DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

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

Notes on the Essay Data

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

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

```
%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"""
```

```
'\nfrom plotly import plotly\nimport plotly.offline as offline\nimport plotly.graph_objs as go\noffline.init_notebook_mode()\nfrom collections import Counter'
```

```
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).
```

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

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_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']
```

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

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

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

1.2 preprocessing of `project_subject_categories`

```
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]))
```

1.3 preprocessing of `project_subject_subcategories`

```
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]))
```

1.4 Text preprocessing

```
# 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.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	project_title	project_essay_1	project_essay_2	project_essay_3	project_essay_4	project_resource_summary	teacher_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2	Educational Support for English Learners at Home	My students are English learners that are work...	\"The limits of your language are the limits o...	NaN	NaN	My students need opportunities to practice beg...	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades 6-8	Wanted: Projector for Hungry Learners	Our students arrive to our school eager to lea...	The projector we need for our school is very c...	NaN	NaN	My students need a projector to help with view...	

1.4.2.3 Using Pretrained Models: TFIDF weighted W2V

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. We are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of language to our school. \r\n\r\n We have over 24 languages
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at least most of the time. At our school, 97.3% of the students receive free or reduced price lunch. Of the 560 students, 97.3% are minority students. \r\
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to create a warm inviting themed room for my s
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest working past their limitations. \r\n\r\n
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-American, making up the largest segment of the
==================================================
```

```
# 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


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

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest working past their limitations. \r\n\r\n
==================================================
```

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

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest working past their limitations.     The
```

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

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitive delays gross fine motor delays to autism They are eager beavers and always strive to work their hardest working past their limitations The materials
```

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

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

```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gross fine motor delays autism they eager beavers always strive work hardest working past limitations the materials ones i seek students i teach title i s
```

1.4 Preprocessing of `project_title`

```
# similarly you can preprocess the titles also
# printing some random project_title.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[99999])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
We Need To Move It While We Input It!
==================================================
Inspiring Minds by Enhancing the Educational Experience
==================================================
```

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

```
100%|██████████| 109248/109248 [00:02<00:00, 45770.90it/s]
```

```
preprocessed_project_title[99999]
```

```
'inspiring minds enhancing educational experience'
```

```
#upperCase to lowercase
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
#removing puntuation from the column
#https://stackoverflow.com/questions/39782418/remove-punctuations-in-pandas
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('[^\w\s]','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')


#Teacher Prefix

#upperCase to lowercase
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
#removing puntuation from the column
#https://stackoverflow.com/questions/39782418/remove-punctuations-in-pandas
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('[^\w\s]','')



#upperCase to lowercase
project_data['school_state'] = project_data['school_state'].str.lower()
project_data.school_state.value_counts()
```

```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

1.5 Preparing data for models

```
project_data.columns
```

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

we are going to consider

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

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

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

1.5.1 Vectorizing Categorical data

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

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (109248, 9)
```

```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSp
Shape of matrix after one hot encodig  (109248, 30)
```

```
#project_grade_category

vectorizer = CountVectorizer(vocabulary=list(project_data['project_grade_category'].unique()), lowercase=False, binary=True)
vectorizer.fit(project_data['project_grade_category'].values)
print(vectorizer.get_feature_names())
project_grade_category_one_hot = vectorizer.transform(project_data['project_grade_category'].values)
print("Shape of matrix after one hot encodig ",project_grade_category_one_hot.shape)
```

```
['grades_prek_2', 'grades_6_8', 'grades_3_5', 'grades_9_12']
Shape of matrix after one hot encodig  (109248, 4)
```

```
#state
vectorizer = CountVectorizer(vocabulary=list(project_data['school_state'].unique()), lowercase=False, binary=True)
vectorizer.fit(project_data['school_state'].values)
print(vectorizer.get_feature_names())

state_one_hot = vectorizer.transform(project_data['school_state'].values)
print("Shape of matrix after one hot encodig ",state_one_hot.shape)
```

```
['in', 'fl', 'az', 'ky', 'tx', 'ct', 'ga', 'sc', 'nc', 'ca', 'ny', 'ok', 'ma', 'nv', 'oh', 'pa', 'al', 'la', 'va', 'ar', 'wa', 'wv', 'id', 'tn', 'ms', 'co', 'ut', 'il', 'mi', 'hi', 'ia', 'ri', 'nj', 'mo', 'de', 'mn', 'me', 'wy', 'nd', 'or', 'ak', '
Shape of matrix after one hot encodig  (109248, 51)
```

```
# Before converting to vecter we have to remove NA values from the column , we are filling the value by column mode
project_data['teacher_prefix'].fillna(project_data.teacher_prefix.mode()[0],inplace=True)


#teacher_prefix
vectorizer = CountVectorizer(vocabulary=list(project_data['teacher_prefix'].unique()), lowercase=False, binary=True)
vectorizer.fit(project_data['teacher_prefix'].values)
print(vectorizer.get_feature_names())
teacher_prefix_one_hot = vectorizer.transform(project_data['teacher_prefix'].values)
print("Shape of matrix after one hot encodig ",teacher_prefix_one_hot.shape)
```

```
['mrs', 'mr', 'ms', 'teacher', 'dr']
Shape of matrix after one hot encodig  (109248, 5)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html
vectorizer = CountVectorizer(min_df=10,max_features=5000,ngram_range=(2,2))
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 5000)
```

```
#preprocessed_project_title
```

```
vectorizer = CountVectorizer(min_df=10,max_features=5000,ngram_range=(2,2))
project_title_bow = vectorizer.fit_transform(preprocessed_project_title)
print("Shape of matrix after one hot encodig ",project_title_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 4249)
```

1.5.2.2 TFIDF vectorizer

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(2,2))
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 5000)
```

```
vectorizer = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(2,2))
project_title_tfidf = vectorizer.fit_transform(preprocessed_project_title)
print("Shape of matrix after one hot encodig ",project_title_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 4249)
```

1.5.2.3 Using Pretrained Models: Avg W2V

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


# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|██████████| 109248/109248 [00:30<00:00, 3579.35it/s]109248
300
```

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_project_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_project_title): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_title.append(vector)
print()
print(len(avg_w2v_vectors_project_title))
print(len(avg_w2v_vectors_project_title[0]))
```

```
100%|██████████| 109248/109248 [00:01<00:00, 68229.34it/s]
109248
300
```

1.5.2.4 Using Pretrained Models: TFIDF weighted W2V

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

# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # 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
    tfidf_w2v_vectors.append(vector)
print()
print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|██████████| 109248/109248 [03:17<00:00, 552.82it/s]
109248
300
```

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_pro_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_project_title): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_pro_title.append(vector)
print()
print(len(avg_w2v_vectors_pro_title))
print(len(avg_w2v_vectors_pro_title[0]))
```

```
100%|██████████| 109248/109248 [00:01<00:00, 66009.01it/s]
109248
300
```

1.5.3 Vectorizing Numerical features

```
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')


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

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

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

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

```
price_standardized
```

```
array([[-0.3905327 ],
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

```
previously_posted_scalar = StandardScaler()
previously_posted_scalar.fit(project_data['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # finding the mean and stand
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
previously_posted_standardized = previously_posted_scalar.transform(project_data['teacher_number_of_previously_posted_projects'].values.resh
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

```
previously_posted_standardized
```

```
array([[-0.40152481],
       [-0.14951799],
       [-0.36552384],
       ...,
       [-0.29352189],
       [-0.40152481],
       [-0.40152481]])
```

1.5.4 Merging all the above features

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

```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 5000)
(109248, 1)
```

```
y = project_data['project_is_approved']

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
```

```
#BoW dataset
X_BoW = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized,previously_posted_standardized,
                project_grade_category_one_hot,state_one_hot ,project_title_bow,teacher_prefix_one_hot))
X_BoW.shape
```

```
(109248, 9350)
```

```
#TFIDF dataset
X_tfidf = hstack((categories_one_hot, sub_categories_one_hot, text_tfidf, price_standardized,previously_posted_standardized,
            project_grade_category_one_hot,state_one_hot ,project_title_tfidf,teacher_prefix_one_hot))
X_tfidf.shape
```

```
(109248, 9350)
```

```
#AVG W2V dataset
X_avg_w2v = hstack((categories_one_hot, sub_categories_one_hot, avg_w2v_vectors, price_standardized,previously_posted_standardized,
            project_grade_category_one_hot,state_one_hot ,avg_w2v_vectors_pro_title,teacher_prefix_one_hot))
X_avg_w2v.shape
```

```
(109248, 701)
```

```
#TFIDF W2V
X_tfidf_w2v = hstack((categories_one_hot, sub_categories_one_hot, tfidf_w2v_vectors, price_standardized,previously_posted_standardized,
                project_grade_category_one_hot,state_one_hot ,avg_w2v_vectors_pro_title,teacher_prefix_one_hot))
X_tfidf_w2v.shape
```

```
(109248, 701)
```

Assignment 7: SVM

1. **[Task-1] Apply Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) 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)

2. **The hyper paramter tuning (best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**
   - 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

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.
   - 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. Please visualize your confusion matrices using seaborn heatmaps.

4. **[Task-2] Apply the Support Vector Machines on these features by finding the best hyper paramter as suggested in step 2 and step 3**
   - Consider these set of features Set 5 :
     - **school_state** : categorical data
     - **clean_categories** : categorical data
     - **clean_subcategories** : categorical data
     - **project_grade_category** :categorical data
     - **teacher_prefix** : categorical data
     - **quantity** : numerical data
     - **teacher_number_of_previously_posted_projects** : numerical data
     - **price** : numerical data
     - **sentiment score's of each of the essay** : numerical data
     - **number of words in the title** : numerical data
     - **number of words in the combine essays** : numerical data
     - **Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method** : numerical data
   - **Conclusion**
     - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-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. Support Vector Machines

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

```
# Bow
from sklearn.model_selection import train_test_split
X_train_Bow, X_test_Bow, y_train_Bow, y_test_Bow = train_test_split(X_BoW, y, test_size=0.33, stratify=y)
#X_train_Bow, X_cv_Bow, y_train_Bow, y_cv_Bow = train_test_split(X_train_Bow, y_train_Bow, test_size=0.33, stratify=y_train_Bow)

# tfidf
```

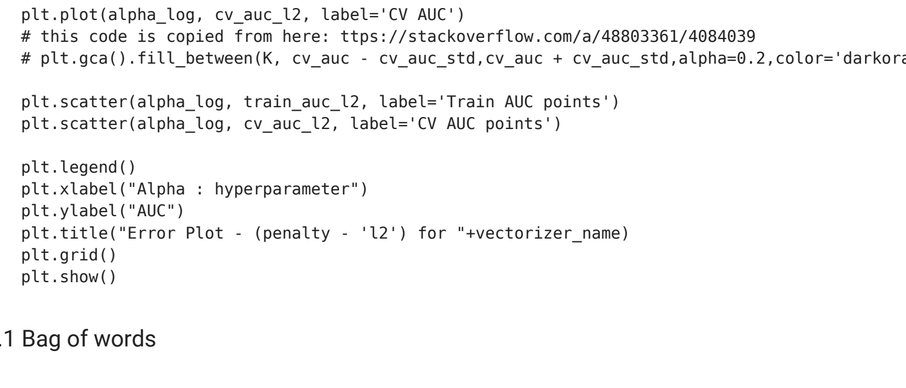
```
# tfidf
X_train_tfidf, X_test_tfidf, y_train_tfidf, y_test_tfidf = train_test_split(X_tfidf, y, test_size=0.33, stratify=y)
#X_train_tfidf, X_cv_tfidf, y_train_tfidf, y_cv_tfidf = train_test_split(X_train_tfidf, y_train_tfidf, test_size=0.33, stratify=y_train_tfid


_avg_w2v

train_avg_w2v, X_test_avg_w2v, y_train_avg_w2v, y_test_avg_w2v = train_test_split(X_avg_w2v, y, test_size=0.33, stratify=y)
_train_avg_w2v, X_cv_avg_w2v, y_train_avg_w2v, y_cv_avg_w2v = train_test_split(X_train_avg_w2v, y_train_avg_w2v, test_size=0.33, stratify=y_



# X_tfidf_w2v
X_train_tfidf_w2v, X_test_tfidf_w2v, y_train_tfidf_w2v, y_test_tfidf_w2v = train_test_split(X_tfidf_w2v, y, test_size=0.33, stratify=y)
#X_train_tfidf_w2v, X_cv_tfidf_w2v, y_train_tfidf_w2v, y_cv_tfidf_w2v = train_test_split(X_train_tfidf_w2v, y_train_tfidf_w2v, test_size=0.3
```

2.2 Make Data Model Ready: encoding numerical, categorical features

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(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))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions


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

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

    return y_data_pred


#this method will plot the graph between AUC vs Alpha Hyperparamter
#first subgraph is for penalty l1 and second is for the l2
def plot_AUC_ROC_Curve(results,alpha_log,vectorizer_name):

      train_auc_l1= results[results['param_penalty' ]  == 'l1']['mean_train_score']
      train_auc_std_l1= results[results['param_penalty' ]  == 'l1']['std_train_score']
      cv_auc_l1 = results[results['param_penalty' ]  == 'l1']['mean_test_score']
      cv_auc_std_l1= results[results['param_penalty' ]  == 'l1']['std_test_score']

      train_auc_l2= results[results['param_penalty' ]  == 'l2']['mean_train_score']
      train_auc_std_l2= results[results['param_penalty' ]  == 'l2']['std_train_score']
      cv_auc_l2 = results[results['param_penalty' ]  == 'l2']['mean_test_score']
      cv_auc_std_l2= results[results['param_penalty' ]  == 'l2']['std_test_score']


      #https://jakevdp.github.io/PythonDataScienceHandbook/04.08-multiple-subplots.html

      plt.figure(figsize=(20,5))
      plt.subplot(1, 3, 1)
      plt.plot(alpha_log, train_auc_l1, label='Train AUC')
      # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
      # plt.gca().fill_between(K, train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.2,color='darkblue')

      plt.plot(alpha_log, cv_auc_l1, label='CV AUC')
      # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
      # plt.gca().fill_between(K, cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='darkorange')

      plt.scatter(alpha_log, train_auc_l1, label='Train AUC points')
      plt.scatter(alpha_log, cv_auc_l1, label='CV AUC points')

      plt.legend()
      plt.xlabel("Alpha : hyperparameter")
      plt.ylabel("AUC")
      plt.title("Error Plot - (penalty - 'l1') for "+vectorizer_name)
      plt.grid()


      plt.subplot(1, 3, 2)
      plt.plot(alpha_log, train_auc_l2, label='Train AUC')
      # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
      # plt.gca().fill_between(K, train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.2,color='darkblue')

      plt.plot(alpha_log, cv_auc_l2, label='CV AUC')
      # this code is copied from here: ttps://stackoverflow.com/a/48803361/4084039
      # plt.gca().fill_between(K, cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color='darkorange')

      plt.scatter(alpha_log, train_auc_l2, label='Train AUC points')
      plt.scatter(alpha_log, cv_auc_l2, label='CV AUC points')

      plt.legend()
      plt.xlabel("Alpha : hyperparameter")
      plt.ylabel("AUC")
      plt.title("Error Plot - (penalty - 'l2') for "+vectorizer_name)
      plt.grid()
      plt.show()
```

2.2.1 Bag of words

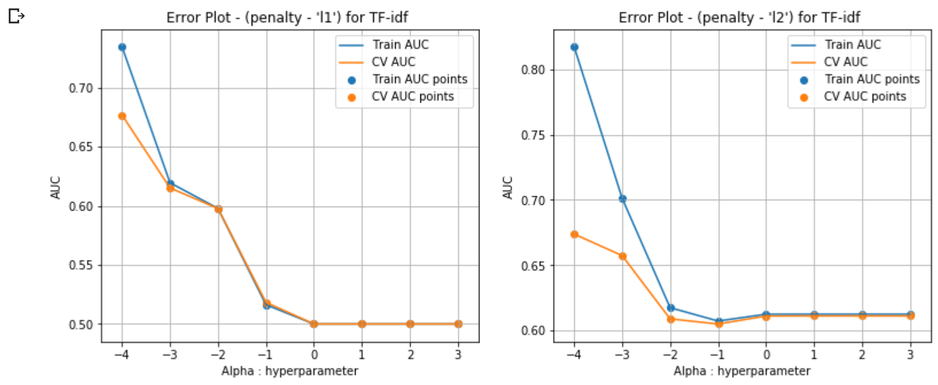
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
import math

alpha = [10**x for x in range(-4,4)]
alpha_log = [math.log(x,10) for x in alpha]
penalty = [ 'l2', 'l1' ]

tuned_parameters = [{'alpha': alpha ,'penalty' : penalty }]


model = GridSearchCV(SGDClassifier(class_weight='balanced'), tuned_parameters, scoring = 'roc_auc', cv=5,return_train_score = True)
model.fit(X_train_Bow, y_train_Bow)



results = pd.DataFrame.from_dict(model.cv_results_)
results = results.sort_values(['param_alpha'])


plot_AUC_ROC_Curve(results,alpha_log,'Bag of Words')
print()
print(model.best_estimator_)
```




```
SGDClassifier(alpha=0.01, average=False, class_weight='balanced',
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=1000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

2.2.2 TF-idf

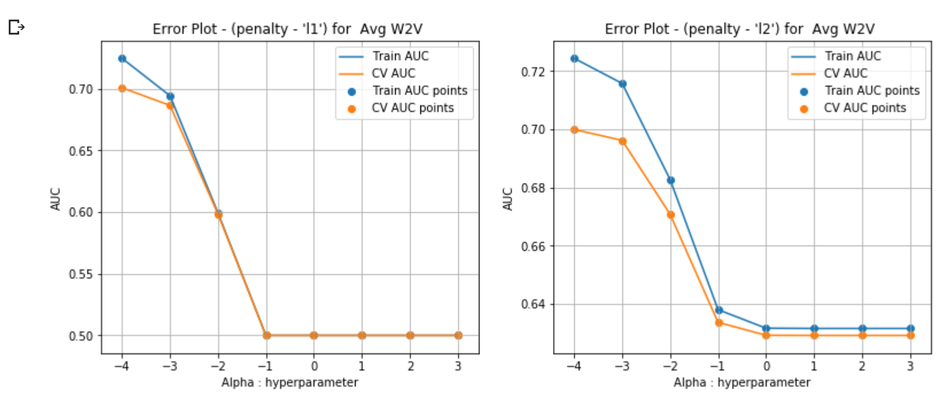
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
import math

alpha = [10**x for x in range(-4,4)]
alpha_log = [math.log(x,10) for x in alpha]
penalty = [ 'l2', 'l1' ]

tuned_parameters = [{'alpha': alpha ,'penalty' : penalty }]


model = GridSearchCV(SGDClassifier(class_weight='balanced'), tuned_parameters, scoring = 'roc_auc', cv=5,return_train_score = True)
model.fit(X_train_tfidf, y_train_tfidf)


results = pd.DataFrame.from_dict(model.cv_results_)
results = results.sort_values(['param_alpha'])


plot_AUC_ROC_Curve(results,alpha_log,'TF-idf ')
print()
print(model.best_estimator_)
```




```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=1000, n_iter_no_change=5, n_jobs=None, penalty='l1',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

2.2.3 Avg W2V

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
import math

alpha = [10**x for x in range(-4,4)]
alpha_log = [math.log(x,10) for x in alpha]
penalty = [ 'l2', 'l1' ]

tuned_parameters = [{'alpha': alpha ,'penalty' : penalty }]


model = GridSearchCV(SGDClassifier(class_weight='balanced'), tuned_parameters, scoring = 'roc_auc', cv=5,return_train_score = True)
model.fit(X_train_avg_w2v, y_train_avg_w2v)



results = pd.DataFrame.from_dict(model.cv_results_)
results = results.sort_values(['param_alpha'])


plot_AUC_ROC_Curve(results,alpha_log,' Avg W2V ')

print()
print(model.best_estimator_)
```




```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=1000, n_iter_no_change=5, n_jobs=None, penalty='l1',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

2.2.4 TFIDF W2V

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
import math

alpha = [10**x for x in range(-4,4)]
alpha_log = [math.log(x,10) for x in alpha]
penalty = [ 'l2', 'l1' ]

tuned_parameters = [{'alpha': alpha ,'penalty' : penalty }]


model = GridSearchCV(SGDClassifier(class_weight='balanced'), tuned_parameters, scoring = 'roc_auc', cv=5,return_train_score = True)
model.fit(X_train_tfidf_w2v, y_train_tfidf_w2v)


results = pd.DataFrame.from_dict(model.cv_results_)
results = results.sort_values(['param_alpha'])


plot_AUC_ROC_Curve(results,alpha_log,' Avg W2V ')

print()
print(model.best_estimator_)
```



```
SGDClassifier(alpha=0.001, average=False, class_weight='balanced',
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=1000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

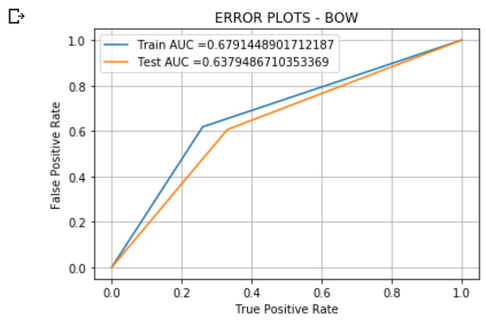
2.2.5 LR With best parameter

```
Best_alpha_bow = 0.01
penalty_bow ='l2'
Best_alpha_tfidf = 0.0001
penalty_tfidf ='l1'
```

```
penalty_tfidf = 'l1'
Best_alpha_Avg_w2v = 0.0001
penalty_Avg_w2v ='l2'
Best_alpha_tfidf_w2v = 0.001
penalty_tfidf_w2v ='l2'
```

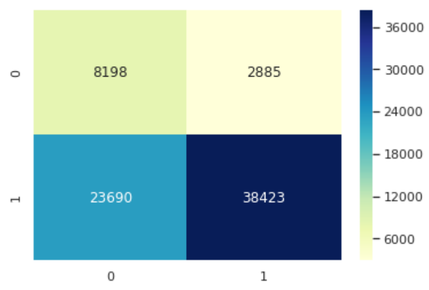
2.2.5.1 Bag of word

```
from sklearn.linear_model import SGDClassifier
classifer = SGDClassifier(class_weight='balanced',  alpha=Best_alpha_bow,penalty=penalty_bow)
classifer.fit(X_train_Bow.toarray(), y_train_Bow)

y_train_pred = classifer.predict( X_train_Bow)
y_test_pred = classifer.predict( X_test_Bow)

train_fpr_bow, train_tpr_bow, tr_thresholds_bow = roc_curve(y_train_Bow, y_train_pred)
test_fpr_bow, test_tpr_bow, te_thresholds_bow = roc_curve(y_test_Bow, y_test_pred)


plt.plot(train_fpr_bow, train_tpr_bow, label="Train AUC ="+str(auc(train_fpr_bow, train_tpr_bow)))
plt.plot(test_fpr_bow, test_tpr_bow, label="Test AUC ="+str(auc(test_fpr_bow, test_tpr_bow)))
plt.legend()
plt.xlabel("True Positive Rate")
plt.ylabel("False Positive Rate")
plt.title("ERROR PLOTS - BOW")
plt.grid()
plt.show()
```



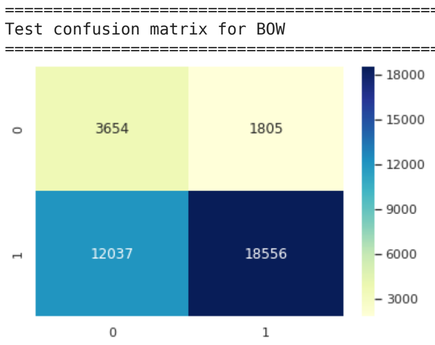

```
import seaborn as sns; sns.set()
best_t = find_best_threshold(tr_thresholds_bow, train_fpr_bow, train_tpr_bow)
print("="*50)
print("Train confusion matrix for BOW")
print("="*50)

#https://seaborn.pydata.org/generated/seaborn.heatmap.html
uniform_data = confusion_matrix(y_train_Bow, predict_with_best_t(y_train_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
The maximum value of tpr*(1-fpr) 0.4575718996572477 for threshold 1
==================================================
Train confusion matrix for BOW
==================================================
```




```
print("="*50)
print("Test confusion matrix for BOW")
print("="*50)

uniform_data = confusion_matrix(y_test_Bow, predict_with_best_t(y_test_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
==================================================
Test confusion matrix for BOW
==================================================
```

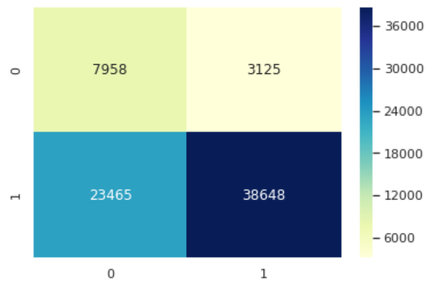


2.2.5.2 Tf-idf

```
from sklearn.linear_model import SGDClassifier
classifer = SGDClassifier(class_weight='balanced',  alpha=Best_alpha_tfidf ,penalty=penalty_tfidf)
classifer.fit(X_train_tfidf.toarray(), y_train_tfidf)

y_train_pred = classifer.predict( X_train_tfidf)
y_test_pred = classifer.predict( X_test_tfidf)

train_fpr_tfidf, train_tpr_tfidf, tr_thresholds_tfidf = roc_curve(y_train_tfidf, y_train_pred)
test_fpr_tfidf, test_tpr_tfidf, te_thresholds_tfidf = roc_curve(y_test_tfidf, y_test_pred)

plt.plot(train_fpr_tfidf, train_tpr_tfidf, label="Train AUC ="+str(auc(train_fpr_tfidf, train_tpr_tfidf)))
plt.plot(test_fpr_tfidf, test_tpr_tfidf, label="Test AUC ="+str(auc(test_fpr_tfidf, test_tpr_tfidf)))
plt.legend()
plt.xlabel("True Positive Rate")
plt.ylabel("False Positive Rate")
plt.title("ERROR PLOTS-TF-idf")
plt.grid()
plt.show()
```


```
best_t = find_best_threshold(tr_thresholds_tfidf, train_fpr_tfidf, train_tpr_tfidf)
print("="*50)
print("Train confusion matrix for TF-idf")
print("="*50)
uniform_data = confusion_matrix(y_train_tfidf, predict_with_best_t(y_train_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

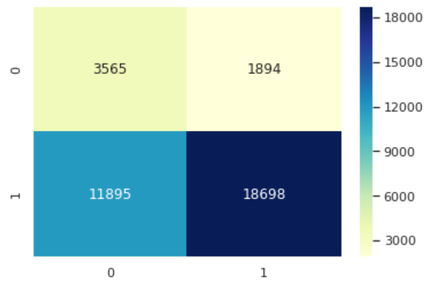
```
The maximum value of tpr*(1-fpr) 0.4467773216531645 for threshold 1
==================================================
Train confusion matrix for TF-idf
==================================================
```




```
print("="*50)
```

```
print("Test confusion matrix for TF-idf")
print("="*50)


uniform_data = confusion_matrix(y_test_tfidf, predict_with_best_t(y_test_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
==================================================
Test confusion matrix for TF-idf
==================================================
```



2.2.5.3 Avg W2V

```
from sklearn.linear_model import SGDClassifier
classifer = SGDClassifier(class_weight='balanced',  alpha=Best_alpha_Avg_w2v ,penalty=penalty_Avg_w2v)
classifer.fit(X_train_avg_w2v.toarray(), y_train_avg_w2v)

y_train_pred = classifer.predict( X_train_avg_w2v)
y_test_pred = classifer.predict( X_test_avg_w2v)


train_fpr_Avg_w2v, train_tpr_Avg_w2v, tr_thresholds_Avg_w2v = roc_curve(y_train_avg_w2v, y_train_pred)
test_fpr_Avg_w2v, test_tpr_Avg_w2v, te_thresholds_Avg_w2v = roc_curve(y_test_avg_w2v, y_test_pred)

plt.plot(train_fpr_Avg_w2v, train_tpr_Avg_w2v, label="Train AUC ="+str(auc(train_fpr_Avg_w2v, train_tpr_Avg_w2v)))
plt.plot(test_fpr_Avg_w2v, test_tpr_Avg_w2v, label="Test AUC ="+str(auc(test_fpr_Avg_w2v, test_tpr_Avg_w2v)))
plt.legend()
plt.xlabel("True Positive Rate")
plt.ylabel("False Positive Rate")
plt.title("ERROR PLOTS- Avg_w2v")
plt.grid()
plt.show()
```

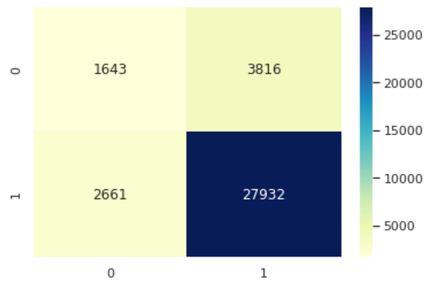

```
best_t = find_best_threshold(tr_thresholds_Avg_w2v, train_fpr_Avg_w2v, train_tpr_Avg_w2v)
print("="*50)
print("Train confusion matrix for Avg W2V")
print("="*50)
uniform_data = confusion_matrix(y_train_avg_w2v, predict_with_best_t(y_train_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
The maximum value of tpr*(1-fpr) 0.2857071370297343 for threshold 1
==================================================
Train confusion matrix for Avg W2V
==================================================
```



```
print("="*50)
print("Test confusion matrix for Avg W2V")
print("="*50)

uniform_data = confusion_matrix(y_test_avg_w2v, predict_with_best_t(y_test_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
==================================================
Test confusion matrix for Avg W2V
==================================================
```

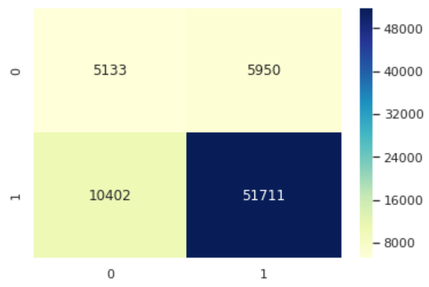


2.2.5.4 TFIDF W2V

```
from sklearn.linear_model import SGDClassifier
classifer = SGDClassifier(class_weight='balanced',  alpha=Best_alpha_Avg_w2v ,penalty=penalty_Avg_w2v)

classifer.fit(X_train_tfidf_w2v.toarray(), y_train_tfidf_w2v)

y_train_pred = classifer.predict( X_train_tfidf_w2v)
y_test_pred = classifer.predict( X_test_tfidf_w2v)



train_fpr_tfidf_w2v, train_tpr_tfidf_w2v, tr_thresholds_tfidf_w2v = roc_curve(y_train_tfidf_w2v, y_train_pred)
test_fpr_tfidf_w2v, test_tpr_tfidf_w2v, te_thresholds_tfidf_w2v = roc_curve(y_test_tfidf_w2v, y_test_pred)

plt.plot(train_fpr_tfidf_w2v, train_tpr_tfidf_w2v, label="Train AUC ="+str(auc(train_fpr_tfidf_w2v, train_tpr_tfidf_w2v)))
plt.plot(test_fpr_tfidf_w2v, test_tpr_tfidf_w2v, label="Test AUC ="+str(auc(test_fpr_tfidf_w2v, test_tpr_tfidf_w2v)))
plt.legend()
plt.xlabel("True Positive Rate")
plt.ylabel("False Positive Rate")
plt.title("ERROR PLOTS- Tfidf_w2v")
plt.grid()
plt.show()
```

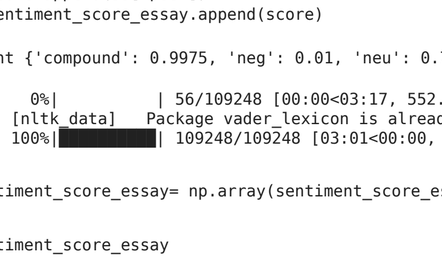

```
best_t = find_best_threshold(tr_thresholds_tfidf_w2v, train_fpr_tfidf_w2v, train_tpr_tfidf_w2v)
print("="*50)
print("Train confusion matrix for Tfidf_w2v")
print("="*50)
uniform_data = confusion_matrix(y_train_tfidf_w2v, predict_with_best_t(y_train_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
The maximum value of tpr*(1-fpr) 0.3855798780142102 for threshold 1
==================================================
Train confusion matrix for Tfidf_w2v
==================================================
```




```
print("="*50)
print("Test confusion matrix for TF-idf")
print("="*50)

uniform_data = confusion_matrix(y_test_tfidf_w2v, predict_with_best_t(y_test_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
==================================================
Test confusion matrix for TF-idf
==================================================
```



2.4 Appling Support Vector Machines on different kind of featurization as mentioned in the instructions

Apply Support Vector Machines 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

2.4.1 Computing Sentiment Scores

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

sentiment_score_essay =[]

for sent in tqdm(preprocessed_essays):
  score = []
  ss = sid.polarity_scores(sent)
  score.append(ss['compound'])
  score.append(ss['neg'])
  score.append(ss['neu'])
  score.append(ss['pos'])
  sentiment_score_essay.append(score)

#sent {'compound': 0.9975, 'neg': 0.01, 'neu': 0.745, 'pos': 0.245}
```

```
  0%|          | 56/109248 [00:00<03:17, 552.73it/s][nltk_data] Downloading package vader_lexicon to /root/nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
100%|██████████| 109248/109248 [03:01<00:00, 602.47it/s]
```

```
sentiment_score_essay= np.array(sentiment_score_essay).reshape(-1,4)

sentiment_score_essay
```

```
array([[0.9694, 0.012 , 0.844 , 0.144 ],
       [0.9856, 0.048 , 0.669 , 0.283 ],
       [0.9816, 0.122 , 0.659 , 0.219 ],
       ...,
       [0.995 , 0.    , 0.601 , 0.399 ],
       [0.9938, 0.02  , 0.659 , 0.321 ],
       [0.9868, 0.059 , 0.693 , 0.248 ]])
```

2.4.2 count no of words in eassay

```
no_of_words_essay =[]
for sent in tqdm(preprocessed_essays):
  count = len(sent.split())
  no_of_words_essay.append(count)
```

```
100%|██████████| 109248/109248 [00:00<00:00, 126555.24it/s]
```

```
no_of_words_essay = np.array(no_of_words_essay).reshape(-1,1)

no_of_words_essay
```

```
array([[161],
       [109],
       [202],
       ...,
       [110],
       [147],
       [158]])
```

2.4.3 count no of words in Project Title

```
no_of_words_project_title =[]
for sent in tqdm(preprocessed_project_title):
  count = len(sent.split())
  no_of_words_project_title.append(count)
```

```
100%|██████████| 109248/109248 [00:00<00:00, 1338687.44it/s]
```

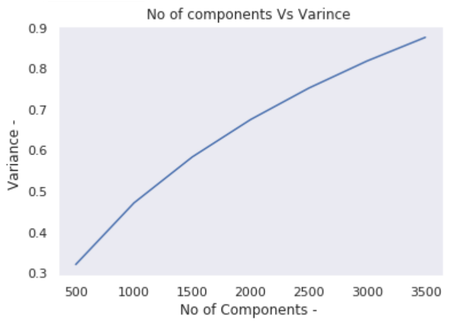
```
no_of_words_project_title= np.array(no_of_words_project_title).reshape(-1,1)

no_of_words_project_title
```

```
array([[5],
       [4],
       [6],
       ...,
       [5],
       [4],
       [6]])
```

2.4.4 Applying TruncatedSVD

```
#few lines of code copied from below websites
#https://stackoverflow.com/questions/44633571/how-can-i-get-the-feature-names-from-sklearn-truncatedsvd-object
#https://chrisalbon.com/machine_learning/feature_engineering/dimensionality_reduction_on_sparse_feature_matrix/

from sklearn.decomposition import TruncatedSVD
n_component = [500,1000,1500,2000,2500,3000,3500]
variance = []
for i in  tqdm(n_component):

  svd = TruncatedSVD(n_components=i, n_iter=7, random_state=42)
  svd.fit(text_tfidf)
  variance.append(svd.explained_variance_ratio_.sum())
  #print(svd.explained_variance_ratio_.sum())

plt.plot(n_component, variance)
plt.xlabel("No of Components - ")
plt.ylabel("Variance - ")
plt.title("No of components Vs Varince ")
plt.grid()
plt.show()
```

```
100%|██████████| 7/7 [42:26<00:00, 482.37s/it]
```




```
#https://stackoverflow.com/questions/36254261/scikit-learn-truncatedsvd-documentation
tsvd = TruncatedSVD(n_components=3500)
text_essay_tsvd = tsvd.fit(text_tfidf).fit_transform(text_tfidf)
text_essay_tsvd.shape
```

```
(109248, 3500)
```

2.4.4 Combining features

```
X_sentiment = hstack((categories_one_hot, sub_categories_one_hot,  price_standardized,previously_posted_standardized,
                project_grade_category_one_hot,state_one_hot ,teacher_prefix_one_hot,
                no_of_words_essay,
                no_of_words_project_title,
                sentiment_score_essay,
                text_essay_tsvd
                 ))
X_sentiment.shape
```

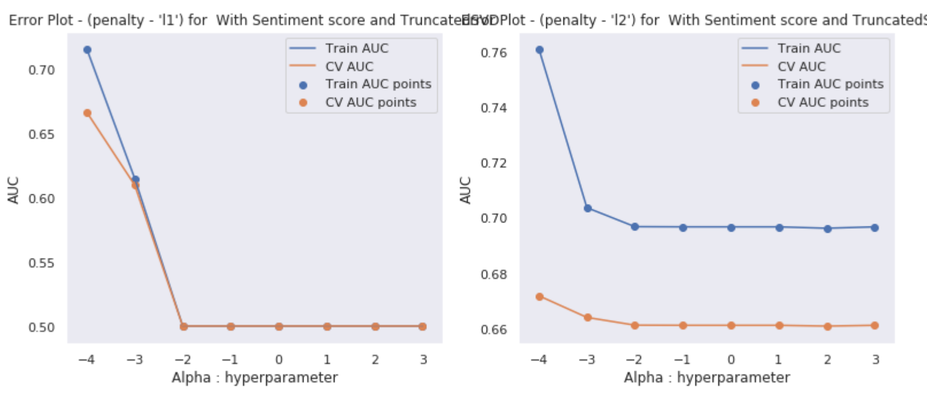
```
(109248, 3607)
```

2.4.5 Spliting the dataset into train test and cv

```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(text_essay_tsvd, y, test_size=0.33, stratify=y)
```

2.5 Support Vector Machines with added Features `Set 5`

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
import math

alpha = [10**x for x in range(-4,4)]
alpha_log = [math.log(x,10) for x in alpha]
penalty = [ 'l2', 'l1' ]

tuned_parameters = [{'alpha': alpha ,'penalty' : penalty }]


model = GridSearchCV(SGDClassifier(class_weight='balanced'), tuned_parameters, scoring = 'roc_auc', cv=5,return_train_score = True)
model.fit(X_train, y_train)



results = pd.DataFrame.from_dict(model.cv_results_)
results = results.sort_values(['param_alpha'])


plot_AUC_ROC_Curve(results,alpha_log,' With Sentiment score and TruncatedSVD')

print()
print(model.best_estimator_)
```



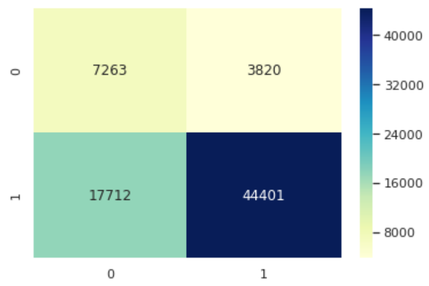

```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=1000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

2.5.1 With Best Hyperparamter

```
Best_alpha =  0.0001
penalty = 'l2'


from sklearn.linear_model import SGDClassifier
classifer = SGDClassifier(class_weight='balanced',  alpha=Best_alpha,penalty=penalty)
classifer.fit(X_train, y_train)

y_train_pred = classifer.predict( X_train)
y_test_pred = classifer.predict( X_test)

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


plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate")
plt.ylabel("False Positive Rate")
plt.title("ERROR PLOTS- Sentiment Score ")
plt.grid()
plt.show()
```

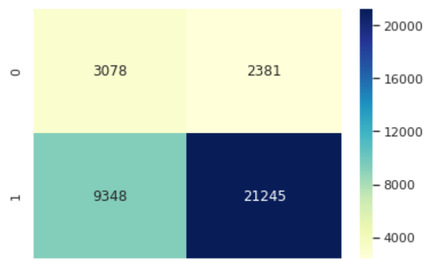

```
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("="*50)
print("Train confusion matrix")
print("="*50)
uniform_data = confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
The maximum value of tpr*(1-fpr) 0.4684561626488083 for threshold 1
==================================================
Train confusion matrix
==================================================
```




```
print("="*50)
print("Test confusion matrix for TF-idf")
print("="*50)

uniform_data = confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t))
ax = sns.heatmap(uniform_data,cmap="YlGnBu",annot=True,fmt="d")
```

```
==================================================
Test confusion matrix for TF-idf
==================================================
```



3. Conclusion

```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "HyperParameter (Alpha)","Penality", "AUC_Train","AUC_Test"]
x.add_row(["Bag of Words", "SGDClassifier", Best_alpha_bow,penalty_bow ,str(auc(train_fpr_bow, train_tpr_bow)),str(auc(test_fpr_bow, test_tp
x.add_row(["TF-idf", "SGDClassifier", Best_alpha_tfidf,penalty_tfidf  ,str(auc(train_fpr_tfidf, train_tpr_tfidf)),str(auc(test_fpr_tfidf, te
x.add_row(["Avg W2V", "SGDClassifier", Best_alpha_Avg_w2v, penalty_Avg_w2v ,str(auc(train_fpr_Avg_w2v, train_tpr_Avg_w2v)),str(auc(test_fpr_
x.add_row(["TF-idf W2V", "SGDClassifier", Best_alpha_tfidf_w2v,penalty_tfidf_w2v,str(auc(train_fpr_tfidf_w2v, train_tpr_tfidf_w2v)),str(auc(
x.add_row(["Sentiment Scores", "SGDClassifier", Best_alpha, penalty,str(auc(train_fpr, train_tpr)),str(auc(test_fpr, test_tpr))])
print(x)
```

```
+------------------+--------------+------------------------+----------+--------------------+--------------------+
|    Vectorizer    |     Model    | HyperParameter (Alpha) | Penality |     AUC_Train      |      AUC_Test      |
+------------------+--------------+------------------------+----------+--------------------+--------------------+
|   Bag of Words   | SGDClassifier |          0.01          |    l2    | 0.6791448901712187 | 0.6379486710353369 |
|      TF-idf      | SGDClassifier |         0.0001         |    l1    | 0.6701287119097067 | 0.632117787242294  |
|     Avg W2V      | SGDClassifier |         0.0001         |    l2    |  0.6132457721839   | 0.6069950959655407 |
|    TF-idf W2V    | SGDClassifier |         0.001          |    l2    | 0.6478363903875491 | 0.6330679319806758 |
| Sentiment Scores | SGDClassifier |         0.0001         |    l2    | 0.6850851416662037 | 0.6291397178014859 |
+------------------+--------------+------------------------+----------+--------------------+--------------------+
```