DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom pro
number of volunteers is needed to manually screen each submission before it's approved to be poste

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there
solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they c
as possible
- How to increase the consistency of project vetting across different volunteers to improve the ex
- 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 submit
the text of project descriptions as well as additional metadata about the project, teacher, and school.
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 f • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`

Feature	Description
`project_subject_categories`	One or more (comma-separated) subject categories for the project fr • `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**
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the proje • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materi`
`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`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:**
`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 tea

* 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 pr resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`

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 tl following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific deta neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your stu lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_e

```
%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
```

1.1 Reading Data

```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('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

# 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", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
        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

# 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", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
        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]))
```

1.3 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	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

```
#### 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 la
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love lear
==================================================
How do you remember your days of school? Was it in a sterile environment with plain wall
==================================================
My kindergarten students have varied disabilities ranging from speech and language delay
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates
==================================================
```

```
# 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 delay
==================================================
```

```
# \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 delay
```

```
#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 delay
```

```
# 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", "yo
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they',
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll"
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'h
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'unt
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'dur
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', '
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'bo
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'ver
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'does
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
            '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())
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/10
```

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

```
'my kindergarten students varied disabilities ranging speech language delays cognitive d
```

1.4 Preprocessing of `project_title`

```
# similarly you can preprocess the titles also
```

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-categorica

```
# 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
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', 'SpecialNee
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, bi
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', 'Extracurric
Shape of matrix after one hot encodig  (109248, 30)
```

```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
```

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)
vectorizer = CountVectorizer(min_df=10)
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, 16623)
```

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

1.5.2.2 TFIDF vectorizer

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
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, 16623)
```

1.5.2.3 Using Pretrained Models: Avg W2V

```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
```

```
            embedding = np.array([float(val) for val in splitLine[1:]])
            model[word] = embedding
        print ("Done.",len(model)," words loaded!")
        return model
    model = loadGloveModel('glove.42B.300d.txt')

    # ============================
    Output:

    Loading Glove Model
    1917495it [06:32, 4879.69it/s]
    Done. 1917495  words loaded!

    # ============================

    words = []
    for i in preproced_texts:
        words.extend(i.split(' '))

    for i in preproced_titles:
        words.extend(i.split(' '))
    print("all the words in the coupus", len(words))
    words = set(words)
    print("the unique words in the coupus", len(words))

    inter_words = set(model.keys()).intersection(words)
    print("The number of words that are present in both glove vectors and our coupus", \
          len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")

    words_courpus = {}
    words_glove = set(model.keys())
    for i in words:
        if i in words_glove:
            words_courpus[i] = model[i]
    print("word 2 vec length", len(words_courpus))


    # stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-

    import pickle
    with open('glove_vectors', 'wb') as f:
        pickle.dump(words_courpus, f)


    '''
```

```
    '\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef


    # stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-
    # make sure you have the glove_vectors file
```

```
with open('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%|██████████████████████████████████████████████████████████████████████████████| 109248/10
109248
300
```

1.5.2.3 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.
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting
            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(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|██████████| 109248/1
109248
300
```

```
# Similarly you can vectorize for title also
```

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.preproce
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.
# 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
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))


price_standardized
```

```
array([[0.00098843, 0.00191166, 0.00330448, ..., 0.00153418, 0.00046704,
        0.00070265]])
```

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, 16623)
(109248, 1)
```

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape
```

```
(109248, 16663)
```

```
# please write all the code with proper documentation, and proper titles for each subsection
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

__ Computing Sentiment Scores__

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

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

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest stude
for learning my students learn in many different ways using all of our senses and multiple in
of techniques to help all my students succeed students in my class come from a variety of dif
for wonderful sharing of experiences and cultures including native americans our school is a
learners which can be seen through collaborative student project based learning in and out of
in my class love to work with hands on materials and have many different opportunities to pra
mastered having the social skills to work cooperatively with friends is a crucial aspect of t
montana is the perfect place to learn about agriculture and nutrition my students love to rol
in the early childhood classroom i have had several kids ask me can we try cooking with real
and create common core cooking lessons where we learn important math and writing concepts whi
food for snack time my students will have a grounded appreciation for the work that went into
of where the ingredients came from as well as how it is healthy for their bodies this project
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade
and mix up healthy plants from our classroom garden in the spring we will also create our own
shared with families students will gain math and literature skills as well as a life long enj
nannan'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
```

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

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

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

The twython library has not been installed. Some functionality from the twitter package

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

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

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

3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data fo figure.
   - Once after you found the best hyper parameter, you need to train your model with it, and fi curve on both train and test.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and o 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 sugges**
   - 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 compc method** : numerical data

- **Conclusion**
  - You need to summarize the results at the end of the notebook, summarize it in the ta 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 transfor
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 San

```
%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_notebook as tqdm1
from tqdm import tqdm
import time
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

from sklearn.model_selection import train_test_split
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

```
project_data = pd.read_csv('../train_data.csv')
resource_data = pd.read_csv('../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']
```

Text preprocessing(1)

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

# 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", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
        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)
project_data.head(5)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
```

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

```
Counter({'Literacy_Language': 52239,
         'History_Civics': 5914,
         'Health_Sports': 14223,
         'Math_Science': 41421,
         'SpecialNeeds': 13642,
         'AppliedLearning': 12135,
         'Music_Arts': 10293,
         'Warmth': 1388,
         'Care_Hunger': 1388})
```

```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))


# ind = np.arange(len(sorted_cat_dict))
# plt.figure(figsize=(20,5))
# p1 = plt.bar(ind, list(sorted_cat_dict.values()))

# plt.ylabel('Projects')
# plt.title('% of projects aproved category wise')
# plt.xticks(ind, list(sorted_cat_dict.keys()))
# plt.show()
# print(sorted_cat_dict)


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

# 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", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
        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)
project_data.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

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

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


# ind = np.arange(len(sorted_sub_cat_dict))
# plt.figure(figsize=(20,5))
# p1 = plt.bar(ind, list(sorted_sub_cat_dict.values()))

# plt.ylabel('Projects')
# plt.title('% of projects aproved state wise')
# plt.xticks(ind, list(sorted_sub_cat_dict.keys()))
# plt.show()


# 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)


# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-grou
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')


#presence of the numerical digits in a strings with numeric : https://stackoverflow.com/a/198
def hasNumbers(inputString):
    return any(i.isdigit() for i in inputString)
p1 = project_data[['id','project_resource_summary']]
p1 = pd.DataFrame(data=p1)
p1.columns = ['id','digits_in_summary']
p1['digits_in_summary'] =  p1['digits_in_summary'].map(hasNumbers)
# https://stackoverflow.com/a/17383325/8089731
p1['digits_in_summary'] = p1['digits_in_summary'].astype(int)
project_data = pd.merge(project_data, p1, on='id', how='left')
project_data.head(5)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	

5 rows × 21 columns

Text preprocessing(2)

```
# 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
```

```
    pnrase = re.sub(r"n\'t", " not", pnrase)
    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", "yo
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they',
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll"
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'h
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'unt
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'dur
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', '
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'bo
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'ver
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'does
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
            'won', "won't", 'wouldn', "wouldn't"]


# Combining all the above statemennts
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)
    sent = re.sub('nannan', '', 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())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/10
```

```
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for title in tqdm(project_data['project_title'].values):
    _title = decontracted(title)
    title =  title.replace('\\r', ' ')
```

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

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109
```

```
preprocessed_titles[1000]
```

```
'sailing into super 4th grade year'
```

```
project_grade_catogories = list(project_data['project_grade_category'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924

# 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

project_grade_cat_list = []
for i in tqdm1(project_grade_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", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    project_grade_cat_list.append(temp.strip())
```

```
HBox(children=(IntProgress(value=0, max=109248), HTML(value='')))
```

```
project_data['clean_project_grade_category'] = project_grade_cat_list
project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

2 rows × 21 columns

```
project_data.drop(['project_essay_1','project_essay_2','project_essay_3','project_essay_4'],
project_data.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

```
#Replacing Nan's with maximum occured value: https://stackoverflow.com/a/51053916/8089731
project_data['teacher_prefix'].value_counts().argmax()
project_data.fillna(value=project_data['teacher_prefix'].value_counts().argmax(),axis=1,inpla

project_data['preprocessed_essays'] = preprocessed_essays
project_data['preprocessed_titles'] = preprocessed_titles
```

```
project_data.columns
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'quantity',
       'digits_in_summary', 'clean_project_grade_category',
       'preprocessed_essays', 'preprocessed_titles'],
      dtype='object')
```

2.2 Make Data Model Ready: encoding numerical, categorical features

```
X_train, X_test, y_train, y_test = train_test_split(project_data,project_data['project_is_app
# X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=

X_train.drop(['project_is_approved'], axis=1, inplace=True)
X_test.drop(['project_is_approved'], axis=1, inplace=True)
# X_cv.drop(['project_is_approved'], axis=1, inplace=True)
print(X_train.shape)
print(X_test.shape)
```

```
(73196, 18)
(36052, 18)
```

1.4.1 Vectorizing Categorical data

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_cat = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, bi
vectorizer_cat.fit(X_train['clean_categories'].values)
print(vectorizer_cat.get_feature_names())


categories_one_hot_train = vectorizer_cat.transform(X_train['clean_categories'].values)
# categories_one_hot_cv = vectorizer_cat.transform(X_cv['clean_categories'].values)
categories_one_hot_test = vectorizer_cat.transform(X_test['clean_categories'].values)
print("Shape of matrix after one hot encodig_train ",categories_one_hot_train.shape)
# print("Shape of matrix after one hot encodig_cv ",categories_one_hot_cv.shape)
print("Shape of matrix after one hot encodig_test ",categories_one_hot_test.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNee
Shape of matrix after one hot encodig_train  (73196, 9)
Shape of matrix after one hot encodig_test  (36052, 9)
```

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer_sub_cat = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=F
vectorizer_sub_cat.fit(X_train['clean_subcategories'].values)
```

```
print(vectorizer_sub_cat.get_feature_names())


sub_categories_one_hot_train = vectorizer_sub_cat.transform(X_train['clean_subcategories'].va
# sub_categories_one_hot_cv = vectorizer_sub_cat.transform(X_cv['clean_subcategories'].values
sub_categories_one_hot_test = vectorizer_sub_cat.transform(X_test['clean_subcategories'].valu
print("Shape of matrix after one hot encodig_train ",sub_categories_one_hot_train.shape)
# print("Shape of matrix after one hot encodig_cv ",sub_categories_one_hot_cv.shape)
print("Shape of matrix after one hot encodig_test ",sub_categories_one_hot_test.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurric
Shape of matrix after one hot encodig_train  (73196, 30)
Shape of matrix after one hot encodig_test  (36052, 30)
```

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_state = CountVectorizer( lowercase=False, binary=True)
vectorizer_state.fit(X_train['school_state'].values)
print(vectorizer_state.get_feature_names())


school_state_one_hot_train = vectorizer_state.transform(X_train['school_state'].values)
# school_state_one_hot_cv = vectorizer_state.transform(X_cv['school_state'].values)
school_state_one_hot_test = vectorizer_state.transform(X_test['school_state'].values)
print("Shape of matrix after one hot encodig_train ",school_state_one_hot_train.shape)
# print("Shape of matrix after one hot encodig_cv ",school_state_one_hot_cv.shape)
print("Shape of matrix after one hot encodig_test ",school_state_one_hot_test.shape)
```

```
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI', 'IA', 'ID', 'IL
Shape of matrix after one hot encodig_train  (73196, 51)
Shape of matrix after one hot encodig_test  (36052, 51)
```

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_teacherprefix = CountVectorizer( lowercase=False, binary=True)
vectorizer_teacherprefix.fit(X_train['teacher_prefix'].values.astype('U'))
print(vectorizer_teacherprefix.get_feature_names())

#https://stackoverflow.com/a/39308809/8089731
teacher_prefix_one_hot_train = vectorizer_teacherprefix.transform(X_train['teacher_prefix'].v
# teacher_prefix_one_hot_cv = vectorizer_teacherprefix.transform(X_cv['teacher_prefix'].value
teacher_prefix_one_hot_test = vectorizer_teacherprefix.transform(X_test['teacher_prefix'].val
print("Shape of matrix after one hot encodig_train ",teacher_prefix_one_hot_train.shape)
# print("Shape of matrix after one hot encodig_cv ",teacher_prefix_one_hot_cv.shape)
print("Shape of matrix after one hot encodig_test ",teacher_prefix_one_hot_test[:5,:])
# print(X_train['teacher_prefix'].value_counts())
```

```
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
Shape of matrix after one hot encodig_train  (73196, 5)
Shape of matrix after one hot encodig_test    (0, 3)    1
  (1, 2)        1
  (2, 2)        1
  (3, 3)        1
  (4, 2)        1
```

```
print(project_data['clean_project_grade_category'].unique())
```

```
['GradesPreK-2' 'Grades6-8' 'Grades3-5' 'Grades9-12']
```

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
# https://stackoverflow.com/a/38161028/8089731
pattern = "(?u)\\b[\\w-]+\\b"
vectorizer_projectgrade = CountVectorizer(token_pattern=pattern, lowercase=False, binary=True
vectorizer_projectgrade.fit(X_train['clean_project_grade_category'].values)
print(vectorizer_projectgrade.get_feature_names())

#https://stackoverflow.com/a/39308809/8089731
project_grade_category_one_hot_train = vectorizer_projectgrade.transform(X_train['clean_proje
# project_grade_category_one_hot_cv = vectorizer_projectgrade.transform(X_cv['clean_project_g
project_grade_category_one_hot_test = vectorizer_projectgrade.transform(X_test['clean_project
print("Shape of matrix after one hot encodig_train ",project_grade_category_one_hot_train.sha
# print("Shape of matrix after one hot encodig_cv ",project_grade_category_one_hot_cv.shape)
print("Shape of matrix after one hot encodig_test ",project_grade_category_one_hot_test[:5,:]
```

```
['Grades3-5', 'Grades6-8', 'Grades9-12', 'GradesPreK-2']
Shape of matrix after one hot encodig_train  (73196, 4)
Shape of matrix after one hot encodig_test    (0, 0)    1
  (1, 0)        1
  (2, 3)        1
  (3, 3)        1
  (4, 1)        1
```

Vectorizing Numerical features

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preproce
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.
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard devia
```

```
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_train = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
# price_standardized_cv = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
price_standardized_test = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
print(price_standardized_train.shape)
# print(price_standardized_cv.shape)
print(price_standardized_test.shape)
```

```
Mean : 298.0709036012897, Standard deviation : 369.46235663856544
(73196, 1)
(36052, 1)
```

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preproce
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.
# Reshape your data either using array.reshape(-1, 1)

quantity_scalar = StandardScaler()
quantity_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and standard
# print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.va

# Now standardize the data with above maen and variance.
quantity_standardized_train = quantity_scalar.transform(X_train['quantity'].values.reshape(-1
# quantity_standardized_cv = quantity_scalar.transform(X_cv['quantity'].values.reshape(-1, 1)
quantity_standardized_test = quantity_scalar.transform(X_test['quantity'].values.reshape(-1,
print(quantity_standardized_train.shape)
# print(quantity_standardized_cv.shape)
print(quantity_standardized_test.shape)
```

```
(73196, 1)
(36052, 1)
```

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preproce
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.
# Reshape your data either using array.reshape(-1, 1)

teacher_number_of_previously_posted_projects_scalar = StandardScaler()
teacher_number_of_previously_posted_projects_scalar.fit(X_train['teacher_number_of_previously
# print(f"Mean : {teacher_number_of_previously_posted_projects_scalar.mean_[0]}, Standard dev

# Now standardize the data with above maen and variance
```

```
# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_train = teacher_number_of_previousl
# teacher_number_of_previously_posted_projects_standardized_cv = teacher_number_of_previously
teacher_number_of_previously_posted_projects_standardized_test = teacher_number_of_previously
print(teacher_number_of_previously_posted_projects_standardized_train.shape)
# print(teacher_number_of_previously_posted_projects_standardized_cv.shape)
print(teacher_number_of_previously_posted_projects_standardized_test.shape)
```

```
(73196, 1)
(36052, 1)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

```
X_train.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
49140	154826	p045152	1121a3f19807afcd94ce6c5cd6d1deb2	Mrs.	FL
85215	39347	p134078	2442338dea5e3b61dc4f316735503930	Mrs.	TX

Bag of Words(BOW) on `project_TEXT/ESSAYS` (Train,Cv,Test)

```
# We are considering only the words which appeared in at least 10 documents(rows or projects)
vectorizer_bow_essays = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1,2))
vectorizer_bow_essays.fit(X_train['preprocessed_essays'])

text_bow_train = vectorizer_bow_essays.transform(X_train['preprocessed_essays'])
# text_bow_cv = vectorizer_bow_essays.transform(X_cv['preprocessed_essays'])
text_bow_test = vectorizer_bow_essays.transform(X_test['preprocessed_essays'])
print("Shape of matrix after BOW_text_train ",text_bow_train.shape)
# print("Shape of matrix after BOW_text_cv ",text_bow_cv.shape)
print("Shape of matrix after BOW_text_test ",text_bow_test.shape)
```

```
Shape of matrix after BOW_text_train  (73196, 5000)
Shape of matrix after BOW_text_test  (36052, 5000)
```

Bag of Words(BOW) on project_title (Train,Cv,Test)

```
# We are considering only the words which appeared in at least 10 documents(rows or projects)
vectorizer_bow_titles = CountVectorizer(min_df=10)
vectorizer_bow_titles.fit(X_train['preprocessed_titles'])

title_bow_train = vectorizer_bow_titles.transform(X_train['preprocessed_titles'])
# title_bow_cv = vectorizer_bow_titles.transform(X_cv['preprocessed_titles'])
title_bow_test = vectorizer_bow_titles.transform(X_test['preprocessed_titles'])
print("Shape of matrix after BOW_title_train ",title_bow_train.shape)
# print("Shape of matrix after BOW_title_cv ",title_bow_cv.shape)
print("Shape of matrix after BOW_title_test ",title_bow_test.shape)
```

```
Shape of matrix after BOW_title_train  (73196, 2638)
Shape of matrix after BOW_title_test  (36052, 2638)
```

TFIDF Vectorizer on project_TEXT/ESSAYS (Train,Cv,Test)

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essays = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1,2))
vectorizer_tfidf_essays.fit(X_train['preprocessed_essays'])

text_tfidf_train = vectorizer_tfidf_essays.transform(X_train['preprocessed_essays'])
# text_tfidf_cv = vectorizer_tfidf_essays.transform(X_cv['preprocessed_essays'])
text_tfidf_test = vectorizer_tfidf_essays.transform(X_test['preprocessed_essays'])
print("Shape of matrix after tfidf_text_train ",text_tfidf_train.shape)
# print("Shape of matrix after tfidf_text_cv ",text_tfidf_cv.shape)
print("Shape of matrix after tfidf_text_test ",text_tfidf_test.shape)
```

```
Shape of matrix after tfidf_text_train  (73196, 5000)
Shape of matrix after tfidf_text_test  (36052, 5000)
```

TFIDF Vectorizer on project_title (Train,Cv,Test)

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(X_train['preprocessed_titles'])

title_tfidf_train = vectorizer_tfidf_title.transform(X_train['preprocessed_titles'])
# title_tfidf_cv = vectorizer_tfidf_title.transform(X_cv['preprocessed_titles'])
title_tfidf_test = vectorizer_tfidf_title.transform(X_test['preprocessed_titles'])
```

```
print("Shape of matrix after tfidf_title_train ",title_tfidf_train.shape)
# print("Shape of matrix after tfidf_title_cv ",title_tfidf_cv.shape)
print("Shape of matrix after tfidf_title_test ",title_tfidf_test.shape)
```

```
Shape of matrix after tfidf_title_train  (73196, 2638)
Shape of matrix after tfidf_title_test  (36052, 2638)
```

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

Avg W2V on TEXT/ESSAYS(Train,cv,test)

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essays_vectors_train = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm1(X_train['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_essays_vectors_train.append(vector)

# avg_w2v_essays_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this li
# for sentence in tqdm1(X_cv['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_essays_vectors_cv.append(vector)

avg_w2v_essays_vectors_test = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm1(X_test['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:
```

```
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essays_vectors_test.append(vector)

print(len(avg_w2v_essays_vectors_train))
# print(len(avg_w2v_essays_vectors_cv))
print(len(avg_w2v_essays_vectors_test))
print(len(avg_w2v_essays_vectors_train[0]))
# print(len(avg_w2v_essays_vectors_cv[0]))
print(len(avg_w2v_essays_vectors_test[0]))
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

73196
36052
300
300
```

Avg W2V on TITLES(Train,cv,test)

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_titles_vectors_train = []; # the avg-w2v for each sentence/review is stored in this l
for sentence in tqdm1(X_train['preprocessed_titles']): # 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_titles_vectors_train.append(vector)

# avg_w2v_titles_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this li
# for sentence in tqdm1(X_cv['preprocessed_titles']): # 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_titles_vectors_cv.append(vector)

avg_w2v_titles_vectors_test = []; # the avg-w2v for each sentence/review is stored in this li
for sentence in tqdm1(X_test['preprocessed_titles']): # 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_titles_vectors_test.append(vector)

print(len(avg_w2v_titles_vectors_train))
# print(len(avg_w2v_titles_vectors_cv))
print(len(avg_w2v_titles_vectors_test))
print(len(avg_w2v_titles_vectors_train[0]))
# print(len(avg_w2v_titles_vectors_cv[0]))
print(len(avg_w2v_titles_vectors_test[0]))
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

73196
36052
300
300
```

TFIDF weighted W2V on TEXT/ESSAYS(Train,cv,test)

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['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_essays_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm1(X_train['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.
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_essays_vectors_train.append(vector)
```

```
# # average Word2Vec
# # compute average word2vec for each review.
# tfidf_w2v_essays_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this
# for sentence in tqdm1(X_cv['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((sentenc
#             tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
#             vector += (vec * tf_idf) # calculating tfidf weighted w2v
#             tf_idf_weight += tf_idf
#     if tf_idf_weight != 0:
#         vector /= tf_idf_weight
#     tfidf_w2v_essays_vectors_cv.append(vector)


# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essays_vectors_test = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm1(X_test['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.
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_essays_vectors_test.append(vector)

print(len(tfidf_w2v_essays_vectors_train))
# print(len(tfidf_w2v_essays_vectors_cv))
print(len(tfidf_w2v_essays_vectors_test))
print(len(tfidf_w2v_essays_vectors_train[0]))
# print(len(tfidf_w2v_essays_vectors_cv[0]))
print(len(tfidf_w2v_essays_vectors_test[0]))
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

73196
36052
300
300
```

TFIDF weighted W2V on TITLES(Train,cv,test)

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['preprocessed_titles'])
# 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_titles_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm1(X_train['preprocessed_titles']): # 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.
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_titles_vectors_train.append(vector)


# # average Word2Vec
# # compute average word2vec for each review.
# tfidf_w2v_titles_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this
# for sentence in tqdm1(X_cv['preprocessed_titles']): # 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((sentenc
#             tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
#             vector += (vec * tf_idf) # calculating tfidf weighted w2v
#             tf_idf_weight += tf_idf
#     if tf_idf_weight != 0:
#         vector /= tf_idf_weight
#     tfidf_w2v_titles_vectors_cv.append(vector)


# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_titles_vectors_test = []; # the avg-w2v for each sentence/review is stored in this
for sentence in tqdm1(X_test['preprocessed_titles']): # 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.
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_titles_vectors_test.append(vector)

print(len(tfidf_w2v_titles_vectors_train))
# print(len(tfidf_w2v_titles_vectors_cv))
print(len(tfidf_w2v_titles_vectors_test))
print(len(tfidf_w2v_titles_vectors_train[0]))
# print(len(tfidf_w2v_titles_vectors_cv[0]))
print(len(tfidf_w2v_titles_vectors_test[0]))
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

73196
36052
300
300
```

```
import dill
dill.dump_session('notebook_env.db')
# dill.load_session('notebook_env.db')
```

```
project_data.columns
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'quantity',
       'digits_in_summary', 'clean_project_grade_category',
       'preprocessed_essays', 'preprocessed_titles'],
      dtype='object')
```

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly
```

```
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4 Appling Support Vector Machines on different kind of featurization 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 Applying SVM on BOW, SET 1

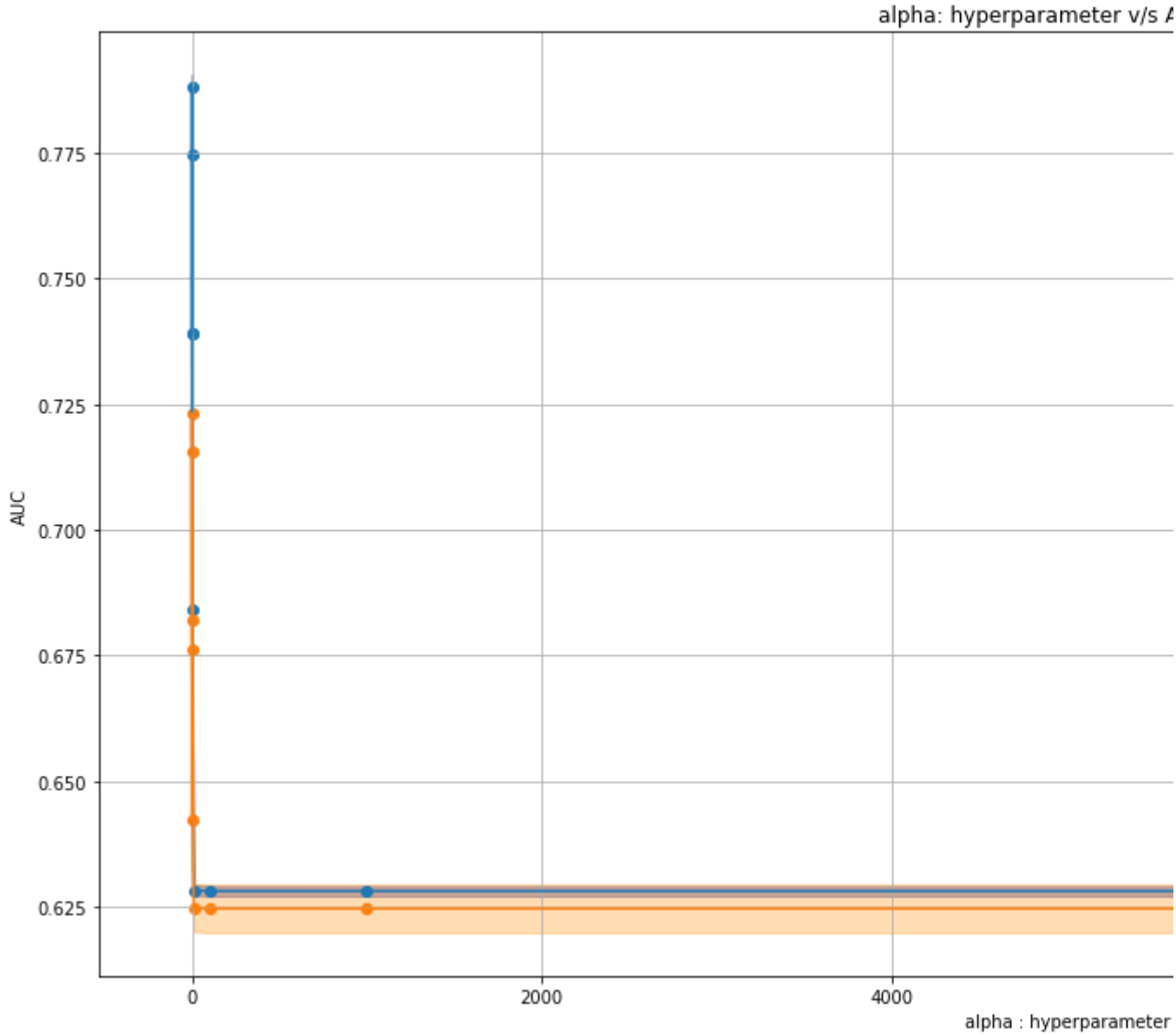
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_one_hot_tra
               ,project_grade_category_one_hot_train,price_standardized_train,quantity_standa
               ,teacher_number_of_previously_posted_projects_standardized_train,text_bow_trai
# X_cr = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_one_hot_cv,teac
#                ,project_grade_category_one_hot_cv,price_standardized_cv,quantity_standardiz
#                ,teacher_number_of_previously_posted_projects_standardized_cv,text_bow_cv,ti
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_one_hot_test,
               ,project_grade_category_one_hot_test,price_standardized_test,quantity_standard
               ,teacher_number_of_previously_posted_projects_standardized_test,text_bow_test,

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

```
Final Data matrix on BOW
(73196, 7740) (73196,)
(36052, 7740) (36052,)
====================================================================================================
```

GridSearchCV using Penalty = 'l2'

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

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
```

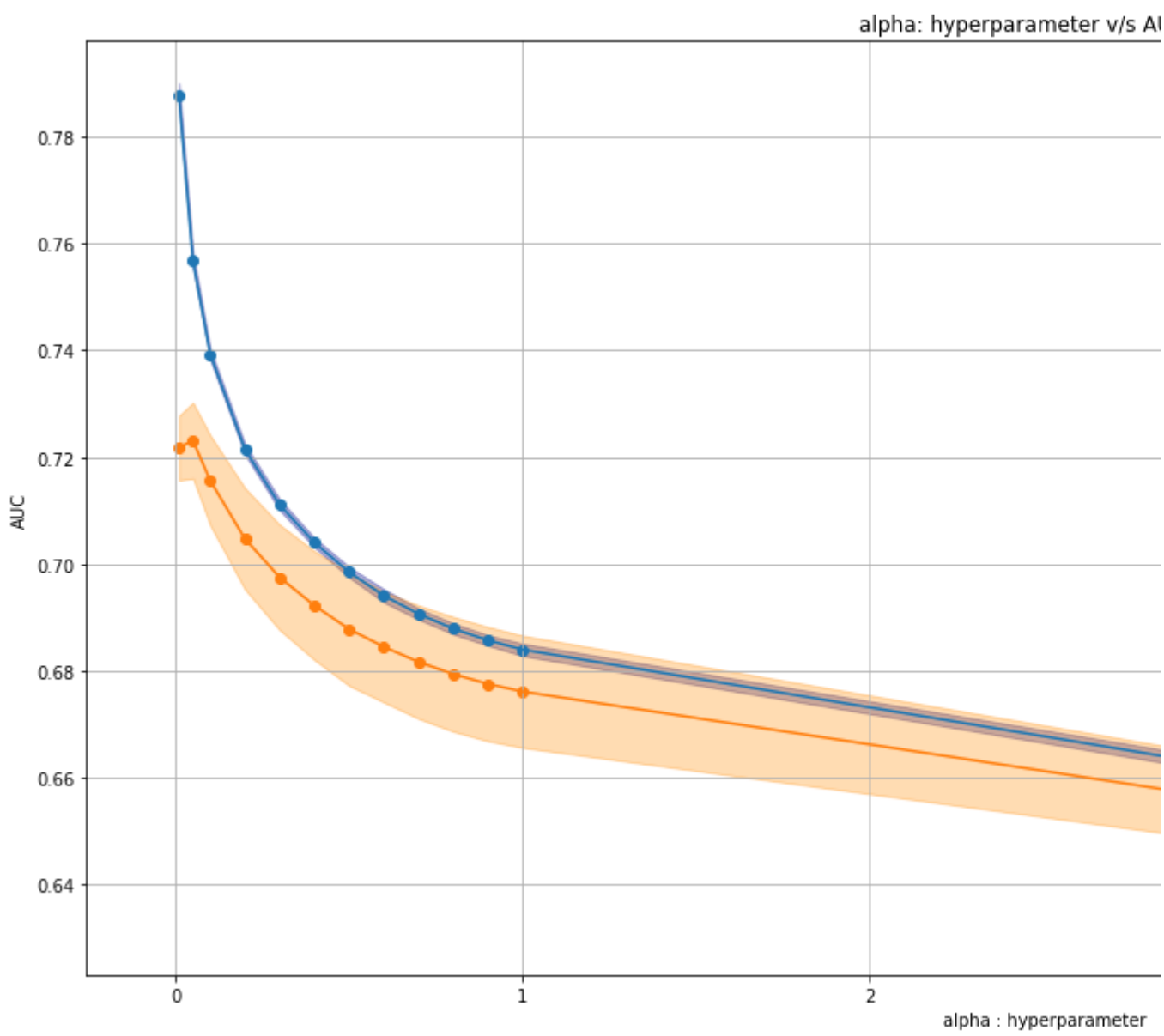
```
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



Not able to visualise with high values of alphas, so we'll reduce

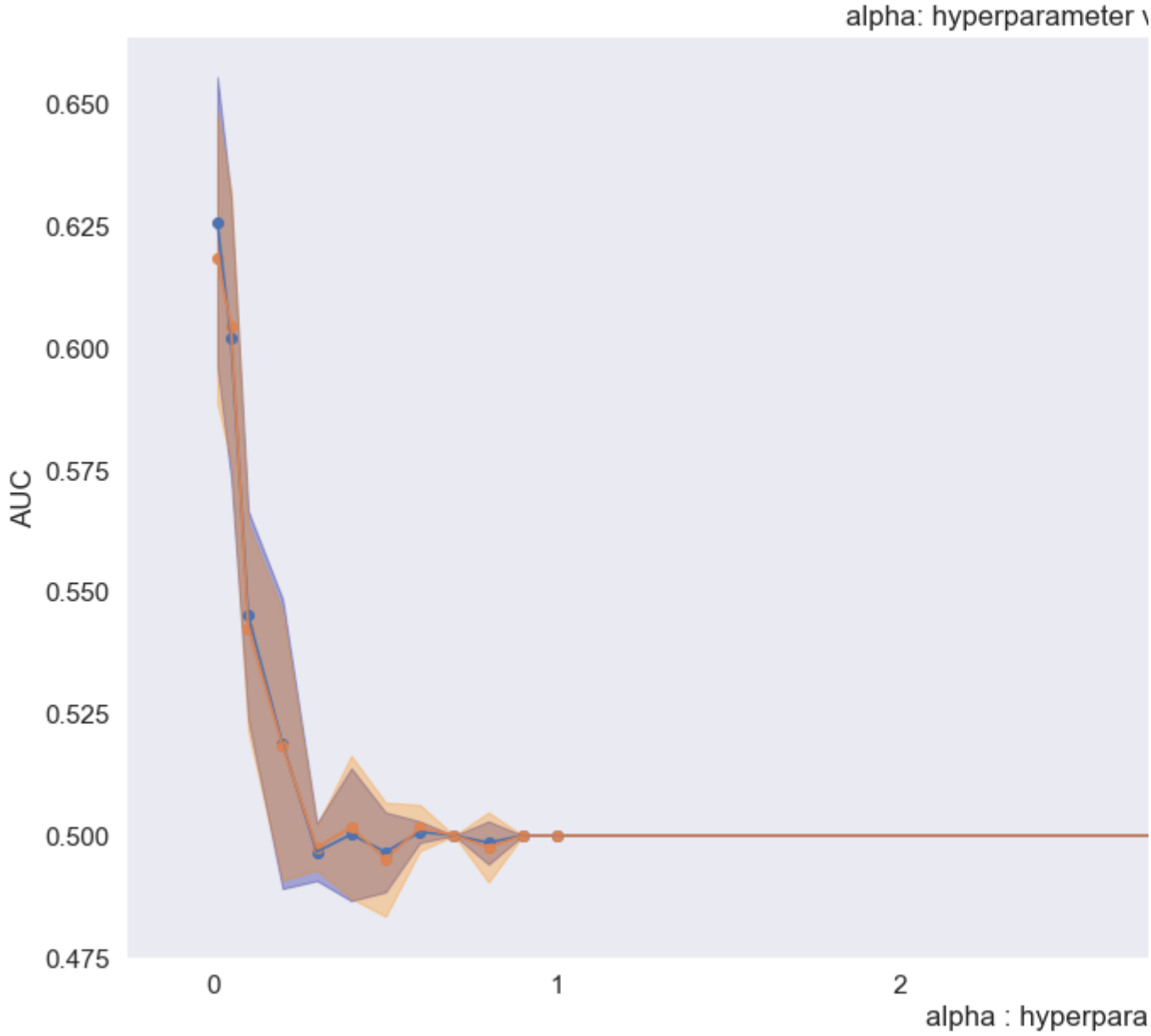
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



GridSearchCV using Penalty = 'l1'

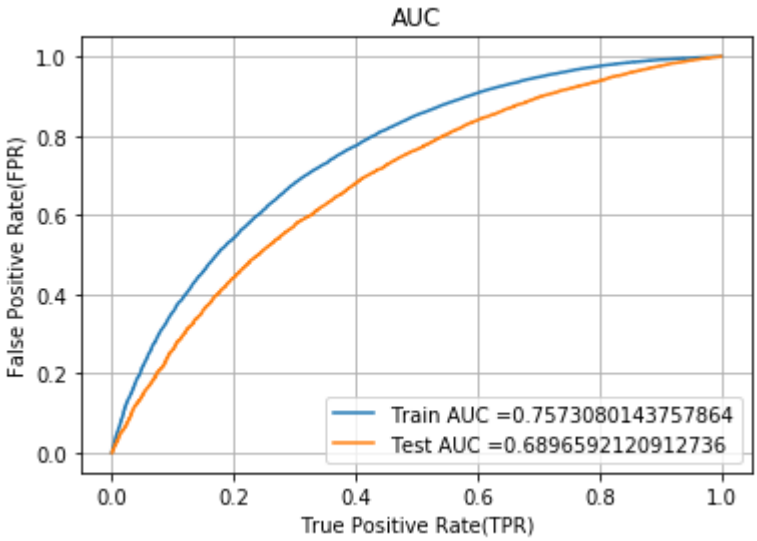
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



L2 performs better

```
from sklearn.metrics import roc_curve, auc

model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.01)
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
# not the predicted outputs
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

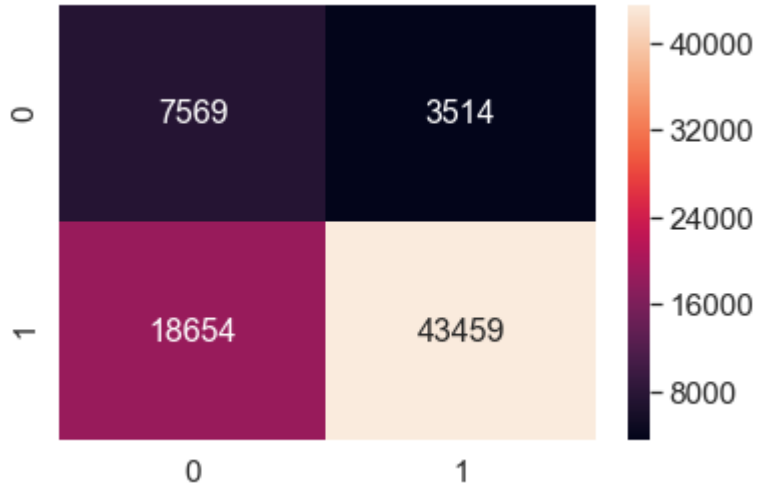



```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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


print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train[:], predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
print("Test confusion matrix")
print(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

```
==========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.47783548165502 for threshold 1.091
[[ 7569  3514]
 [18654 43459]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.40881225069673194 for threshold 1.17
[[ 4149  1310]
 [15335 15258]]
```

```
conf_matr_df_train =  pd.DataFrame(confusion_matrix(y_train[:], predict(y_train_pred, tr_thre
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.47783548165502 for threshold 1.091
<matplotlib.axes._subplots.AxesSubplot at 0x1a5dea6bac8>
```




```
conf_matr_df_test =  pd.DataFrame(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresho
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

2.4.2 Applying SVM on TFIDF, SET 2

```
import dill
# dill.dump_session('notebook_env.db')
dill.load_session('notebook_env.db')
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\smart_open\ssh.py:34: UserWarning: paramiko
  warnings.warn('paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip in
C:\Users\LENOVO\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

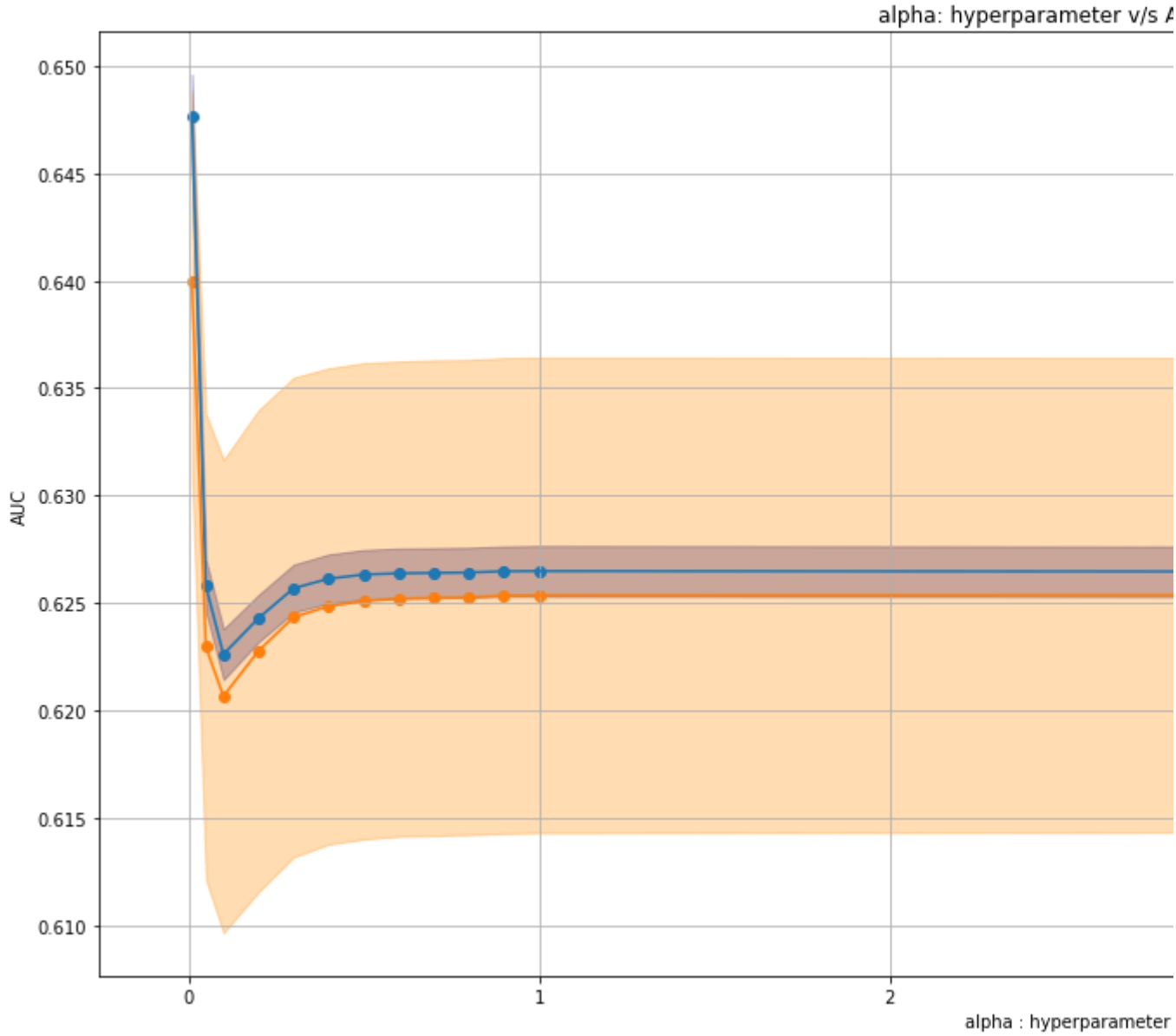
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_one_hot_tra
               ,project_grade_category_one_hot_train,price_standardized_train,quantity_standa
               ,teacher_number_of_previously_posted_projects_standardized_train,text_tfidf_tr
# X_cr = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_one_hot_cv,teac
#                ,project_grade_category_one_hot_cv,price_standardized_cv,quantity_standardiz
#                ,teacher_number_of_previously_posted_projects_standardized_cv,text_tfidf_cv,
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_one_hot_test,
               ,project_grade_category_one_hot_test,price_standardized_test,quantity_standard
               ,teacher_number_of_previously_posted_projects_standardized_test,text_tfidf_tes

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

```
Final Data matrix on TFIDF
(73196, 7741) (73196,)
(36052, 7741) (36052,)
====================================================================================================
```

GridSearchCV using Penalty = 'l2'

```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV
# https://machinelearningmastery.com/how-to-fix-futurewarning-messages-in-scikit-learn/
from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)


sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}
```

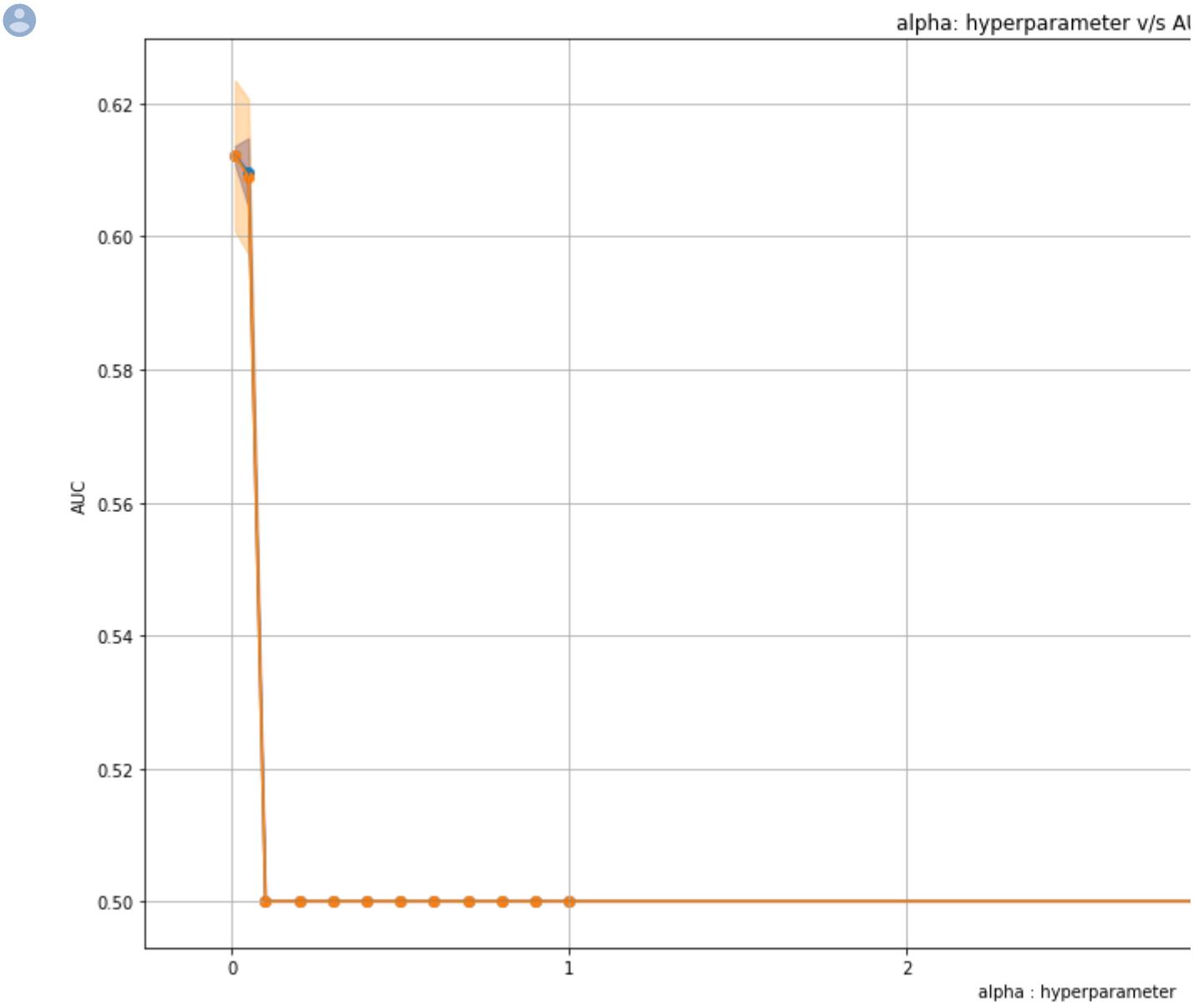
```
clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



GridSearchCV using Penalty = 'l1'

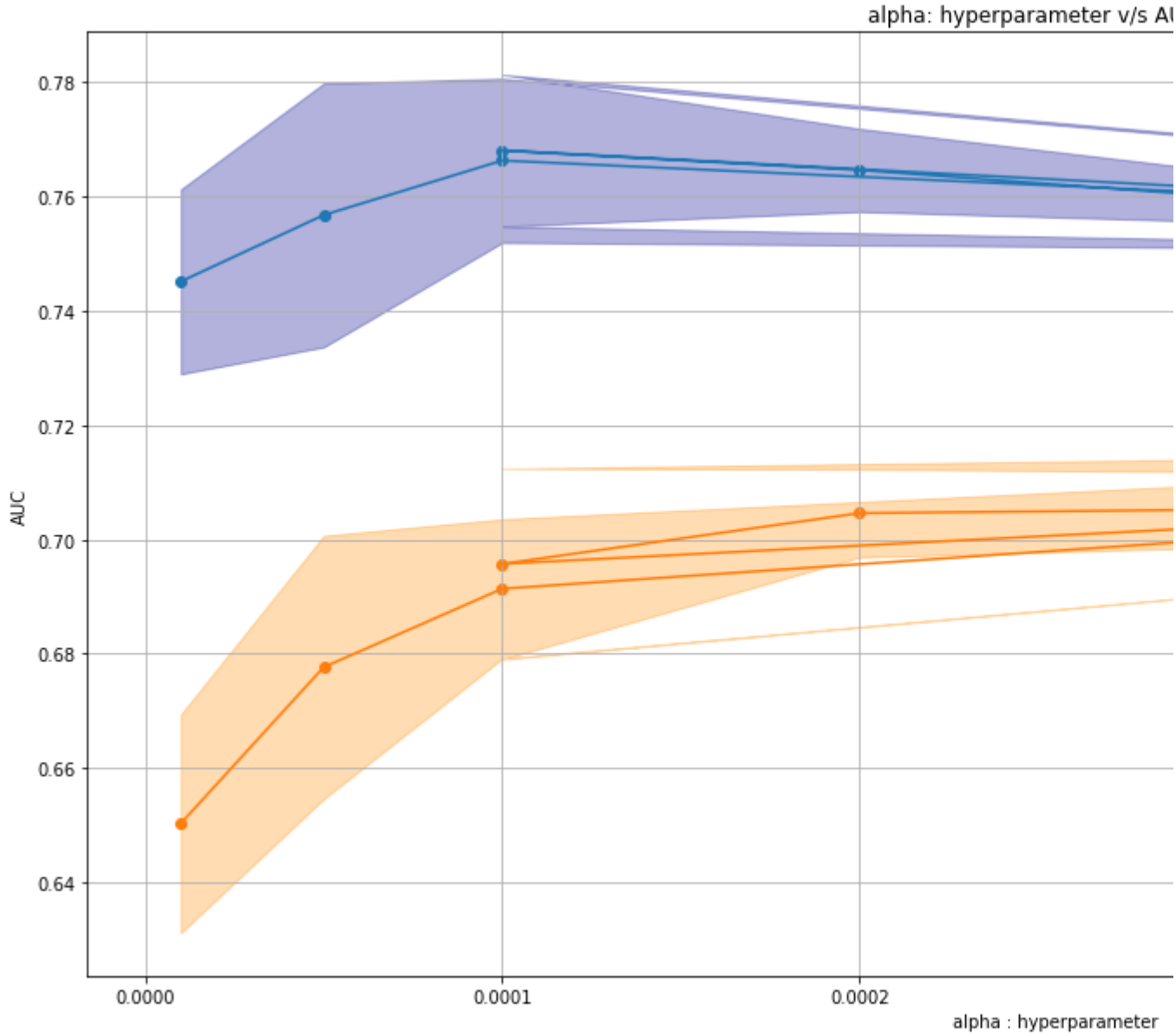
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



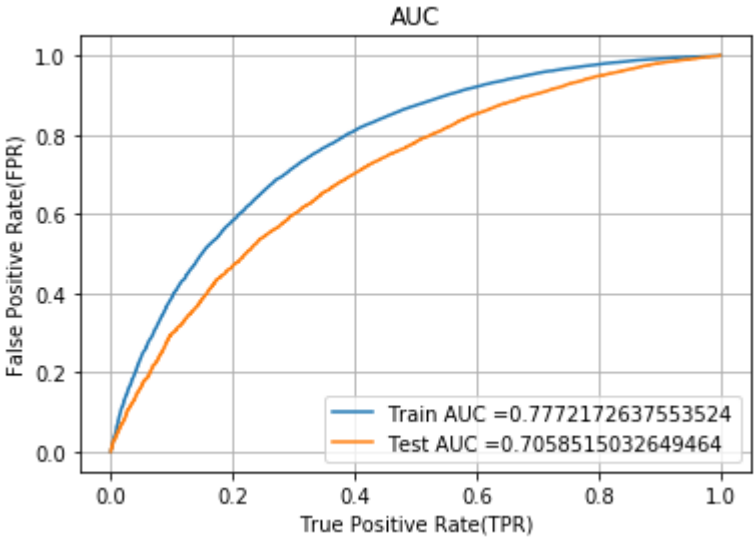
Lets see for smaller values of alphas for L2

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

from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.00001,0.00005,0.0001, 0.0005, 0.0001, 0.0002, 0.0003]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```




```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.0002)
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
# not the predicted outputs
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

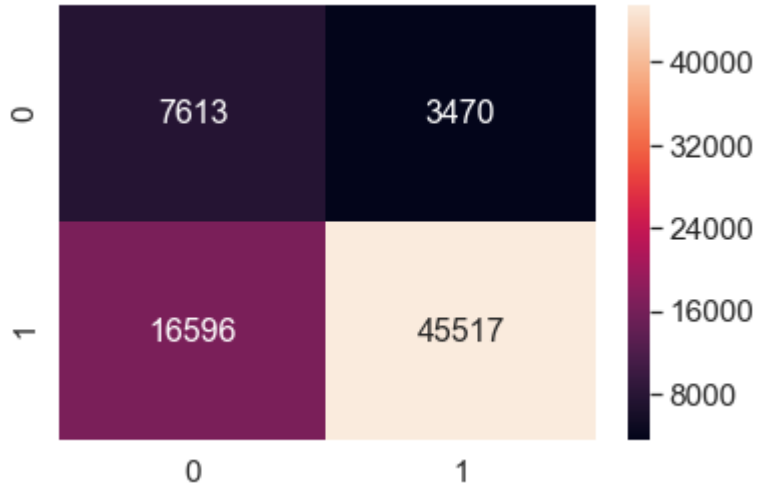



```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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


print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train[:], predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
print("Test confusion matrix")
print(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

```
==================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5033726568377059 for threshold 1.084
[[ 7613  3470]
 [16596 45517]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4264309655128794 for threshold 1.173
[[ 4241  1218]
 [15214 15379]]
```

```
conf_matr_df_train =  pd.DataFrame(confusion_matrix(y_train[:], predict(y_train_pred, tr_thre
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.5033726568377059 for threshold 1.084
<matplotlib.axes._subplots.AxesSubplot at 0x1ddd6f833c8>
```




```
conf_matr_df_test =  pd.DataFrame(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresho
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

2.4.3 Applying SVM on AVG W2V, SET 3

```
import dill
# dill.dump_session('notebook_env.db')
dill.load_session('notebook_env.db')
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\smart_open\ssh.py:34: UserWarning: paramiko
  warnings.warn('paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip in
C:\Users\LENOVO\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

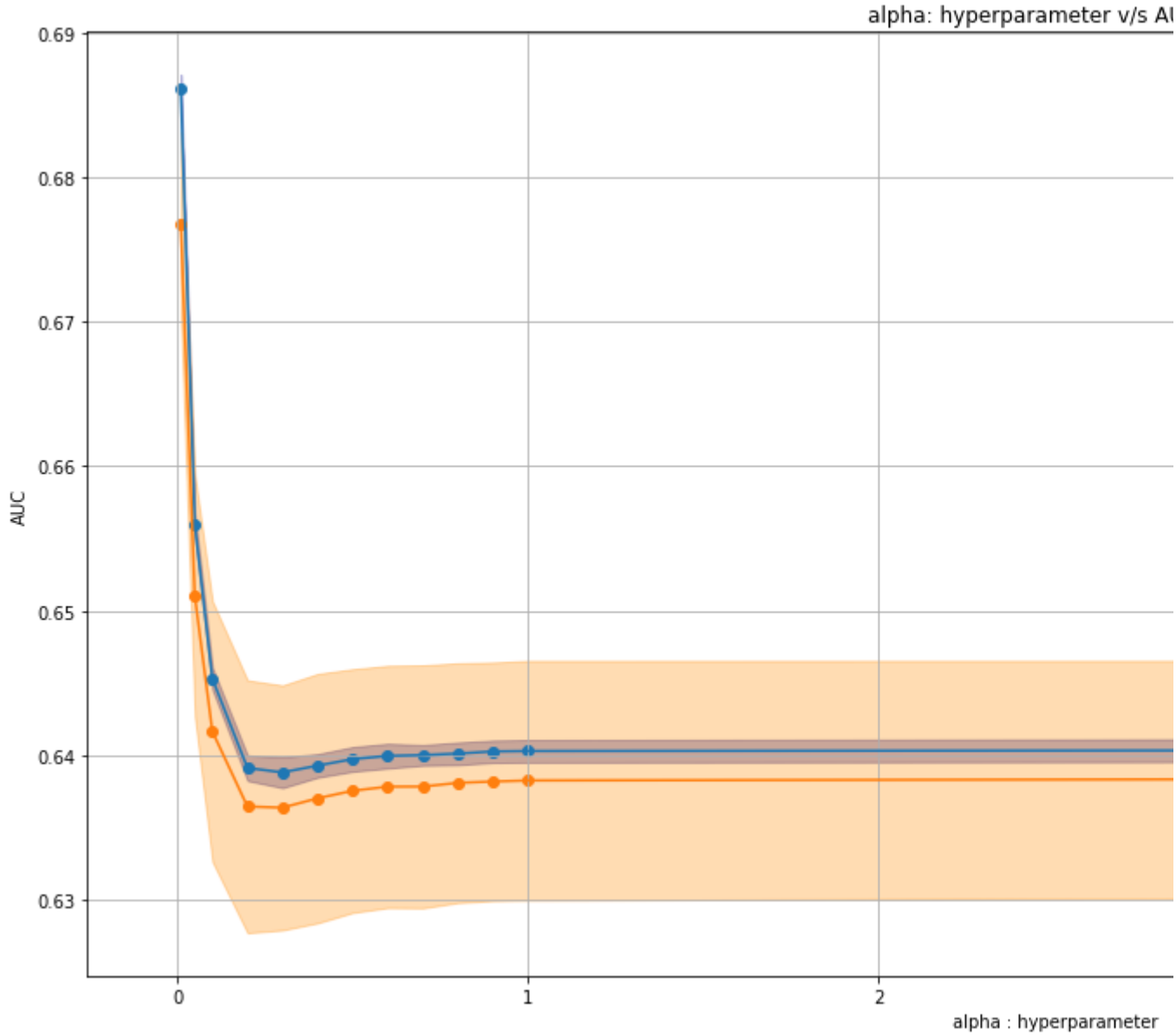
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_one_hot_tra
               ,project_grade_category_one_hot_train,price_standardized_train,quantity_standa
               ,teacher_number_of_previously_posted_projects_standardized_train,avg_w2v_essay
               ,avg_w2v_titles_vectors_train)).tocsr()
# X_cr = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_one_hot_cv,teac
#                ,project_grade_category_one_hot_cv,price_standardized_cv,quantity_standardiz
#                ,teacher_number_of_previously_posted_projects_standardized_cv,avg_w2v_essays
#                ,avg_w2v_titles_vectors_cv)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_one_hot_test,
               ,project_grade_category_one_hot_test,price_standardized_test,quantity_standard
               ,teacher_number_of_previously_posted_projects_standardized_test,avg_w2v_essays
               ,avg_w2v_titles_vectors_test)).tocsr()

print("Final Data matrix on AVGW2V")
print(X_tr.shape, y_train.shape)
# print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix on AVGW2V
(73196, 702) (73196,)
(36052, 702) (36052,)
====================================================================================================
```

GridSearchCV using Penalty = 'l2'

```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV
# https://machinelearningmastery.com/how-to-fix-futurewarning-messages-in-scikit-learn/
from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)
```

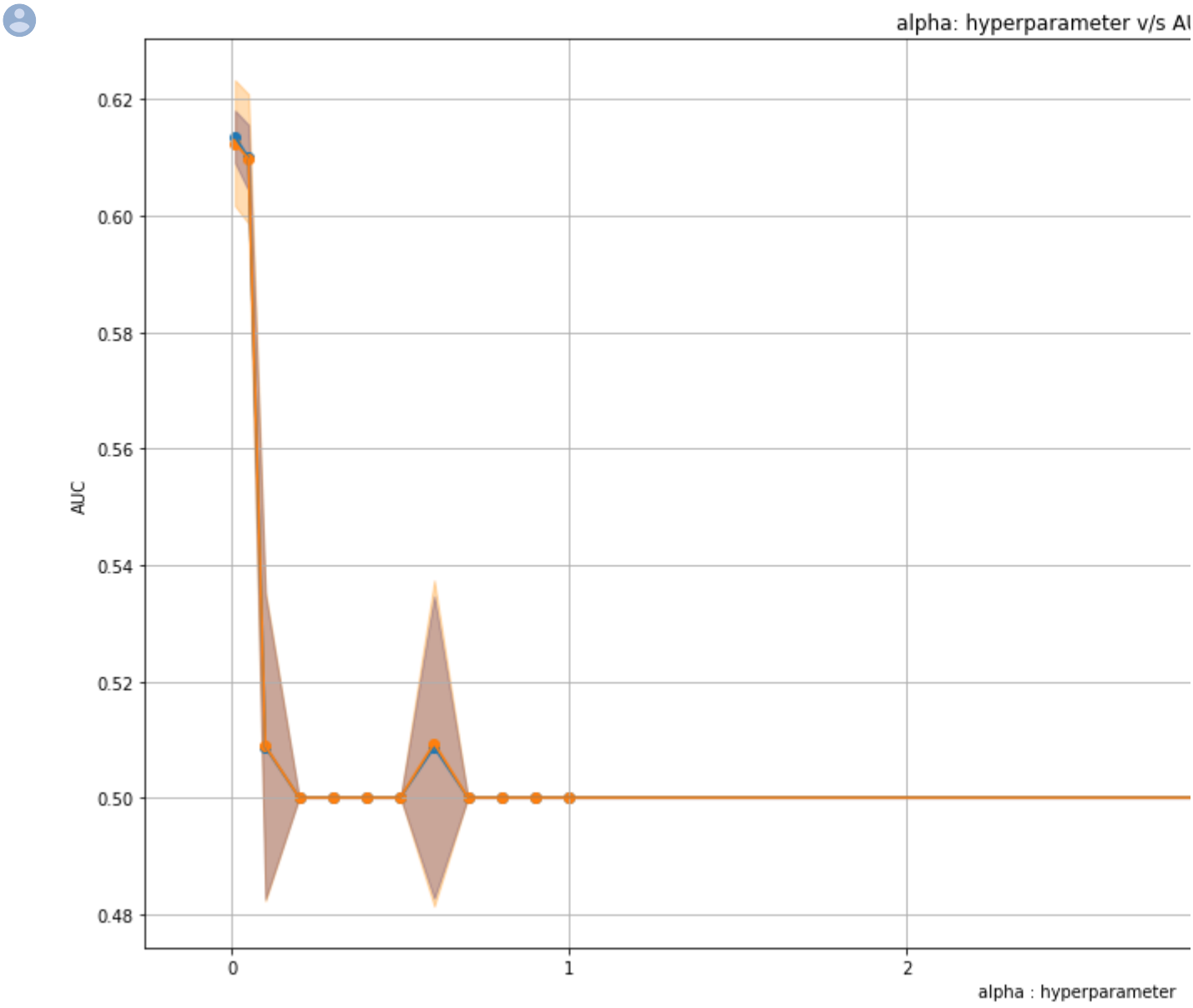
```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



GridSearchCV using Penalty = 'l1'

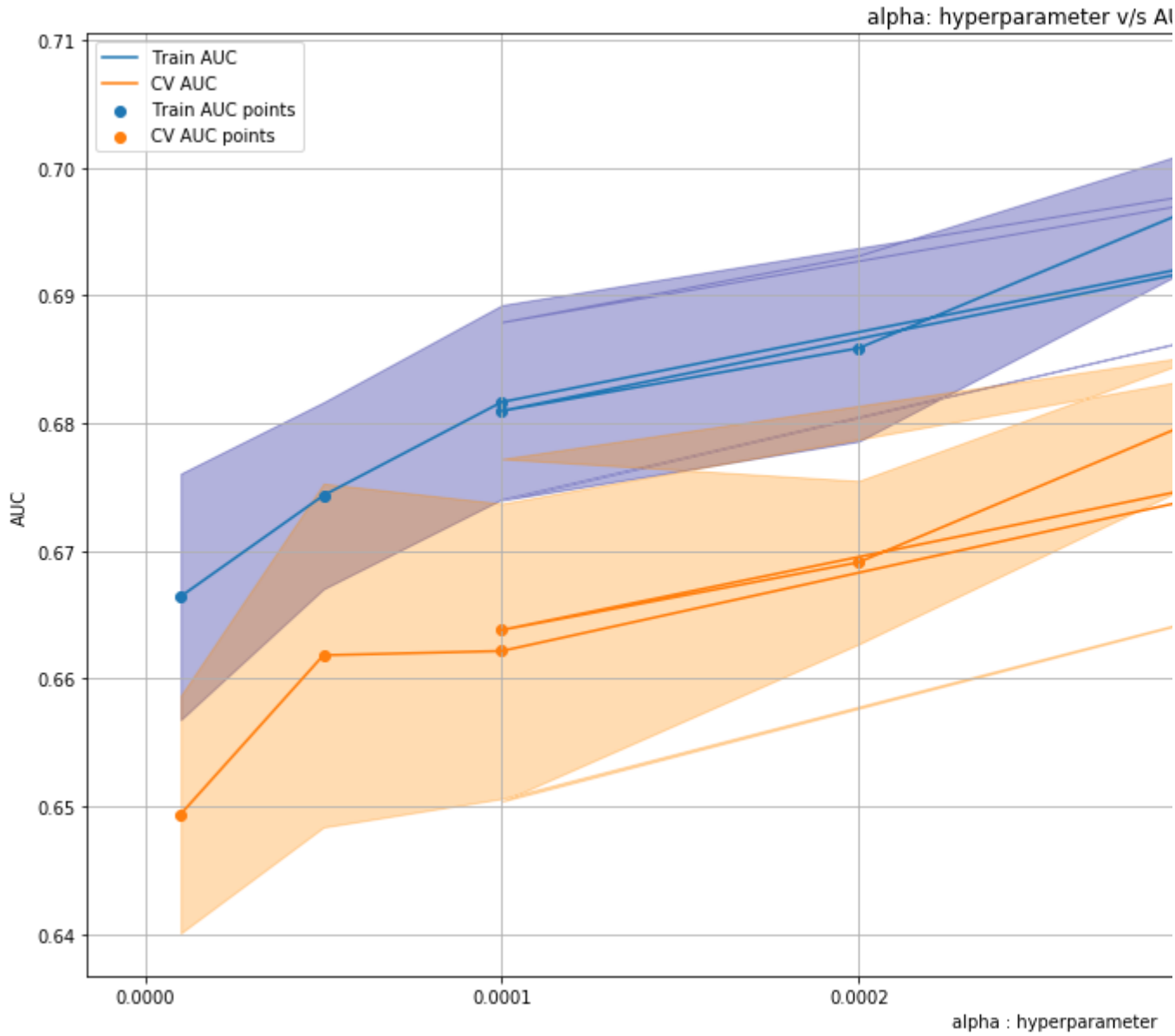
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



Lets see for smaller values of alphas for L2

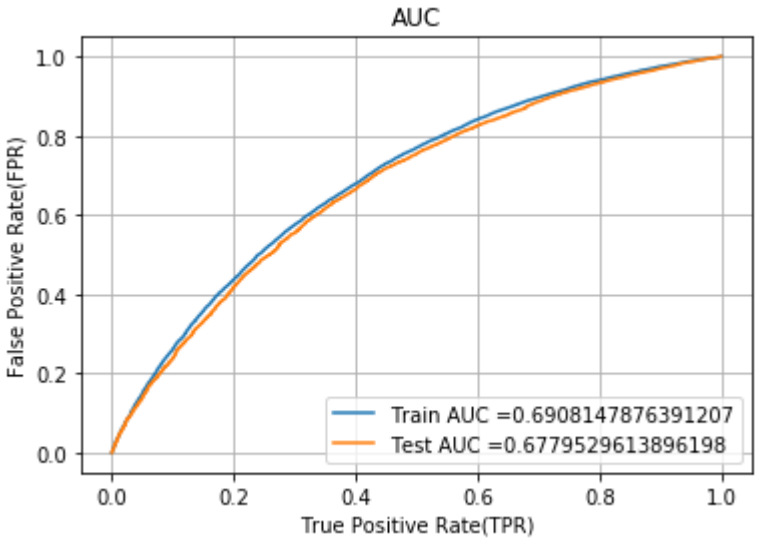
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.00001,0.00005,0.0001, 0.0005, 0.0001, 0.0002, 0.0003]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```




```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.0005)
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
# not the predicted outputs
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\linear_model\stochastic_gradient.py:

max_iter and tol parameters have been added in SGDClassifier in 0.19. If both are left u
```

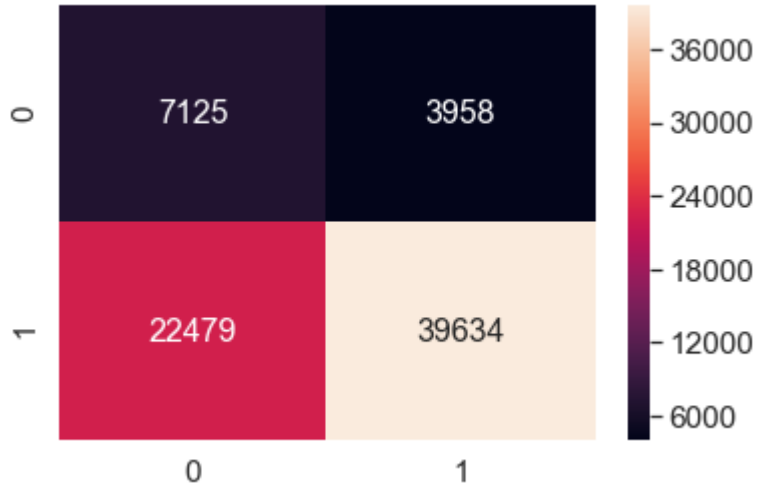



```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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


print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train[:], predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
print("Test confusion matrix")
print(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

```
==========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4102163203960711 for threshold 1.177
[[ 7125  3958]
 [22479 39634]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4027674808988909 for threshold 1.306
[[ 4415  1044]
 [18313 12280]]
```

```
conf_matr_df_train =  pd.DataFrame(confusion_matrix(y_train[:], predict(y_train_pred, tr_thre
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.4102163203960711 for threshold 1.177
<matplotlib.axes._subplots.AxesSubplot at 0x135e2583080>
```




```
conf_matr_df_test =  pd.DataFrame(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresho
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

2.4.4 Applying SVM on TFIDF W2V, SET 4

```
import dill
# dill.dump_session('notebook_env.db')
dill.load_session('notebook_env.db')
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\smart_open\ssh.py:34: UserWarning: paramiko
  warnings.warn('paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip in
C:\Users\LENOVO\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

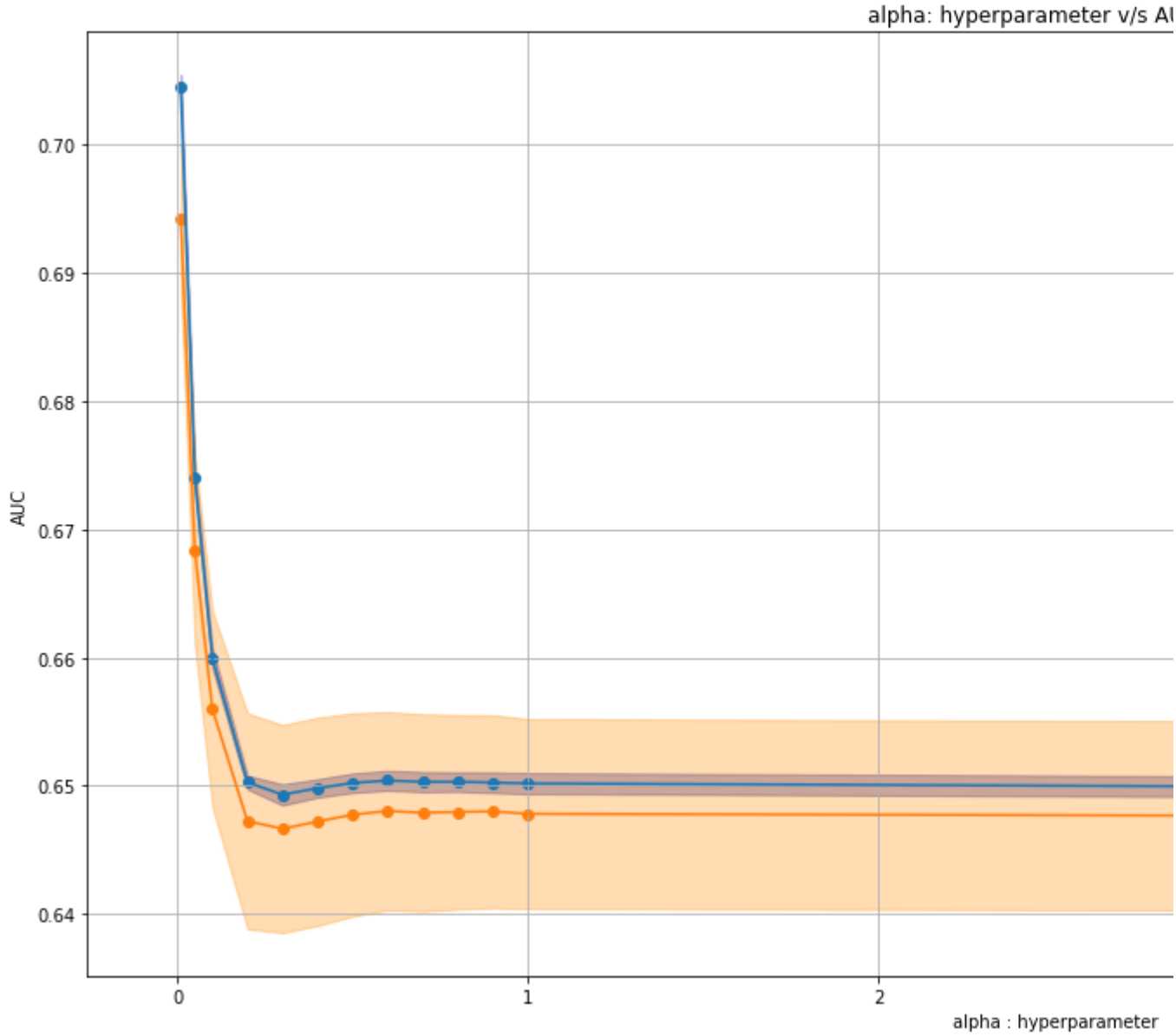
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_one_hot_tra
               ,project_grade_category_one_hot_train,price_standardized_train,quantity_standa
               ,teacher_number_of_previously_posted_projects_standardized_train,tfidf_w2v_ess
               ,tfidf_w2v_titles_vectors_train)).tocsr()
# X_cr = hstack((categories_one_hot_cv,sub_categories_one_hot_cv,school_state_one_hot_cv,teac
#                ,project_grade_category_one_hot_cv,price_standardized_cv,quantity_standardiz
#                ,teacher_number_of_previously_posted_projects_standardized_cv,tfidf_w2v_essa
#                ,tfidf_w2v_titles_vectors_cv)).tocsr()
X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_one_hot_test,
               ,project_grade_category_one_hot_test,price_standardized_test,quantity_standard
               ,teacher_number_of_previously_posted_projects_standardized_test,tfidf_w2v_essa
               ,tfidf_w2v_titles_vectors_test)).tocsr()

print("Final Data matrix on TFIDF W2V")
print(X_tr.shape, y_train.shape)
# print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix on TFIDF W2V
(73196, 702) (73196,)
(36052, 702) (36052,)
====================================================================================================
```

GridSearchCV using Penalty = 'l2'

```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV
# https://machinelearningmastery.com/how-to-fix-futurewarning-messages-in-scikit-learn/
from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)
```

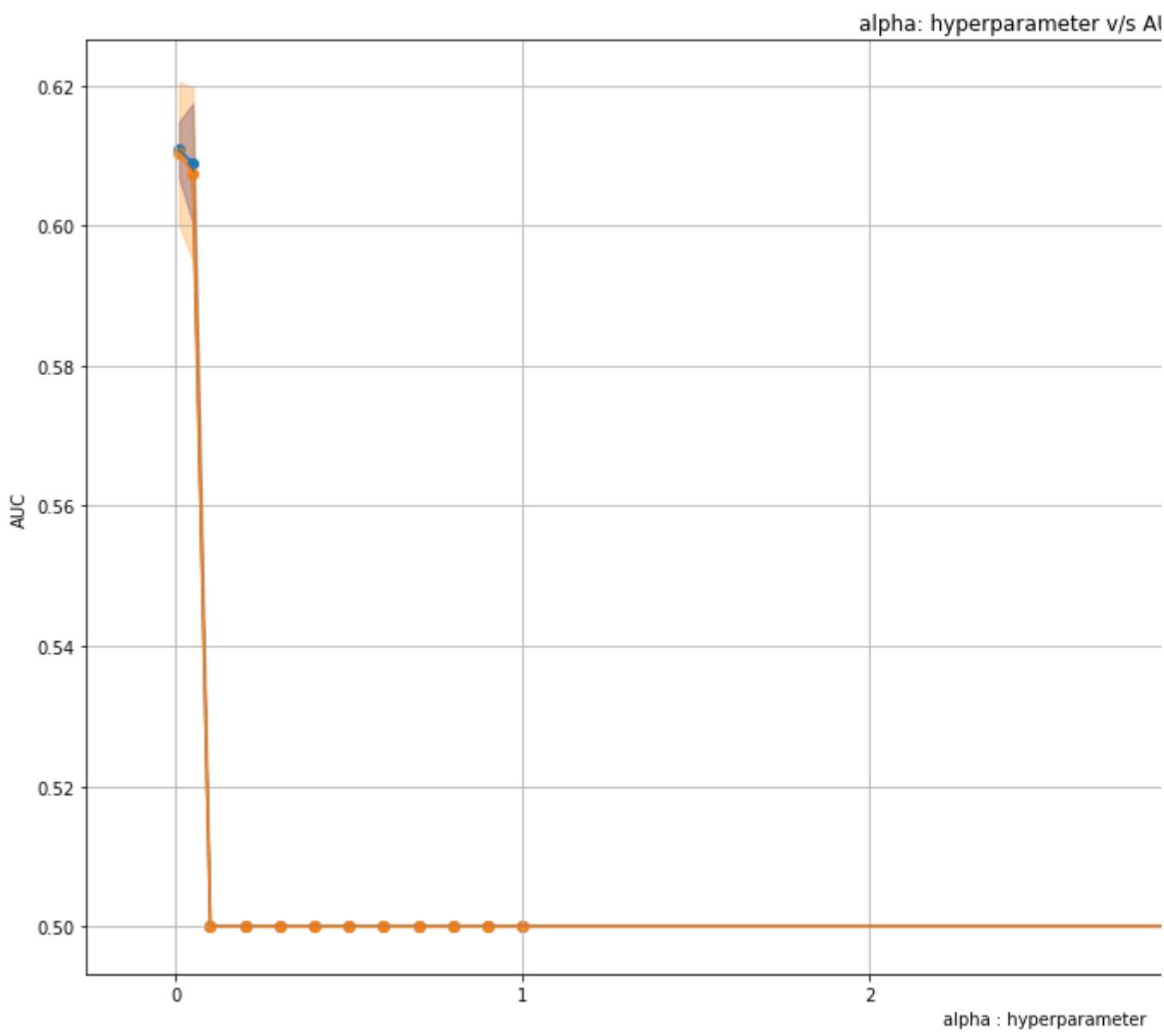
```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



GridSearchCV using Penalty = 'l1'

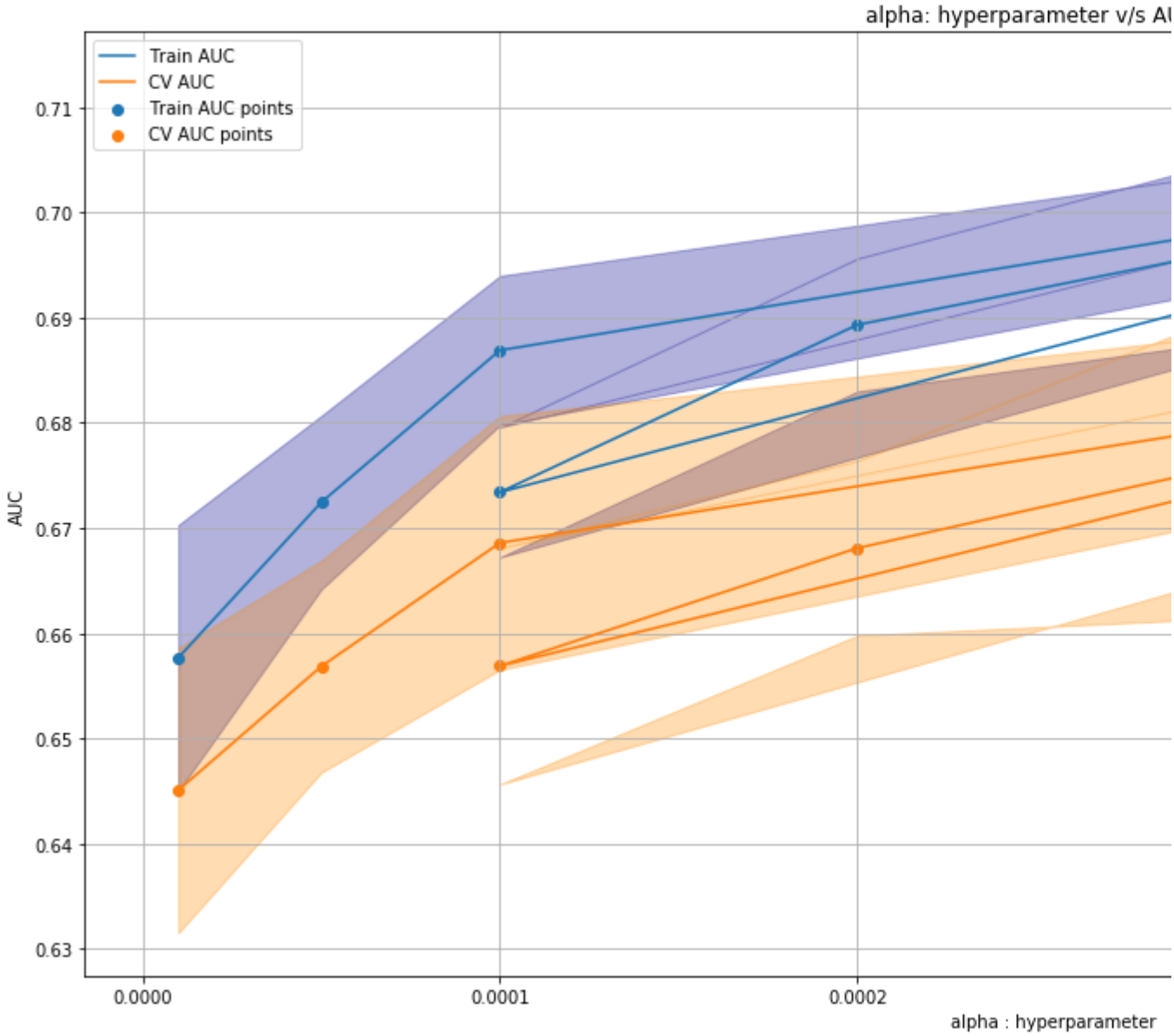
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



Lets see for smaller values of alphas for L2

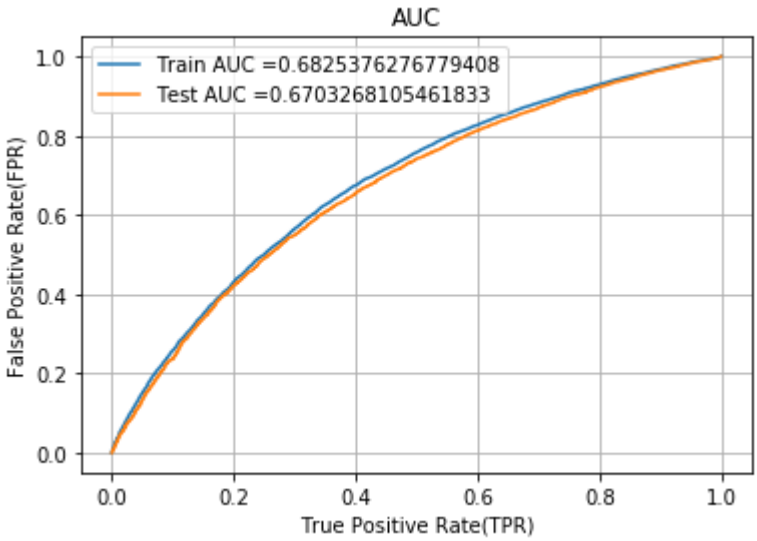
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.00001,0.00005,0.0001, 0.0005, 0.0001, 0.0002, 0.0003]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```




```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.0005)
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
# not the predicted outputs
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\linear_model\stochastic_gradient.py:

max_iter and tol parameters have been added in SGDClassifier in 0.19. If both are left u
```

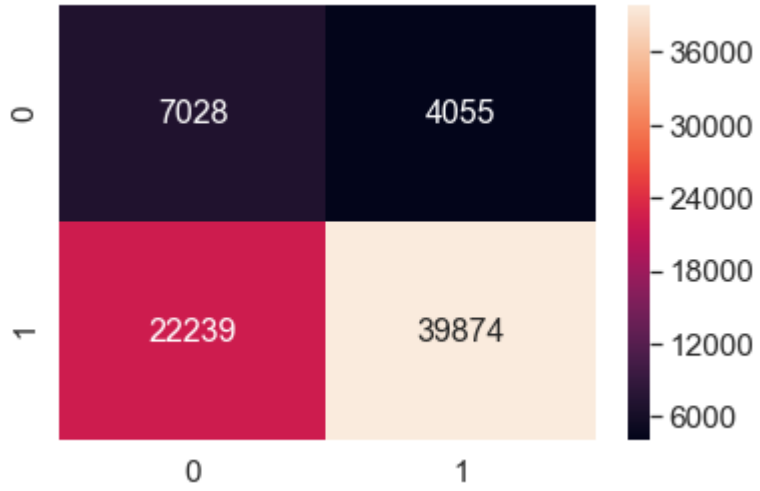



```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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


print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train[:], predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
print("Test confusion matrix")
print(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

```
========================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4070818301563723 for threshold 1.32
[[ 7028  4055]
 [22239 39874]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3957570999624106 for threshold 1.487
[[ 4474   985]
 [18553 12040]]
```

```
conf_matr_df_train =  pd.DataFrame(confusion_matrix(y_train[:], predict(y_train_pred, tr_thre
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.4070818301563723 for threshold 1.32
<matplotlib.axes._subplots.AxesSubplot at 0x11fd29a5438>
```




```
conf_matr_df_test =  pd.DataFrame(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresho
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

2.5 Support Vector Machines with added Features `Set 5`

2.5.1 Applying SVM on AVG W2V, SET 5

```
import dill
# dill.dump_session('notebook_env.db')
dill.load_session('notebook_env.db')
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\smart_open\ssh.py:34: UserWarning: paramiko
  warnings.warn('paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip in
C:\Users\LENOVO\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

Adding number of words in TITLES feature

```
print(X_train.shape)
print(X_test.shape)
```

```
(73196, 18)
(36052, 18)
```

```
type(quantity_standardized_train)
```

```
numpy.ndarray
```

Word counts(TITLES)

```
title_wordcount_train = []
title_train = list(X_train['preprocessed_titles'])
for i in tqdm1(title_train):
    b = len(str(i).split())
    title_wordcount_train.append(b)
title_wordcount_train = np.array(title_wordcount_train)

title_wordcount_test = []
title_test = list(X_test['preprocessed_titles'])
for i in tqdm1(title_test):
    b = len(str(i).split())
    title_wordcount_test.append(b)
title_wordcount_test = np.array(title_wordcount_test)

print(title_wordcount_train.shape)
print(title_wordcount_test.shape)
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

(73196,)
(36052,)
```

Standardizing Word counts(TITLES)

```
from sklearn.preprocessing import StandardScaler

title_wordcount_scalar = StandardScaler()
title_wordcount_scalar.fit(title_wordcount_train.reshape(-1,1))

title_wordcount_standardized_train = title_wordcount_scalar.transform(title_wordcount_train.r
title_wordcount_standardized_test = title_wordcount_scalar.transform(title_wordcount_test.res

print(title_wordcount_standardized_train.shape)
print(title_wordcount_standardized_test.shape)
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

(73196, 1)
(36052, 1)
```

Word counts(ESSAYS)

```
essay_wordcount_train = []
essay_train = list(X_train['preprocessed_essays'])
for i in tqdm1(essay_train):
    b = len(str(i).split())
    essay_wordcount_train.append(b)
essay_wordcount_train = np.array(essay_wordcount_train)


essay_wordcount_test = []
essay_test = list(X_test['preprocessed_titles'])
for i in tqdm1(essay_test):
    b = len(str(i).split())
```

```
    essay_wordcount_test.append(b)
essay_wordcount_test = np.array(essay_wordcount_test)

print(essay_wordcount_train.shape)
print(essay_wordcount_test.shape)
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

(73196,)
(36052,)
```

Standardizing Word counts(ESSAYS)

```
from sklearn.preprocessing import StandardScaler

essay_wordcount_scalar = StandardScaler()
essay_wordcount_scalar.fit(essay_wordcount_train.reshape(-1,1))

essay_wordcount_standardized_train = essay_wordcount_scalar.transform(essay_wordcount_train.r
essay_wordcount_standardized_test = essay_wordcount_scalar.transform(essay_wordcount_test.res

print(essay_wordcount_standardized_train.shape)
print(essay_wordcount_standardized_test.shape)
```

```
C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

C:\Users\LENOVO\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConvers

Data with input dtype int32 was converted to float64 by StandardScaler.

(73196, 1)
(36052, 1)
```

Sentiment scores for each essay

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

import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()
```

```
sid = SentimentIntensityAnalyzer()

essay_sentscore_train = []
essay_train = list(X_train['preprocessed_essays'])
for i in tqdm1(essay_train):
    ss = sid.polarity_scores(str(i))
    essay_sentscore_train.append(ss)
essay_sentscore_train = np.array(essay_sentscore_train)

essay_negscore_train = []
essay_neuscore_train = []
essay_posscore_train = []
essay_compoundscore_train = []
for it in essay_sentscore_train:
    a = it['neg']
    essay_negscore_train.append(a)
    b = it['neu']
    essay_neuscore_train.append(b)
    c = it['pos']
    essay_posscore_train.append(c)
    d = it['compound']
    essay_compoundscore_train.append(d)

essay_negscore_train = np.array(essay_negscore_train).reshape(-1,1)
essay_neuscore_train = np.array(essay_neuscore_train).reshape(-1,1)
essay_posscore_train = np.array(essay_posscore_train).reshape(-1,1)
essay_compoundscore_train = np.array(essay_compoundscore_train).reshape(-1,1)

print((essay_negscore_train.shape))
print((essay_neuscore_train.shape))
print((essay_posscore_train.shape))
print((essay_compoundscore_train.shape))


##################################################################

essay_sentscore_test = []
essay_test = list(X_test['preprocessed_essays'])
for i in tqdm1(essay_test):
    ss = sid.polarity_scores(str(i))
    essay_sentscore_test.append(ss)
essay_sentscore_test = np.array(essay_sentscore_test)

essay_negscore_test = []
essay_neuscore_test = []
essay_posscore_test = []
essay_compoundscore_test = []
for it in essay_sentscore_test:
    a = it['neg']
    essay_negscore_test.append(a)
    b = it['neu']
    essay_neuscore_test.append(b)
```

```
    c = it['pos']
    essay_posscore_test.append(c)
    d = it['compound']
    essay_compoundscore_test.append(d)

essay_negscore_test = np.array(essay_negscore_test).reshape(-1,1)
essay_neuscore_test = np.array(essay_neuscore_test).reshape(-1,1)
essay_posscore_test = np.array(essay_posscore_test).reshape(-1,1)
essay_compoundscore_test = np.array(essay_compoundscore_test).reshape(-1,1)

print((essay_negscore_test.shape))
print((essay_neuscore_test.shape))
print((essay_posscore_test.shape))
print((essay_compoundscore_test.shape))
```

```
HBox(children=(IntProgress(value=0, max=73196), HTML(value='')))

(73196, 1)
(73196, 1)
(73196, 1)
(73196, 1)
HBox(children=(IntProgress(value=0, max=36052), HTML(value='')))

(36052, 1)
(36052, 1)
(36052, 1)
(36052, 1)
```

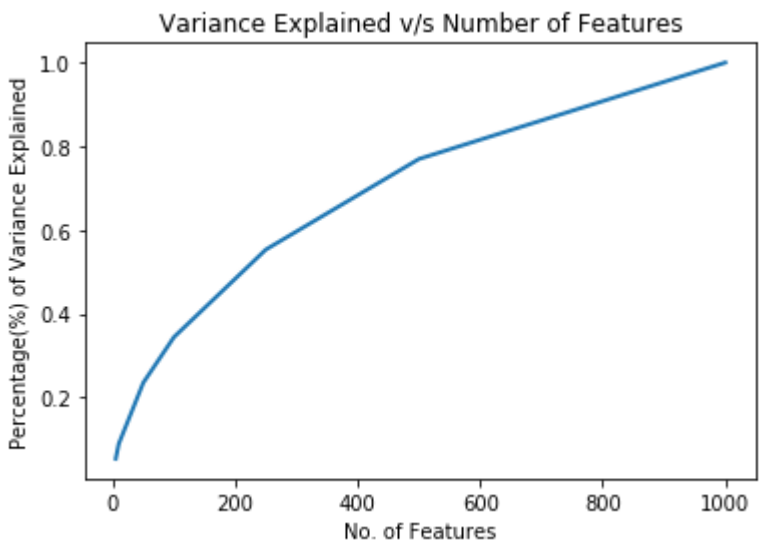
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essays = TfidfVectorizer(min_df=10,max_features=1010,ngram_range=(1,2))
vectorizer_tfidf_essays.fit(X_train['preprocessed_essays'])

text_tfidf_train1 = vectorizer_tfidf_essays.transform(X_train['preprocessed_essays'])
# text_tfidf_cv = vectorizer_tfidf_essays.transform(X_cv['preprocessed_essays'])
text_tfidf_test1 = vectorizer_tfidf_essays.transform(X_test['preprocessed_essays'])


text_tfidf_train1.shape
```

```
(73196, 1010)
```

```
from sklearn.decomposition import TruncatedSVD

features = [5,10,50,100,250,500,1000]
variance = []
# https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html

for i in tqdm1(features):
    svd = TruncatedSVD(n_components= i, n_iter=10, random_state=1)
    svd.fit(text_tfidf_train1)
    variance.append(svd.explained_variance_ratio_.sum())
```

```
HBox(children=(IntProgress(value=0, max=7), HTML(value='')))
```

```
plt.xlabel("No. of Features")
plt.ylabel("Percentage(%) of Variance Explained")
plt.title("Variance Explained v/s Number of Features")
plt.plot(features,variance,lw=2)
plt.show()
```



We'll pick the n-components as 1000 as it preserves above 95% of the variance

```
svd = TruncatedSVD(n_components= 1000, n_iter=7, random_state=42)
svd.fit(text_tfidf_train)
svd_train = svd.transform(text_tfidf_train)
svd_test = svd.transform(text_tfidf_test)
```

```
print(svd_train.shape)
print(svd_test.shape)
```

```
(73196, 1000)
(36052, 1000)
```

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((categories_one_hot_train,sub_categories_one_hot_train,school_state_one_hot_tra
               ,project_grade_category_one_hot_train,price_standardized_train,quantity_standa
               ,teacher_number_of_previously_posted_projects_standardized_train,title_wordcou
               ,essay_wordcount_standardized_train,essay_negscore_train,essay_neuscore_train,
               ,essay_compoundscore_train,svd_train)).tocsr()

X_te = hstack((categories_one_hot_test,sub_categories_one_hot_test,school_state_one_hot_test,
               ,project_grade_category_one_hot_test,price_standardized_test,quantity_standard
```

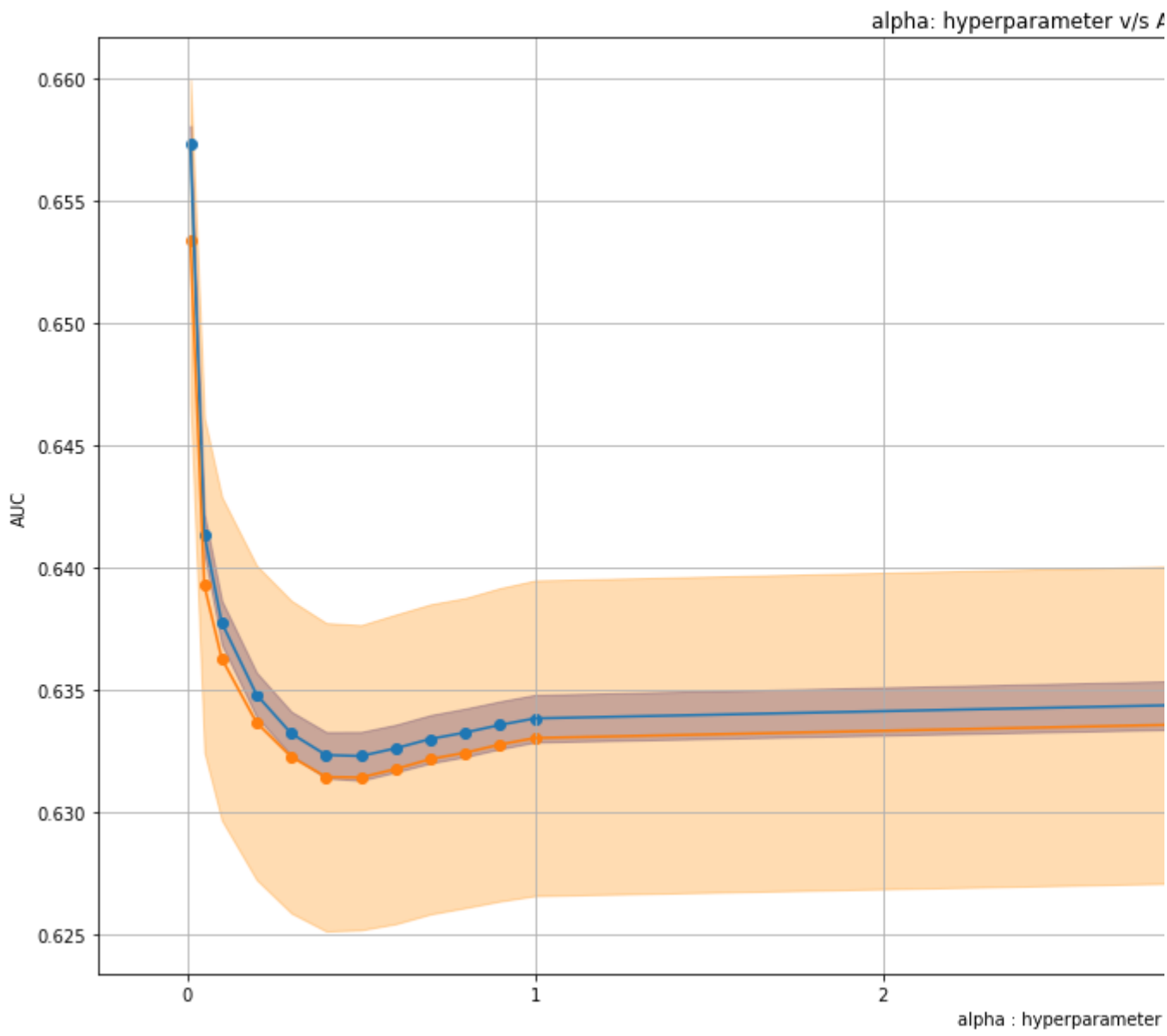
```
                ,teacher_number_of_previously_posted_projects_standardized_test,title_wordcoun
                ,essay_wordcount_standardized_test,essay_negscore_test,essay_neuscore_test,ess
                ,essay_compoundscore_test,svd_test)).tocsr()

print("Final Data matrix on TFIDF W2V")
print(X_tr.shape, y_train.shape)
# print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix on TFIDF W2V
(73196, 1108) (73196,)
(36052, 1108) (36052,)
====================================================================================================
```

GridSearchCV using Penalty = 'l2'

```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV
# https://machinelearningmastery.com/how-to-fix-futurewarning-messages-in-scikit-learn/
from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)


sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
```

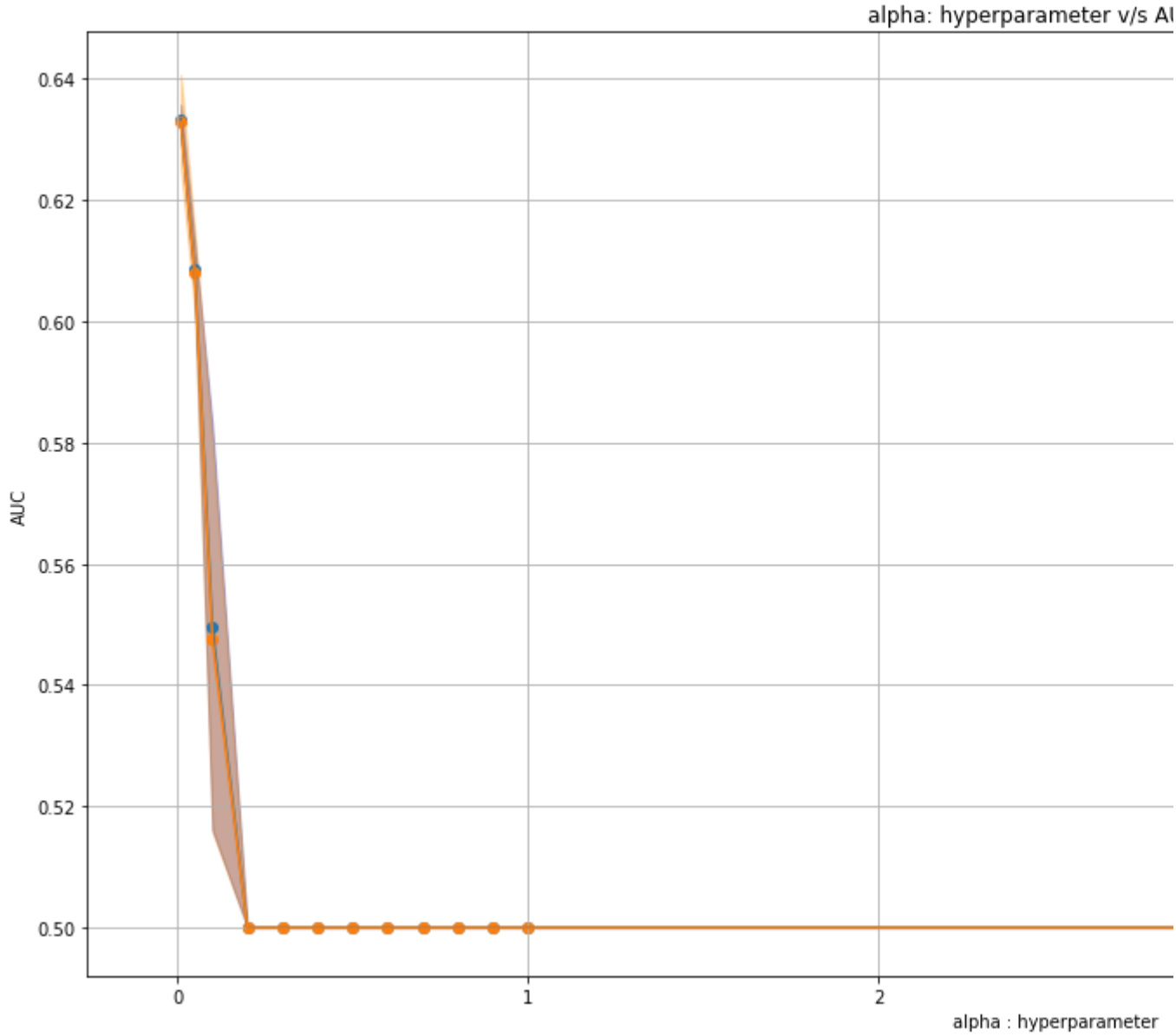
```
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



GridSearchCV using Penalty = 'l1'

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

sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')
parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)

train_auc= clf.cv_results_['mean_train_score']
```

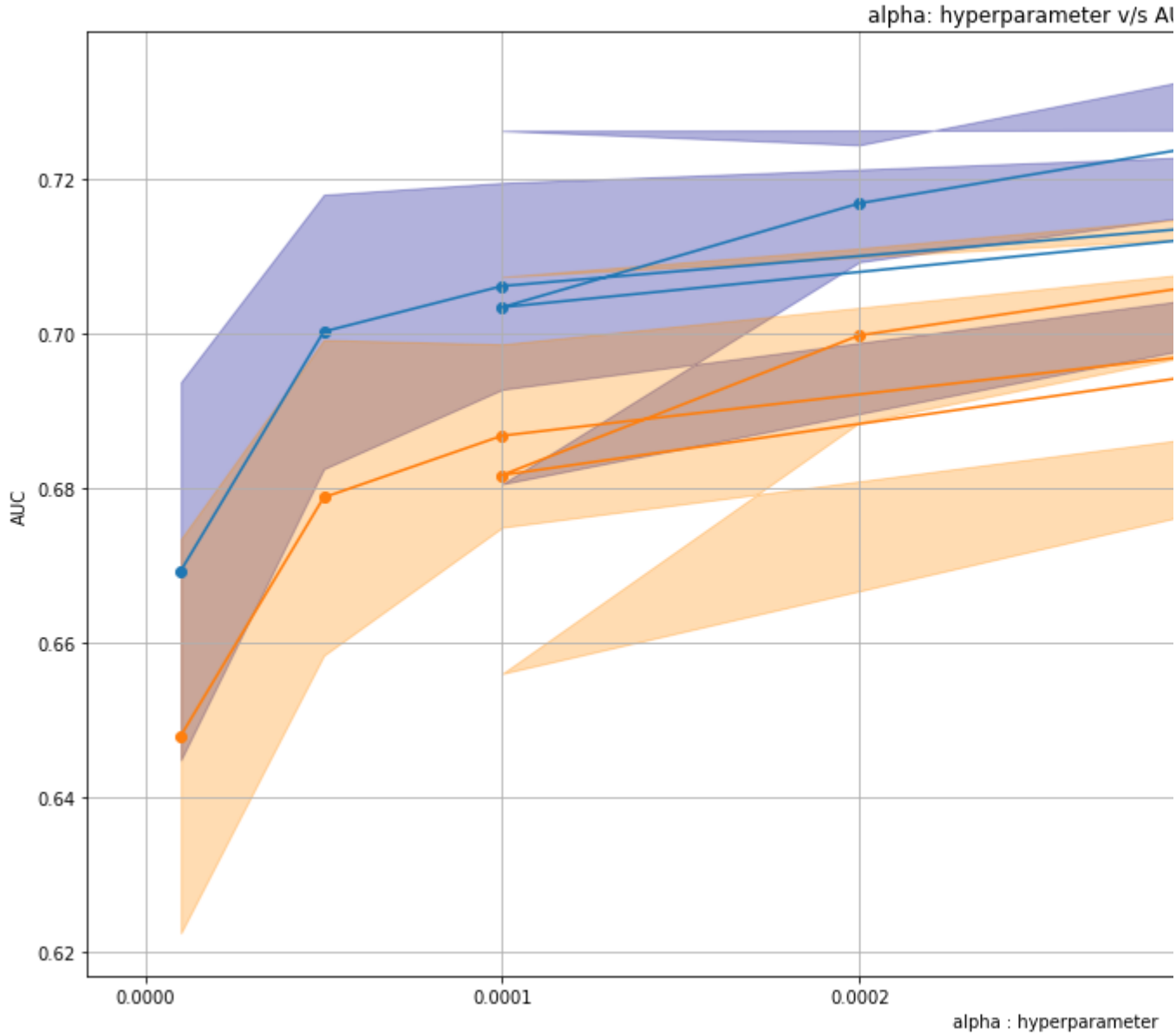
```
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



Lets see for smaller values of alphas for L2

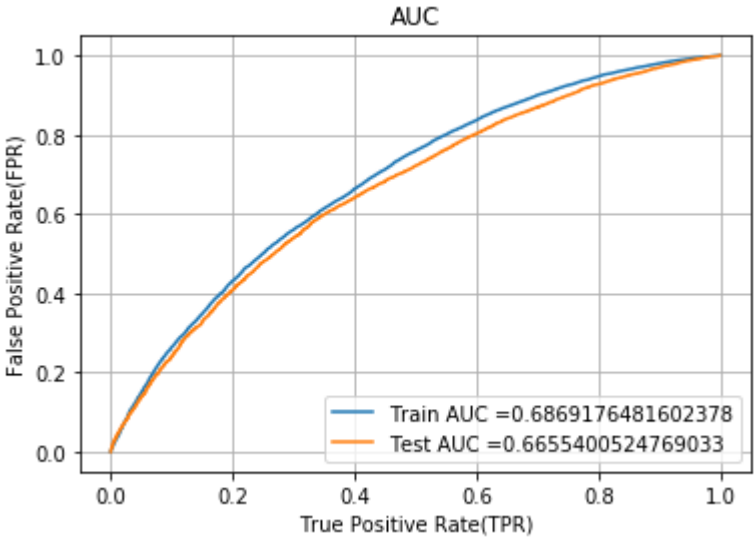
```
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV

from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)

sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')
parameters = {'alpha':[0.00001,0.00005,0.0001, 0.0005, 0.0001, 0.0002, 0.0003]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
clf.fit(X_tr, y_train)
```

```
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.figure(figsize=(20,10))
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```




```
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.0005)
model.fit(X_tr, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
# not the predicted outputs
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

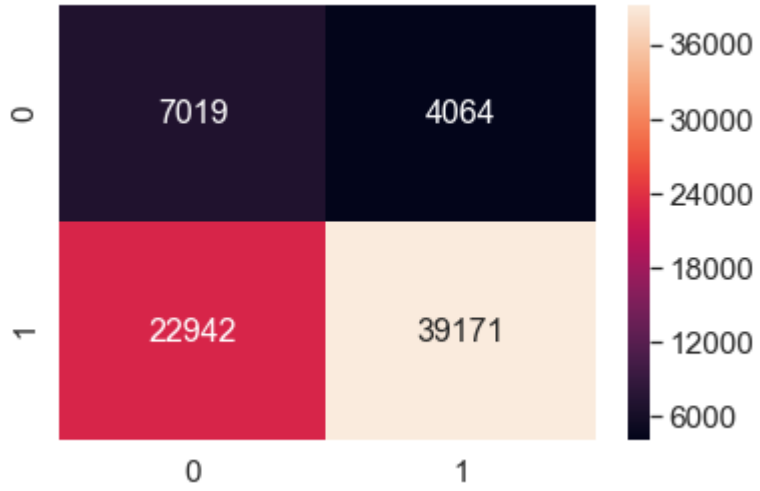



```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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


print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train[:], predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
print("Test confusion matrix")
print(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)))
```

```
==================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.39939264441527694 for threshold 1.044
[[ 7019  4064]
 [22942 39171]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.38964115957476736 for threshold 1.097
[[ 5394    65]
 [29192  1401]]
```

```
conf_matr_df_train =  pd.DataFrame(confusion_matrix(y_train[:], predict(y_train_pred, tr_thre
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
the maximum value of tpr*(1-fpr) 0.39939264441527694 for threshold 1.044
<matplotlib.axes._subplots.AxesSubplot at 0x1b5db3c2be0>
```




```
conf_matr_df_test =  pd.DataFrame(confusion_matrix(y_test[:], predict(y_test_pred, tr_thresho
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test, annot=True,annot_kws={"size": 16}, fmt='g')
```

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

3. Conclusion

0 1

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


from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyper Parameter", "AUC"]
x.add_row(["BOW", "SVM", 0.01, 0.68])
x.add_row(["TFIDF", "SVM", 0.0002, 0.70])
x.add_row(["AVG W2V", "SVM", 0.0005, 0.67])
x.add_row(["TFIDF W2V", "SVM", 0.0005, 0.67])
x.add_row(["TRUNCATED SVD", "SVM", 0.0005, 0.66])
print(x)
```

```
+---------------+-------+-----------------+------+
|   Vectorizer  | Model | Hyper Parameter | AUC  |
+---------------+-------+-----------------+------+
|      BOW      |  SVM  |       0.01      | 0.68 |
|     TFIDF     |  SVM  |      0.0002     | 0.7  |
|    AVG W2V    |  SVM  |      0.0005     | 0.67 |
|   TFIDF W2V   |  SVM  |      0.0005     | 0.67 |
| TRUNCATED SVD |  SVM  |      0.0005     | 0.66 |
+---------------+-------+-----------------+------+
```