1. Importing Packages

In [1]:

```
%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
```

2. Loading Data

In [10]:

```
project_data = pd.read_csv('D:\\train_data.csv',nrows = 50000)
resource_data = pd.read_csv('D:\\resources.csv')
```

In [11]:

```
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 (50000, 17)
==================================================
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [12]:

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

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

In [13]:

```
resource_data.head()
```

Out[13]:

	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
2	p069063	Cory Stories: A Kid's Book About Living With Adhd	1	8.45
3	p069063	Dixon Ticonderoga Wood-Cased #2 HB Pencils, Bo...	2	13.59
4	p069063	EDUCATIONAL INSIGHTS FLUORESCENT LIGHT FILTERS...	3	24.95

In [14]:

```
project_data.head()
```

Out[14]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grade
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Grades P
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Grades P

In [ ]:

In [15]:

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

Out[15]:

	id	price	quantity

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [16]:

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

In [17]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].replace(np.NaN,'Mrs.')
```

3. Text Preprocessing

3.1. Concatenating all essay text

In [18]:

```
# 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)
```

3.2. Preprocessing Essay text

In [19]:

```
# printing some random essays.
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[49999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves
to get together and celebrate. Around Halloween there is a whole school parade to show off the bea
utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by
the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t
he hard work put in during the school year, with a dunk tank being the most popular activity.My st
udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged
```

```
chairs. As I will only have a total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During independent reading time they
will be used as special chairs students will each use on occasion. I will utilize them in place of
chairs at my small group tables during math and reading times. The rest of the day they will be us
ed by the students who need the highest amount of movement in their life in order to stay focused
on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki
Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i
n group with me on the Hokki Stools, they are always moving, but at the same time doing their
work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are
disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours
a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th
e same time. These stools will help students to meet their 60 minutes a day of movement by
allowing them to activate their core muscles for balance while they sit. For many of my students,
these chairs will take away the barrier that exists in schools for a child who can't sit
still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of
desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work
hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n
\r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in
Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq
ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage
r learners; they are like sponges, absorbing all the information and experiences and keep on wanti
ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin
g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to
be one of a themed nautical environment. Creating a classroom environment is very important in the
success in each and every child's education. The nautical photo props will be used with each child
as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic
tures of each child with them, have them developed, and then hung in our classroom ready for their
first day of 4th grade.  This kind gesture will set the tone before even the first day of school!
The nautical thank you cards will be used throughout the year by the students as they create thank
you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our
classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of
my own pocket on resources to get our classroom ready. Please consider helping with this project t
o make our new school year a very successful one. Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju
mping and playing. Physical engagement is the key to our success. The number toss and color and sh
ape mats can make that happen. My students will forget they are doing work and just have the fun a
6 year old deserves.nannan
==================================================
We have GRIT!  If you want to meet tenacious, respectful seven year olds with growth mindsets, you
need to come to our classroom.  We give hugs, high-fives, and compliments! We Begin with the End i
n Mind and work hard everyday to reach our goals.\r\n\r\nWe don't believe in making excuses, but t
here are times in life when you just need to ask for help.  As a classroom teacher in a low-income
/high poverty school district, my 2nd grade students face real-life struggles both in and out of t
he classroom.  Even though, as a visitor to my classroom, you wouldn't know the daily struggle for
some of them.  I ask you. How can you learn with your belly growling?  How can I provide the absol
ute best learning environment when we do not have the money to buy research-based materials?  \r\n
\r\n“Education is not the filling of a pail, but the lighting of a fire,\" William Butler Yeats.
We are not asking you to fill our pail with \"things,\"but to help provide resources to light the
fire in young minds.Receiving books written by the same author will teach students how to develop
their own Writer's Craft.  It will inspire them to think about different ways established authors
have developed successful text that appeal to various audiences.  \r\n\r\nWe never forget our
first love.  My mother read the Berenstain Bears series to me when I was five and I fell in love w
ith the Berenstain family.  She took me to the public library every week and I would hunt for book
s written by Stan and Jan Berenstain.  Next, was the curious monkey and the man in the yellow hat,
Curious George!  Thank you Margaret and H.A. Rey for creating a series that captured my heart and
attention.  \r\n\r\nAs a teacher, it is my hope and dream to inspire the students in my classroom
to find their first love in reading.  Help me help them to discover writer's craft, go on
adventures in their minds, and develop a tenacious love for reading for the sake of reading.nannan
==================================================
```

```
In [20]:
```

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [21]:

```
sent = decontracted(project_data['essay'].values[16499])
print(sent)
print("="*50)
```

```
I teach an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav
e limited time to spend with their wonderfully talented children. My students work hard in class g
iving 110% with everything that they do. They persevere through difficult topics, enjoy being
engaged in their hands-on activities, and they love to laugh while learning. I set high
expectation for my students. They understand that true, authentic learning takes hard work,
dedication, and requires them to take ownership over their education. My goal for my students is t
o leave my class as life long learners. The students work hard to overcome all obstacles in their
path to meet and grow past my expectations.My students love being active while they are learning a
nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa
dly, one is not enough to reach all my students. My students love to use the Hokki stools while th
ey learn and want more! One of my students suggested that I write a project since I \"only have on
e, and we need more.\" These stools help my amazing kiddos get focused while engaging their core t
o keep them happy and healthy.\r\n\r\nMy students love to wiggle so they can not only focus on the
ir work, but engage in a healthy lifestyle.\r\n\r\n\r\nThe Hokki stools would allow my students to
continue to be active throughout the day whether they are in small groups or working at their own
seat.\r\nnannan
==================================================
```

In [22]:

```
# \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)
```

```
I teach an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav
e limited time to spend with their wonderfully talented children. My students work hard in class g
iving 110% with everything that they do. They persevere through difficult topics, enjoy being
engaged in their hands-on activities, and they love to laugh while learning. I set high
expectation for my students. They understand that true, authentic learning takes hard work,
dedication, and requires them to take ownership over their education. My goal for my students is t
o leave my class as life long learners. The students work hard to overcome all obstacles in their
path to meet and grow past my expectations.My students love being active while they are learning a
nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa
dly, one is not enough to reach all my students. My students love to use the Hokki stools while th
ey learn and want more! One of my students suggested that I write a project since I  only have one
, and we need more.  These stools help my amazing kiddos get focused while engaging their core to
keep them happy and healthy.    My students love to wiggle so they can not only focus on their wor
k, but engage in a healthy lifestyle.      The Hokki stools would allow my students to continue to
be active throughout the day whether they are in small groups or working at their own seat.
nannan
```

In [23]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
```

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

```
I teach an amazing energetic engaged and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis Many of my students have parents who work odd hours and have
limited time to spend with their wonderfully talented children My students work hard in class givi
ng 110 with everything that they do They persevere through difficult topics enjoy being engaged in
their hands on activities and they love to laugh while learning I set high expectation for my stud
ents They understand that true authentic learning takes hard work dedication and requires them to
take ownership over their education My goal for my students is to leave my class as life long
learners The students work hard to overcome all obstacles in their path to meet and grow past my e
xpectations My students love being active while they are learning and wiggling while they are work
ing I am lucky enough to have one Hokki stools in my classroom Sadly one is not enough to reach al
l my students My students love to use the Hokki stools while they learn and want more One of my st
udents suggested that I write a project since I only have one and we need more These stools help m
y amazing kiddos get focused while engaging their core to keep them happy and healthy My students
love to wiggle so they can not only focus on their work but engage in a healthy lifestyle The Hokk
i stools would allow my students to continue to be active throughout the day whether they are in s
mall groups or working at their own seat nannan
```

In [24]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "do
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [25]:

```
# 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)
    # https://gist.github.com/sebleier/554280
    sent = sent.lower()
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.strip())
```

```
100%|██████████| 50000/50000 [00:27<00:00, 1805.72it/s]
```

In [26]:

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

Out[26]:

```
'kindergarten students varied disabilities ranging speech language delays cognitive delays gross f
ine motor delays autism eager beavers always strive work hardest working past limitations
materials ones seek students teach title school students receive free reduced price lunch despite
disabilities limitations students love coming school come eager learn explore ever felt like ants
pants needed groove move meeting kids feel time want able move learn say wobble chairs answer love
develop core enhances gross motor turn fine motor skills also want learn games kids not want sit w
orksheets want learn count jumping playing physical engagement key success number toss color shape
mats make happen students forget work fun 6 year old deserves nannan'
```

In [27]:

```
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
project_data.head(2)
```

Out[27]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

3.3. Preprocessing Title text

In [28]:

```
# printing some random titles.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[49999])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
We Need To Move It While We Input It!
==================================================
Inspiring Young Authors Through Reading
==================================================
```

In [29]:

```
# 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"won\'t", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [30]:

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

```
We Need To Move It While We Input It!
==================================================
```

In [31]:

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

```
We Need To Move It While We Input It!
```

In [32]:

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

```
We Need To Move It While We Input It
```

In [33]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "do
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
 wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [34]:

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

```
100%|██████████| 50000/50000 [00:01<00:00, 40377.60it/s]
```

In [35]:

```
# after preprocesing
preprocessed_titles[20000]
```

Out[35]:

```
'need move input'
```

In [36]:

```
project_data['preprocessed_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(2)
```

Out[36]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [37]:

```
project_data.head()
```

Out[37]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grade
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Grades P

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Grades P

3.4. Preprocessing project_grade_category

In [38]:

```
project_grade_clean_category = []

for i in range(len(project_data)):
    a = project_data["project_grade_category"][i].replace(" ", "_").replace("-", "_")
    project_grade_clean_category.append(a)
```

In [39]:

```
project_grade_clean_category[0:5]
```

Out[39]:

```
['Grades_PreK_2', 'Grades_6_8', 'Grades_6_8', 'Grades_PreK_2', 'Grades_PreK_2']
```

In [40]:

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

Out[40]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_subject_ca
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Literacy & L
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	History & Civics,

3.5. Preprocessing project_subject_categories

In [41]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())
    cat_list.append(temp.strip())
```

In [42]:

```
cat_list[0:5]
```

Out[42]:

```
['Literacy_Language',
 'History_Civics Health_Sports',
 'Health_Sports',
 'Literacy_Language Math_Science',
 'Math_Science']
```

In [43]:

```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

Out[43]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_subject_su
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Civics & Gover

3.6. Preprocessing project_subject_subcategories

In [44]:

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

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

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

In [45]:

```
sub_cat_list[0:5]
```

Out[45]:

```
['ESL Literacy',
 'Civics_Government TeamSports',
 'Health_Wellness TeamSports',
 'Literacy Mathematics',
 'Literacy Mathematics',
 'Mathematics']
```

In [46]:

```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(5)
```

Out[46]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\"True champions aren't always the ones th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I work at a unique school filled with both ESL...
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our second grade classroom next year will be m...

In [ ]:

```

```

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

In [47]:

```
from sklearn.model_selection import train_test_split

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

5. Dropping Target values from Train, Test and CV set

In [48]:

```
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)
```

In [49]:

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

```
(22445, 19)
(16500, 19)
(11055, 19)
```

In [50]:

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

Out[50]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
5658	167487	p030511	67aef6e22c00ef8a9f0936095414d0c8	Mr.	MN	2016-11-06 12:59:17	My students are a group of fun energetic stud..
7497	54745	p013501	2bcdc75056a431aae98d6fac11f67787	Mrs.	NY	2016-10-03 09:55:30	My students are smart, motivated and caring k..

In [51]:

```
y_train.head(10)
```

Out[51]:

```
5658     1
7497     1
26305    1
18437    1
7590     1
47476    1
24593    1
24006    1
29840    1
45625    1
Name: project_is_approved, dtype: int64
```

In [ ]:

```

```

In [ ]:

```

```

Method 1:

Working of Response Coding

--

In [134]:

```
# combine_xy = pd.concat([X_train,y_train],axis = 1)
```

In [135]:

```
# combine_xy.head()
```

Out[135]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay
10007	128696	p100675	19831e83439fecd7126d90f9bed7ed97	Mrs.	FL	2016-08-09 17:44:30	My students a always full of l and ready
17077	144988	p228015	d3a250dc853151963992a016f5836e01	Ms.	OR	2017-01-11 02:49:24	As a teacher ir low-income/hi poverty scho
28354	173218	p034881	3f440f54c74c9ddfff49864d1787ad00	Mrs.	LA	2016-09-22 20:08:06	My students not have t number experier
11779	22215	p239368	4f6582127ca2840a9d9064bb79119315	Ms.	CA	2016-09-30 21:20:01	My students a taking colle preparatc ger
27680	80133	p194308	682bcf32e9cba62e6d415c5f4efa13bd	Mrs.	SC	2016-10-19 22:05:30	I am currently third gra teacher in a Tit

In [136]:

```
# a = combine_xy.groupby(['clean_categories','project_is_approved']).size()
```

In [137]:

```
# a = a.unstack()
```

In [138]:

```
# a.head()
```

Out[138]:

project_is_approved	0	1
clean_categories		
AppliedLearning	152.0	626.0
AppliedLearning Health_Sports	21.0	105.0
AppliedLearning History_Civics	7.0	21.0
AppliedLearning Literacy_Language	77.0	362.0
AppliedLearning Math_Science	37.0	176.0

In [139]:

```
# #https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
# b = a.rename_axis([None],axis = 1).reset_index()
```

In [140]:

```
# b.head()
```

Out[140]:

	clean_categories	0	1
0	AppliedLearning	152.0	626.0
1	AppliedLearning Health_Sports	21.0	105.0
2	AppliedLearning History_Civics	7.0	21.0
3	AppliedLearning Literacy_Language	77.0	362.0
4	AppliedLearning Math_Science	37.0	176.0

In [141]:

```
# c = b.rename({0: "project_not_approved",1:"project_approved"},axis = 1)
```

In [142]:

```
# c.head()
```

Out[142]:

	clean_categories	project_not_approved	project_approved
0	AppliedLearning	152.0	626.0
1	AppliedLearning Health_Sports	21.0	105.0
2	AppliedLearning History_Civics	7.0	21.0
3	AppliedLearning Literacy_Language	77.0	362.0
4	AppliedLearning Math_Science	37.0	176.0

In [143]:

```
# c['sum'] = c['project_not_approved'] + c['project_approved']
```

In [144]:

```
# c.head()
```

Out[144]:

	clean_categories	project_not_approved	project_approved	sum
0	AppliedLearning	152.0	626.0	778.0
1	AppliedLearning Health_Sports	21.0	105.0	126.0
2	AppliedLearning History_Civics	7.0	21.0	28.0
3	AppliedLearning Literacy_Language	77.0	362.0	439.0
4	AppliedLearning Math_Science	37.0	176.0	213.0

In [145]:

```
# c['clean_category_not_accepted'] = c['project_not_approved'] / c['sum']
```

In [146]:

```
# c['clean_category_accepted'] = c['project_approved'] / c['sum']
```

In [147]:

```
# c.head()
```

Out[147]:

	clean_categories	project_not_approved	project_approved	sum	clean_category_not_accepted	clean_category_accepted
0	AppliedLearning	152.0	626.0	778.0	0.195373	0.804627
1	AppliedLearning Health_Sports	21.0	105.0	126.0	0.166667	0.833333
2	AppliedLearning History_Civics	7.0	21.0	28.0	0.250000	0.750000
3	AppliedLearning Literacy_Language	77.0	362.0	439.0	0.175399	0.824601
4	AppliedLearning Math_Science	37.0	176.0	213.0	0.173709	0.826291

In [148]:

```
# d = c[['clean_categories','clean_category_not_accepted','clean_category_accepted']]
```

In [149]:

```
# d.head()
```

Out[149]:

	clean_categories	clean_category_not_accepted	clean_category_accepted
0	AppliedLearning	0.195373	0.804627
1	AppliedLearning Health_Sports	0.166667	0.833333
2	AppliedLearning History_Civics	0.250000	0.750000
3	AppliedLearning Literacy_Language	0.175399	0.824601
4	AppliedLearning Math_Science	0.173709	0.826291

In [150]:

```
# d.shape
```

Out[150]:

```
(49, 3)
```

In [151]:

```
# # mergedStuff = pd.merge(df1, df2, on=['Name'], how='inner')
# # mergedStuff.head()
# X_train = pd.merge(X_train, d, on=['clean_categories'], how='inner')
```

In [152]:

```
# X_train.head()
```

Out[152]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	128696	p100675	19831e83439fecd7126d90f9bed7ed97	Mrs.	FL	2016-08-09 17:44:30	My students are always full of life and ready ...
1	16876	p169319	04cb0557218fc7edbbc32f3164be1eee	Mr.	LA	2016-07-27 22:28:45	All kids deserve to be praised and rewarded fo...
2	103755	p174526	c4a8db6cc37978558c142e0d29993b1e	Ms.	CT	2016-10-06 15:06:01	Each day my students walk into our building fa...
3	131557	p234179	d60659e1f1da84bdca1e8971bb1bcb2b	Mrs.	KS	2016-08-04 19:41:51	My students like all Kindergarten students are...
4	59284	p076757	bbc1ed8de159d60eefd6b48b7522cd36	Ms.	MA	2017-03-07 12:47:35	I currently have a classroom of six little sma...

5 rows × 21 columns

In [163]:

```
# X_train.isnull().any()
```

Out[163]:

```
Unnamed: 0                                        False
id                                                False
```

```
teacher_id                                      False
teacher_prefix                                  False
school_state                                    False
project_submitted_datetime                      False
project_essay_1                                 False
project_essay_2                                 False
project_essay_3                                  True
project_essay_4                                  True
project_resource_summary                        False
teacher_number_of_previously_posted_projects    False
price                                           False
quantity                                        False
preprocessed_essays                             False
preprocessed_titles                             False
project_grade_clean_category                    False
clean_categories                                False
clean_subcategories                             False
clean_category_not_accepted                      True
clean_category_accepted                          True
dtype: bool
```

In [164]:

```
# X_train["clean_category_not_accepted"].fillna(0.5, inplace = True)
```

In [165]:

```
# X_train["clean_category_accepted"].fillna(0.5, inplace = True)
```

In [166]:

```
# X_train.isnull().any()
```

Out[166]:

```
Unnamed: 0                                      False
id                                              False
teacher_id                                      False
teacher_prefix                                  False
school_state                                    False
project_submitted_datetime                      False
project_essay_1                                 False
project_essay_2                                 False
project_essay_3                                  True
project_essay_4                                  True
project_resource_summary                        False
teacher_number_of_previously_posted_projects    False
price                                           False
quantity                                        False
preprocessed_essays                             False
preprocessed_titles                             False
project_grade_clean_category                    False
clean_categories                                False
clean_subcategories                             False
clean_category_not_accepted                     False
clean_category_accepted                         False
dtype: bool
```

In [167]:

```
# categories_response_code_Xtrain =
X_train[['clean_category_not_accepted','clean_category_accepted']].values
```

In [168]:

```
# categories_response_code_Xtrain
```

Out[168]:

```
array([[0.18037975, 0.81962025],
       [0.18037975, 0.81962025],
       [0.18037975, 0.81962025],
       [0.18037975, 0.81962025],
       ...,
       [0.5       , 0.5       ],
       [0.5       , 0.5       ],
       [0.5       , 0.5       ]])
```

In [173]:

```
# from scipy import sparse
# categories_response_code_Xtrain = sparse.csr_matrix(categories_response_code_Xtrain)
```

In [174]:

```
# categories_response_code_Xtrain
```

Out[174]:

```
<22445x2 sparse matrix of type '<class 'numpy.float64'>'
 with 44890 stored elements in Compressed Sparse Row format>
```

In [169]:

```
# categories_response_code_Xtrain.shape
```

Out[169]:

```
(22445, 2)
```

In [ ]:

```

```

In [ ]:

```

```

--

Method 2

--

In [44]:

```
# #Concatenating X_train and Y_train
# combine_xy = pd.concat([X_train,y_train],axis = 1)

# #grouping categories on project_is_approved,unstacking and renaming the unstacked data
# #https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
# a =
combine_xy.groupby(['clean_categories','project_is_approved']).size().unstack().rename_axis([None],
= 1).reset_index()

# b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# # computations for finding probabilities for each classes
# b['sum'] = b['project_not_approved'] + b['project_approved']
# b['clean_categories_not_accepted'] = b['project_not_approved'] / b['sum']
# b['clean_categories_accepted'] = b['project_approved'] / b['sum']
# # probabilities computed for X_train
# probabilities_Xtrain_clean_categories =
b[['clean_categories','clean_categories_not_accepted','clean_categories_accepted']]
```

In [340]:

```
# probabilities_Xtrain_clean_categories.head()
```

Out[340]:

	clean_categories	clean_categories_not_accepted	clean_categories_accepted
0	AppliedLearning	0.180412	0.819588
1	AppliedLearning Health_Sports	0.150000	0.850000
2	AppliedLearning History_Civics	0.166667	0.833333
3	AppliedLearning Literacy_Language	0.129670	0.870330
4	AppliedLearning Math_Science	0.194175	0.805825

In [341]:

```
# x = probabilities_Xtrain_clean_categories.set_index('clean_categories').T.to_dict('list')
```

In [342]:

```
# print(x)
```

```
{'AppliedLearning': [0.18041237113402062, 0.8195876288659794], 'AppliedLearning Health_Sports': [0
.15, 0.85], 'AppliedLearning History_Civics': [0.16666666666666666, 0.8333333333333334],
'AppliedLearning Literacy_Language': [0.12967032967032968, 0.8703296703296703], 'AppliedLearning M
ath_Science': [0.1941747572815534, 0.8058252427184466], 'AppliedLearning Music_Arts':
[0.21739130434782608, 0.782608695652174], 'AppliedLearning SpecialNeeds': [0.1779935275080906, 0.8
220064724919094], 'AppliedLearning Warmth Care_Hunger': [nan, nan], 'Health_Sports':
[0.15208034433285508, 0.8479196556671449], 'Health_Sports AppliedLearning': [0.25, 0.75],
'Health_Sports History_Civics': [nan, nan], 'Health_Sports Literacy_Language':
[0.1736842105263158, 0.8263157894736842], 'Health_Sports Math_Science': [0.2727272727272727,
0.7272727272727273], 'Health_Sports Music_Arts': [0.25925925925925924, 0.7407407407407407],
'Health_Sports SpecialNeeds': [0.13553113553113552, 0.8644688644688645], 'Health_Sports Warmth Car
e_Hunger': [nan, nan], 'History_Civics': [0.21899736147757257, 0.7810026385224275],
'History_Civics AppliedLearning': [0.25, 0.75], 'History_Civics Health_Sports': [nan, nan],
'History_Civics Literacy_Language': [0.10610932475884244, 0.8938906752411575], 'History_Civics Mat
h_Science': [0.09230769230769231, 0.9076923076923077], 'History_Civics Music_Arts':
[0.14285714285714285, 0.8571428571428571], 'History_Civics SpecialNeeds': [0.20833333333333334, 0.
7916666666666666], 'Literacy_Language': [0.14083350441387804, 0.8591664955861219],
'Literacy_Language AppliedLearning': [0.1864406779661017, 0.8135593220338984], 'Literacy_Language
Health_Sports': [0.08333333333333333, 0.9166666666666666], 'Literacy_Language History_Civics': [0.
12582781456953643, 0.8741721854304636], 'Literacy_Language Math_Science': [0.13337779259753252, 0.
8666222074024675], 'Literacy_Language Music_Arts': [0.18028169014084508, 0.819718309859155],
'Literacy_Language SpecialNeeds': [0.14116251482799524, 0.8588374851720048], 'Math_Science':
[0.17705949656750572, 0.8229405034324943], 'Math_Science AppliedLearning': [0.1446280991735537,
0.8553719008264463], 'Math_Science Health_Sports': [0.27848101265822783, 0.7215189873417721],
'Math_Science History_Civics': [0.17355371900826447, 0.8264462809917356], 'Math_Science
Literacy_Language': [0.12394957983193278, 0.8760504201680672], 'Math_Science Music_Arts':
[0.19469026548672566, 0.8053097345132744], 'Math_Science SpecialNeeds': [0.19230769230769232,
0.8076923076923077], 'Math_Science Warmth Care_Hunger': [nan, nan], 'Music_Arts':
[0.13333333333333333, 0.8666666666666667], 'Music_Arts Health_Sports': [0.2, 0.8], 'Music_Arts
History_Civics': [nan, nan], 'Music_Arts SpecialNeeds': [0.13333333333333333, 0.8666666666666667],
'Music_Arts Warmth Care_Hunger': [nan, nan], 'SpecialNeeds': [0.1827354260089686,
0.8172645739910314], 'SpecialNeeds Health_Sports': [0.25, 0.75], 'SpecialNeeds Music_Arts':
[0.13559322033898305, 0.864406779661017], 'SpecialNeeds Warmth Care_Hunger': [nan, nan], 'Warmth
Care_Hunger': [0.07168458781362007, 0.9283154121863799]}
```

In [343]:

```
# type(x)
```

Out[343]:

```
dict
```

In [344]:

```
# cat = []
```

In [345]:

```
# for i in X_train['clean_categories']:
#     if(i in x):
#         cat.append(x[i])
```

In [346]:

```
# cat[0:5]
```

Out[346]:

```
[[0.19469026548672566, 0.8053097345132744],
 [0.15208034433285508, 0.8479196556671449],
 [0.14083350441387804, 0.8591664955861219],
 [0.12394957983193278, 0.8760504201680672],
 [0.14083350441387804, 0.8591664955861219]]
```

In [347]:

```
# df = pd.DataFrame.from_records(cat, columns=["clean_categories_not_approved",
"clean_categories_approved"])
```

In [348]:

```
# df.head()
```

Out[348]:

	clean_categories_not_approved	clean_categories_approved
0	0.194690	0.805310
1	0.152080	0.847920
2	0.140834	0.859166
3	0.123950	0.876050
4	0.140834	0.859166

In [349]:

```
# X_train.head()
```

Out[349]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay
22394	96904	p178231	37c8e089e72aac2a226dfb6aa230d662	Mr.	OH	2017-04-13 10:19:57	The Daws Bryant Lo School Distric lo
31806	119026	p035768	7c605c5654515b38b026c0c30da2dde4	Mrs.	SC	2016-08-03 19:48:39	A majority of students co from a lower i
9582	165293	p229215	55e6824491cd70ec6a434022154df85f	Ms.	IN	2016-06-26 13:43:45	We a fisherman set to fill our n wit
36957	133415	p173112	470cdf6aac6bb1a40e6b50a21040c714	Mrs.	TX	2016-06-29 21:23:45	As you enter classroom, prepared fo
30435	89343	p136023	f52f7b8b44f5e64dee41e04006611d01	Ms.	CA	2016-12-29 00:59:37	My students a excited to le

Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay
						every day wh

In [350]:

```
# df.shape
```

Out[350]:

```
(22445, 2)
```

In [351]:

```
# df.isnull().any()
```

Out[351]:

```
clean_categories_not_approved    True
clean_categories_approved        True
dtype: bool
```

In [352]:

```
# df['column'] = df['column'].replace(np.nan, 0)
```

In [353]:

```
# df.fillna(0.5 ,inplace = True)
```

In [355]:

```
# df.head()
```

Out[355]:

	clean_categories_not_approved	clean_categories_approved
0	0.194690	0.805310
1	0.152080	0.847920
2	0.140834	0.859166
3	0.123950	0.876050
4	0.140834	0.859166

In [356]:

```
# df.isnull().any()
```

Out[356]:

```
clean_categories_not_approved    False
clean_categories_approved        False
dtype: bool
```

--

In [ ]:

```

```

In [ ]:

6. Encoding Categorical Data

6.1. Response coding of clean_categories

In [52]:

```
#Concatenating X_train and Y_train
combine_xy = pd.concat([X_train,y_train],axis = 1)

#grouping categories on project_is_approved,unstacking and renaming the unstacked data
#https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
a = combine_xy.groupby(['clean_categories','project_is_approved']).size().unstack().rename_axis([N
one],axis = 1).reset_index()

b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# computations for finding probabilities for each classes
b['sum'] = b['project_not_approved'] + b['project_approved']
b['clean_categories_not_accepted'] = b['project_not_approved'] / b['sum']
b['clean_categories_accepted'] = b['project_approved'] / b['sum']

# probabilities computed for X_train
probabilities_Xtrain_clean_categories =
b[['clean_categories','clean_categories_not_accepted','clean_categories_accepted']]
```

In [53]:

```
clean_categories_to_dict =
probabilities_Xtrain_clean_categories.set_index('clean_categories').T.to_dict('list')
```

In [54]:

```
cat_train = []
for i in X_train['clean_categories']:
    if(i in clean_categories_to_dict):
        cat_train.append(clean_categories_to_dict[i])
    else:
        cat_train.append([0.5,0.5])


categories_response_code_Xtrain = pd.DataFrame.from_records(cat_train,
columns=["clean_categories_not_approved", "clean_categories_approved"])

# replacing null values
categories_response_code_Xtrain.fillna(0.5,inplace = True)
```

In [55]:

```
# response coding for X_train
from scipy import sparse

categories_response_code_Xtrain = sparse.csr_matrix(categories_response_code_Xtrain)
print(categories_response_code_Xtrain.shape)
```

```
(22445, 2)
```

In [56]:

```
cat_test = []
for i in X_test['clean_categories']:
    if(i in clean_categories_to_dict):
        cat_test.append(clean_categories_to_dict[i])
    else:
        cat_test.append([0.5,0.5])

categories_response_code_Xtest = pd.DataFrame.from_records(cat_test,
categories_response_code_Xtest = pd.DataFrame.from_records(cat_test,
columns=["clean_categories_not_approved", "clean_categories_approved"])

# replacing null values
categories_response_code_Xtest.fillna(0.5,inplace = True)
```

In [57]:

```
categories_response_code_Xtest.shape
```

Out[57]:

```
(16500, 2)
```

In [117]:

```
# cat_test = []
# val = X_test['clean_categories']
# count = 0
# for x in  X_test['clean_categories']:
#     count = count + 1
# print(count)
# #     # to do
# #     if(val in clean_categories_to_dict):
# #         cat_test.append(clean_categories_to_dict[val])

# # categories_response_code_Xtest = pd.DataFrame.from_records(cat_test, columns=
["clean_categories_not_approved", "clean_categories_approved"])

# # # replacing null values
# # categories_response_code_Xtest.fillna(0.5,inplace = True)
```

```
16500
```

In [193]:

```
DF_new_row=categories_response_code_Xtest.loc[categories_response_code_Xtest['clean_categories_not_
approved']=='']
```

In [194]:

```
DF_new_row
```

Out[194]:

	clean_categories_not_approved	clean_categories_approved

In [195]:

```
# categories_response_code_Xtest[categories_response_code_Xtest['clean_categories_not_approved'] =
= ''].index
```

Out[195]:

```
Int64Index([], dtype='int64')
```

In [196]:

```
#
categories_response_code_Xtest[categories_response_code_Xtest['clean_categories_not_approved'].isnu
].index
```

Out[196]:

```
Int64Index([], dtype='int64')
```

In [212]:

```
# is_0_5 =  categories_response_code_Xtest['clean_categories_not_approved'] == 0.5
# gapminder_0_5 =categories_response_code_Xtest[is_0_5]
```

In [215]:

```
# gapminder_0_5.shape
```

Out[215]:

```
(22, 2)
```

In [199]:

```
# categories_response_code_Xtest.shape
```

Out[199]:

```
(16500, 2)
```

In [58]:

```
# response coding for X_test
from scipy import sparse

categories_response_code_Xtest = sparse.csr_matrix(categories_response_code_Xtest)
print(categories_response_code_Xtest.shape)
```

```
(16500, 2)
```

In [59]:

```
cat_cv = []
for i in X_cv['clean_categories']:
    if(i in clean_categories_to_dict):
        cat_cv.append(clean_categories_to_dict[i])
    else:
        cat_cv.append([0.5,0.5])

categories_response_code_Xcv = pd.DataFrame.from_records(cat_cv,
columns=["clean_categories_not_approved", "clean_categories_approved"])

# replacing null values
categories_response_code_Xcv.fillna(0.5,inplace = True)
```

In [60]:

```
# response coding for X_cv
from scipy import sparse

categories_response_code_Xcv = sparse.csr_matrix(categories_response_code_Xcv)
print(categories_response_code_Xcv.shape)
```

```
(11055, 2)
```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

6.2. Response coding of clean_subcategories

In [61]:

```
#Concatenating X_train and Y_train
combine_xy = pd.concat([X_train,y_train],axis = 1)

#grouping categories on project_is_approved,unstacking and renaming the unstacked data
#https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
a = combine_xy.groupby(['clean_subcategories','project_is_approved']).size().unstack().rename_axis
([None],axis = 1).reset_index()

b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# computations for finding probabilities for each classes
b['sum'] = b['project_not_approved'] + b['project_approved']
b['clean_subcategories_not_accepted'] = b['project_not_approved'] / b['sum']
b['clean_subcategories_accepted'] = b['project_approved'] / b['sum']

# probabilities computed for X_train
probabilities_Xtrain_clean_subcategories =
b[['clean_subcategories','clean_subcategories_not_accepted','clean_subcategories_accepted']]
```

In [62]:

```
clean_subcategories_to_dict =
probabilities_Xtrain_clean_subcategories.set_index('clean_subcategories').T.to_dict('list')
```

In [63]:

```
cat_train = []
for i in X_train['clean_subcategories']:
    if(i in clean_subcategories_to_dict):
        cat_train.append(clean_subcategories_to_dict[i])
    else:
        cat_train.append([0.5,0.5])

subcategories_response_code_Xtrain = pd.DataFrame.from_records(cat_train,
columns=["clean_subcategories_not_approved", "clean_subcategories_approved"])

# replacing null values
subcategories_response_code_Xtrain.fillna(0.5,inplace = True)
```

In [64]:

```
# response coding for X_train
from scipy import sparse

subcategories_response_code_Xtrain = sparse.csr_matrix(subcategories_response_code_Xtrain)
print(subcategories_response_code_Xtrain.shape)
```

```
(22445, 2)
```

In [65]:

```
cat_test = []
for i in X_test['clean_subcategories']:
    if(i in clean_subcategories_to_dict):
        cat_test.append(clean_subcategories_to_dict[i])
    else:
        cat_test.append([0.5,0.5])

subcategories_response_code_Xtest = pd.DataFrame.from_records(cat_test,
columns=["clean_subcategories_not_approved", "clean_subcategories_approved"])

# replacing null values
subcategories_response_code_Xtest.fillna(0.5,inplace = True)
```

In [66]:

```
# response coding for X_test
from scipy import sparse

subcategories_response_code_Xtest = sparse.csr_matrix(subcategories_response_code_Xtest)
print(subcategories_response_code_Xtest.shape)
```

```
(16500, 2)
```

In [67]:

```
cat_cv = []
for i in X_cv['clean_subcategories']:
    if(i in clean_subcategories_to_dict):
        cat_cv.append(clean_subcategories_to_dict[i])
    else:
        cat_cv.append([0.5,0.5])

subcategories_response_code_Xcv = pd.DataFrame.from_records(cat_cv,
columns=["clean_subcategories_not_approved", "clean_subcategories_approved"])

# replacing null values
subcategories_response_code_Xcv.fillna(0.5,inplace = True)
```

In [68]:

```
# response coding for X_cv
from scipy import sparse

subcategories_response_code_Xcv = sparse.csr_matrix(subcategories_response_code_Xcv)
print(subcategories_response_code_Xcv.shape)
```

```
(11055, 2)
```

In [ ]:

```

```

In [ ]:

```

```

6.3. Response coding of school_state

In [69]:

```
#Concatenating X_train and Y_train
combine_xy = pd.concat([X_train,y_train],axis = 1)

#grouping categories on project_is_approved,unstacking and renaming the unstacked data
#https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
a = combine_xy.groupby(['school_state','project_is_approved']).size().unstack().rename_axis([None]
,axis = 1).reset_index()

b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# computations for finding probabilities for each classes
b['sum'] = b['project_not_approved'] + b['project_approved']
b['school_state_not_accepted'] = b['project_not_approved'] / b['sum']
b['school_state_accepted'] = b['project_approved'] / b['sum']

# probabilities computed for X_train
probabilities_Xtrain_school_state =
b[['school_state','school_state_not_accepted','school_state_accepted']]
```

In [70]:

```
school_state_to_dict =
probabilities_Xtrain_school_state.set_index('school_state').T.to_dict('list')
```

In [71]:

```
cat_train = []
for i in X_train['school_state']:
    if(i in school_state_to_dict):
        cat_train.append(school_state_to_dict[i])
    else:
        cat_train.append([0.5,0.5])

school_state_response_code_Xtrain = pd.DataFrame.from_records(cat_train,
columns=["school_state_not_approved", "school_state_approved"])

# replacing null values
school_state_response_code_Xtrain.fillna(0.5,inplace = True)
```

In [72]:

```
# response coding for X_train
from scipy import sparse

school_state_response_code_Xtrain = sparse.csr_matrix(school_state_response_code_Xtrain)
print(school_state_response_code_Xtrain.shape)
```

```
(22445, 2)
```

In [73]:

```
cat_test = []
for i in X_test['school_state']:
    if(i in school_state_to_dict):
        cat_test.append(school_state_to_dict[i])
    else:
        cat_test.append([0.5,0.5])

school_state_response_code_Xtest = pd.DataFrame.from_records(cat_test,
columns=["school_state_not_approved", "school_state_approved"])

# replacing null values
school_state_response_code_Xtest.fillna(0.5,inplace = True)
```

In [74]:

```
# response coding for X_test
from scipy import sparse

school_state_response_code_Xtest = sparse.csr_matrix(school_state_response_code_Xtest)
print(school_state_response_code_Xtest.shape)
```

```
(16500, 2)
```

In [75]:

```
cat_cv = []
for i in X_cv['school_state']:
    if(i in school_state_to_dict):
        cat_cv.append(school_state_to_dict[i])
    else:
        cat_cv.append([0.5,0.5])

school_state_response_code_Xcv = pd.DataFrame.from_records(cat_cv,
columns=["school_state_not_approved", "school_state_approved"])

# replacing null values
school_state_response_code_Xcv.fillna(0.5,inplace = True)
```

In [76]:

In [76]:

```
# response coding for X_cv
from scipy import sparse

school_state_response_code_Xcv = sparse.csr_matrix(school_state_response_code_Xcv)
print(school_state_response_code_Xcv.shape)
```

```
(11055, 2)
```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

6.4. Response coding of teacher_prefix

In [77]:

```
#Concatenating X_train and Y_train
combine_xy = pd.concat([X_train,y_train],axis = 1)

#grouping categories on project_is_approved,unstacking and renaming the unstacked data
#https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
a = combine_xy.groupby(['teacher_prefix','project_is_approved']).size().unstack().rename_axis([None],axis = 1).reset_index()

b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# computations for finding probabilities for each classes
b['sum'] = b['project_not_approved'] + b['project_approved']
b['teacher_prefix_not_accepted'] = b['project_not_approved'] / b['sum']
b['teacher_prefix_accepted'] = b['project_approved'] / b['sum']

# probabilities computed for X_train
probabilities_Xtrain_teacher_prefix = b[['teacher_prefix','teacher_prefix_not_accepted','teacher_prefix_accepted']]
```

In [78]:

```
teacher_prefix_to_dict = probabilities_Xtrain_teacher_prefix.set_index('teacher_prefix').T.to_dict('list')
```

In [79]:

```
cat_train = []
for i in X_train['teacher_prefix']:
    if(i in teacher_prefix_to_dict):
        cat_train.append(teacher_prefix_to_dict[i])
    else:
        cat_train.append([0.5,0.5])

teacher_prefix_response_code_Xtrain = pd.DataFrame.from_records(cat_train
teacher_prefix_response_code_Xtrain = pd.DataFrame.from_records(cat_train,
columns=["teacher_prefix_not_approved", "teacher_prefix_approved"])

# replacing null values
teacher_prefix_response_code_Xtrain.fillna(0.5,inplace = True)
```

In [80]:

```
# response coding for X_train
from scipy import sparse

teacher_prefix_response_code_Xtrain = sparse.csr_matrix(teacher_prefix_response_code_Xtrain)
print(teacher_prefix_response_code_Xtrain.shape)
```

```
(22445, 2)
```

In [81]:

```
cat_test = []
for i in X_test['teacher_prefix']:
    if(i in teacher_prefix_to_dict):
        cat_test.append(teacher_prefix_to_dict[i])
    else:
        cat_test.append([0.5,0.5])

teacher_prefix_response_code_Xtest = pd.DataFrame.from_records(cat_test,
columns=["teacher_prefix_not_approved", "teacher_prefix_approved"])

# replacing null values
teacher_prefix_response_code_Xtest.fillna(0.5,inplace = True)
```

In [82]:

```
# response coding for X_test
from scipy import sparse

teacher_prefix_response_code_Xtest = sparse.csr_matrix(teacher_prefix_response_code_Xtest)
print(teacher_prefix_response_code_Xtest.shape)
```

```
(16500, 2)
```

In [83]:

```
cat_cv = []
for i in X_cv['teacher_prefix']:
    if(i in teacher_prefix_to_dict):
        cat_cv.append(teacher_prefix_to_dict[i])
    else:
        cat_cv.append([0.5,0.5])

teacher_prefix_response_code_Xcv = pd.DataFrame.from_records(cat_cv,
columns=["teacher_prefix_not_approved", "teacher_prefix_approved"])

# replacing null values
teacher_prefix_response_code_Xcv.fillna(0.5,inplace = True)
```

In [84]:

```
# response coding for X_cv
from scipy import sparse

teacher_prefix_response_code_Xcv = sparse.csr_matrix(teacher_prefix_response_code_Xcv)
print(teacher_prefix_response_code_Xcv.shape)
```

```
(11055, 2)
```

In [ ]:

In [ ]:

In [ ]:

6.5. Response coding of project_grade_clean_category

In [85]:

```
#Concatenating X_train and Y_train
combine_xy = pd.concat([X_train,y_train],axis = 1)

#grouping categories on project_is_approved,unstacking and renaming the unstacked data
#https://stackoverflow.com/questions/37840043/pandas-unstack-column-values-into-new-columns
a = combine_xy.groupby(['project_grade_clean_category','project_is_approved']).size().unstack().re
name_axis([None],axis = 1).reset_index()

b = a.rename({0: "project_not_approved",1:"project_approved"},axis = 1)

# computations for finding probabilities for each classes
b['sum'] = b['project_not_approved'] + b['project_approved']
b['project_grade_clean_category_not_accepted'] = b['project_not_approved'] / b['sum']
b['project_grade_clean_category_accepted'] = b['project_approved'] / b['sum']

# probabilities computed for X_train
probabilities_Xtrain_project_grade_clean_category =
b[['project_grade_clean_category','project_grade_clean_category_not_accepted','project_grade_clean_
category_accepted']]
```

In [86]:

```
project_grade_clean_category_to_dict = probabilities_Xtrain_project_grade_clean_category.set_index
('project_grade_clean_category').T.to_dict('list')
```

In [87]:

```
cat_train = []
for i in X_train['project_grade_clean_category']:
    if(i in project_grade_clean_category_to_dict):
        cat_train.append(project_grade_clean_category_to_dict[i])
    else:
        cat_train.append([0.5,0.5])

project_grade_clean_category_response_code_Xtrain = pd.DataFrame.from_records(cat_train, columns=[
"project_grade_clean_category_not_approved", "project_grade_clean_category_approved"])

# replacing null values
project_grade_clean_category_response_code_Xtrain.fillna(0.5,inplace = True)
```

In [88]:

```
# response coding for X_train
from scipy import sparse

project_grade_clean_category_response_code_Xtrain =
sparse.csr_matrix(project_grade_clean_category_response_code_Xtrain)
print(project_grade_clean_category_response_code_Xtrain.shape)
```

```
(22445, 2)
```

In [89]:

```
cat_test = []
for i in X_test['project_grade_clean_category']:
    if(i in project_grade_clean_category_to_dict):
        cat_test.append(project_grade_clean_category_to_dict[i])
    else:
        cat_test.append([0.5,0.5])

project_grade_clean_category_response_code_Xtest = pd.DataFrame.from_records(cat_test, columns=["project_grade_clean_category_not_approved", "project_grade_clean_category_approved"])

# replacing null values
project_grade_clean_category_response_code_Xtest.fillna(0.5,inplace = True)
```

In [90]:

```
# response coding for X_test
from scipy import sparse

project_grade_clean_category_response_code_Xtest =
sparse.csr_matrix(project_grade_clean_category_response_code_Xtest)
print(project_grade_clean_category_response_code_Xtest.shape)
```

```
(16500, 2)
```

In [91]:

```
cat_cv = []
for i in X_cv['project_grade_clean_category']:
    if(i in project_grade_clean_category_to_dict):
        cat_cv.append(project_grade_clean_category_to_dict[i])
    else:
        cat_cv.append([0.5,0.5])

project_grade_clean_category_response_code_Xcv = pd.DataFrame.from_records(cat_cv,
columns=["project_grade_clean_category_not_approved", "project_grade_clean_category_approved"])

# replacing null values
project_grade_clean_category_response_code_Xcv.fillna(0.5,inplace = True)
```

In [92]:

```
# response coding for X_cv
from scipy import sparse

project_grade_clean_category_response_code_Xcv =
sparse.csr_matrix(project_grade_clean_category_response_code_Xcv)
print(project_grade_clean_category_response_code_Xcv.shape)
```

```
(11055, 2)
```

In [ ]:

In [ ]:

7. Encoding of Text Data

7.1. BOW encoding of preprocessed_essays

In [93]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer1 = CountVectorizer(min_df=10)
text_bow_Xtrain = vectorizer1.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtrain.shape)
```

```
text_bow_Xtest = vectorizer1.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtest.shape)
text_bow_Xcv = vectorizer1.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 8793)
Shape of matrix after one hot encodig  (16500, 8793)
Shape of matrix after one hot encodig  (11055, 8793)
```

7.2. BOW encoding of preprocessed_titles

In [94]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer2 = CountVectorizer(min_df=10)
title_bow_Xtrain = vectorizer2.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtrain.shape)
title_bow_Xtest = vectorizer2.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtest.shape)
title_bow_Xcv = vectorizer2.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 1145)
Shape of matrix after one hot encodig  (16500, 1145)
Shape of matrix after one hot encodig  (11055, 1145)
```

7.3. TFIDF encoding of preprocessed_essays

In [95]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer3 = TfidfVectorizer(min_df=10)
text_tfidf_Xtrain = vectorizer3.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtrain.shape)
text_tfidf_Xtest = vectorizer3.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtest.shape)
text_tfidf_Xcv = vectorizer3.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 8793)
Shape of matrix after one hot encodig  (16500, 8793)
Shape of matrix after one hot encodig  (11055, 8793)
```

7.4. TFIDF encoding of preprocessed_titles

In [96]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer4 = TfidfVectorizer(min_df=10)
title_tfidf_Xtrain = vectorizer4.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtrain.shape)
title_tfidf_Xtest = vectorizer4.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtest.shape)
title_tfidf_Xcv = vectorizer4.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (22445, 1145)
Shape of matrix after one hot encodig  (16500, 1145)
Shape of matrix after one hot encodig  (11055, 1145)
```

7.5. Average Word2Vec encoding of preprocessed_essays on Train Data

In [99]:

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

In [100]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # 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_essays_Xtrain.append(vector)

print(len(avg_w2v_vectors_essays_Xtrain))
print(len(avg_w2v_vectors_essays_Xtrain[2]))
```

```
100%|██████████| 22445/22445 [00:06<00:00, 3457.52it/s]
```

```
22445
300
```

In [101]:

```
average_w2v_on_essay_Xtrain = np.vstack(avg_w2v_vectors_essays_Xtrain)
print(average_w2v_on_essay_Xtrain.shape)
```

```
(22445, 300)
```

7.6. Average Word2Vec encoding of preprocessed_essays on Test Data

In [102]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # 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_essays_Xtest.append(vector)

print(len(avg_w2v_vectors_essays_Xtest))
print(len(avg_w2v_vectors_essays_Xtest[2]))
```

```
100%|██████████| 16500/16500 [00:04<00:00, 3462.79it/s]
```

```
16500
300
```

In [103]:

```
average_w2v_on_essay_Xtest = np.vstack(avg_w2v_vectors_essays_Xtest)
print(average_w2v_on_essay_Xtest.shape)
```

```
(16500, 300)
```

7.7. Average Word2Vec encoding of preprocessed_essays on CV Data

In [104]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # 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_essays_Xcv.append(vector)

print(len(avg_w2v_vectors_essays_Xcv))
print(len(avg_w2v_vectors_essays_Xcv[2]))
```

```
100%|██████████| 11055/11055 [00:03<00:00, 3372.14it/s]
```

```
11055
300
```

In [105]:

```
average_w2v_on_essay_Xcv = np.vstack(avg_w2v_vectors_essays_Xcv)
print(average_w2v_on_essay_Xcv.shape)
```

```
(11055, 300)
```

7.8. Average Word2Vec encoding of preprocessed_titles on Train Data

In [106]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_train['preprocessed_titles'].values): # 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 t.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_titles_Xtrain.append(vector)

print(len(avg_w2v_vectors_titles_Xtrain))
print(len(avg_w2v_vectors_titles_Xtrain[0]))
```

```
100%|██████████| 22445/22445 [00:00<00:00, 70400.65it/s]
```

```
22445
300
```

In [107]:

```
average_w2v_on_titles_Xtrain = np.vstack(avg_w2v_vectors_titles_Xtrain)
print(average_w2v_on_titles_Xtrain.shape)
```

```
(22445, 300)
```

7.9. Average Word2Vec encoding of preprocessed_titles on Test Data

In [108]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_test['preprocessed_titles'].values): # 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 t.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_titles_Xtest.append(vector)

print(len(avg_w2v_vectors_titles_Xtest))
print(len(avg_w2v_vectors_titles_Xtest[0]))
```

```
100%|██████████| 16500/16500 [00:00<00:00, 72728.63it/s]
```

```
16500
300
```

In [109]:

```
average_w2v_on_titles_Xtest = np.vstack(avg_w2v_vectors_titles_Xtest)
print(average_w2v_on_titles_Xtest.shape)
```

```
(16500, 300)
```

7.10. Average Word2Vec encoding of preprocessed_titles on CV Data

In [110]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_cv['preprocessed_titles'].values): # 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 t.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_titles_Xcv.append(vector)
```

```
print(len(avg_w2v_vectors_titles_Xcv))
print(len(avg_w2v_vectors_titles_Xcv[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 70454.43it/s]
```

```
11055
300
```

In [111]:

```
average_w2v_on_titles_Xcv = np.vstack(avg_w2v_vectors_titles_Xcv)
print(average_w2v_on_titles_Xcv.shape)
```

```
(11055, 300)
```

7.11. TFIDF weighted Word2Vec encoding of preprocessed_essays on Train Data

In [112]:

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

In [113]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtrain = []; # the avg-w2v for each sentence/review is stored i
n this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain[0]))
```

```
100%|██████████| 22445/22445 [00:42<00:00, 524.36it/s]
```

```
22445
300
```

In [114]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtrain)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
```

```
(22445, 300)
```

7.12. TFIDF weighted Word2Vec encoding of preprocessed_essays on Test Data

In [115]:

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

In [116]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtest = []; # the avg-w2v for each sentence/review is stored in
this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtest))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtest[0]))
```

```
100%|██████████| 16500/16500 [00:30<00:00, 536.75it/s]
```

```
16500
300
```

In [117]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtest)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
```

```
(16500, 300)
```

7.13. TFIDF weighted Word2Vec encoding of preprocessed_essays on CV Data

In [118]:

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

In [119]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xcv = []; # the avg-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # for each review/sentence
```

```
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf 
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf 
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xcv.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xcv))
print(len(tfidf_weighted_w2v_vectors_eassays_Xcv[0]))
```

```
100%|██████████| 11055/11055 [00:20<00:00, 527.73it/s]
```

```
11055
300
```

In [120]:

```
tfidf_weighted_w2v_on_essay_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xcv)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
```

```
(11055, 300)
```

7.14. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Train Data

In [121]:

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

In [122]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xtrain = []; # the avg-w2v for each sentence/review is stored in 
this list
for t in tqdm(X_train['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf 
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(t.count(word)/len(t.split())) # getting the tfidf value for 
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtrain))
print(len(tfidf_weighted_w2v_vectors_title_Xtrain[0]))
```

```
100%|██████████| 22445/22445 [00:00<00:00, 32945.76it/s]
```

```
22445
300
```

In [123]:

```
tfidf_weighted_w2v_on_title_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_title_Xtrain)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
```

```
(22445, 300)
```

7.15. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Test Data

In [124]:

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

In [125]:

```
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xtest = []; # the avg-w2v for each sentence/review is stored in t
his list
for t in tqdm(X_test['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtest))
print(len(tfidf_weighted_w2v_vectors_title_Xtest[0]))
```

```
100%|██████████| 16500/16500 [00:00<00:00, 31412.47it/s]
```

```
16500
300
```

In [126]:

```
tfidf_weighted_w2v_on_title_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_title_Xtest)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
```

```
(16500, 300)
```

7.16. TFIDF Weighted Word2Vec encoding of preprocessed_titles on CV Data

In [127]:

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

In [128]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xcv = []; # the avg-w2v for each sentence/review is stored in thi
s list
for t in tqdm(X_cv['preprocessed_titles'].values): # 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 t.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xcv.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xcv))
print(len(tfidf_weighted_w2v_vectors_title_Xcv[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 29814.93it/s]
```

```
11055
300
```

In [129]:

```
tfidf_weighted_w2v_on_title_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_title_Xcv)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
```

```
(11055, 300)
```

8. Encoding of Numerical Data

8.1. Encoding of price on Train,Test and CV data

In [130]:

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


scalar = MinMaxScaler()

price_standardized_Xtrain = scalar.fit_transform(X_train['price'].values.reshape(-1, 1))
price_standardized_Xtest = scalar.transform(X_test['price'].values.reshape(-1,1))
price_standardized_Xcv = scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

In [131]:

```
price_standardized_Xtrain
```

Out[131]:

```
array([[0.01043373],
        [0.02140655],
        [0.01433438],
        ...,
        [0.01641072],
        [0.03993963],
        [0.13694573]])
```

In [132]:

```
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

8.2. Encoding of quantity on Train,Test and CV data

In [133]:

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

scalar = MinMaxScaler()

quantity_standardized_Xtrain = scalar.fit_transform(X_train['quantity'].values.reshape(-1, 1))
quantity_standardized_Xtest = scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_Xcv = scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
```

In [134]:

```
quantity_standardized_Xtrain
```

Out[134]:

```
array([[0.00375469],
       [0.00250313],
       [0.01001252],
       ...,
       [0.00500626],
       [0.00375469],
       [0.        ]])
```

In [135]:

```
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

8.3. Encoding of teacher_number_of_previously_posted_projects on Train,Test and CV data

In [136]:

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

scalar = MinMaxScaler()
```

```
# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_Xtrain = scalar.fit_transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xtest =
scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xcv =
scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
```

In [137]:

```
teacher_number_of_previously_posted_projects_standardized_Xtrain
```

Out[137]:

```
array([[0.00472813],
       [0.15602837],
       [0.00236407],
       ...,
       [0.00236407],
       [0.        ],
       [0.00945626]])
```

In [138]:

```
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xcv.shape)
```

```
(22445, 1)
(16500, 1)
(11055, 1)
```

9. Printing Dimensions of all Preprocessed Data

In [139]:

```
print(categories_response_code_Xtrain.shape)
print(categories_response_code_Xtest.shape)
print(categories_response_code_Xcv.shape)
print(subcategories_response_code_Xtrain.shape)
print(subcategories_response_code_Xtest.shape)
print(subcategories_response_code_Xcv.shape)
print(school_state_response_code_Xtrain.shape)
print(school_state_response_code_Xtest.shape)
print(school_state_response_code_Xcv.shape)
print(teacher_prefix_response_code_Xtrain.shape)
print(teacher_prefix_response_code_Xtest.shape)
print(teacher_prefix_response_code_Xcv.shape)
print(project_grade_clean_category_response_code_Xtrain.shape)
print(project_grade_clean_category_response_code_Xtest.shape)
print(project_grade_clean_category_response_code_Xcv.shape)
print(text_bow_Xtrain.shape)
print(text_bow_Xtest.shape)
print(text_bow_Xcv.shape)
print(title_bow_Xtrain.shape)
print(title_bow_Xtest.shape)
print(title_bow_Xcv.shape)
print(text_tfidf_Xtrain.shape)
print(text_tfidf_Xtest.shape)
print(text_tfidf_Xcv.shape)
print(title_tfidf_Xtrain.shape)
print(title_tfidf_Xtest.shape)
print(title_tfidf_Xcv.shape)
print(average_w2v_on_essay_Xtrain.shape)
print(average_w2v_on_essay_Xtest.shape)
print(average_w2v_on_essay_Xcv.shape)
print(average_w2v_on_titles_Xtrain.shape)
print(average_w2v_on_titles_Xtest.shape)
print(average_w2v_on_titles_Xcv.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xcv .shape)
```

```
(22445, 2)
(16500, 2)
(11055, 2)
(22445, 2)
(16500, 2)
(11055, 2)
(22445, 2)
(16500, 2)
(11055, 2)
(22445, 2)
(16500, 2)
(11055, 2)
(22445, 2)
(16500, 2)
(11055, 2)
(22445, 8793)
(16500, 8793)
(11055, 8793)
(22445, 1145)
(16500, 1145)
(11055, 1145)
(22445, 8793)
(16500, 8793)
(11055, 8793)
(22445, 1145)
(16500, 1145)
(11055, 1145)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 300)
(16500, 300)
(11055, 300)
(22445, 1)
(16500, 1)
(11055, 1)
(22445, 1)
(16500, 1)
(11055, 1)
(22445, 1)
(16500, 1)
(11055, 1)
```

In [ ]:

In [ ]:

In [ ]:

10. Creating Different Sets of Data for Training Model

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

In [140]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain1 =
hstack((categories_response_code_Xtrain,subcategories_response_code_Xtrain,school_state_response_co
de_Xtrain,teacher_prefix_response_code_Xtrain,project_grade_clean_category_response_code_Xtrain,pr
ice_standardized_Xtrain,quantity_standardized_Xtrain,teacher_number_of_previously_posted_projects_st
andardized_Xtrain,text_bow_Xtrain,title_bow_Xtrain)).tocsr()
Xtest1 =
hstack((categories_response_code_Xtest,subcategories_response_code_Xtest,school_state_response_code
_Xtest,teacher_prefix_response_code_Xtest,project_grade_clean_category_response_code_Xtest,price_st
andardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previously_posted_projects_standardi
d_Xtest,text_bow_Xtest,title_bow_Xtest)).tocsr()
Xcv1 =
hstack((categories_response_code_Xcv,subcategories_response_code_Xcv,school_state_response_code_Xcv
,teacher_prefix_response_code_Xcv,project_grade_clean_category_response_code_Xcv,price_standardized
_Xcv,quantity_standardized_Xcv,teacher_number_of_previously_posted_projects_standardized_Xcv,text_
bow_Xcv,title_bow_Xcv)).tocsr()

print(Xtrain1.shape,y_train.shape)
print(Xtest1.shape,y_test.shape)
print(Xcv1.shape,y_cv.shape)
```

```
(22445, 9951) (22445,)
(16500, 9951) (16500,)
(11055, 9951) (11055,)
```

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

In [141]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain2 =
hstack((categories_response_code_Xtrain,subcategories_response_code_Xtrain,school_state_response_co
de_Xtrain,teacher_prefix_response_code_Xtrain,project_grade_clean_category_response_code_Xtrain,pr
ice_standardized_Xtrain,quantity_standardized_Xtrain,teacher_number_of_previously_posted_projects_st
andardized_Xtrain,text_tfidf_Xtrain,title_tfidf_Xtrain)).tocsr()
Xtest2 =
hstack((categories_response_code_Xtest,subcategories_response_code_Xtest,school_state_response_code
_Xtest,teacher_prefix_response_code_Xtest,project_grade_clean_category_response_code_Xtest,price_st
andardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previously_posted_projects_standardi
d_Xtest,text_tfidf_Xtest,title_tfidf_Xtest)).tocsr()
Xcv2 =
hstack((categories_response_code_Xcv,subcategories_response_code_Xcv,school_state_response_code_Xcv
,teacher_prefix_response_code_Xcv,project_grade_clean_category_response_code_Xcv,price_standardized
_Xcv,quantity_standardized_Xcv,teacher_number_of_previously_posted_projects_standardized_Xcv,text_
tfidf_Xcv,title_tfidf_Xcv)).tocsr()

print(Xtrain2.shape,y_train.shape)
print(Xtest2.shape,y_test.shape)
print(Xcv2.shape,y_cv.shape)
```

```
(22445, 9951) (22445,)
(16500, 9951) (16500,)
(11055, 9951) (11055,)
```

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

In [142]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain3 =
hstack((categories_response_code_Xtrain,subcategories_response_code_Xtrain,school_state_response_co
de_Xtrain,teacher_prefix_response_code_Xtrain,project_grade_clean_category_response_code_Xtrain,pr
ice_standardized_Xtrain,quantity_standardized_Xtrain,teacher_number_of_previously_posted_projects_st
andardized_Xtrain,average_w2v_on_essay_Xtrain,average_w2v_on_titles_Xtrain)).tocsr()
Xtest3 =
hstack((categories_response_code_Xtest,subcategories_response_code_Xtest,school_state_response_code
_Xtest,teacher_prefix_response_code_Xtest,project_grade_clean_category_response_code_Xtest,price_st
andardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previously_posted_projects_standardize
d_Xtest,average_w2v_on_essay_Xtest,average_w2v_on_titles_Xtest)).tocsr()
Xcv3 =
hstack((categories_response_code_Xcv,subcategories_response_code_Xcv,school_state_response_code_Xcv
,teacher_prefix_response_code_Xcv,project_grade_clean_category_response_code_Xcv,price_standardized
_Xcv,quantity_standardized_Xcv,teacher_number_of_previously_posted_projects_standardized_Xcv,avera
ge_w2v_on_essay_Xcv,average_w2v_on_titles_Xcv)).tocsr()

print(Xtrain3.shape,y_train.shape)
print(Xtest3.shape,y_test.shape)
print(Xcv3.shape,y_cv.shape)
```

```
(22445, 613) (22445,)
(16500, 613) (16500,)
(11055, 613) (11055,)
```

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

In [143]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain4 =
hstack((categories_response_code_Xtrain,subcategories_response_code_Xtrain,school_state_response_co
de_Xtrain,teacher_prefix_response_code_Xtrain,project_grade_clean_category_response_code_Xtrain,pr
ice_standardized_Xtrain,quantity_standardized_Xtrain,teacher_number_of_previously_posted_projects_st
andardized_Xtrain,tfidf_weighted_w2v_on_essay_matrix_Xtrain,tfidf_weighted_w2v_on_title_matrix_Xtrai
n)).tocsr()
Xtest4 =
hstack((categories_response_code_Xtest,subcategories_response_code_Xtest,school_state_response_code
_Xtest,teacher_prefix_response_code_Xtest,project_grade_clean_category_response_code_Xtest,price_st
andardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previously_posted_projects_standardize
d_Xtest,tfidf_weighted_w2v_on_essay_matrix_Xtest,tfidf_weighted_w2v_on_title_matrix_Xtest)).tocsr(
)
Xcv4 =
hstack((categories_response_code_Xcv,subcategories_response_code_Xcv,school_state_response_code_Xcv
,teacher_prefix_response_code_Xcv,project_grade_clean_category_response_code_Xcv,price_standardized
_Xcv,quantity_standardized_Xcv,teacher_number_of_previously_posted_projects_standardized_Xcv,tfidf
_weighted_w2v_on_essay_matrix_Xcv,tfidf_weighted_w2v_on_title_matrix_Xcv)).tocsr()

print(Xtrain4.shape,y_train.shape)
print(Xtest4.shape,y_test.shape)
print(Xcv4.shape,y_cv.shape)
```

```
(22445, 613) (22445,)
(16500, 613) (16500,)
(11055, 613) (11055,)
```

In [ ]:

11. Applying Random Forest on different kind of featurization

Function for predicting Target values Batchwise

In [ ]:

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

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

#     return y_data_pred
```

11.1. Applying Random Forest on BOW, SET 1

In [309]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier
import seaborn as sb


RF = RandomForestClassifier(class_weight = 'balanced')
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
RFT = GridSearchCV(RF, parameters, cv=3, scoring='roc_auc',return_train_score=True)
RFT.fit(Xtrain1, y_train)
print(RFT.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
                       criterion='gini', max_depth=500, max_features='auto',
                       max_leaf_nodes=None, min_impurity_decrease=0.0,
                       min_impurity_split=None, min_samples_leaf=1,
                       min_samples_split=2, min_weight_fraction_leaf=0.0,
                       n_estimators=1000, n_jobs=None, oob_score=False,
                       random_state=None, verbose=0, warm_start=False)
```

11.1.1. Finding The Best Hyperparameter "max_depth" and " n_estimators"

In [310]:

```
RFT = pd.DataFrame.from_dict(RFT.cv_results_)
RFT.head()
```

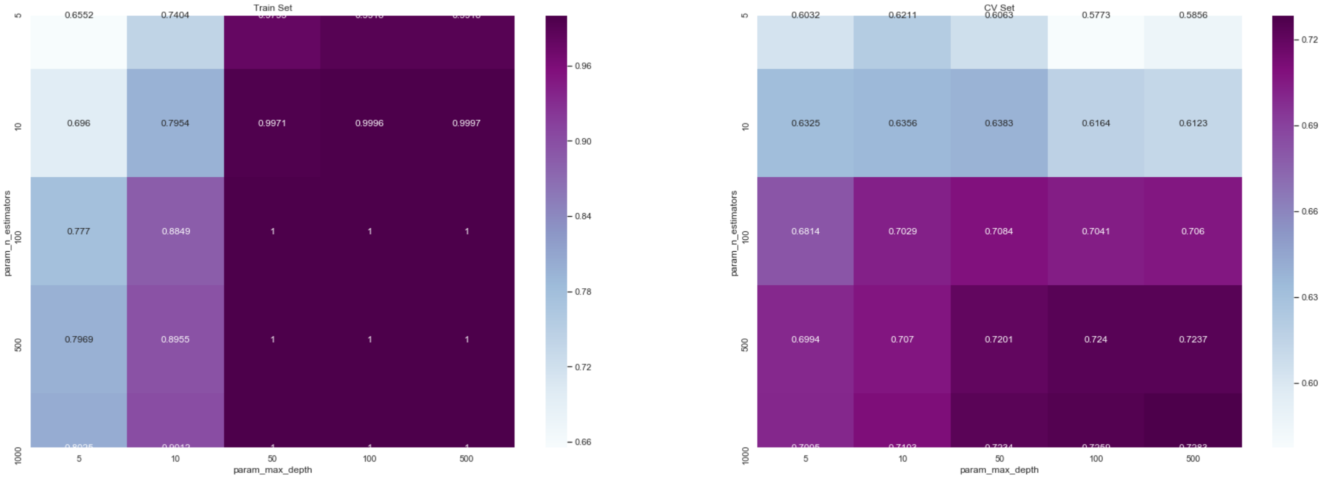
Out[310]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_n_estimators	params	split0_test_sco
0	0.833303	0.924336	0.286475	0.283662	5	5	{'max_depth': 5, 'n_estimators': 5}	0.6030
1	0.291652	0.044795	0.348985	0.228687	5	10	{'max_depth': 5, 'n_estimators':	0.6078

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_max_depth	param_n_estimators	params	split0_test_sco
2	0.916600	0.125862	0.406251	0.012767	5	100	{'max_depth': 5, 'n_estimators': 100}	0.6744
3	3.275843	0.320805	1.911313	0.019465	5	500	{'max_depth': 5, 'n_estimators': 500}	0.6945
4	6.882251	0.560365	3.963775	0.130929	5	1000	{'max_depth': 5, 'n_estimators': 1000}	0.6911

In [311]:

```
max_scores_bow = RFT.groupby(['param_n_estimators',
                              'param_max_depth']).max()
max_scores_bow = max_scores_bow.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_bow.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_bow.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [ ]:

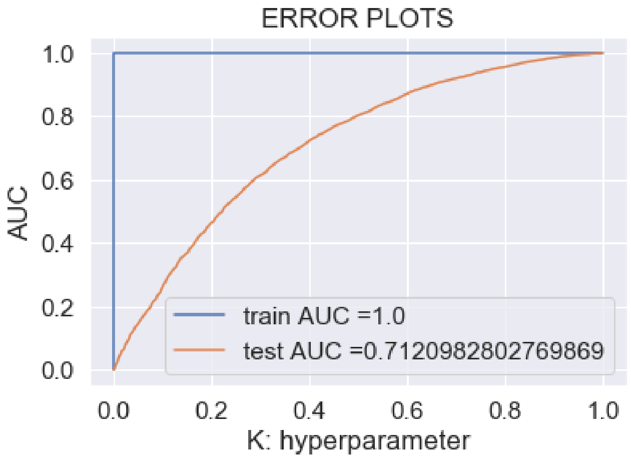
```
# best_parameters_bow = [{'max_depth':[10], 'min_samples_split':[500] } ]
```

11.1.2. Testing the performance of the model on test data, plotting ROC Curves

In [312]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF = RandomForestClassifier(class_weight = 'balanced', max_depth = 500  ,n_estimators =  1000)
RF.fit(Xtrain1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred_bow = RF.predict_proba(Xtrain1)[:,1]
y_test_pred_bow = RF.predict_proba(Xtest1)[:,1]
```

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_bow)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



11.1.3. Building Confsuion Matrix

Function for confusion matrix

In [149]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    return t

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

In [314]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_bow, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_bow, best_t)))
```

```
====================================================================================================

the maximum value of tpr*(1-fpr) 1.0 for threshold 0.766
Train confusion matrix
```

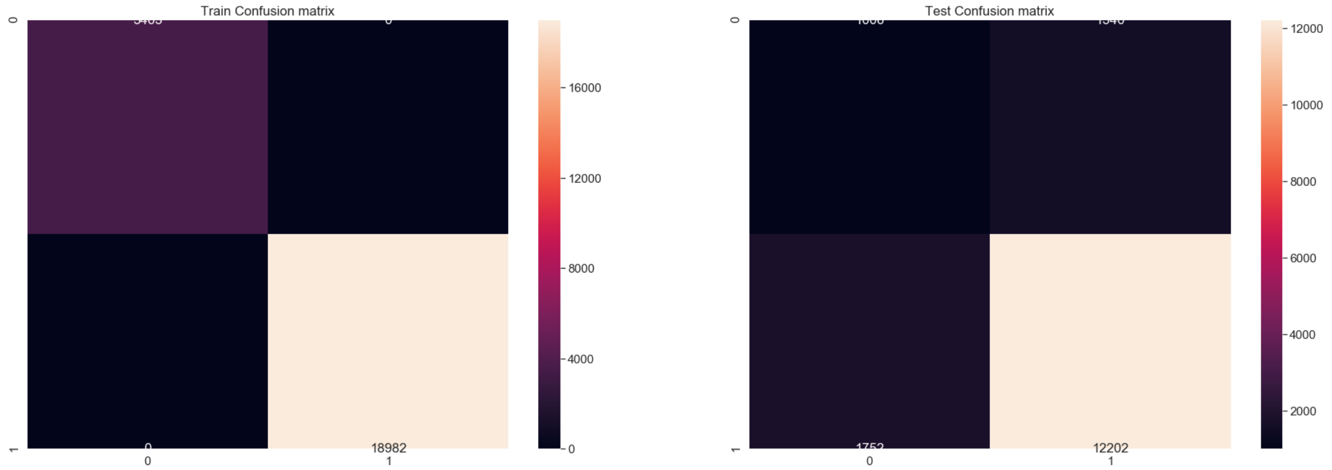
```
[[ 3463     0]
 [    0 18982]]
Test confusion matrix
[[ 1006  1540]
 [ 1752 12202]]
```

In [315]:

```
confusion_matrix_train_bow = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_bow, best_t)))
confusion_matrix_test_bow = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_bow, best_t)))
```

In [316]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_bow,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_bow,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



11.2. Applying Random Forests on TFIDF, SET 2

In [317]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier
import seaborn as sb


RF = RandomForestClassifier(class_weight = 'balanced')
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
RFT2 = GridSearchCV(RF, parameters, cv=3, scoring='roc_auc',return_train_score=True)
RFT2.fit(Xtrain2, y_train)
print(RFT2.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
                       criterion='gini', max_depth=100, max_features='auto',
                       max_leaf_nodes=None, min_impurity_decrease=0.0,
                       min_impurity_split=None, min_samples_leaf=1,
                       min_samples_split=2, min_weight_fraction_leaf=0.0,
                       n_estimators=1000, n_jobs=None, oob_score=False,
                       random_state=None, verbose=0, warm_start=False)
```

11.2.1. Finding The Best Hyperparameter "max_depth" and

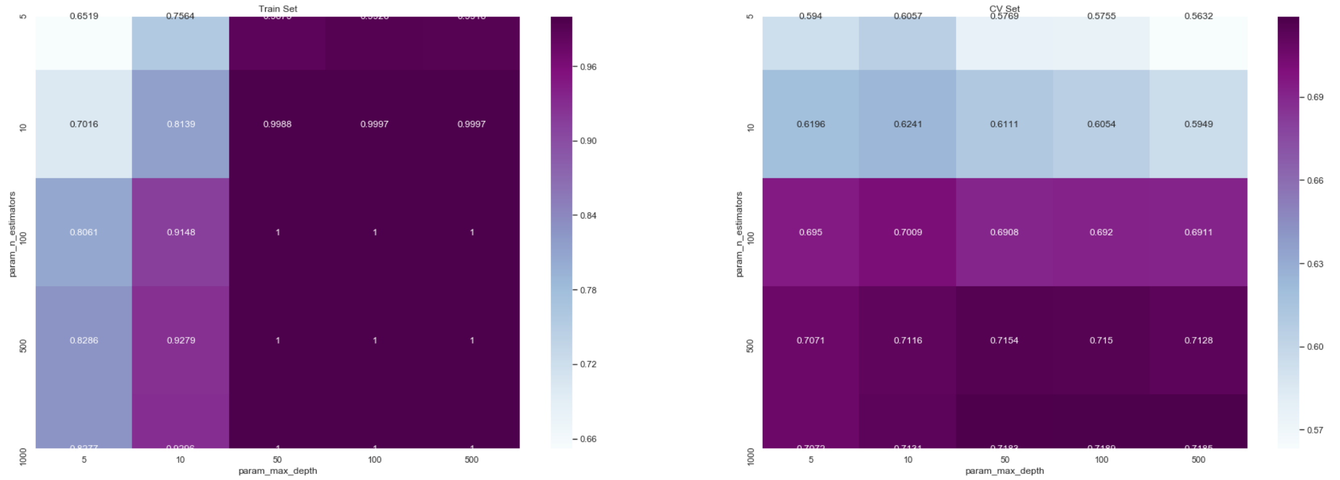
"n_estimators"

In [318]:

```
RFT2 = pd.DataFrame.from_dict(RFT2.cv_results_)
```

In [319]:

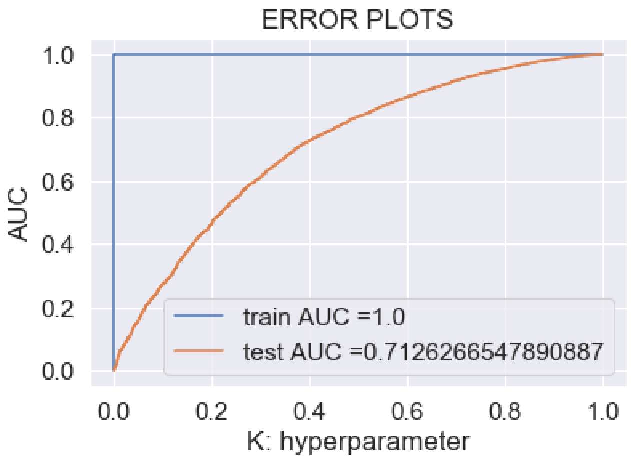
```
max_scores_tfidf = RFT2.groupby(['param_n_estimators',
                                    'param_max_depth']).max()
max_scores_tfidf = max_scores_tfidf.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidf.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_tfidf.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



11.2.2. Testing the performance of the model on test data, plotting ROC Curves

In [320]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF2 = RandomForestClassifier(class_weight = 'balanced', max_depth = 100  ,n_estimators =  1000)
RF2.fit(Xtrain2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidf = RF2.predict_proba(Xtrain2)[:,1]
y_test_pred_tfidf = RF2.predict_proba(Xtest2)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



11.2.3. Buiding Confusion Matrix

In [321]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf, best_t)))
```

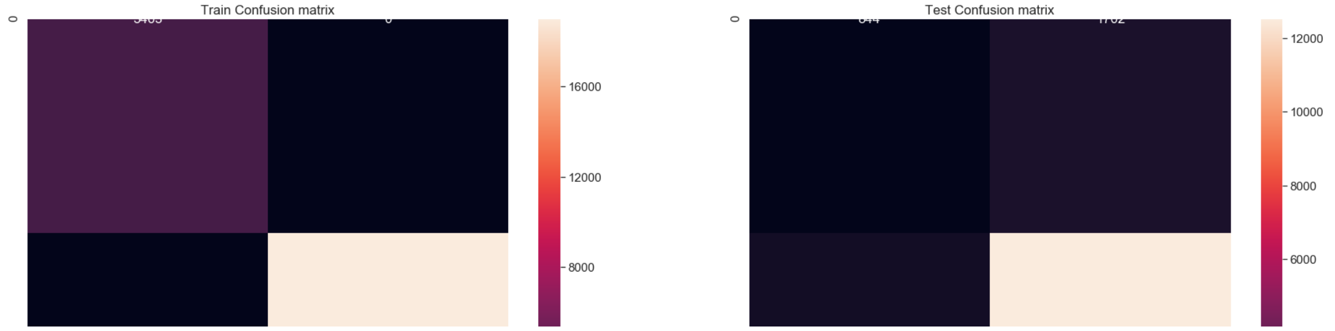
```
====================================================================================================

the maximum value of tpr*(1-fpr) 1.0 for threshold 0.753
Train confusion matrix
[[ 3463     0]
 [    0 18982]]
Test confusion matrix
[[  844  1702]
 [ 1421 12533]]
```

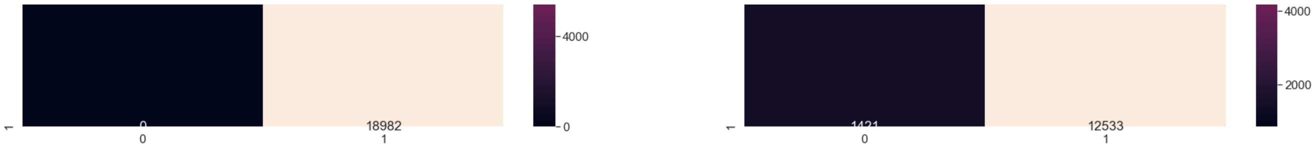
In [322]:

```
confusion_matrix_train_tfidf = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf, best_t)))
confusion_matrix_test_tfidf = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf, best_t)))
```

In [323]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```





11.3. Applying Random Forests on AVG W2V, SET 3

In [324]:

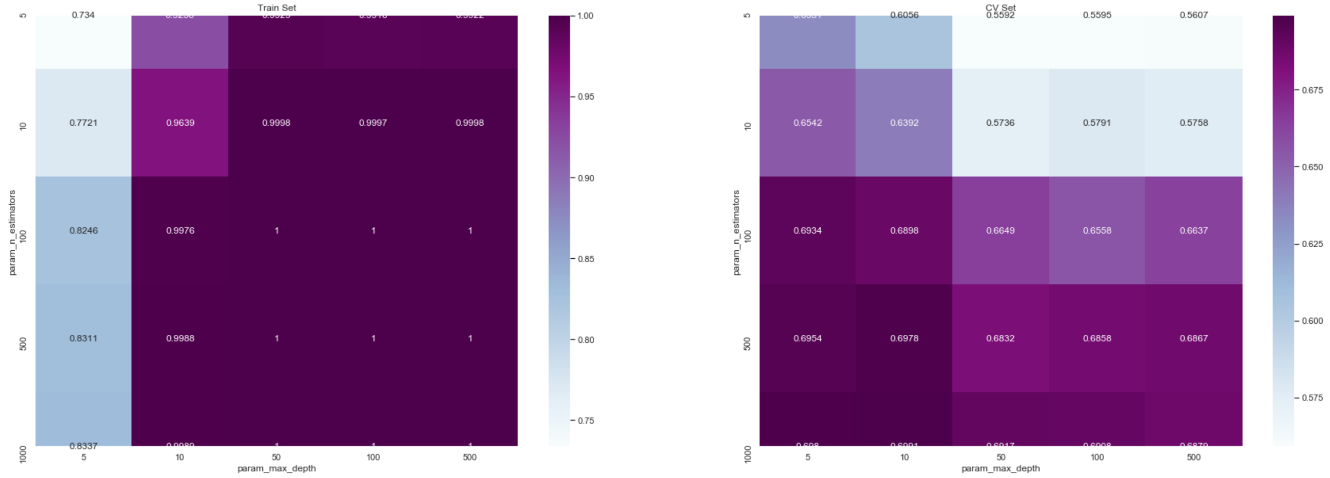
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GrisssdSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier
import seaborn as sb


RF = RandomForestClassifier(class_weight = 'balanced')
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
RFT3 = GridSearchCV(RF, parameters, cv=3, scoring='roc_auc',return_train_score=True)
RFT3.fit(Xtrain3, y_train)
print(RFT3.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
                       criterion='gini', max_depth=10, max_features='auto',
                       max_leaf_nodes=None, min_impurity_decrease=0.0,
                       min_impurity_split=None, min_samples_leaf=1,
                       min_samples_split=2, min_weight_fraction_leaf=0.0,
                       n_estimators=1000, n_jobs=None, oob_score=False,
                       random_state=None, verbose=0, warm_start=False)
```

11.3.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [325]:

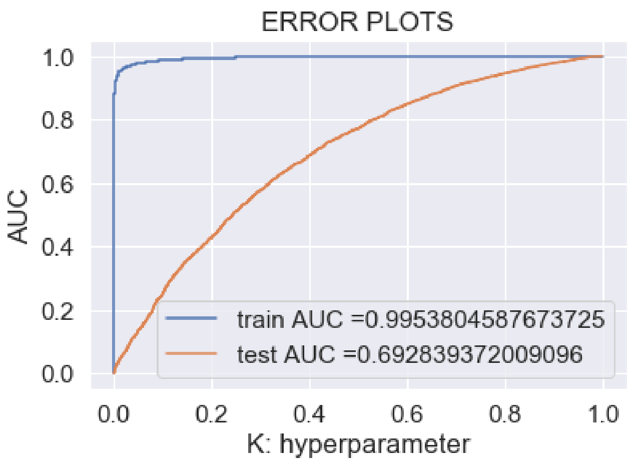
```
RFT3 = pd.DataFrame(RFT3.cv_results_)
max_scores_avg_w2v = RFT3.groupby(['param_n_estimators',
                                    'param_max_depth']).max()
max_scores_avg_w2v = max_scores_avg_w2v.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_avg_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_avg_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



11.3.2. Testing the performance of the model on test data, plotting ROC Curves

In [326]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF3 = RandomForestClassifier(class_weight = 'balanced', max_depth = 10  ,n_estimators =  1000)
RF3.fit(Xtrain3, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred_avg_w2v = RF3.predict_proba(Xtrain3)[:,1]
y_test_pred_avg_w2v = RF3.predict_proba(Xtest3)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avg_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avg_w2v)

sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



11.3.3. Building Confusion matrix

In [327]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_avg_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.943469766774201 for threshold 0.534
Train confusion matrix
[[ 3405    58]
 [  768 18214]]
Test confusion matrix
```

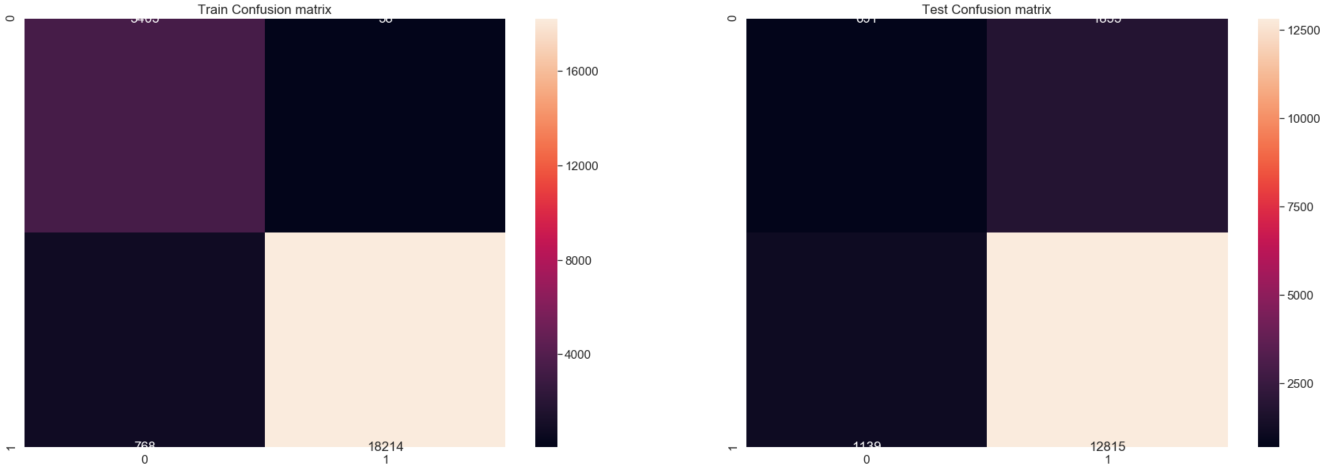
```
[[  691  1855]
 [ 1139 12815]]
```

In [328]:

```
confusion_matrix_train_avg_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_avg_w2v, best_t)))
confusion_matrix_test_avg_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

In [329]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_avg_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_avg_w2v,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



11.4. Applying Random Forests on TFIDF W2V, SET 4

In [330]:

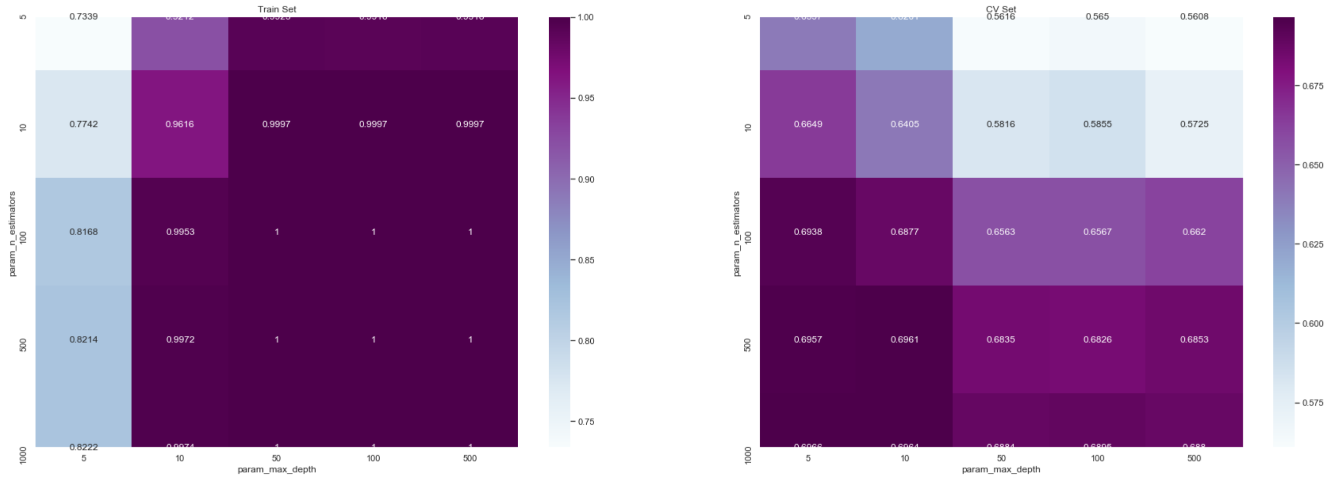
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier
import seaborn as sb


RF = RandomForestClassifier(class_weight = 'balanced')
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
RFT4 = GridSearchCV(RF, parameters, cv=3, scoring='roc_auc',return_train_score=True)
RFT4.fit(Xtrain4, y_train)
print(RFT4.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, min_impurity_decrease=0.0,
                       min_impurity_split=None, min_samples_leaf=1,
                       min_samples_split=2, min_weight_fraction_leaf=0.0,
                       n_estimators=1000, n_jobs=None, oob_score=False,
                       random_state=None, verbose=0, warm_start=False)
```

11.4.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [331]:

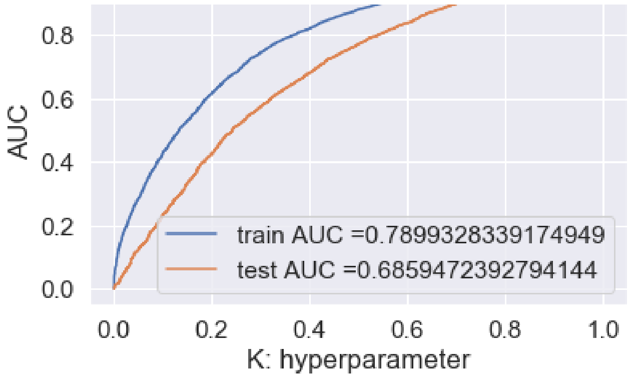
```
RFT4 = pd.DataFrame.from_dict(RFT4.cv_results_)
max_scores_tfidf_weighted_w2v = RFT4.groupby(['param_n_estimators',
                                         'param_max_depth']).max()
max_scores_tfidf_weighted_w2v = max_scores_tfidf_weighted_w2v.unstack()[['mean_test_score', 'mea
n_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidf_weighted_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu",
ax=ax[0])
sns.heatmap(max_scores_tfidf_weighted_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax
=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



11.4.2. Testing the performance of the model on test data, plotting ROC Curves

In [334]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF4 = RandomForestClassifier(class_weight = 'balanced', max_depth = 5  ,n_estimators =  1000)
RF4.fit(Xtrain4, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidf_weighted_w2v = RF4.predict_proba(Xtrain4)[:,1]
y_test_pred_tfidf_weighted_w2v = RF4.predict_proba(Xtest4)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_weighted_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_weighted_w2v)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



11.4.3. Building Confusion Matrix

In [335]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

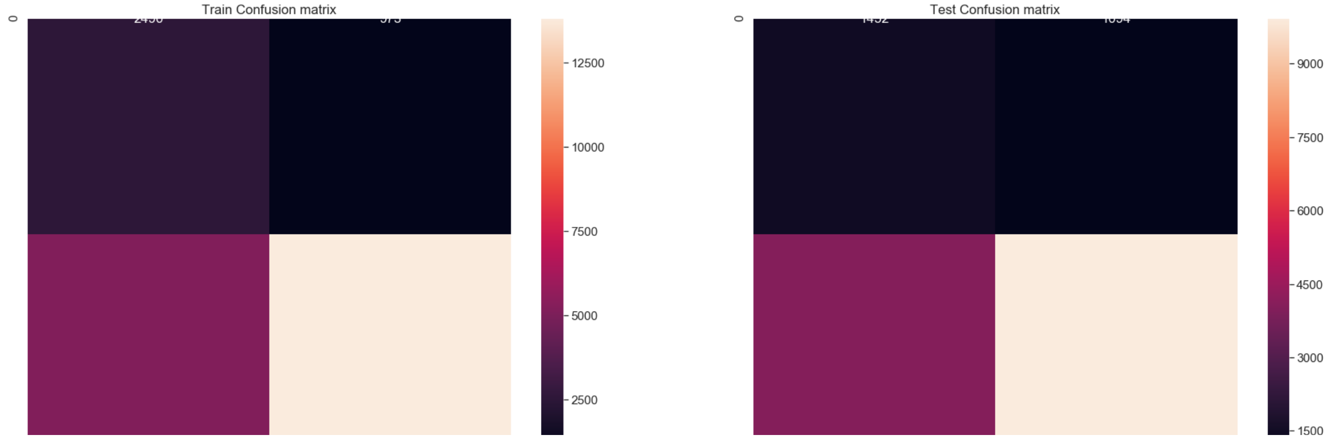
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.5227757603575562 for threshold 0.498
Train confusion matrix
[[ 2490   973]
 [ 5181 13801]]
Test confusion matrix
[[1452 1094]
 [4033 9921]]
```

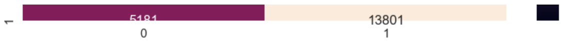
In [336]:

```
confusion_matrix_train_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
confusion_matrix_test_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

In [337]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf_weighted_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf_weighted_w2v,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```





In [ ]:

```

```

12. Applying GBDT on different kind of featurization

12.1. Applying XGBOOST on BOW, SET 1

In [342]:

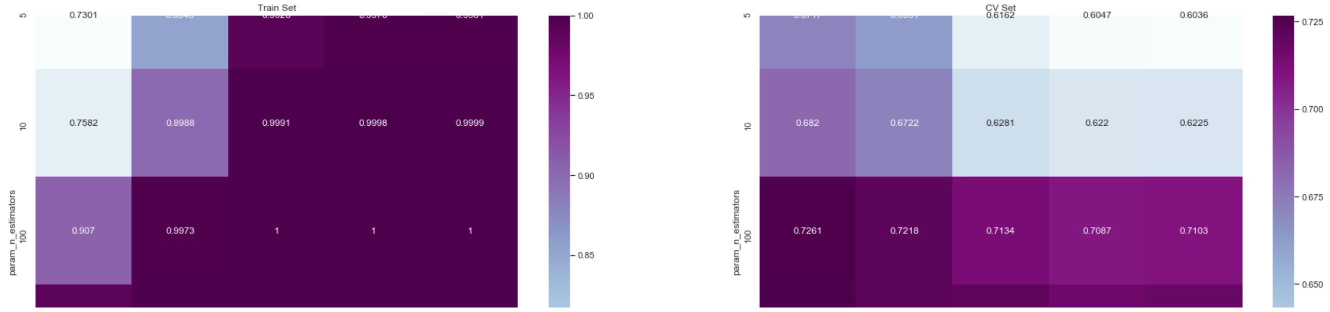
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
import xgboost
import seaborn as sb


XG = xgboost.XGBClassifier(scale_pos_weight=1, n_jobs = -1)
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
XGB = GridSearchCV(XG, parameters, cv=3, scoring='roc_auc',return_train_score=True)
XGB.fit(Xtrain1, y_train)
print('Best estimator', XGB.best_estimator_)
print('Best score', XGB.best_score_)
```

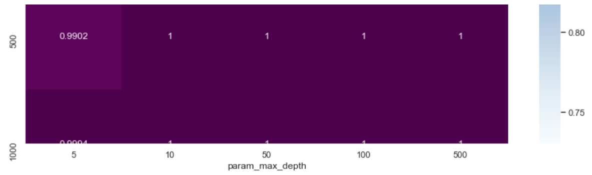
```
Best estimator XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0,
              learning_rate=0.1, max_delta_step=0, max_depth=5,
              min_child_weight=1, missing=None, n_estimators=500, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
Best score 0.7267182263981559
```

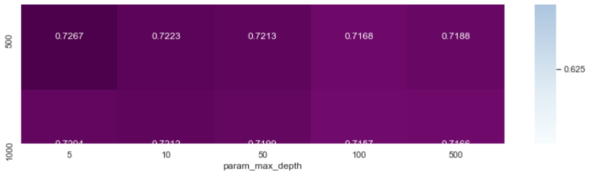
12.1.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [343]:

```
XGB = pd.DataFrame.from_dict(XGB.cv_results_)
max_scores_bow = XGB.groupby(['param_n_estimators',
                              'param_max_depth']).max()
max_scores_bow = max_scores_bow.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_bow.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_bow.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



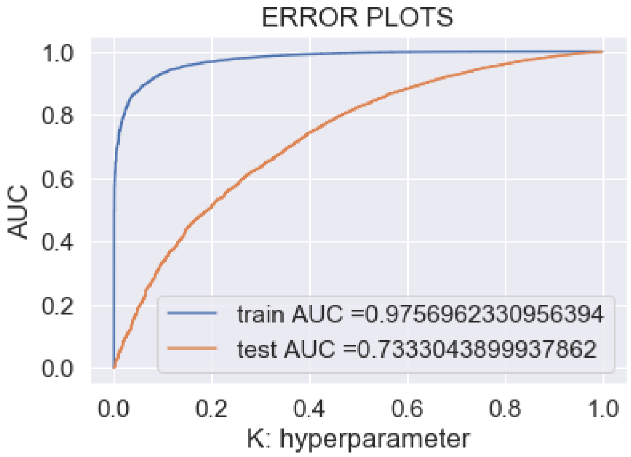




12.1.2. Testing the performance of the model on test data, plotting ROC Curves

In [345]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


XG1 = xgboost.XGBClassifier(scale_pos_weight=1,n_jobs = -1, max_depth = 5  ,n_estimators =  500)
XG1.fit(Xtrain1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred_bow = XG1.predict_proba(Xtrain1)[:,1]
y_test_pred_bow = XG1.predict_proba(Xtest1)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_bow)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



12.1.3. Building Confusion matrix

In [346]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_bow, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_bow, best_t)))
```

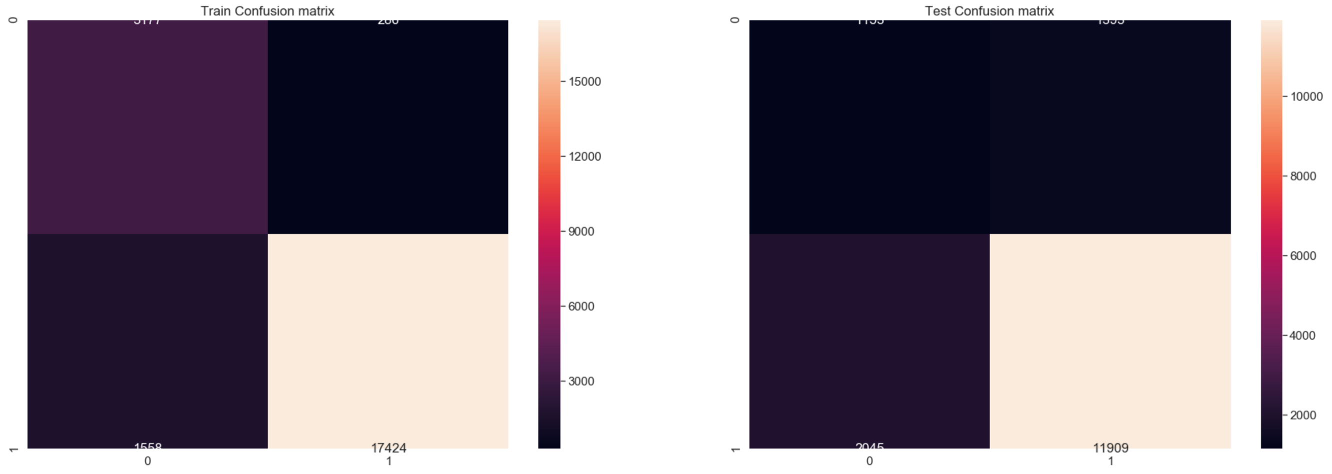
```
====================================================================================================
the maximum value of tpr*(1-fpr) 0.8421134747988221 for threshold 0.776
Train confusion matrix
[[ 3177   286]
 [ 1558 17424]]
Test confusion matrix
[[ 1153  1393]
 [ 2045 11909]]
```

In [347]:

```
confusion_matrix_train_bow = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_bow, best_t)))
confusion_matrix_test_bow = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_bow, best_t)))
```

In [348]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_bow,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_bow,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



12.2. Applying XGBOOST on TFIDF, SET 2

In [349]:

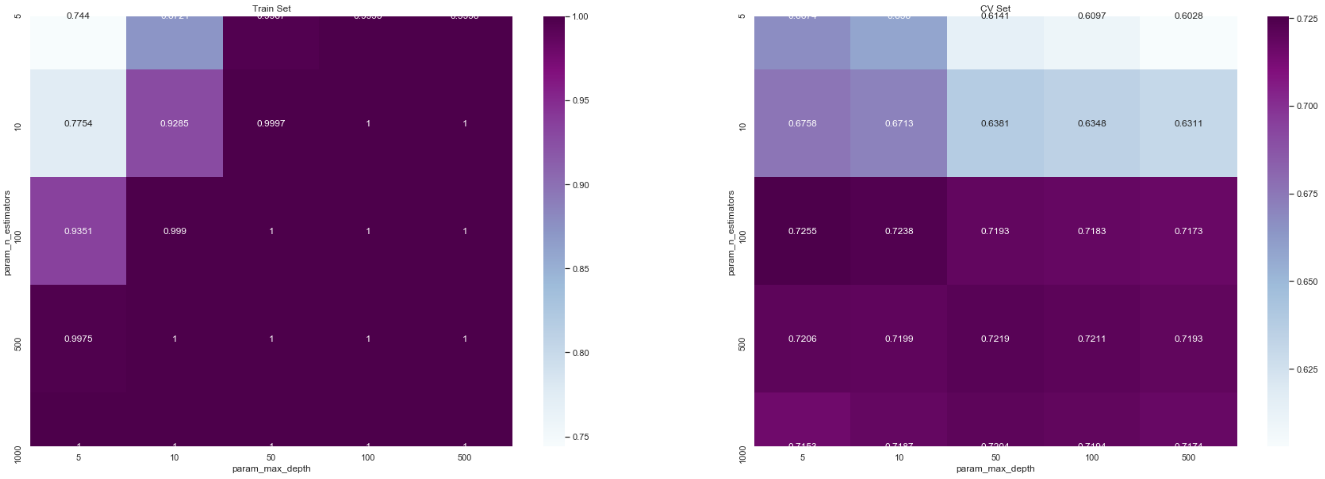
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
import xgboost
import seaborn as sb


XG = xgboost.XGBClassifier(scale_pos_weight=1, n_jobs = -1)
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
XGB2 = GridSearchCV(XG, parameters, cv=3, scoring='roc_auc',return_train_score=True)
XGB2.fit(Xtrain2, y_train)
print('Best estimator', XGB2.best_estimator_)
print('Best score', XGB2.best_score_)
```

```
Best estimator XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0,
              learning_rate=0.1, max_delta_step=0, max_depth=5,
              min_child_weight=1, missing=None, n_estimators=100, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
Best score 0.7255455767717093
```

12.2.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [350]:

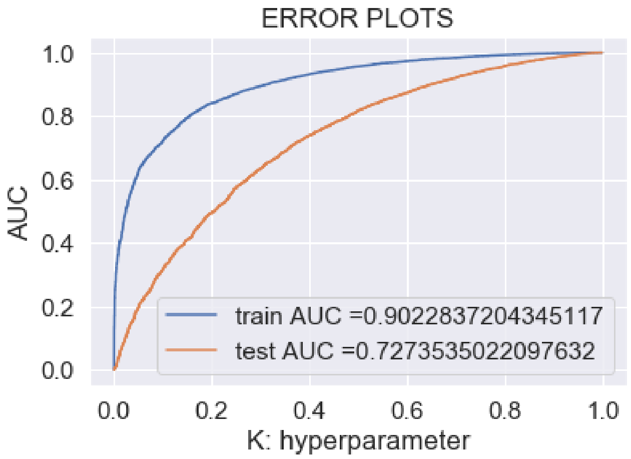
```
XGB2 = pd.DataFrame.from_dict(XGB2.cv_results_)
max_scores_tfidf = XGB2.groupby(['param_n_estimators',
                                  'param_max_depth']).max()
max_scores_tfidf = max_scores_tfidf.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidf.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_tfidf.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



12.2.2. Testing the performance of the model on test data, plotting ROC Curves

In [351]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


XG2 = xgboost.XGBClassifier(scale_pos_weight=1,n_jobs = -1, max_depth = 5  ,n_estimators =  100)
XG2.fit(Xtrain2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred_tfidf = XG2.predict_proba(Xtrain2)[:,1]
y_test_pred_tfidf = XG2.predict_proba(Xtest2)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



12.2.3. Building Confusion matrix

In [352]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf, best_t)))
```

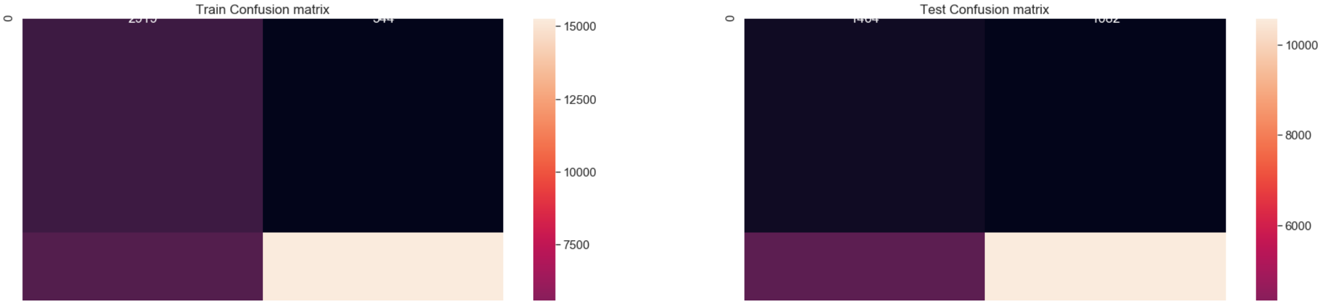
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.6775435962510253 for threshold 0.825
Train confusion matrix
[[ 2919   544]
 [ 3724 15258]]
Test confusion matrix
[[ 1464  1082]
 [ 3372 10582]]
```

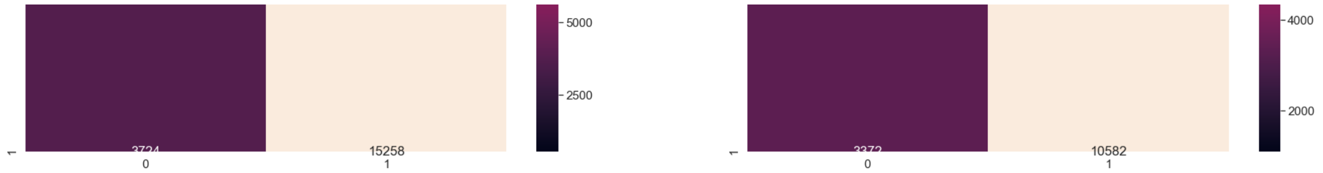
In [353]:

```
confusion_matrix_train_tfidf = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf, best_t)))
confusion_matrix_test_tfidf = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf, best_t)))
```

In [354]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```





In [ ]:

12.3. Applying Random Forests on AVG W2V, SET 3

In [355]:

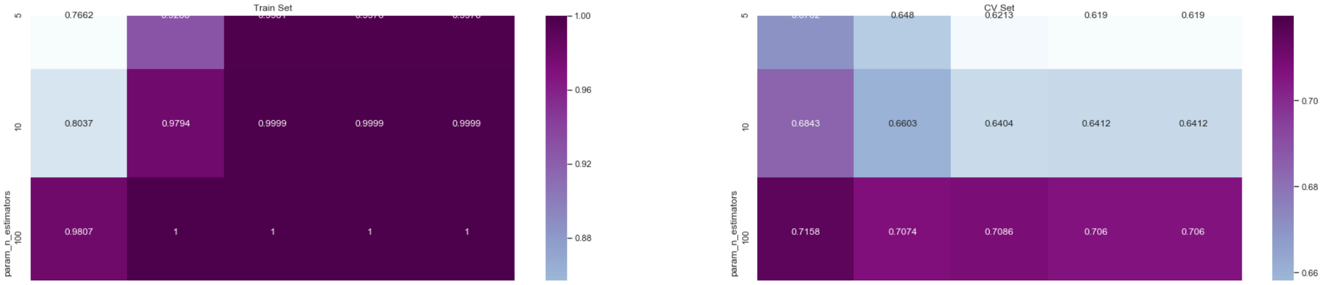
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
import xgboost
import seaborn as sb


XG = xgboost.XGBClassifier(scale_pos_weight=1, n_jobs = -1)
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
XGB3 = GridSearchCV(XG, parameters, cv=3, scoring='roc_auc',return_train_score=True)
XGB3.fit(Xtrain3, y_train)
print('Best estimator', XGB3.best_estimator_)
print('Best score', XGB3.best_score_)
```

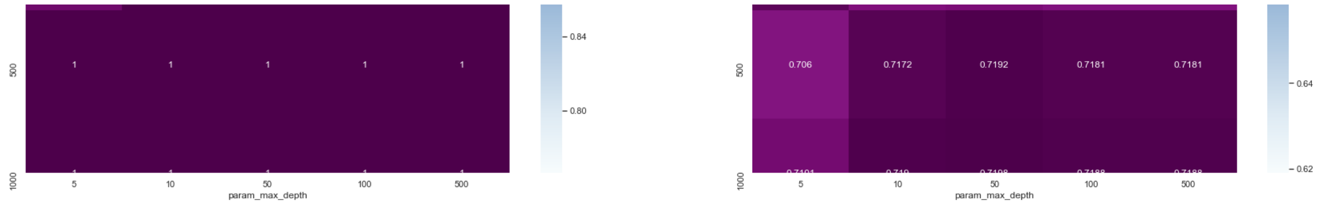
```
Best estimator XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0,
              learning_rate=0.1, max_delta_step=0, max_depth=50,
              min_child_weight=1, missing=None, n_estimators=1000, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
Best score 0.7197987856804764
```

12.3.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [356]:

```
XGB3 = pd.DataFrame(XGB3.cv_results_)
max_scores_avg_w2v = XGB3.groupby(['param_n_estimators',
                                    'param_max_depth']).max()
max_scores_avg_w2v = max_scores_avg_w2v.unstack()[['mean_test_score', 'mean_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_avg_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu", ax=ax[0])
sns.heatmap(max_scores_avg_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```

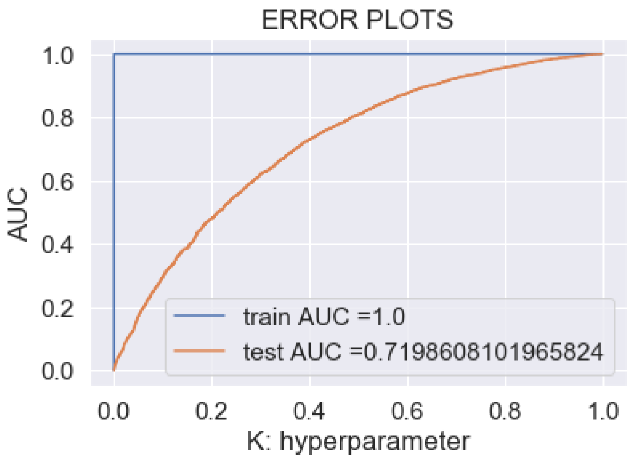




12.3.2. Testing the performance of the model on test data, plotting ROC Curves

In [357]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


XG3 = xgboost.XGBClassifier(scale_pos_weight=1,n_jobs = -1, max_depth = 50  ,n_estimators =  1000)
XG3.fit(Xtrain3, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_avg_w2v = XG3.predict_proba(Xtrain3)[:,1]
y_test_pred_avg_w2v = XG3.predict_proba(Xtest3)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avg_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avg_w2v)

sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



12.3.3. Building Confusion matrix

In [358]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_avg_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

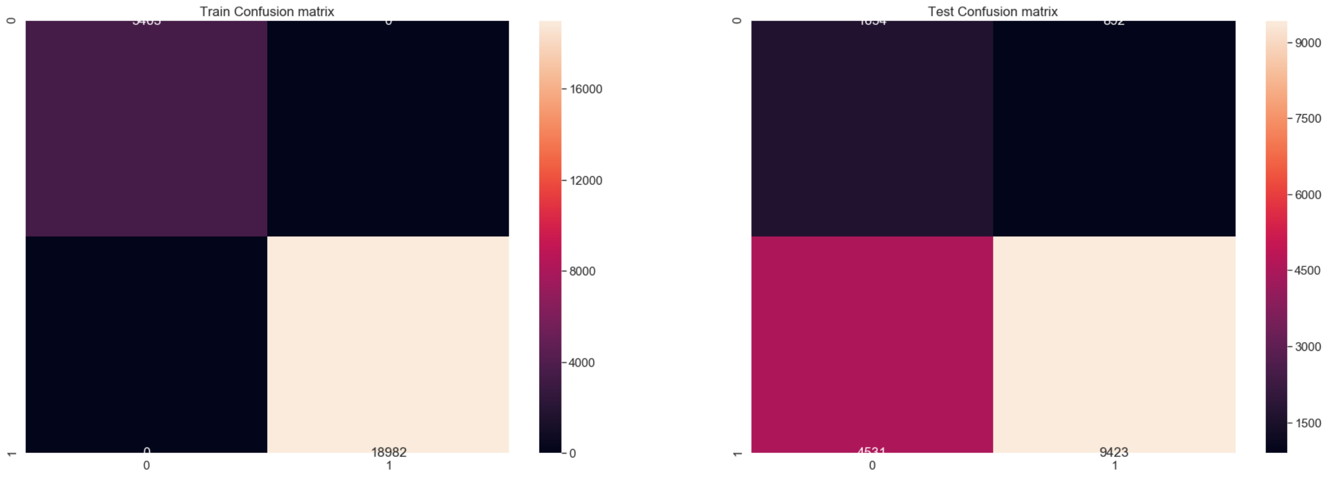
```
====================================================================================================

the maximum value of tpr*(1-fpr) 1.0 for threshold 0.995
Train confusion matrix
[[ 3463     0]
 [    0 18982]]
Test confusion matrix
[[1654  892]
 [4531 9423]]
```

In [359]:

```
confusion_matrix_train_avg_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_avg_w2v, best_t)))
confusion_matrix_test_avg_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_avg_w2v, best_t)))
```

In [360]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_avg_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_avg_w2v,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



In [ ]:

12.4. Applying Random Forests on TFIDF W2V, SET 4

In [144]:

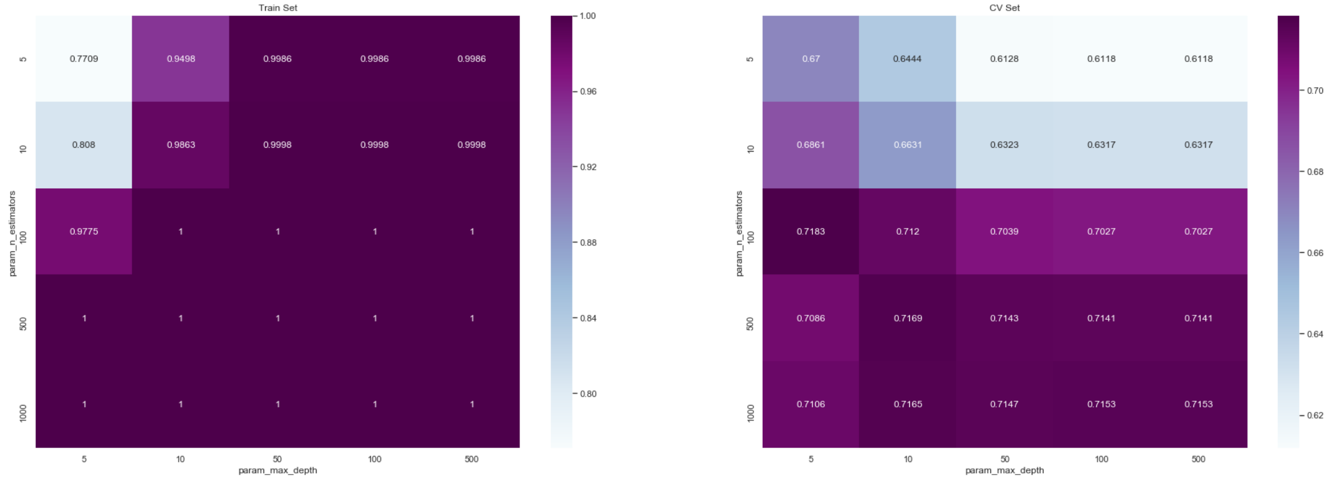
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
import xgboost
import seaborn as sb


XG = xgboost.XGBClassifier(scale_pos_weight=1, n_jobs = -1)
parameters = {'max_depth':(5,10,50,100,500) , 'n_estimators':(5,10,100,500,1000)}
XGB4 = GridSearchCV(XG, parameters, cv=3, scoring='roc_auc',return_train_score=True)
XGB4.fit(Xtrain4, y_train)
print('Best estimator', XGB4.best_estimator_)
print('Best score', XGB4.best_score_)
```

```
Best estimator XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
Best estimator XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bynode=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
       max_delta_step=0, max_depth=5, min_child_weight=1, missing=None,
       n_estimators=100, n_jobs=-1, nthread=None,
       objective='binary:logistic', random_state=0, reg_alpha=0,
       reg_lambda=1, scale_pos_weight=1, seed=None, silent=None,
       subsample=1, verbosity=1)
Best score 0.7183001870051354
```

12.4.1. Finding The Best Hyperparameter "max_depth" and "n_estimators"

In [145]:

```
XGB4 = pd.DataFrame.from_dict(XGB4.cv_results_)
max_scores_tfidf_weighted_w2v = XGB4.groupby(['param_n_estimators',
                                              'param_max_depth']).max()
max_scores_tfidf_weighted_w2v = max_scores_tfidf_weighted_w2v.unstack()[['mean_test_score', 'mea
n_train_score']]
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-
python-ba2885eab2e9
import seaborn as sns; sns.set()

fig, ax = plt.subplots(1,2, figsize=(30,10))
sns.heatmap(max_scores_tfidf_weighted_w2v.mean_train_score, annot = True, fmt='.4g',cmap= "BuPu",
ax=ax[0])
sns.heatmap(max_scores_tfidf_weighted_w2v.mean_test_score, annot = True, fmt='.4g',cmap="BuPu", ax
=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```

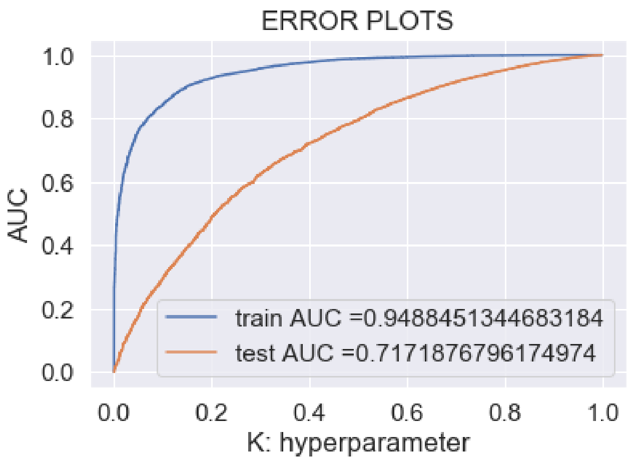


12.4.2. Testing the performance of the model on test data, plotting ROC Curves

In [146]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


XG4 = xgboost.XGBClassifier(scale_pos_weight=1,n_jobs = -1, max_depth = 5  ,n_estimators =  100)
XG4.fit(Xtrain4, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidf_weighted_w2v = XG4.predict_proba(Xtrain4)[:,1]
y_test_pred_tfidf_weighted_w2v = XG4.predict_proba(Xtest4)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_weighted_w2v)
```

```
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_weighted_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_weighted_w2v)
sns.set(font_scale = 1.4)
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("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



12.4.3. Building Confusion matrix

In [150]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

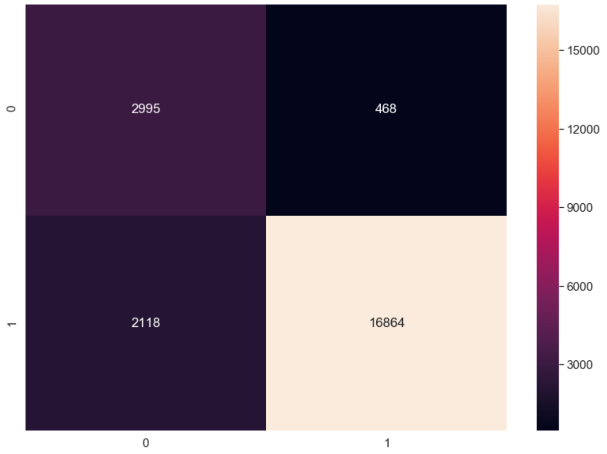
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.768356836254405 for threshold 0.792
Train confusion matrix
[[ 2995   468]
 [ 2118 16864]]
Test confusion matrix
[[ 1212  1334]
 [ 2589 11365]]
```

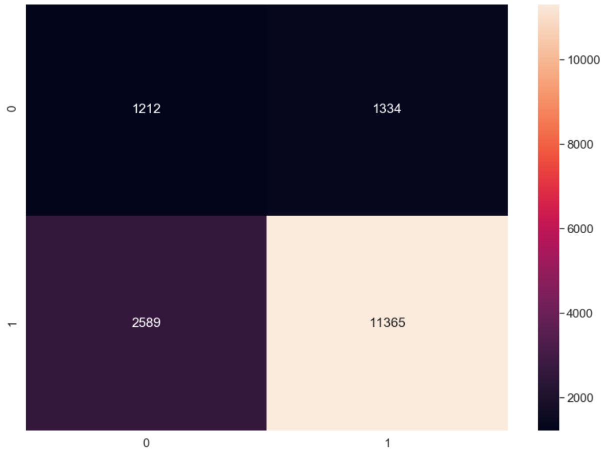
In [151]:

```
confusion_matrix_train_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf_weighted_w2v, best_t)))
confusion_matrix_test_tfidf_weighted_w2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf_weighted_w2v, best_t)))
```

In [152]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf_weighted_w2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf_weighted_w2v,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```





In [ ]:

13. Conclusion

In [10]:

```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "max_depth","n_estimators" ,"Train AUC","Test AUC"]

x.add_row(["BOW", "Random Forest", 500,1000,1, 0.7120])
x.add_row(["TFIDF", "Random Forest", 100,1000,1, 0.7126])
x.add_row(["W2V", "Random Forest", 10,1000,0.9953, 0.6928])
x.add_row(["TFIDF W2V","Random Forest", 5,1000,0.7899, 0.6859])


print ("RANDOM FOREST \n")
print(x)
# http://zetcode.com


# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

y = PrettyTable()

y.field_names = ["Vectorizer", "Model", "max_depth","n_estimators" ,"Train AUC","Test AUC"]

y.add_row(["BOW", "XG Boost", 5,500,0.9756, 0.7333])
y.add_row(["TFIDF", "XG Boost", 5,100,0.9022, 0.7273])
y.add_row(["W2V", "XG Boost", 50,1000,1, 0.7198])
y.add_row(["TFIDF W2V","XG Boost", 5,100,0.9488, 0.7171])

print("\n")
print("XG BOOST \n")
print(y)
```

```
RANDOM FOREST

+------------+---------------+-----------+--------------+-----------+----------+
| Vectorizer |     Model     | max_depth | n_estimators | Train AUC | Test AUC |
+------------+---------------+-----------+--------------+-----------+----------+
|    BOW     | Random Forest |    500    |     1000     |     1     |  0.712   |
|   TFIDF    | Random Forest |    100    |     1000     |     1     |  0.7126  |
|    W2V     | Random Forest |     10    |     1000     |   0.9953  |  0.6928  |
| TFIDF W2V  | Random Forest |     5     |     1000     |   0.7899  |  0.6859  |
+------------+--------------+----------+-------------+----------+----------+


XG BOOST

+------------+----------+-----------+--------------+-----------+----------+
| Vectorizer |  Model   | max_depth | n_estimators | Train AUC | Test AUC |
+------------+----------+-----------+--------------+-----------+----------+
|    BOW     | XG Boost |     5     |     500      |   0.9756  |  0.7333  |
|   TFIDF    | XG Boost |     5     |     100      |   0.9022  |  0.7273  |
|    W2V     | XG Boost |     50    |     1000     |     1     |  0.7198  |
| TFIDF W2V  | XG Boost |     5     |     100      |   0.9488  |  0.7171  |
+------------+----------+-----------+--------------+-----------+----------+
```