460475988554
3	[Task-2]-Non Zero Features Importance	DecisionTree	10	500	0.6155285512428185

SUMMARY:

1. Compare to KNN and SVM "**DecisionTree**" had less space and time complexity.
2. Overall test accuracy score is average.
3. There is no much difference in the AUC score for Non Zero important fetaures and TFIDF. Both are look similar only.
4. "**TFIDF W2V**" performing very well in accuracy and misclassification scores.When compare to other vectorizer's.