DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values:

	• Grades PreK-2 • Grades 3-5 • Grades 6-8 • Grades 9-12
project_subject_categories	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • Applied Learning • Care & Hunger • Health & Sports • History & Civics • Literacy & Language • Math & Science • Music & The Arts • Special Needs • Warmth **Examples:** • Music & The Arts • Literacy & Language, Math & Science
school_state	State where school is located (Two-letter U.S. postal code). **Example:** WY
project_subject_subcategories	One or more (comma-separated) subject subcategories for the project. **Examples:** • Literacy • Literature & Writing, Social Sciences
project_resource_summary	An explanation of the resources needed for the project. **Example:** • My students need hands on literacy materials to

	manage sensory needs!
project_essay_1	First application essay*
project_essay_2	Second application essay*
project_essay_3	Third application essay*
project_essay_4	Fourth application essay*
project_submitted_datetime	Datetime when project application was submitted. **Example:** 2016-04-28 12:43:56.245
teacher_id	A unique identifier for the teacher of the proposed project. **Example:** bdf8baa8fedef6bfeec7ae4ff1c15c56
teacher_prefix	Teacher's title. One of the following enumerated values: • nan • Dr. • Mr. • Mrs. • Ms. • Teacher.
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the same teacher. **Example:** 2

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

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

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

`price`	Price of the resource required. **Example:** `9.95`

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [1]:
```
%config IPCompleter.greedy=True
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
```

```
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:
```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [3]:
```
print("Number of data points in train data", project_data.shape)
```

```
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 's
chool_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 [4]:
```
# 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 [5]:
```
# 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', 'it
self', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 't
hat', "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', 'becau
```

```
se', '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', 'a
ll', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'tha
n', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "shoul
d've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn',
"didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'm
a', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shoul
dn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

1.2 preprocessing of `project_subject_categories`

In [6]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-fr
om-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-strin
g-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 & Scienc
e", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on
space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to
replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(emp
ty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the tra
iling spaces
```

```
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

In [7]:
```
sorted_cat_dict
```

Out[7]:
```
{'Warmth': 1388,
 'Care_Hunger': 1388,
 'History_Civics': 5914,
 'Music_Arts': 10293,
 'AppliedLearning': 12135,
 'SpecialNeeds': 13642,
 'Health_Sports': 14223,
 'Math_Science': 41421,
 'Literacy_Language': 52239}
```

1.3 preprocessing of `project_subject_subcategories`

In [8]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflo
w.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-fr
om-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-strin
g-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 & Scienc
```

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

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

# count of all the words in corpus python: https://stackoverflow.com/a/2289859
5/4084039
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

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

In [9]:
```
sorted_sub_cat_dict
```

Out[9]:
```
{'Economics': 269,
 'CommunityService': 441,
 'FinancialLiteracy': 568,
 'ParentInvolvement': 677,
 'Extracurricular': 810,
 'Civics_Government': 815,
 'ForeignLanguages': 890,
 'NutritionEducation': 1355,
 'Warmth': 1388,
 'Care_Hunger': 1388,
 'SocialSciences': 1920,
 'PerformingArts': 1961,
 'CharacterEducation': 2065,
 'TeamSports': 2192,
 'Other': 2372,
 'College_CareerPrep': 2568,
 'Music': 3145,
 'History_Geography': 3171,
 'Health_LifeScience': 4235,
 'EarlyDevelopment': 4254,
```

```
'ESL': 4367,
'Gym_Fitness': 4509,
'EnvironmentalScience': 5591,
'VisualArts': 6278,
'Health_Wellness': 10234,
'AppliedSciences': 10816,
'SpecialNeeds': 13642,
'Literature_Writing': 22179,
'Mathematics': 28074,
'Literacy': 33700}
```

1.3 Text preprocessing

In [10]:
```
# 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)
```

In [11]:
```
project_data.head(2)
```

Out[11]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
0	34858	p000002	638363148ff34bcbe004fcaeb7c9a544	Mrs.	HI
1	89122	p000003	c8e40d76c14dbc404075f9013d5cd166	Mrs.	NY

In [12]:
```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[50000])
print("="*50)
```

```
Our native Hawaiian students of the valley hail from a tight knit community.
Many are from low socioeconomic backgrounds. Yet they remain a proud people
not inclined to ask for hand outs. They  are genuine souls who face trials
and tribulations on a daily basis. \r\n\r\nOur students come from predominat
ely low socio-economic backgrounds with over 80% of our students receiving f
ree or reduced lunch.  We also have a population of students who are homeles
s. \r\n\r\nIn spite of their struggles they come to school with positive att
itudes and a smile. They are genuine, caring, and always thankful. Many aspi
re to attend college and will work hard to make that happen.We like to combi
ne 21st century learning with traditional learning.  This allows our student
s the time to acclimate to the changes and become active 21st century learne
rs.  \r\n\r\nAs 21st century learners, the students require access to a vari
ety of tools and technology. Use of technology serves to engage the students
with varying learning styles.  We watch videos individually and as a whole c
lass. The lamps allow us to turn off the overhead lights and minimize glare.
The headphones are used when videos are watched individually and work well f
or students with hearing aids.  The workbooks provide daily practice and str
ucture. The carpet runners are for those students who need variety. The carp
et allows them to get out of their seats and sit on the floor or gives a com
fortable space to stretch themselves out as our classroom space is limite
d.\r\n\r\nNew materials and supplies are always exciting for the students. I
t's their own little Christmas in school. It gives them a sense of ownership
and importance. Making school somewhere they want to be.nannan
==================================================
Processing sensory input is a big focus for my students on a daily basis. I
love to see them participate in activities that help to calm themselves.\r\n
\r\nMany of the students have autism and struggle to participate in standard
educational tasks, often becoming over stimulated or over apprehensive of th
eir performance.\r\n\r\nAfter participating in a sensory activity that is so
mething they prefer, I see many of my students able to join in a educational
activity and actually complete a task that is not their favorite.\r\n\r\nHav
ing the ability to use a platform swing, when needed, will allow my students
to calm themselves when overstimulated helping them to be able to then focus
on the learning activity at hand.  It will also allow them to have a calming
atmosphere to use while receiving various therapies.\r\n\r\nSwinging has suc
```

h a calming effect on so many kids, whether a student is over stimulated or having a problem processing a task at hand, being able to move to the platfo rm swing will help to calm them and create a better learning environment for each student in the classroom, no just the student needing a calming activit y.\r\n\r\nnannan

==========

The students I serve are attending a college preparatory school. \r\nOur sch ool is in a high poverty neighborhood in which 85% of them are on free or re duced lunch.\r\nFor many, they will be the first to attend college in their family. I want to help them achieve this dream and to start believing in it as early as kindergarten. This dream starts on the first day of school when I meet them all and say congratulations you are a UNT eagle.This is truly a different type of request for a classroom. I have selected some items to dec orate my classroom for next school year. Each item I have selected is to rep resent my love for the school I graduated from. I am passing on that joy wit h my class. \r\nEven though they are in kindergarten they love knowing that one day they too can go to UNT just like their teacher. \r\nThese items woul d be a constant reminder that college is closer than they may even imagine. I have chosen some flags and football helmets to bring out the school spirit inside of the classroom. My classroom decor and name represent UNT. I want m y students to walk in and feel the pride and understand that no matter who t hey are or where they have come from, college is a possibility. \r\nThat bel ief starts with a space that is full of Mean Green Pride!nannan

==========

Art experiences are important in the elementary school classroom. I've seen, in the last several years, the majority of my student lack exposure to basic art techniques. Cutting, painting, even using glue properly is very awkward for them. \r\n\r\nI would like watercolor paint sets for my students. Waterc olor sets provide beautiful options for expression in a format that allows f or teaching about how to use the tools of an artist. \r\n\r\nI hope through providing tools for my students to create art it will enrich their appreciat ion and awareness of the beauties around us; those created by nature and by the human hand. \r\n\r\nArt expression is important for elementary aged chil dren. Over the past several years my students have come to me lacking basic art skills such as cutting, painting, and gluing. Academics that are testabl e have overshadowed and all but wiped out the nontestable learning. Time chi ldren spend making and communicating through art has all but disappeared. \r \n\r\nI would like my students to have watercolor paint sets. By using water colors children will be able to learn how to gently hold a paint brush and a pply paint with varying degrees of pressure and color. Watercolors provide b eautiful options in a teachable format that I'm sure my students would love illustrating with them and also be able to learn brush and painting techniqu es.nannan

==========

Differentiation is the key to effective instruction in our classroom. Having students that have special academic strategies to others that are gifted and

```
require enriched instruction, differentiation is the only way to ensure that
the academic needs of all students are met. One thing that is common among a
ll my students is the need for compassion.  With the majority of my students
living below the poverty line, in single parent (or grandparent) homes, and
many of them with little to academic support at home, our classroom serves a
s an extended family setting. Children will know right at the start of the y
ear that I will do my job of loving them and teaching them and they are expe
cted to learn and love each other.  Having had the same group of students fo
r the past two years, starting 2016-17 will be a little nervous, but as we g
row and learn together, I have no doubt we will become a close-knit family i
n the 1248 hours  we will spend together.My students' learning will be great
ly enhanced by donations to this project by enabling more hands-on and in-de
pth study of the \"why\" behind the math. The domain-based stations allow sk
ills to be spiraled (reviewed) continuously. I am constantly pulling from ev
ery available resource to come up with authentic and purposeful activities f
or our classroom stations. These materials will be a perfect addition to tho
se activities already in place. UPDATE: The domain-based stations REALLY pay
off. Despite being a Title I school (high poverty), my students scored in th
e top 5% of the state as far as making the highest score on our state assess
ment this past year. Quite the accomplishment. It is also the perfect exampl
e to demonstrate to my kiddos what I constantly tell them, \"There are situa
tions, not excuses.\"nannan
==================================================
```

In [13]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████
██| 109248/109248 [01:32<00:00, 1182.46it/s]
```

In [14]:
```
# after preprocesing
project_data['essay']=preprocessed_essays
print(project_data['essay'][0])
```

```
native hawaiian students valley hail tight knit community many low socioecon
omic backgrounds yet remain proud people not inclined ask hand outs genuine
souls face trials tribulations daily basis students come predominately low s
ocio economic backgrounds 80 students receiving free reduced lunch also popu
lation students homeless spite struggles come school positive attitudes smil
e genuine caring always thankful many aspire attend college work hard make h
appen like combine 21st century learning traditional learning allows student
s time acclimate changes become active 21st century learners 21st century le
arners students require access variety tools technology use technology serve
s engage students varying learning styles watch videos individually whole cl
ass lamps allow us turn overhead lights minimize glare headphones used video
s watched individually work well students hearing aids workbooks provide dai
ly practice structure carpet runners students need variety carpet allows get
seats sit floor gives comfortable space stretch classroom space limited new
materials supplies always exciting students little christmas school gives se
nse ownership importance making school somewhere want nannan
```

1.4 Preprocessing of `project_title`

In [15]:
```
# similarly you can preprocess the titles also
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles.append(sent.lower().strip())
```

```
100%|
| 109248/109248 [00:03<00:00, 30783.65it/s]
```

In [16]:
```
# after preprocesing
project_data['project_title']=preprocessed_titles
print(project_data['project_title'][0])
```

```
21st century learners across ocean
```

In [17]:
```
#Preprocessing the project_grade_category
project_grade_category_cleaned=[]
for grade in tqdm(project_data['project_grade_category'].values):
    grade = grade.replace(' ', '_')
    grade = grade.replace('-', '_')
    project_grade_category_cleaned.append(grade)
project_data['Project_grade_category']=project_grade_category_cleaned
```

```
100%|██████████████████████████████████████████████████████████████████████████████|
109248/109248 [00:00<00:00, 414429.09it/s]
```

In [18]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'
}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [19]:
```
project_data.head(2)
```

Out[19]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
0	34858	p000002	638363148ff34bcbe004fcaeb7c9a544	Mrs.	HI
1	89122	p000003	c8e40d76c14dbc404075f9013d5cd166	Mrs.	NY

2 rows × 21 columns

Assignment 3: Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**

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

- Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
- Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning to find best K**

- Find the best hyper parameter which results in the maximum AUC value
- Find the best hyper paramter using k-fold cross validation (or) simple cross validation data
- Use gridsearch-cv or randomsearch-cv or write your own for loops to do this task

3. **Representation of results**

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

 Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.

 Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

 **[Task-2]**

- Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features
-
```
from sklearn.datasets import load_digits
from sklearn.feature_selection import Sel
ectKBest, chi2
X, y = load_digits(return_X_y=True)
X.shape
X_new = SelectKBest(chi2, k=20).fit_trans
form(X, y)
X_new.shape
========
output:
(1797, 64)
```

```
(1797, 20)
```

- Repeat the steps 2 and 3 on the data matrix after feature selection

5. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

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

2. K Nearest Neighbor

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

In [20]:
```
from sklearn.model_selection import train_test_split
# split the data set into train and test respectively 80% and 20%
y=project_data['project_is_approved']
project_data.drop(['project_is_approved'],axis=1, inplace=True)
x=project_data
X_temp,X_test,Y_temp,Y_test=train_test_split(x,y,test_size=0.2,random_state=1)
# split the data set into train and cv respectively 60% and 20%
X_train,X_cv,Y_train,Y_cv=train_test_split(X_temp,Y_temp,test_size=0.2,random_
state=1)
print("Shape of Train data set X={} Y={}".format(X_train.shape,Y_train.shape))
print("Shape of Test data set X={} Y={}".format(X_test.shape,Y_test.shape))
print("Shape of CV data set X={} Y={}".format(X_cv.shape,Y_cv.shape))
```

```
Shape of Train data set X=(69918, 20) Y=(69918,)
Shape of Test data set X=(21850, 20) Y=(21850,)
Shape of CV data set X=(17480, 20) Y=(17480,)
```

In [21]:
```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/
4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(X_train
.columns)]
#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702
492/4084039
X_train['Date'] = pd.to_datetime(X_train['project_submitted_datetime'])
X_train.drop('project_submitted_datetime', axis=1, inplace=True)
X_train.sort_values(by=['Date'], inplace=True)
# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4
084039
X_train = X_train[cols]
X_train.head(2)
```

Out[21]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_
18308	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT
79692	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA

1.5 Preparing data for models

In [22]:
```
X_train.columns
```

Out[22]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
```

```
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'Project_grade_category', 'price',
       'quantity'],
      dtype='object')
```

we are going to consider

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

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

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

2.2 Make Data Model Ready: encoding numerical, categorical features

1.5.1 Vectorizing Categorical data

In [23]:
```
# we use count vectorizer to convert the values into one hot encoded features
# Project categories
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_categories = CountVectorizer(vocabulary=list(sorted_cat_dict.keys
()),lowercase=False, binary=True)

tr_categories_one_hot=vectorizer_categories.fit_transform(X_train['clean_categ
ories'].values)
print(vectorizer_categories.get_feature_names())

cv_categories_one_hot =vectorizer_categories.transform(X_cv['clean_categories'
```

```
].values)
te_categories_one_hot =vectorizer_categories.transform(X_test['clean_categorie
s'].values)

print(tr_categories_one_hot.toarray()[0:1])
print("\nShape of matrix after one hot encodig for 'Project categories'\nTrain
data-{},\nCV data\t-{}\nTest data-{}".format(tr_categories_one_hot.shape,cv_ca
tegories_one_hot.shape,te_categories_one_hot.shape))
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning',
'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
[[0 0 0 0 0 1 0 0 0]]

Shape of matrix after one hot encodig for 'Project categories'
Train data-(69918, 9),
CV data -(17480, 9)
Test data-(21850, 9)
```

In [24]:

```
# we use count vectorizer to convert the values into one hot encoded features
# Project subcategories
vectorizer_subcategories = CountVectorizer(vocabulary=list(sorted_sub_cat_dict
.keys()), lowercase=False, binary=True)

tr_sub_categories_one_hot=vectorizer_subcategories.fit_transform(X_train['clea
n_subcategories'].values)
print(vectorizer_subcategories.get_feature_names())

cv_sub_categories_one_hot = vectorizer_subcategories.transform(X_cv['clean_sub
categories'].values)
te_sub_categories_one_hot = vectorizer_subcategories.transform(X_test['clean_s
ubcategories'].values)

print(tr_sub_categories_one_hot.toarray()[0:2])
print("\nShape of matrix after one hot encodig for 'Project sub categories'\nT
rain data-{},\nCV data\t-{}\nTest data-{}".format(tr_sub_categories_one_hot.sh
ape,cv_sub_categories_one_hot.shape,te_sub_categories_one_hot.shape))
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement',
'Extracurricular', 'Civics_Government', 'ForeignLanguages', 'NutritionEducat
ion', 'Warmth', 'Care_Hunger', 'SocialSciences', 'PerformingArts', 'Characte
rEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_
Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness',
'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1]]
```

```
Shape of matrix after one hot encodig for 'Project sub categories'
Train data-(69918, 30),
CV data -(17480, 30)
Test data-(21850, 30)
```

In [25]:
```
# you can do the similar thing with state, teacher_prefix and project_grade_ca
tegory also
# we use count vectorizer to convert the values into one hot encoded features
#teacher_prefix
vectorizer_teacher_prefix = CountVectorizer(lowercase=False, binary=True)
tr_teacher_prefix_one_hot=vectorizer_teacher_prefix.fit_transform(X_train['tea
cher_prefix'].values.astype('str'))
print(vectorizer_teacher_prefix.get_feature_names())

cv_teacher_prefix_one_hot = vectorizer_teacher_prefix.transform(X_cv['teacher_
prefix'].values.astype('str'))
te_teacher_prefix_one_hot = vectorizer_teacher_prefix.transform(X_test['teache
r_prefix'].values.astype('str'))

print(tr_teacher_prefix_one_hot.toarray()[0:1])
print("\nShape of matrix after one hot encodig for 'teacher_prefix'\nTrain dat
a-{},\nCV data\t-{}\nTest data-{}".format(tr_teacher_prefix_one_hot.shape,cv_t
eacher_prefix_one_hot.shape,te_teacher_prefix_one_hot.shape))
```

```
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher', 'nan']
[[0 0 0 1 0 0]]

Shape of matrix after one hot encodig for 'teacher_prefix'
Train data-(69918, 6),
CV data -(17480, 6)
Test data-(21850, 6)
```

In [26]:
```
# we use count vectorizer to convert the values into one hot encoded features
#school_state
vectorizer_school_state = CountVectorizer(lowercase=False, binary=True)
tr_school_state_one_hot=vectorizer_school_state.fit_transform(X_train['school_
state'].values.astype('str'))
print(vectorizer_school_state.get_feature_names())

cv_school_state_one_hot = vectorizer_school_state.transform(X_cv['school_stat
e'].values.astype('str'))
te_school_state_one_hot = vectorizer_school_state.transform(X_test['school_sta
te'].values.astype('str'))
```

```
print(tr_school_state_one_hot.toarray()[0:1])
print("\nShape of matrix after one hot encodig for 'teacher_prefix'\nTrain dat
a-{},\nCV data\t-{}\nTest data-{}".format(tr_school_state_one_hot.shape,cv_sch
ool_state_one_hot.shape,te_school_state_one_hot.shape))
```

```
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI', 'I
A', 'ID', 'IL', 'IN', 'KS', 'KY', 'LA', 'MA', 'MD', 'ME', 'MI', 'MN', 'MO',
'MS', 'MT', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM', 'NV', 'NY', 'OH', 'OK', 'O
R', 'PA', 'RI', 'SC', 'SD', 'TN', 'TX', 'UT', 'VA', 'VT', 'WA', 'WI', 'WV',
'WY']
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 1 0 0 0 0 0 0]]

Shape of matrix after one hot encodig for 'teacher_prefix'
Train data-(69918, 51),
CV data -(17480, 51)
Test data-(21850, 51)
```

In [27]:
```
# we use count vectorizer to convert the values into one hot encoded features
#project_grade_category
vectorizer_grade_category = CountVectorizer(lowercase=False, binary=True)
tr_grade_category_one_hot=vectorizer_grade_category.fit_transform(X_train['Pro
ject_grade_category'])
print(vectorizer_grade_category.get_feature_names())

cv_grade_category_one_hot = vectorizer_grade_category.transform(X_cv['Project_
grade_category'])
te_grade_category_one_hot = vectorizer_grade_category.transform(X_test['Projec
t_grade_category'])

print(tr_grade_category_one_hot.toarray()[0:1])
print(cv_grade_category_one_hot.toarray()[0:1])
print(te_grade_category_one_hot.toarray()[0:1])
print("\nShape of matrix after one hot encodig for 'project_grade_category'\nT
rain data-{},\nCV data\t-{}\nTest data-{}".format(tr_grade_category_one_hot.sh
ape,cv_grade_category_one_hot.shape,te_grade_category_one_hot.shape))
```

```
['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2']
[[1 0 0 0]]
[[0 0 0 1]]
[[0 1 0 0]]

Shape of matrix after one hot encodig for 'project_grade_category'
Train data-(69918, 4),
CV data -(17480, 4)
Test data-(21850, 4)
```

1.5.2 standardizing Numerical features

In [28]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler

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

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

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

```
Mean : 297.05198518264257, Standard deviation : 367.67309409512563
```

In [29]:
```
print("\nShape of matrix after column standardization for 'price'\nTrain data-{},\nCV data\t-{}\nTest data-{}".format(tr_price_standardized.shape,cv_price_standardized.shape,te_price_standardized.shape))
```

```
Shape of matrix after column standardization for 'price'
Train data-(69918, 1),
CV data -(17480, 1)
Test data-(21850, 1)
```

In [30]:
```
#quantity
quantity_scalar = StandardScaler()
tr_quantity_standardized=quantity_scalar.fit_transform(X_train['quantity'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.var_[0])}")
```

```
# Now standardize the data with above maen and variance.
cv_quantity_standardized = quantity_scalar.transform(X_cv['quantity'].values.r
eshape(-1, 1))
te_quantity_standardized = quantity_scalar.transform(X_test['quantity'].values
.reshape(-1, 1))
print("\nShape of matrix after column standardization for 'quantity'\nTrain da
ta-{},\nCV data\t-{}\nTest data-{}".format(tr_quantity_standardized.shape,cv_q
uantity_standardized.shape,te_quantity_standardized.shape))
```

```
C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.
```

```
Mean : 17.053619954804198, Standard deviation : 26.479145940777403
```

```
C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.
```

```
Shape of matrix after column standardization for 'quantity'
Train data-(69918, 1),
CV data -(17480, 1)
Test data-(21850, 1)
```

In [31]:

```
#teacher_number_of_previously_posted_projects
teacher_number_of_previously_posted_projects_scalar = StandardScaler()
tr_teacher_number_of_previously_posted_projects_standardized=teacher_number_of
_previously_posted_projects_scalar.fit_transform(X_train['teacher_number_of_pr
eviously_posted_projects'].values.reshape(-1,1)) # finding the mean and standa
rd deviation of this data
print(f"Mean : {teacher_number_of_previously_posted_projects_scalar.mean_[0]},
Standard deviation : {np.sqrt(teacher_number_of_previously_posted_projects_sca
lar.var_[0])}")
```

```
# Now standardize the data with above maen and variance.
cv_teacher_number_of_previously_posted_projects_standardized = teacher_number_
of_previously_posted_projects_scalar.transform(X_cv['teacher_number_of_previou
sly_posted_projects'].values.reshape(-1, 1))
te_teacher_number_of_previously_posted_projects_standardized = teacher_number_
of_previously_posted_projects_scalar.transform(X_test['teacher_number_of_previ
ously_posted_projects'].values.reshape(-1, 1))
print("\nShape of matrix after column standardization for 'teacher_number_of_p
reviously_posted_projects'\nTrain data-{},\nCV data\t-{}\nTest data-{}".format
(tr_teacher_number_of_previously_posted_projects_standardized.shape,cv_teacher
_number_of_previously_posted_projects_standardized.shape,te_teacher_number_of_
previously_posted_projects_standardized.shape))
```

```
C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.
```

```
Mean : 11.187576875768757, Standard deviation : 27.867468947288852
```

```
C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.

C:\Users\nnagari\AppData\Local\Continuum\anaconda\lib\site-packages\sklearn
\utils\validation.py:475: DataConversionWarning:

Data with input dtype int64 was converted to float64 by StandardScaler.
```

```
Shape of matrix after column standardization for 'teacher_number_of_previous
ly_posted_projects'
Train data-(69918, 1),
CV data -(17480, 1)
Test data-(21850, 1)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

1.5.2 Vectorizing Text data

1.5.2.1

Bag of Words on `preprocessed_essay`

In [32]:
```
#Bag of words of Project essays
# We are considering only the words which appeared in at least 10 documents(rows or projects) and max feature is 8000.
#Fitting train data because we need all and transforming  train ,cv and test vector shape should be same.
vectorizer_essays = CountVectorizer(min_df=10,max_features=8000)#max_features=8000
tr_text_bow=vectorizer_essays.fit_transform(X_train['essay']) # fitting train data

#transforming train,cv and test data

cv_text_bow = vectorizer_essays.transform(X_cv['essay'])
te_text_bow = vectorizer_essays.transform(X_test['essay'])
print("Shape of matrix after one hot encodig \nTrain data-{},\nCV data\t-{}\nTest data-{}".format(tr_text_bow.shape,cv_text_bow.shape,te_text_bow.shape))
```

```
Shape of matrix after one hot encodig
Train data-(69918, 8000),
CV data -(17480, 8000)
Test data-(21850, 8000)
```

In [33]:
```
print('Some feature names of bag of words of the essays')
print('='*50)
print(vectorizer_essays.get_feature_names()[1000:1020])
print(tr_text_bow.toarray()[0:1])
```

```
Some feature names of bag of words of the essays
==================================================
['brush', 'brushes', 'bubble', 'bubbles', 'bubbly', 'bucket', 'buckets', 'bucks', 'buddies', 'budding', 'buddy', 'budget', 'budgeting', 'budgets', 'buds', 'bug', 'bugs', 'build', 'builder', 'builders']
[[0 0 0 ... 0 0 0]]
```

Bag of Words on `project_title`

In [34]:
```
#Bag of words project_title
# We are considering only the words which appeared in at least 5 documents(row
s or projects) and max number of feature is 1700.
#Fitting train data and transforming  train ,cv and test vector shape should b
e same.
vectorizer_title = CountVectorizer(min_df=5,max_features=1700)
tr_text_bow_title=vectorizer_title.fit_transform(X_train['project_title'])
cv_text_bow_title = vectorizer_title.transform(X_cv['project_title'])
te_text_bow_title = vectorizer_title.transform(X_test['project_title'])
print("Shape of matrix after one hot encodig \nTrain data-{},\nCV data\t-{}\nT
est data-{}".format(tr_text_bow_title.shape,cv_text_bow_title.shape,te_text_bo
w_title.shape))
```

```
Shape of matrix after one hot encodig
Train data-(69918, 1700),
CV data -(17480, 1700)
Test data-(21850, 1700)
```

In [35]:
```
print('Some feature names of bag of words of the project title')
print('='*50)
print(vectorizer_title.get_feature_names()[1000:1020])
print(tr_text_bow_title.toarray()[0:2])
```

```
Some feature names of bag of words of the project title
==================================================
['motion', 'motivate', 'motivated', 'motivating', 'motivation', 'motor', 'mo
use', 'move', 'movement', 'movers', 'moves', 'movie', 'movin', 'moving', 'm
r', 'mrs', 'ms', 'much', 'multi', 'multicultural']
[[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]
```

1.5.2.2 TFIDF vectorizer

TFIDF Vectorizer on `preprocessed_essay`

In [36]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer_essays = TfidfVectorizer(min_df=10)
#Fitting train data and transforming  train ,cv and test vector shape should b
e same.
tr_text_tfidf=tfidf_vectorizer_essays.fit_transform(X_train['project_title'])
cv_text_tfidf = tfidf_vectorizer_essays.transform(X_cv['project_title'])
te_text_tfidf = tfidf_vectorizer_essays.transform(X_test['project_title'])
```

```
print("Shape of matrix TFIDF Vectorizer on essays \nTrain data-{},\nCV data\t-
{}\nTest data-{}".format(tr_text_tfidf.shape,cv_text_tfidf.shape,te_text_tfidf
.shape))
```

```
Shape of matrix TFIDF Vectorizer on essays
Train data-(69918, 2562),
CV data -(17480, 2562)
Test data-(21850, 2562)
```

In [37]:
```
print('Sample of TFIDF Vectorizer on essays')
print('='*50)
print(tr_text_tfidf.toarray()[0:1])
print(tfidf_vectorizer_essays.get_feature_names()[300:310])
```

```
Sample of TFIDF Vectorizer on essays
==================================================
[[0. 0. 0. ... 0. 0. 0.]]
['build', 'builders', 'building', 'builds', 'bump', 'bundle', 'burning', 'bu
siness', 'busy', 'but']
```

1.4.2.4 TFIDF Vectorizer on `project_title`

In [38]:
```
# Similarly you can vectorize for title also
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer_title = TfidfVectorizer(min_df=10)
#Fitting train data and transforming  train ,cv and test vector shape should b
e same.
tr_title_tfidf=tfidf_vectorizer_title.fit_transform(X_train['project_title'])

cv_title_tfidf = tfidf_vectorizer_title.transform(X_cv['project_title'])
te_title_tfidf = tfidf_vectorizer_title.transform(X_test['project_title'])

print("Shape of matrix TFIDF Vectorizer on essays \nTrain data-{},\nCV data\t-
{}\nTest data-{}".format(tr_title_tfidf.shape,cv_title_tfidf.shape,te_title_tf
idf.shape))
```

```
Shape of matrix TFIDF Vectorizer on essays
Train data-(69918, 2562),
CV data -(17480, 2562)
Test data-(21850, 2562)
```

In [39]:
```
print('Sample of TFIDF Vectorizer on `project_title`')
print('='*50)
```

```
print(tr_title_tfidf.toarray()[0:1,1980:2000])
print(tfidf_vectorizer_title.get_feature_names()[100:110])
```

```
Sample of TFIDF Vectorizer on `project_title`
==================================================
[[0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.57100504 0.         0.
  0.         0.        ]]
['another', 'answer', 'answers', 'ants', 'any', 'anymore', 'anyone', 'anythi
ng', 'anywhere', 'ap']
```

In [40]:

```
'''# Reading glove vectors in python: https://stackoverflow.com/a/38230349/408
4039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

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

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

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

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


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

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

Out[40]:
```
'\nwords = []\nfor i in preprocessed_essays:\n    words.extend(i.split(\'
\'))\n\nfor i in preprocessed_titles:\n    words.extend(i.split(\' \'))\npri
nt("all the words in the coupus", len(words))\nwords = set(words)\nprint("th
e unique words in the coupus", len(words))\n\ninter_words = set(model.keys
()).intersection(words)\nprint("The number of words that are present in both
glove vectors and our coupus",       len(inter_words),"(",np.round(len(inter
_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(mod
el.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus
[i] = model[i]\nprint("word 2 vec length", len(words_courpus))\n\n\n# strong
ing variables into pickle files python: http://www.jessicayung.com/how-to-us
e-pickle-to-save-and-load-variables-in-python/\n\nimport pickle\nwith open
(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)'
```

In [41]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how
-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

Using Pretrained Models: AVG W2V on `preprocessed_essay`

In [42]:
```
# average Word2Vec
# compute average word2vec for each review.
```

```
def AVG_w2v(preprocessed_data):
    avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in
 this list
    for sentence in tqdm(preprocessed_data): # 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/revie
w
        for word in sentence.split(): # for each word in a review/sentence
            if word in glove_words:
                vector += model[word]
                cnt_words += 1
        if cnt_words != 0:
            vector /= cnt_words
        avg_w2v_vectors.append(vector)
    return(avg_w2v_vectors)

#print(len(avg_w2v_vectors))
#print(len(avg_w2v_vectors[1]))
```

In [43]:
```
#using above defined function "AVG_w2v" to compute average word2vec for each r
eview in train,cv and test data.
tr_avg_w2v_vectors=AVG_w2v(X_train['essay'])
cv_avg_w2v_vectors=AVG_w2v(X_cv['essay'])
te_avg_w2v_vectors=AVG_w2v(X_test['essay'])
```

```
100%|
| 69918/69918 [00:27<00:00, 2522.14it/s]
100%|
| 17480/17480 [00:06<00:00, 2829.10it/s]
100%|
| 21850/21850 [00:09<00:00, 2271.64it/s]
```

In [44]:
```
print(len(tr_avg_w2v_vectors),len(cv_avg_w2v_vectors),len(te_avg_w2v_vectors))
```

```
69918 17480 21850
```

Using Pretrained Models: AVG W2V on `project_title`

In [45]:
```
#using above defined function "AVG_w2v" to compute average word2vec for each r
eview in train,cv and test data.
tr_avg_w2v_vectors_project_title=AVG_w2v(X_train['project_title'])
cv_avg_w2v_vectors_project_title=AVG_w2v(X_cv['project_title'])
te_avg_w2v_vectors_project_title=AVG_w2v(X_test['project_title'])
```

```
100%|██████████| 69918/69918 [00:01<00:00, 42701.07it/s]
100%|██████████| 17480/17480 [00:00<00:00, 48261.13it/s]
100%|██████████| 21850/21850 [00:00<00:00, 52552.06it/s]
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [46]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['essay'])
# 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 [47]:
```
# average Word2Vec
# compute average word2vec for each review.
def tfidf_w2v(preprocessed_data,words):
    tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored i
n this list
    for sentence in tqdm(preprocessed_data): # 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/r
eview
        for word in sentence.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in 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.s
plit())) # getting the tfidf value for each word
                vector += (vec * tf_idf) # calculating tfidf weighted w2v
                tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        tfidf_w2v_vectors.append(vector)
    return(tfidf_w2v_vectors)
```

In [48]:
```
#using above defined function "tfidf w2v" to compute average word2vec for each
review in train,cv and test data.
words=tfidf_words
```

```
tr_tfidf_w2v_vectors=tfidf_w2v(X_train['essay'],words)
cv_tfidf_w2v_vectors=tfidf_w2v(X_cv['essay'],words)
te_tfidf_w2v_vectors=tfidf_w2v(X_test['essay'],words)
```

```
100%|████| 69918/69918 [03:21<00:00, 346.77it/s]
100%|████| 17480/17480 [00:56<00:00, 310.96it/s]
100%|████| 21850/21850 [00:56<00:00, 384.43it/s]
```

Using Pretrained Models: TFIDF weighted W2V on `project_title`

In [49]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model_project_title = TfidfVectorizer()
tfidf_model_project_title.fit(X_train['project_title'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model_project_title.get_feature_names(), list(tfid
f_model_project_title.idf_)))
tfidf_project_title_words = set(tfidf_model_project_title.get_feature_names())
```

In [50]:
```
#using above defined function "tfidf w2v" to compute average word2vec for each
review in train,cv and test data.
words=tfidf_project_title_words
tr_tfidf_w2v_project_title_vectors=tfidf_w2v(X_train['project_title'],words)
cv_tfidf_w2v_project_title_vectors=tfidf_w2v(X_cv['project_title'],words)
te_tfidf_w2v_project_title_vectors=tfidf_w2v(X_test['project_title'],words)
```

```
100%|██| 69918/69918 [00:03<00:00, 19982.03it/s]
100%|██| 17480/17480 [00:00<00:00, 18023.35it/s]
100%|██| 21850/21850 [00:01<00:00, 20402.42it/s]
```

In [51]:
```
print(len(tr_tfidf_w2v_project_title_vectors),len(cv_tfidf_w2v_project_title_v
ectors),len(te_tfidf_w2v_project_title_vectors))
```

```
69918 17480 21850
```

1.5.4 Merging all the above features

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

In [52]:
```
print(tr_school_state_one_hot.shape)
print(tr_categories_one_hot.shape)
#print(sub_categories.shape)
print(tr_sub_categories_one_hot.shape)
print(tr_teacher_prefix_one_hot.shape)
print(tr_grade_category_one_hot.shape)
print(tr_price_standardized.shape)
print(tr_quantity_standardized.shape)
print(tr_teacher_number_of_previously_posted_projects_standardized.shape)
print(tr_text_bow_title.shape)
print(tr_text_bow.shape)
print()
```

```
(69918, 51)
(69918, 9)
(69918, 30)
(69918, 6)
(69918, 4)
(69918, 1)
(69918, 1)
(69918, 1)
(69918, 1700)
(69918, 8000)
```

In [53]:
```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#categorical, numerical features + project_title(BOW)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a den
se matirx :)
tr_X_BOW= hstack((tr_school_state_one_hot,tr_categories_one_hot,tr_sub_categor
ies_one_hot,tr_teacher_prefix_one_hot,tr_grade_category_one_hot,tr_price_stand
ardized,tr_teacher_number_of_previously_posted_projects_standardized,tr_text_b
ow_title,tr_text_bow)).tocsr()
cv_X_BOW= hstack((cv_school_state_one_hot,cv_categories_one_hot,cv_sub_categor
ies_one_hot,cv_teacher_prefix_one_hot,cv_grade_category_one_hot,cv_price_stand
ardized,cv_teacher_number_of_previously_posted_projects_standardized,cv_text_b
ow_title,cv_text_bow)).tocsr()
te_X_BOW= hstack((te_school_state_one_hot,te_categories_one_hot,te_sub_categor
ies_one_hot,te_teacher_prefix_one_hot,te_grade_category_one_hot,te_price_stand
ardized,te_teacher_number_of_previously_posted_projects_standardized,te_text_b
ow_title,te_text_bow)).tocsr()
```

```
tr_X_BOW=tr_X_BOW.toarray()
cv_X_BOW=cv_X_BOW.toarray()
te_X_BOW=te_X_BOW.toarray()
print(tr_X_BOW.shape)
print(cv_X_BOW.shape)
print(te_X_BOW.shape)
```

```
(69918, 9802)
(17480, 9802)
(21850, 9802)
Wall time: 4.94 s
```

In [54]:

```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#categorical, numerical features + project_title(TFIDF)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a den
se matirx :)
tr_X_TFIDF= hstack((tr_school_state_one_hot,tr_categories_one_hot, tr_sub_cate
gories_one_hot,tr_teacher_prefix_one_hot,tr_grade_category_one_hot,tr_price_st
andardized,tr_teacher_number_of_previously_posted_projects_standardized,tr_tit
le_tfidf,tr_text_tfidf))
cv_X_TFIDF= hstack((cv_school_state_one_hot,cv_categories_one_hot, cv_sub_cate
gories_one_hot,cv_teacher_prefix_one_hot,cv_grade_category_one_hot,cv_price_st
andardized,cv_teacher_number_of_previously_posted_projects_standardized,cv_tit
le_tfidf,cv_text_tfidf))
te_X_TFIDF= hstack((te_school_state_one_hot,te_categories_one_hot, te_sub_cate
gories_one_hot,te_teacher_prefix_one_hot,te_grade_category_one_hot,te_price_st
andardized,te_teacher_number_of_previously_posted_projects_standardized,te_tit
le_tfidf,te_text_tfidf))

tr_X_TFIDF=tr_X_TFIDF.toarray()
cv_X_TFIDF=cv_X_TFIDF.toarray()
te_X_TFIDF=te_X_TFIDF.toarray()
print(tr_X_TFIDF.shape)
print(cv_X_TFIDF.shape)
print(te_X_TFIDF.shape)
```

```
(69918, 5226)
(17480, 5226)
(21850, 5226)
Wall time: 10.8 s
```

In [143]:

```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# categorical, numerical features + project_title(AVG W2V)
```

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a den
se matirx :)
tr_X_AVG_W2V= hstack((tr_school_state_one_hot,tr_categories_one_hot, tr_sub_ca
tegories_one_hot,tr_teacher_prefix_one_hot,tr_grade_category_one_hot,tr_price_
standardized,tr_teacher_number_of_previously_posted_projects_standardized,tr_a
vg_w2v_vectors_project_title,tr_avg_w2v_vectors))
cv_X_AVG_W2V= hstack((cv_school_state_one_hot,cv_categories_one_hot, cv_sub_ca
tegories_one_hot,cv_teacher_prefix_one_hot,cv_grade_category_one_hot,cv_price_
standardized,cv_teacher_number_of_previously_posted_projects_standardized,cv_a
vg_w2v_vectors_project_title,cv_avg_w2v_vectors))
te_X_AVG_W2V= hstack((te_school_state_one_hot,te_categories_one_hot, te_sub_ca
tegories_one_hot,te_teacher_prefix_one_hot,te_grade_category_one_hot,te_price_
standardized,te_teacher_number_of_previously_posted_projects_standardized,te_a
vg_w2v_vectors_project_title,te_avg_w2v_vectors))
tr_X_AVG_W2V=tr_X_AVG_W2V.toarray()
cv_X_AVG_W2V=cv_X_AVG_W2V.toarray()
te_X_AVG_W2V=te_X_AVG_W2V.toarray()
print(tr_X_AVG_W2V.shape,cv_X_AVG_W2V.shape,te_X_AVG_W2V.shape)
```

```
(69918, 702) (17480, 702) (21850, 702)
Wall time: 7.9 s
```

In [144]:

```
%%time
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# categorical, numerical features + project_title(TFIDF W2V)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a den
se matirx :)
tr_X_tfidf_w2v= hstack((tr_school_state_one_hot,tr_categories_one_hot, tr_sub_
categories_one_hot,tr_teacher_prefix_one_hot,tr_grade_category_one_hot,tr_pric
e_standardized,tr_teacher_number_of_previously_posted_projects_standardized,tr
_tfidf_w2v_project_title_vectors,tr_tfidf_w2v_vectors))
cv_X_tfidf_w2v= hstack((cv_school_state_one_hot,cv_categories_one_hot, cv_sub_
categories_one_hot,cv_teacher_prefix_one_hot,cv_grade_category_one_hot,cv_pric
e_standardized,cv_teacher_number_of_previously_posted_projects_standardized,cv
_tfidf_w2v_project_title_vectors,cv_tfidf_w2v_vectors))
te_X_tfidf_w2v= hstack((te_school_state_one_hot,te_categories_one_hot, te_sub_
categories_one_hot,te_teacher_prefix_one_hot,te_grade_category_one_hot,te_pric
e_standardized,te_teacher_number_of_previously_posted_projects_standardized,te
_tfidf_w2v_project_title_vectors,te_tfidf_w2v_vectors))
tr_X_tfidf_w2v=tr_X_tfidf_w2v.toarray()
cv_X_tfidf_w2v=cv_X_tfidf_w2v.toarray()
te_X_tfidf_w2v=te_X_tfidf_w2v.toarray()
print(tr_X_tfidf_w2v.shape)
```

```
print(cv_X_tfidf_w2v.shape)
print(te_X_tfidf_w2v.shape)
```

```
(69918, 702)
(17480, 702)
(21850, 702)
Wall time: 7.69 s
```

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

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

In [223]:
```
#functino for KNN
from sklearn.neighbors import KNeighborsClassifier
def knn(x,y,n=5):
    n_neighbors=n
    neigh = KNeighborsClassifier(n_neighbors,algorithm='brute')
    neigh.fit(x,y)
    print("Accuracy of classifier with k=",n_neighbors)

    return(neigh)
```

2.4.1 Applying KNN brute force on BOW, SET 1

In [224]:
```
%%time
#Training classifier with K=5
clf=knn(tr_X_BOW,Y_train,5)
print(clf.score(cv_X_BOW,Y_cv))
```

```
Accuracy of classifier with k= 5
0.831979405034325
Wall time: 10min 37s
```

In [225]:
```
%%time
#Training classifier with K=13
clf=knn(tr_X_BOW,Y_train,13)
print(clf.score(cv_X_BOW,Y_cv))
```

```
Accuracy of classifier with k= 13
```

```
0.8482265446224256
Wall time: 11min 40s
```

In [226]:
```
%%time
#Training classifier with K=17
clf=knn(tr_X_BOW,Y_train,17)
print(clf.score(cv_X_BOW,Y_cv))
```

```
Accuracy of classifier with k= 17
0.8489130434782609
Wall time: 40min 20s
```

2.4.2 Applying KNN brute force on TFIDF, SET 2

In [227]:
```
%%time
#Training classifier with K=5
clf=knn(tr_X_TFIDF,Y_train,5)
print(clf.score(cv_X_TFIDF,Y_cv))
```

```
Accuracy of classifier with k= 5
0.8282608695652174
Wall time: 6min 59s
```

In [228]:
```
%%time
#Training classifier with K=13
clf=knn(tr_X_TFIDF,Y_train,13)
print(clf.score(cv_X_TFIDF,Y_cv))
```

```
Accuracy of classifier with k= 13
0.8474256292906178
Wall time: 6min 35s
```

In [229]:
```
%%time
#Training classifier with K=17
clf=knn(tr_X_TFIDF,Y_train,17)
print(clf.score(cv_X_TFIDF,Y_cv))
```

```
Accuracy of classifier with k= 17
0.8485697940503433
Wall time: 6min 43s
```

2.4.3 Applying KNN brute force on AVG W2V, SET 3

In [230]:
```
%%time
#Training classifier with K=5
clf=knn(tr_X_AVG_W2V,Y_train,5)
print(clf.score(cv_X_AVG_W2V,Y_cv))
```

```
Accuracy of classifier with k= 5
0.8305491990846682
Wall time: 2min 49s
```

In [231]:
```
%%time
#Training classifier with K=13
clf=knn(tr_X_AVG_W2V,Y_train,13)
print(clf.score(cv_X_AVG_W2V,Y_cv))
```

```
Accuracy of classifier with k= 13
0.848512585812357
Wall time: 3min 4s
```

In [232]:
```
%%time
#Training classifier with K=17
clf=knn(tr_X_AVG_W2V,Y_train,11)
print(clf.score(cv_X_AVG_W2V,Y_cv))
```

```
Accuracy of classifier with k= 11
0.8478260869565217
Wall time: 2min 56s
```

2.4.4 Applying KNN brute force on TFIDF W2V, SET 4

In [233]:
```
%%time
#Training classifier with K=5
clf=knn(tr_X_tfidf_w2v,Y_train,5)
print(clf.score(cv_X_tfidf_w2v,Y_cv))
```

```
Accuracy of classifier with k= 5
0.8287185354691076
Wall time: 2min 37s
```

In [234]:
```
%%time
#Training classifier with K=13
clf=knn(tr_X_tfidf_w2v,Y_train,13)
print(clf.score(cv_X_tfidf_w2v,Y_cv))
```

```
Accuracy of classifier with k= 13
```

```
0.8482265446224256
Wall time: 2min 52s
```

In [235]:
```
%%time
#Training classifier with K=17
clf=knn(tr_X_tfidf_w2v,Y_train,17)
print(clf.score(cv_X_tfidf_w2v,Y_cv))
```

```
Accuracy of classifier with k= 17
0.8489130434782609
Wall time: 2min 57s
```

Hyper paramter tuning to find best K

In [73]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#Drawing confusion matrix
def draw_confusion_matrix(clf,threshold,y_true,y_hat,tpr,fpr,t):
    result=[]
    y_pred=[]

    #finding threshold which maximises the tpr and minimises the fpr
    thr=threshold[np.argmax((tpr*(1-fpr)))]

    for probab in y_hat:

        if probab >= thr:
            y_pred.append(1)
        else:
            y_pred.append(0)

    result=confusion_matrix(y_true,y_pred,labels=[0,1])
    df_cm = pd.DataFrame(result,range(2),range(2))
    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})
    plt.figure(figsize = (5,3))
    plt.title(t)
    sns.heatmap(df_cm, annot=True,annot_kws={"size": 12}, fmt='g')
```

In [81]:
```
#function to plot lines
def plot_curve(train_auc_scores_tmp,validation_auc_scores_tmp,k_n,title):
    plt.plot(k_n,train_auc_scores_tmp,label="Train curve")
    plt.plot(k_n,validation_auc_scores_tmp,label="Validation curve")
```

```
    plt.scatter(k_n, train_auc_scores_tmp, label='Train AUC points')
    plt.scatter(k_n, validation_auc_scores_tmp, label='CV AUC points')
    plt.title(title)
    plt.xlabel("k-hyper paramters")
    plt.ylabel("AUC")
    plt.legend()
    plt.show()
```

In [82]:

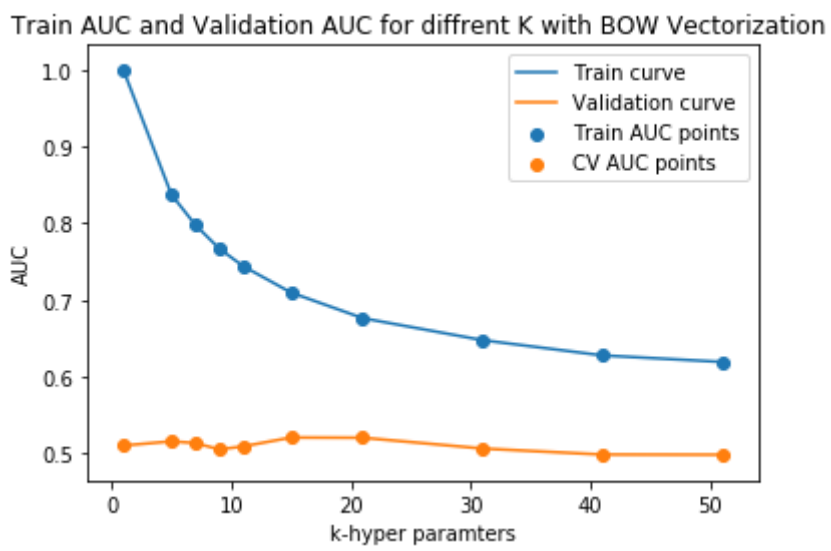
```
#refered link :https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classification-in-python/
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import GridSearchCV
def roc_auc_compute(x_train,y_train,x_test_temp,y_test_temp,k_n,title,title2):
    n_neighbors=k_n
    train_auc_scores=[]
    validation_auc_scores=[]
    train_cv_scores=[]
    validation_cv_scores=[]
    i=1
    for k in n_neighbors:
        parameters = {'n_neighbors':[k]}
        trained_knn = KNeighborsClassifier(n_neighbors=k,algorithm='brute')
        #trainning model
        trained_knn.fit(x_train,y_train)

        # predict the response on the cross validation
        pradicted_labels=trained_knn.predict_proba(x_test_temp)

        #Calculating validation auc scores
        validation_auc=roc_auc_score(y_test_temp,pradicted_labels[:,1]) #1-roc_auc_score for validation error

        # predict the response on the train and calculating the train auc
        train_auc=roc_auc_score(y_train,trained_knn.predict_proba(x_train)[:,1]) #1-roc_auc_score for train error

        # K-flod cross validation
        gs = GridSearchCV(trained_knn,parameters, cv=3, scoring='roc_auc')
        gs.fit(x_train,y_train)
        train_auc= gs.cv_results_['mean_train_score']
        cv_auc = gs.cv_results_['mean_test_score']

        train_cv_scores.append(train_auc)
```

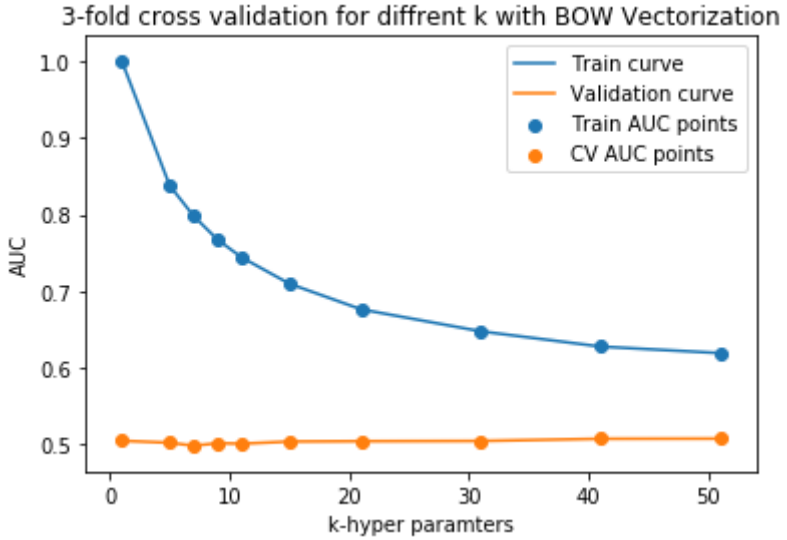
```
        validation_cv_scores.append(cv_auc)

        print("finished with K=",k)
        train_auc_scores.append(train_auc)
        validation_auc_scores.append(validation_auc)
        i=i+1
    plot_curve(train_auc_scores,validation_auc_scores,k_n,title)
    plot_curve(train_cv_scores,validation_cv_scores,k_n,title2)
```

Applying KNN brute force on BOW

In [84]:
```
%%time
title="Train AUC and Validation AUC for diffrent K with BOW Vectorization "
title2="3-fold cross validation for diffrent k with BOW Vectorization"
#Reason for choosing odd k's is there will not be difficulties while calculati
ng majority votes for data point.
#Subseting the trian and cv data because my laptop has only 8GB of RAM
roc_auc_compute(tr_X_BOW[:15000],Y_train[:15000],cv_X_BOW[:3000],Y_cv[:3000],
[1,5,7,9, 11, 15, 21, 31, 41, 51],title,title2)
```

```
finished with K= 1
finished with K= 5
finished with K= 7
finished with K= 9
finished with K= 11
finished with K= 15
finished with K= 21
finished with K= 31
finished with K= 41
finished with K= 51
```





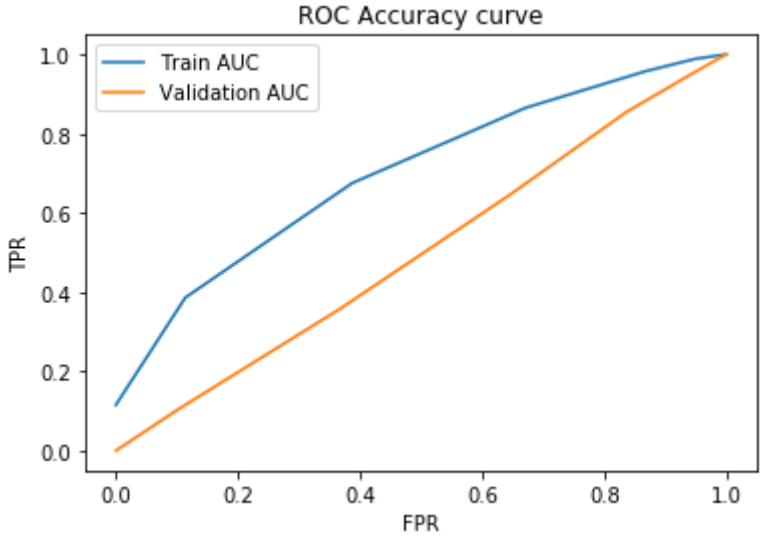

```
Wall time: 31min 15s
```

From the above figure the we see can that AUC is stable after k=15 so i choose k=15.
Reason behind choosing k=15 is

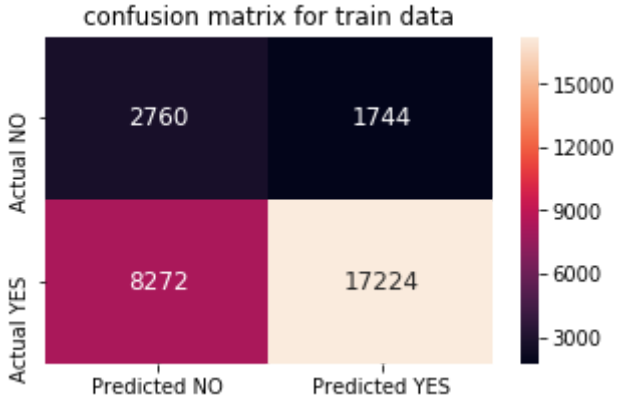
• Donor choose data set is imbalanced data.
• Whenever we take majority vote we will get majority for "project approved"(label-1) then classifier classifies every data point to class label 1.

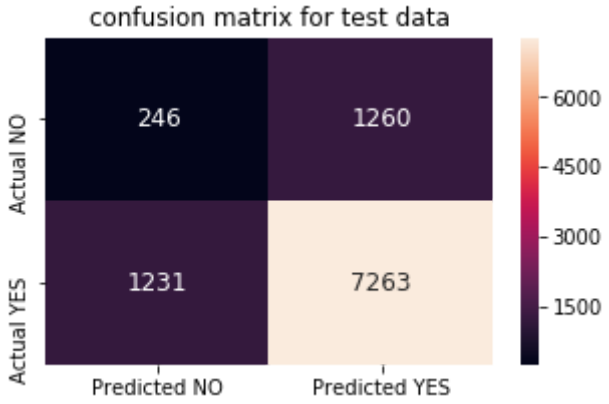
In [156]:
```
%%time
```

```
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for
-classification-in-python/
from sklearn.metrics import roc_curve, auc
#training model with best K-Hyper paramter
trained_knn_BOW= KNeighborsClassifier(n_neighbors=15,algorithm='brute')
#trainning model
trained_knn_BOW.fit(tr_X_BOW[:30000],Y_train[:30000])
# predict the response on the train data
predicted_labels_train=trained_knn_BOW.predict_proba(tr_X_BOW[:30000])
# predict the response on the test data
predicted_labels_test=trained_knn_BOW.predict_proba(te_X_BOW[:10000])
#Calculating FPR and TPR for train and test data
tr_fpr,tr_tpr,tr_threshold=roc_curve(Y_train[:30000],predicted_labels_train[:,
1])
te_fpr,te_tpr,te_threshold=roc_curve(Y_test[:10000],predicted_labels_test[:,
1])
#drawing ROC ROC Accuracy curve for test and train data
plt.plot(tr_fpr,tr_tpr,label="Train AUC")
plt.plot(te_fpr,te_tpr,label="Validation AUC")
plt.title("ROC Accuracy curve")
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.legend()
plt.show()
print("Train AUC =",auc(tr_fpr,tr_tpr))
print("Test AUC =",auc(te_fpr,te_tpr))
#drawing confusion matrix for test and train data
t2="confusion matrix for train data"
draw_confusion_matrix(trained_knn_BOW,tr_threshold,Y_train[:30000],predicted_l
abels_train[:,1],tr_tpr,tr_fpr,t2)
t1="confusion matrix for test data"
draw_confusion_matrix(trained_knn_BOW,tr_threshold,Y_test[:10000],predicted_la
bels_test[:,1],te_tpr,te_fpr,t1)
```




```
Train AUC = 0.7015966850022378
Test AUC = 0.5013740266936336
Wall time: 5min 38s
```

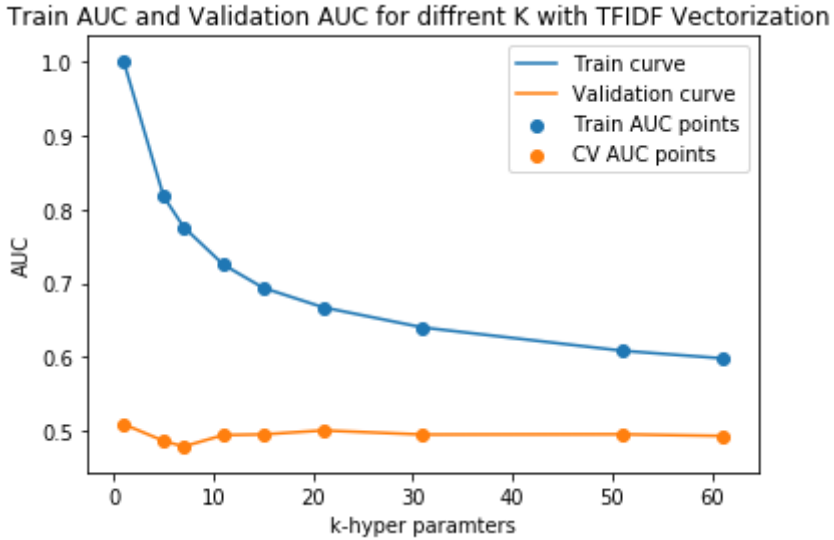


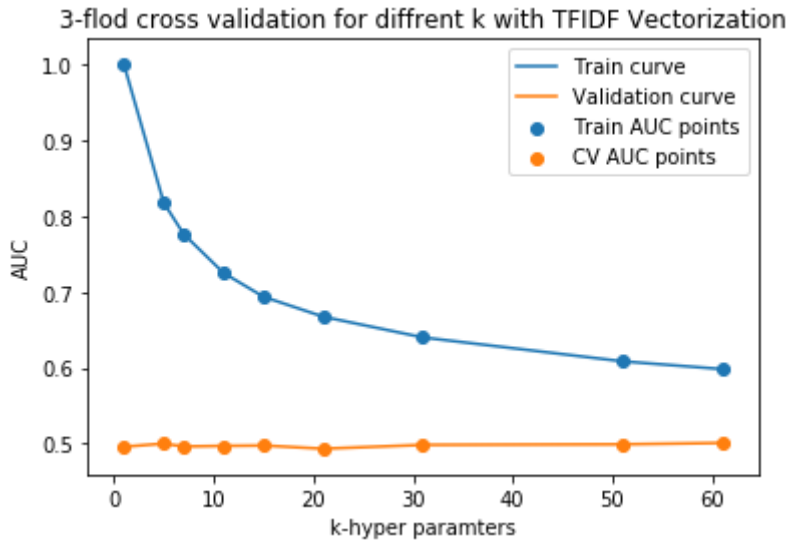


Applying KNN brute force on TFIDF

In [86]:
```
%%time
title="Train AUC and Validation AUC for diffrent K with TFIDF Vectorization "
title2="3-flod cross validation for diffrent k with TFIDF Vectorization"
#Reason for choosing odd k's is there will not be difficulties while calculati
ng majority votes for data point.
#Subseting the trian and cv data because my laptop has only 8GB of RAM
roc_auc_compute(tr_X_TFIDF[:30000],Y_train[:30000],cv_X_TFIDF[:2500],Y_cv[:250
0],[1,5,7,11,15,21,31,51,61],title,title2)
```

```
finished with K= 1
finished with K= 5
finished with K= 7
finished with K= 11
finished with K= 15
finished with K= 21
finished with K= 31
finished with K= 51
finished with K= 61
```






```
Wall time: 1h 5min 40s
```

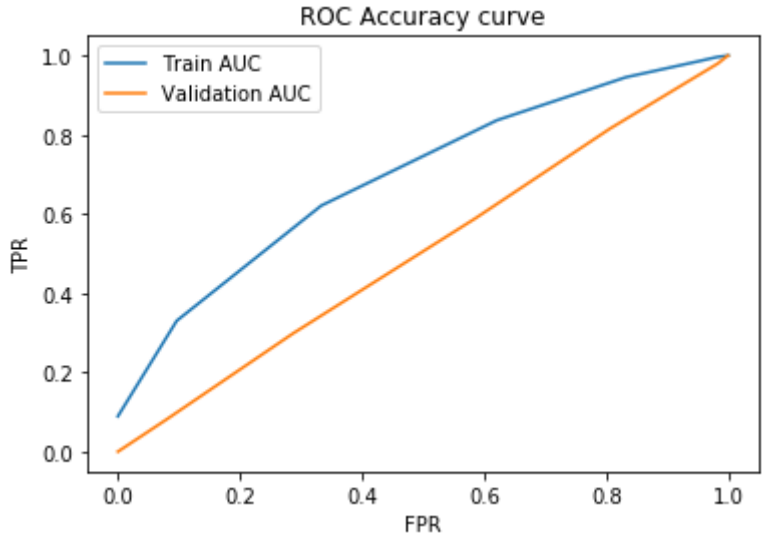
From the above figure the we see can that AUC is stable after k=15 so i choose k=15.
Reason behind choosing k=15 is

• Donor choose data set is imbalanced data.
• Whenever we take majority vote we will get majority for "project approved"(label-1) then classifier classifies every data point to class label 1.

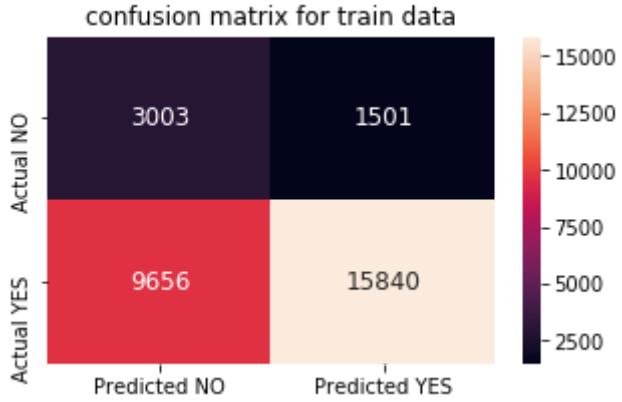
In [157]:

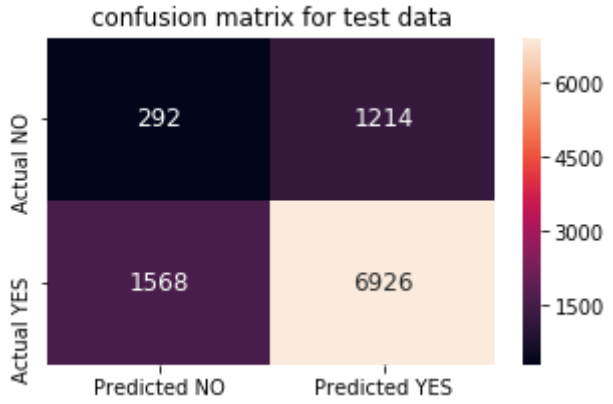
```
%%time
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for
-classification-in-python/
from sklearn.metrics import roc_curve, auc
#training model with best K-Hyper paramter
trained_knn_TFIDF= KNeighborsClassifier(n_neighbors=15,algorithm='brute')
#trainning model
trained_knn_TFIDF.fit(tr_X_TFIDF[:30000],Y_train[:30000])
# predict the response on the train data
predicted_labels_train=trained_knn_TFIDF.predict_proba(tr_X_TFIDF[:30000])
# predict the response on the test data
predicted_labels_test=trained_knn_TFIDF.predict_proba(te_X_TFIDF[:10000])
#Calculating FPR and TPR for train and test data
tr_fpr,tr_tpr,tr_threshold=roc_curve(Y_train[:30000],predicted_labels_train[:,
1])
te_fpr,te_tpr,te_threshold=roc_curve(Y_test[:10000],predicted_labels_test[:,
1])
#drawing ROC ROC Accuracy curve for test and train data
```

```
plt.plot(tr_fpr,tr_tpr,label="Train AUC")
plt.plot(te_fpr,te_tpr,label="Validation AUC")
plt.title("ROC Accuracy curve")
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.legend()
plt.show()
print("Train AUC =",auc(tr_fpr,tr_tpr))
print("Test AUC =",auc(te_fpr,te_tpr))
#drawing confusion matrix for test and train data
t2="confusion matrix for train data"
draw_confusion_matrix(trained_knn_TFIDF,tr_threshold,Y_train[:30000],predicted
_labels_train[:,1],tr_tpr,tr_fpr,t2)
t1="confusion matrix for test data"
draw_confusion_matrix(trained_knn_TFIDF,tr_threshold,Y_test[:10000],predicted_
labels_test[:,1],te_tpr,te_fpr,t1)
```




```
Train AUC = 0.6942680051926091
Test AUC = 0.5055786586016032
Wall time: 3min 57s
```



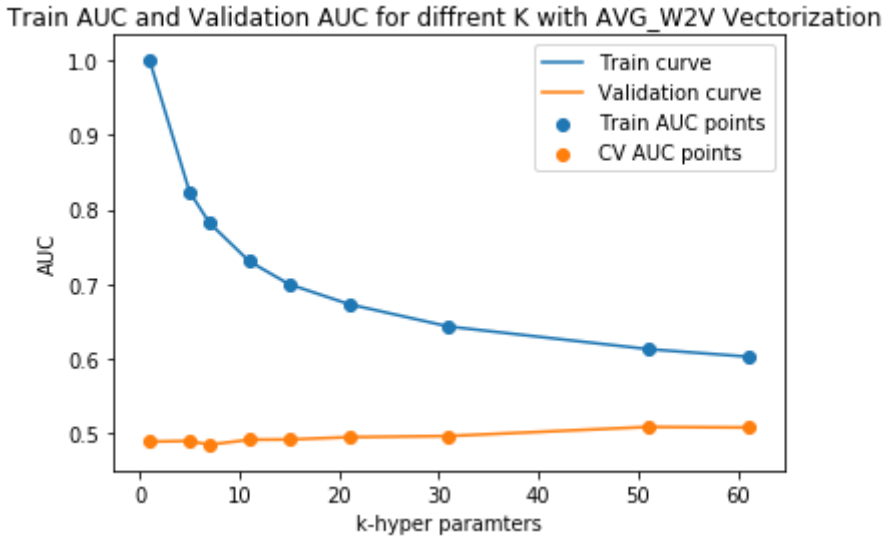


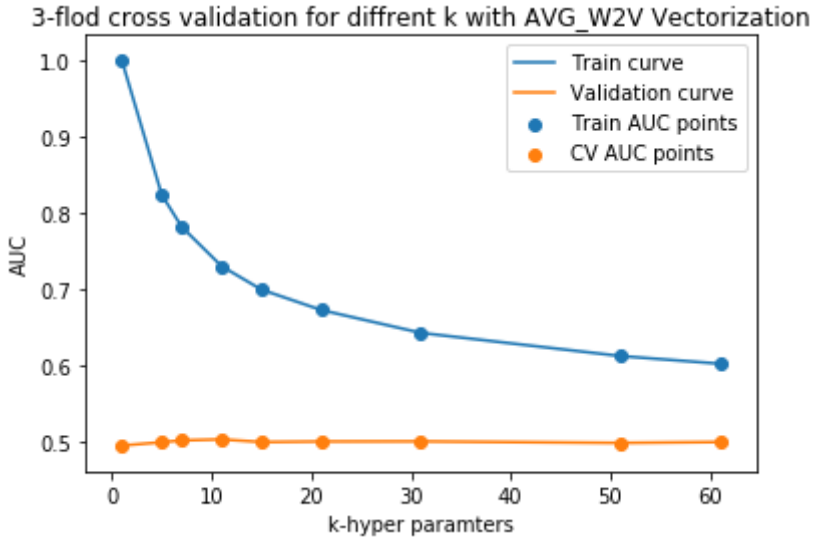
Applying KNN brute force on AVG W2V

In [125]:
```
%%time
title="Train AUC and Validation AUC for diffrent K with AVG_W2V Vectorization
 "
title2="3-flod cross validation for diffrent k with AVG_W2V Vectorization"
#Reason for choosing odd k's is there will not be difficulties while calculati
ng majority votes for data point.
#Subseting the trian and cv data because my laptop has only 8GB of RAM
roc_auc_compute(tr_X_AVG_W2V[:30000],Y_train[:30000],cv_X_AVG_W2V[:2500],Y_cv
[:2500],[1,5,7,11,15,21,31,51,61],title,title2)
```

```
finished with K= 1
finished with K= 5
finished with K= 7
```

```
finished with K= 11
finished with K= 15
finished with K= 21
finished with K= 31
finished with K= 51
finished with K= 61
```



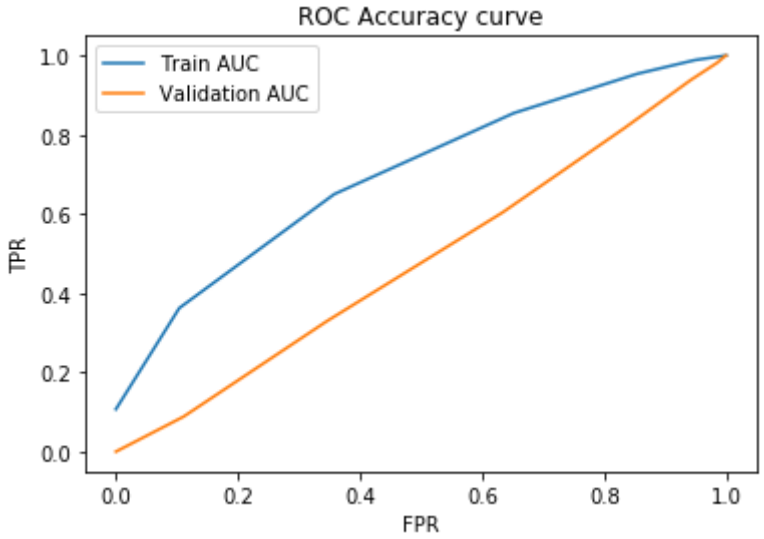



```
Wall time: 24min 7s
```

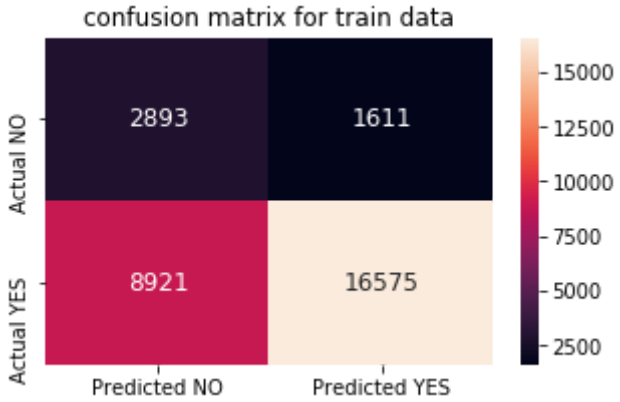
From the above figure the we see can that AUC is stable after k=11 so i choose k=11.
Reason behind choosing k=11 is

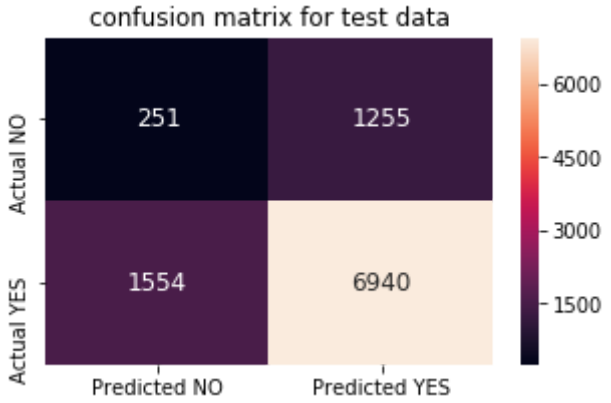
• Donor choose data set is imbalanced data.
• Whenever we take majority vote we will get majority for "project approved"(label-1) then classifier classifies every data point to class label 1.

In [162]:
```
%%time
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for
-classification-in-python/
from sklearn.metrics import roc_curve, auc
#training model with best K-Hyper paramter
trained_knn_AVG_W2V= KNeighborsClassifier(n_neighbors=15,algorithm='brute')
#trainning model
trained_knn_AVG_W2V.fit(tr_X_AVG_W2V[:30000],Y_train[:30000])
# predict the response on the train data
predicted_labels_train=trained_knn_AVG_W2V.predict_proba(tr_X_AVG_W2V[:30000])
# predict the response on the test data
predicted_labels_test=trained_knn_AVG_W2V.predict_proba(te_X_AVG_W2V[:10000])
#Calculating FPR and TPR for train and test data
tr_fpr,tr_tpr,tr_threshold=roc_curve(Y_train[:30000],predicted_labels_train[:,
1])
te_fpr,te_tpr,te_threshold=roc_curve(Y_test[:10000],predicted_labels_test[:,
1])
#drawing ROC ROC Accuracy curve for test and train data
plt.plot(tr_fpr,tr_tpr,label="Train AUC")
plt.plot(te_fpr,te_tpr,label="Validation AUC")
plt.title("ROC Accuracy curve")
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.legend()
plt.show()
print("Train AUC =",auc(tr_fpr,tr_tpr))
print("Test AUC =",auc(te_fpr,te_tpr))
#drawing confusion matrix for test and train data
t2="confusion matrix for train data"
draw_confusion_matrix(trained_knn_AVG_W2V,tr_threshold,Y_train[:30000],predict
ed_labels_train[:,1],tr_tpr,tr_fpr,t2)
t1="confusion matrix for test data"
draw_confusion_matrix(trained_knn_AVG_W2V,tr_threshold,Y_test[:10000],predicte
d_labels_test[:,1],te_tpr,te_fpr,t1)
```




```
Train AUC = 0.7000603453765045
Test AUC = 0.48177848217834257
Wall time: 1min 43s
```

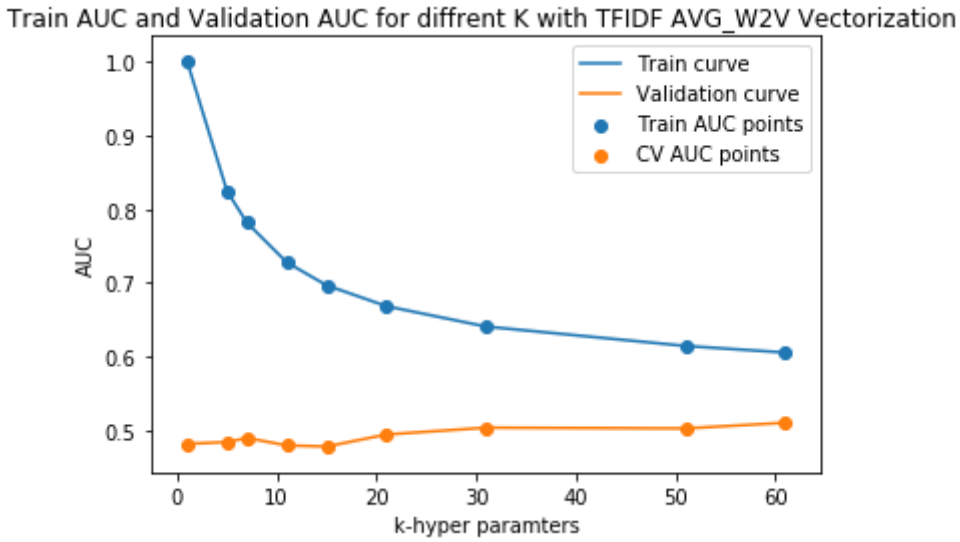


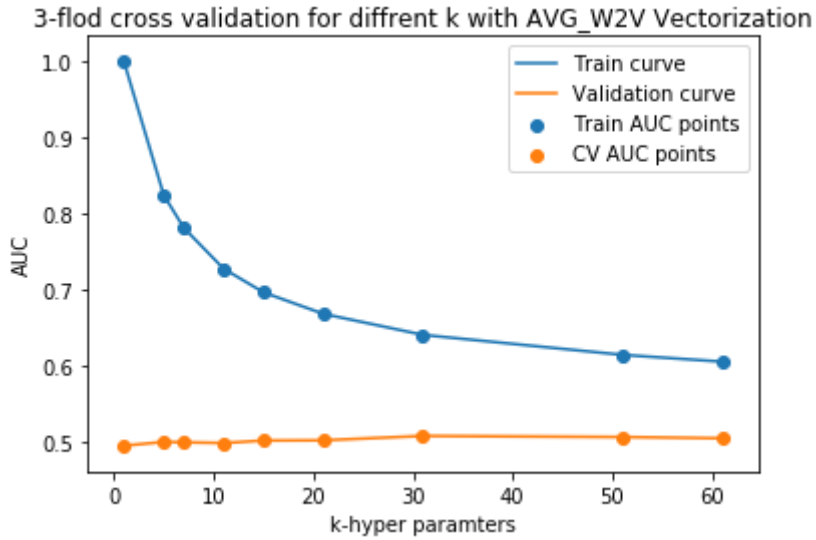


Applying KNN brute force on TFIDF W2V

In [126]:
```
%%time
title="Train AUC and Validation AUC for diffrent K with TFIDF AVG_W2V Vectoriz
ation "
title2="3-flod cross validation for diffrent k with AVG_W2V Vectorization"
#Reason for choosing odd k's is there will not be difficulties while calculati
ng majority votes for data point.
#Subseting the trian and cv data because my laptop has only 8GB of RAM
roc_auc_compute(tr_X_tfidf_w2v[:30000],Y_train[:30000],cv_X_tfidf_w2v[:2500],Y
_cv[:2500],[1,5,7,11,15,21,31,51,61],title,title2)
```

```
finished with K= 1
finished with K= 5
finished with K= 7
finished with K= 11
finished with K= 15
finished with K= 21
finished with K= 31
finished with K= 51
finished with K= 61
```






```
Wall time: 24min 26s
```

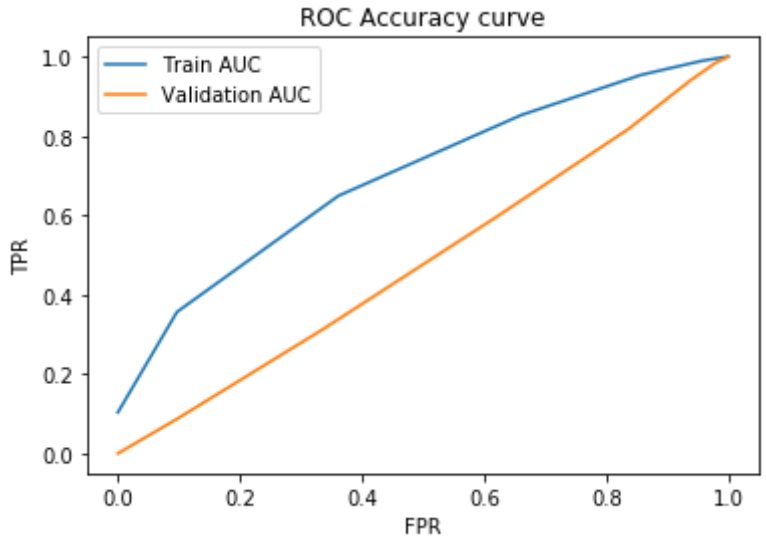
From the above figure the we see can that AUC is stable after k=15 so i choose k=15.
Reason behind choosing k=15 is

• Donor choose data set is imbalanced data.
• Whenever we take majority vote we will get majority for "project approved"(label-1) then classifier classifies every data point to class label 1.

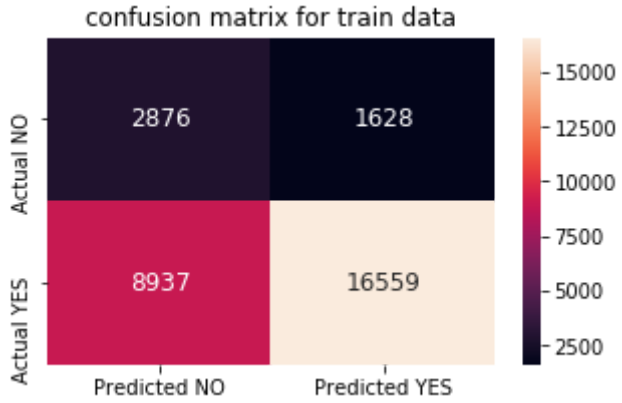
In [159]:

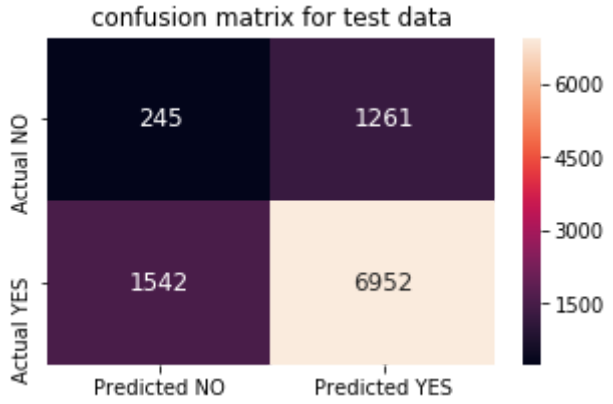
```
%%time
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for
-classification-in-python/
from sklearn.metrics import roc_curve, auc
#training model with best K-Hyper paramter
trained_knn_tfidf_w2v= KNeighborsClassifier(n_neighbors=15,algorithm='brute')
#trainning model
trained_knn_tfidf_w2v.fit(tr_X_tfidf_w2v[:30000],Y_train[:30000])
# predict the response on the train data
predicted_labels_train=trained_knn_tfidf_w2v.predict_proba(tr_X_tfidf_w2v[:300
00])
# predict the response on the test data
predicted_labels_test=trained_knn_tfidf_w2v.predict_proba(te_X_tfidf_w2v[:1000
0])
#Calculating FPR and TPR for train and test data
tr_fpr,tr_tpr,tr_threshold=roc_curve(Y_train[:30000],predicted_labels_train[:,
1])
te_fpr,te_tpr,te_threshold=roc_curve(Y_test[:10000],predicted_labels_test[:,
```

```
1])
#drawing ROC ROC Accuracy curve for test and train data
plt.plot(tr_fpr,tr_tpr,label="Train AUC")
plt.plot(te_fpr,te_tpr,label="Validation AUC")
plt.title("ROC Accuracy curve")
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.legend()
plt.show()
print("Train AUC =",auc(tr_fpr,tr_tpr))
print("Test AUC =",auc(te_fpr,te_tpr))
#drawing confusion matrix for test and train data
t2="confusion matrix for train data"
draw_confusion_matrix(trained_knn_tfidf_w2v,tr_threshold,Y_train[:30000],predi
cted_labels_train[:,1],tr_tpr,tr_fpr,t2)
t1="confusion matrix for test data"
draw_confusion_matrix(trained_knn_tfidf_w2v,tr_threshold,Y_test[:10000],predic
ted_labels_test[:,1],te_tpr,te_fpr,t1)
```




```
Train AUC = 0.6975095412521785
Test AUC = 0.48363136419083097
Wall time: 1min 34s
```





2.5 Feature selection with `SelectKBest`

Numerical feature normalization

We need to normalize the numerical futures because 'SelectKBest` wont accept the negative value and if numerical futures are not normalized then we will face this error (ValueError: Input X must be non-negative)

In [127]:
```
#https://stats.stackexchange.com/questions/70801/how-to-normalize-data-to-0-1-range
#Normalized price

tr_price_normalized = np.array((X_train['price']-min(X_train['price']))/(max(X
```

```
_train['price'])-min(X_train['price']))).reshape(-1, 1)
cv_price_normalized = np.array((X_cv['price']-min(X_cv['price']))/(max(X_cv['p
rice'])-min(X_cv['price']))).reshape(-1, 1)
te_price_normalized = np.array((X_test['price']-min(X_test['price']))/(max(X_t
est['price'])-min(X_test['price']))).reshape(-1, 1)
```

In [128]:
```
#https://stats.stackexchange.com/questions/70801/how-to-normalize-data-to-0-1-
range
#Normalized quantity
tr_quantity_normalized = np.array((X_train['quantity']-min(X_train['quantity'
]))/(max(X_train['quantity'])-min(X_train['quantity']))).reshape(-1,1)
cv_quantity_normalized =  np.array((X_cv['quantity']-min(X_cv['quantity']))/(m
ax(X_cv['quantity'])-min(X_cv['quantity']))).reshape(-1, 1)
te_quantity_normalized =  np.array((X_test['quantity']-min(X_test['quantity'
]))/(max(X_test['quantity'])-min(X_test['quantity']))).reshape(-1, 1)
```

In [129]:
```
#https://stats.stackexchange.com/questions/70801/how-to-normalize-data-to-0-1-
range
#Normalized teacher_number_of_previously_posted_projects
tr_teacher_number_of_previously_posted_projects_normalized = np.array( (X_trai
n['teacher_number_of_previously_posted_projects']-min(X_train['teacher_number_
of_previously_posted_projects']))/(max(X_train['teacher_number_of_previously_p
osted_projects'])-min(X_train['teacher_number_of_previously_posted_projects'
]))).reshape(-1, 1)
cv_teacher_number_of_previously_posted_projects_normalized =  np.array((X_cv[
'teacher_number_of_previously_posted_projects']-min(X_cv['teacher_number_of_pr
eviously_posted_projects']))/(max(X_cv['teacher_number_of_previously_posted_pr
ojects'])-min(X_cv['teacher_number_of_previously_posted_projects']))).reshape(
-1, 1)
te_teacher_number_of_previously_posted_projects_normalized = np.array( (X_test
['teacher_number_of_previously_posted_projects']-min(X_test['teacher_number_of
_previously_posted_projects']))/(max(X_test['teacher_number_of_previously_post
ed_projects'])-min(X_test['teacher_number_of_previously_posted_projects']))).r
eshape(-1, 1)
```

In [130]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
#categorical, numerical features + project_title(TFIDF_norm)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a den
se matirx :)
tr_X_TFIDF_norm= hstack((tr_school_state_one_hot,tr_categories_one_hot, tr_sub
_categories_one_hot,tr_teacher_prefix_one_hot,tr_grade_category_one_hot,tr_pri
ce_normalized,tr_teacher_number_of_previously_posted_projects_normalized,tr_ti
tle_tfidf,tr_text_tfidf))
cv_X_TFIDF_norm= hstack((cv_school_state_one_hot,cv_categories_one_hot, cv_sub
```

```
_categories_one_hot,cv_teacher_prefix_one_hot,cv_grade_category_one_hot,cv_pri
ce_normalized,cv_teacher_number_of_previously_posted_projects_normalized,cv_ti
tle_tfidf,cv_text_tfidf))
te_X_TFIDF_norm= hstack((te_school_state_one_hot,te_categories_one_hot, te_sub
_categories_one_hot,te_teacher_prefix_one_hot,te_grade_category_one_hot,te_pri
ce_normalized,te_teacher_number_of_previously_posted_projects_normalized,te_ti
tle_tfidf,te_text_tfidf))

tr_X_TFIDF_norm=tr_X_TFIDF_norm.toarray()
cv_X_TFIDF_norm=cv_X_TFIDF_norm.toarray()
te_X_TFIDF_norm=te_X_TFIDF_norm.toarray()
print(tr_X_TFIDF_norm.shape)
print(cv_X_TFIDF_norm.shape)
print(te_X_TFIDF_norm.shape)
```

```
(69918, 5226)
(17480, 5226)
(21850, 5226)
```

In [131]:

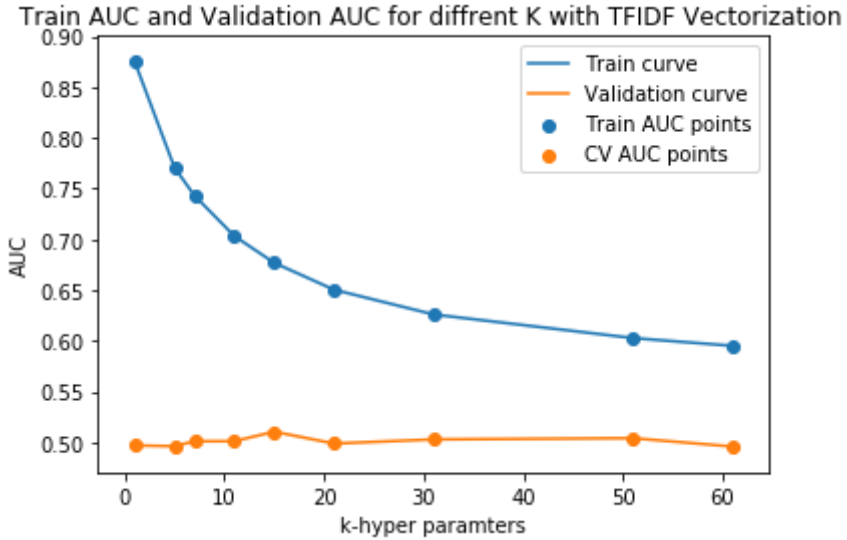
```
%%time
from sklearn.feature_selection import SelectKBest, chi2
print("Shape of dataset before selecting important features \n",tr_X_TFIDF_nor
m.shape,Y_train.shape)
print(cv_X_TFIDF_norm.shape,Y_cv.shape)
print(te_X_TFIDF_norm.shape,Y_test.shape)
select_best=SelectKBest(chi2, k=2000)
tr_X_new=select_best.fit_transform(tr_X_TFIDF_norm, Y_train)
te_X_new = select_best.transform(te_X_TFIDF_norm)
cv_X_new = select_best.transform(cv_X_TFIDF_norm)
print("Shape of dataset after selecting important features")
print(tr_X_new.shape,Y_train.shape)
print(te_X_new.shape,Y_test.shape)
print(cv_X_new.shape,Y_cv.shape)
```

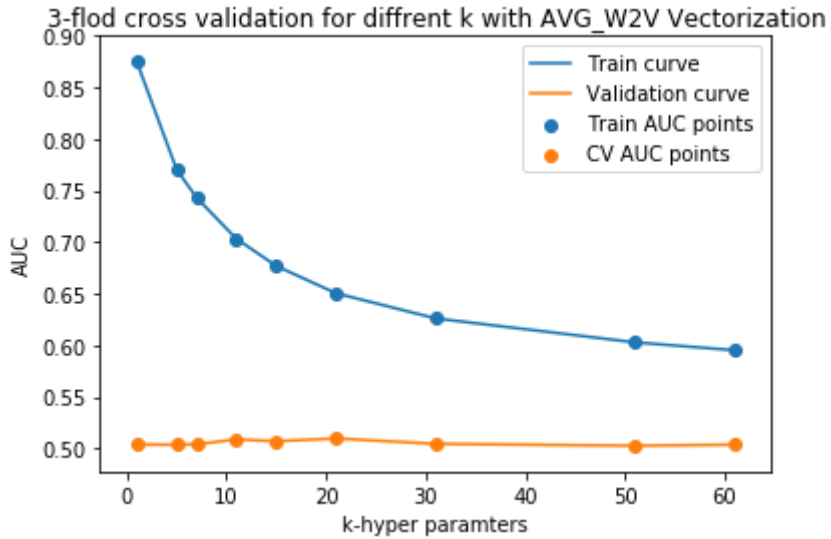
```
Shape of dataset before selecting important features
 (69918, 5226) (69918,)
(17480, 5226) (17480,)
(21850, 5226) (21850,)
Shape of dataset after selecting important features
(69918, 2000) (69918,)
(21850, 2000) (21850,)
(17480, 2000) (17480,)
Wall time: 8.2 s
```

Applying KNN brute force on selected feature TFIDF

In [132]:
```
%%time
title="Train AUC and Validation AUC for diffrent K with TFIDF Vectorization "
title2="3-flod cross validation for diffrent k with AVG_W2V Vectorization"
#Reason for choosing odd k's is there will not be difficulties while calculati
ng majority votes for data point.
#Subseting the trian and cv data because my laptop has only 8GB of RAM
roc_auc_compute(tr_X_new[:30000],Y_train[:30000],cv_X_new[:3000],Y_cv[:3000],
[1,5,7,11,15,21,31,51,61],title,title2)
```

```
finished with K= 1
finished with K= 5
finished with K= 7
finished with K= 11
finished with K= 15
finished with K= 21
finished with K= 31
finished with K= 51
finished with K= 61
```






```
Wall time: 38min 21s
```

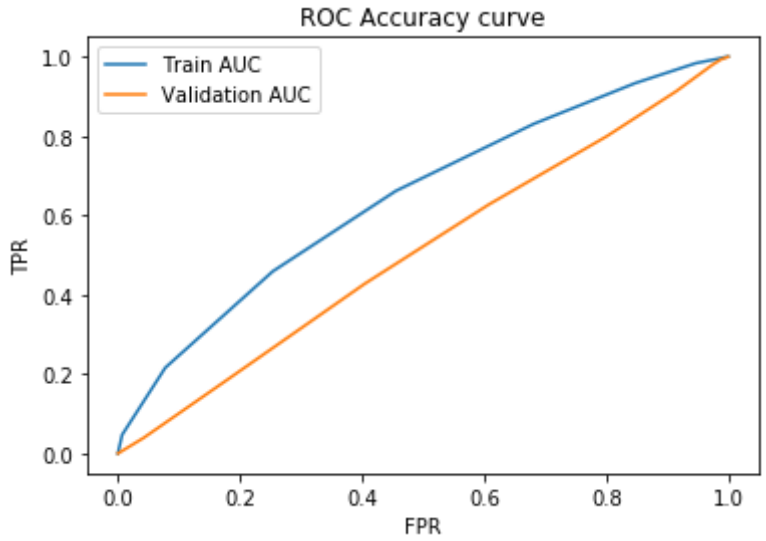
From the above figure the we see can that AUC is stable after k=21 so i choose k=21.
Reason behind choosing k=21 is

• Donor choose data set is imbalanced data.
• Whenever we take majority vote we will get majority for "project approved"(label-1) then classifier classifies every data point to class label 1.

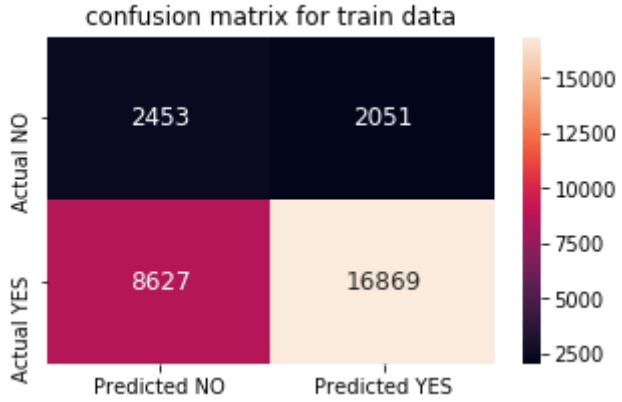
In [164]:

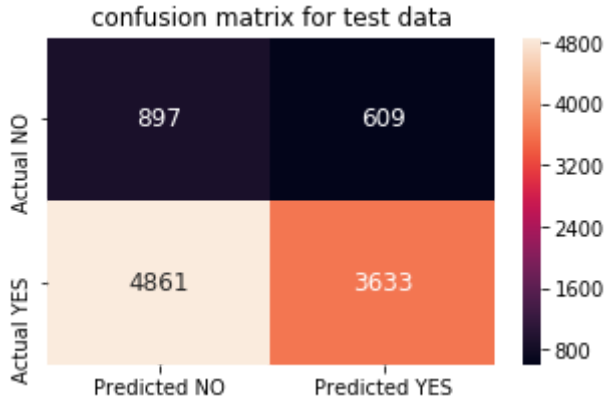
```
%%time
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for
-classification-in-python/
from sklearn.metrics import roc_curve, auc
#training model with best K-Hyper paramter
trained_knn_new= KNeighborsClassifier(n_neighbors=21,algorithm='brute')
#trainning model
trained_knn_new.fit(tr_X_new[:30000],Y_train[:30000])
# predict the response on the train data
predicted_labels_train=trained_knn_new.predict_proba(tr_X_new[:30000])
# predict the response on the test data
predicted_labels_test=trained_knn_new.predict_proba(te_X_new[:10000])
#Calculating FPR and TPR for train and test data
tr_fpr,tr_tpr,tr_threshold=roc_curve(Y_train[:30000],predicted_labels_train[:,
1])
te_fpr,te_tpr,te_threshold=roc_curve(Y_test[:10000],predicted_labels_test[:,
1])
#drawing ROC ROC Accuracy curve for test and train data
```

```
plt.plot(tr_fpr,tr_tpr,label="Train AUC")
plt.plot(te_fpr,te_tpr,label="Validation AUC")
plt.title("ROC Accuracy curve")
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.legend()
plt.show()
print("Train AUC =",auc(tr_fpr,tr_tpr))
print("Test AUC =",auc(te_fpr,te_tpr))
#drawing confusion matrix for test and train data
#drawing confusion matrix for test and train data
t2="confusion matrix for train data"
draw_confusion_matrix(trained_knn_new,tr_threshold,Y_train[:30000],predicted_l
abels_train[:,1],tr_tpr,tr_fpr,t2)
t1="confusion matrix for test data"
draw_confusion_matrix(trained_knn_new,tr_threshold,Y_test[:10000],predicted_la
bels_test[:,1],te_tpr,te_fpr,t1)
```




```
Train AUC = 0.6449876240469024
Test AUC = 0.5097069926087973
Wall time: 2min 25s
```





3. Conclusions

In [166]:
```
# Please compare all your models using Prettytable library
from prettytable import PrettyTable

table = PrettyTable()

table.field_names = ["Vectorizer", "Model", "Hyper parameter", "Test AUC"]

table.add_row(["BOW", "Brute", "15","0.501" ])
table.add_row(["TFIDF", "Brute","15", "0.505"])
table.add_row(["AVG W2V", "Brute", "11","0.490" ])
table.add_row(["TFIDF W2V", "Brute", "15","0.485" ])
table.add_row(["TFIDF 2000 features", "Brute","21" ,"0.509" ])
print(table)
```

```
+--------------------+-------+----------------+----------+
```

Vectorizer	Model	Hyper parameter	Test AUC
BOW	Brute	15	0.501
TFIDF	Brute	15	0.505
AVG W2V	Brute	11	0.490
TFIDF W2V	Brute	15	0.485
TFIDF 2000 features	Brute	21	0.509