Random Forest and GBDT on 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.

In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

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

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

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

from tqdm import tqdm
import os
import chart_studio.plotly as py
from scipy.sparse import hstack
import chart_studio.plotly as py


from collections import Counter
```

1. LOAD AND PROCESS DATA

1.1 Reading Data

In [2]:

```
data=pd.read_csv("train_data.csv",nrows=50000)
resource_data=pd.read_csv("resources.csv")
data.columns
```

Out[2]:

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

In [3]:

```
price_data=resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
```

In [4]:

```
project_data=pd.merge(data, price_data, on='id', how='left')
```

In [5]:

```
project_data.columns
```

Out[5]:

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

1.2 process Project Essay

In [6]:

```
project_data.head(3)
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades 6-8	
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grades 6-8	

In [7]:

```
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 [8]:

```
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 [9]:

```
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'befor
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
```

```
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'w
            'won', "won't", 'wouldn', "wouldn't"]
```

In [10]:

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

```
100%|██████████| 50000/50000 [00:26<00:00, 1888.95it/s]
```

1.2 process Project Title

In [11]:

```
# https://stackoverflow.com/a/47091490/4084039
from tqdm import tqdm
preprocessed_title = []
# tqdm is for printing the status bar
for sentance in tqdm(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_title.append(sent.lower().strip())
project_data['cleaned_project_title']=preprocessed_title
```

```
100%|██████████| 50000/50000 [00:01<00:00, 38272.34it/s]
```

1.3 teacher_prefix

In [12]:

```
temp1=data.teacher_prefix.apply(lambda x: str(x).replace('.', ''))
project_data['teacher_prefix']=temp1
project_data['teacher_prefix'].value_counts()
```

Out[12]:

```
Mrs        26140
Ms         17936
Mr          4859
Teacher     1061
nan            2
Dr             2
Name: teacher_prefix, dtype: int64
```

1.4 project grade

In [13]:

```
project_data.project_grade_category.value_counts()
```

Out[13]:

```
Grades PreK-2    20316
Grades 3-5       16968
Grades 6-8        7750
Grades 9-12       4966
Name: project_grade_category, dtype: int64
```

In [14]:

```
grade_list=[]
for i in project_data['project_grade_category'].values:
    i=i.replace(' ','_')
    i=i.replace('-','_')
    grade_list.append(i.strip())
```

```
project_data['project_grade_category']=grade_list
```

In [15]:

```
project_data['project_grade_category'].value_counts()
```

Out[15]:

```
Grades_PreK_2    20316
Grades_3_5       16968
Grades_6_8        7750
Grades_9_12       4966
Name: project_grade_category, dtype: int64
```

1.5 project_subject_categories

In [16]:

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

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

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

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

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

1.6 project_subject_subcategories

In [17]:

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

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

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

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

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

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

1.7 counting words in title

In [18]:

```
#https://stackoverflow.com/questions/49984905/count-number-of-words-per-row
project_data['totalwords_title'] = project_data['cleaned_project_title'].str.split().str.len()
```

1.8 number of words in the essay

In [19]:

```
project_data['totalwords_essay'] = project_data['cleaned_essay'].str.split().str.len()
```

1.9 sentiment score's of each of the essay

In [20]:

```
from vaderSentiment.vaderSentiment import SentimentIntensityAnalyzer
analyser = SentimentIntensityAnalyzer()
neg=[]
compound=[]
pos=[]
neu=[]
for sent in (project_data['cleaned_essay'].values):
    score = analyser.polarity_scores(sent)
    neg.append(score.get('neg'))
    neu.append(score.get('neu'))
    pos.append(score.get('pos'))
    compound.append(score.get('compound'))
project_data['neg']=neg
project_data['neu']=neu
project_data['pos']=pos
project_data['compound']=compound
```

1.10 droping unnecesarry columns

In [21]:

```
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
```

In [22]:

```
project_data.head(3)
```

Out[22]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	2016-12-05 13:43:57	Grades_PreK_2	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	2016-10-25 09:22:10	Grades_6_8	pr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms	AZ	2016-08-31 12:03:56	Grades_6_8	

3 rows × 23 columns

1.11 Making dependant(label) and independant variables

In [23]:

```
y = project_data['project_is_approved'].values

project_data.head(1)
x=project_data
x.head(3)
```

Out[23]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	pr
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs	IN	2016-12-05 13:43:57	Grades_PreK_2	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr	FL	2016-10-25 09:22:10	Grades_6_8	pr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms	AZ	2016-08-31 12:03:56	Grades_6_8	

3 rows × 23 columns

1.12 Traing and Test split

In [25]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(x, y, test_size=0.33, stratify=y,random_state=42)

#X_train, X_cv, Y_train, Y_cv = train_test_split(X_train,Y_train, test_size=0.33, stratify=Y_train,rando
```

2.Text Vectorization and encoding catagories,normalization numerical features

2.1 converting the essay to vectors using BOW

In [28]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['cleaned_essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['cleaned_essay'].values)
#X_cv_essay_bow = vectorizer.transform(X_cv['cleaned_essay'].values)
X_test_essay_bow = vectorizer.transform(X_test['cleaned_essay'].values)

print("After vectorizations")
print(X_train_essay_bow.shape, Y_train.shape)
print(X_test_essay_bow.shape, Y_test.shape)
print(X_cv_essay_bow.shape, Y_cv.shape)
print("="*100)
```

```
After vectorizations
(22445, 5000) (22445,)
(16500, 5000) (16500,)
(11055, 5000) (11055,)
====================================================================================================
```

2.2 converting the title to vectors using BOW

In [29]:

```
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['cleaned_project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['cleaned_project_title'].values)
#X_cv_title_bow = vectorizer.transform(X_cv['cleaned_project_title'].values)
X_test_title_bow = vectorizer.transform(X_test['cleaned_project_title'].values)

print("After vectorizations")
print(X_train_title_bow.shape, Y_train.shape)
print(X_cv_title_bow.shape, Y_cv.shape)
print(X_test_title_bow.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 2004) (22445,)
(11055, 2004) (11055,)
(16500, 2004) (16500,)
====================================================================================================
```

2.3 converting the title to vectors using TFIDF

In [31]:

```
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['cleaned_project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['cleaned_project_title'].values)
#X_cv_title_tfidf = vectorizer.transform(X_cv['cleaned_project_title'].values)
X_test_title_tfidf = vectorizer.transform(X_test['cleaned_project_title'].values)

print("After vectorizations")
print(X_train_title_tfidf.shape, Y_train.shape)
print(X_cv_title_tfidf.shape, Y_cv.shape)
print(X_test_title_tfidf.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1229) (22445,)
(11055, 1229) (11055,)
(16500, 1229) (16500,)
====================================================================================================
```

2.4 converting the essay to vectors using TFIDF

In [32]:

```
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['cleaned_essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer.transform(X_train['cleaned_essay'].values)
#X_cv_essay_tfidf = vectorizer.transform(X_cv['cleaned_essay'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['cleaned_essay'].values)

print("After vectorizations")
print(X_train_essay_tfidf.shape, Y_train.shape)
print(X_cv_essay_tfidf.shape, Y_cv.shape)
print(X_test_essay_tfidf.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 8869) (22445,)
(11055, 8869) (11055,)
(16500, 8869) (16500,)
====================================================================================================
```

2.5 load glove mode

In [33]:

```
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

```
1544it [00:00, 7538.34it/s]
Loading Glove Model
1917495it [03:58, 8038.90it/s]
Done. 1917495  words loaded!
```

Out[33]:

```
'Output:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n'
```

In [34]:

```python
words = []
for i in X_train['cleaned_essay'].values:
    words.extend(i.split(' '))

for i in X_train['cleaned_project_title'].values:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

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

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


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

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

```
all the words in the coupus 3499621
the unique words in the coupus 31643
The number of words that are present in both glove vectors and our coupus 29734 ( 93.967 %)
word 2 vec length 29734
```

In [35]:

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

2.6 Avg w2v on essay

In [36]:

```python
Text_avg_w2v_train_essay= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_train_essay.append(vector)

print(len(Text_avg_w2v_train_essay))
print(len(Text_avg_w2v_train_essay[0]))
```

```
100%|██████████| 22445/22445 [00:07<00:00, 3001.38it/s]
22445
300
```

In [37]:

```python
''''Text_avg_w2v_cv_essay= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
```

```
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_cv_essay.append(vector)

print(len(Text_avg_w2v_cv_essay))
print(len(Text_avg_w2v_cv_essay[0]))
```

```
100%|██████████| 11055/11055 [00:03<00:00, 2936.08it/s]
11055
300
```

In [38]:

```
Text_avg_w2v_test_essay= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_test_essay.append(vector)

print(len(Text_avg_w2v_test_essay))
print(len(Text_avg_w2v_test_essay[0]))
```

```
100%|██████████| 16500/16500 [00:05<00:00, 3068.97it/s]
16500
300
```

In [ ]:

2.7 Avg w2v on title

In [39]:

```
Text_avg_w2v_train_title= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_train_title.append(vector)

print(len(Text_avg_w2v_train_title))
print(len(Text_avg_w2v_train_title[0]))
```

```
100%|██████████| 22445/22445 [00:00<00:00, 64112.56it/s]
22445
300
```

In [40]:

```
'''''Text_avg_w2v_cv_title= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_cv_title.append(vector)

print(len(Text_avg_w2v_cv_title))
print(len(Text_avg_w2v_cv_title[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 62313.07it/s]
11055
300
```

In [41]:

```
Text_avg_w2v_test_title= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
```

```
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    Text_avg_w2v_test_title.append(vector)

print(len(Text_avg_w2v_test_title))
print(len(Text_avg_w2v_test_title[0]))
```

```
100%|██████████| 16500/16500 [00:00<00:00, 63445.37it/s]
16500
300
```

2.4 TFIDF weighted W2V on essay

In [47]:

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

In [48]:

```
Text_tfidf_w2v_train_essay= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_train_essay.append(vector)

print(len(Text_tfidf_w2v_train_essay))
print(len(Text_tfidf_w2v_train_essay[0]))
```

```
100%|██████████| 22445/22445 [00:55<00:00, 401.57it/s]
22445
300
```

In [49]:

```
''''Text_tfidf_w2v_cv_essay= []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_cv_essay.append(vector)

print(len(Text_tfidf_w2v_cv_essay))
print(len(Text_tfidf_w2v_cv_essay[0]))
```

```
100%|██████████| 11055/11055 [00:27<00:00, 406.31it/s]
11055
300
```

In [50]:

```
Text_tfidf_w2v_test_essay= [];
for sentence in tqdm(X_test['cleaned_essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
```

```
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_test_essay.append(vector)

print(len(Text_tfidf_w2v_test_essay))
print(len(Text_tfidf_w2v_test_essay[0]))
```

```
100%|██████████| 16500/16500 [00:40<00:00, 411.46it/s]
16500
300
```

2.5 TFIDF weighted W2V on title

In [51]:

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

In [52]:

```
Text_tfidf_w2v_train_title= [];
for sentence in tqdm(X_train['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_train_title.append(vector)

print(len(Text_tfidf_w2v_train_title))
print(len(Text_tfidf_w2v_train_title[0]))
```

```
100%|██████████| 22445/22445 [00:00<00:00, 28213.44it/s]
22445
300
```

In [53]:

```
'''''Text_tfidf_w2v_cv_title= [];
for sentence in tqdm(X_cv['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_cv_title.append(vector)

print(len(Text_tfidf_w2v_cv_title))
print(len(Text_tfidf_w2v_cv_title[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 29009.32it/s]
11055
300
```

In [54]:

```
Text_tfidf_w2v_test_title= [];
for sentence in tqdm(X_test['cleaned_project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
```

```
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word),
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Text_tfidf_w2v_test_title.append(vector)

print(len(Text_tfidf_w2v_test_title))
print(len(Text_tfidf_w2v_test_title[0]))
```

```
100%|██████████| 16500/16500 [00:00<00:00, 28295.55it/s]
16500
300
```

In [55]:

```
X_train.columns
```

Out[55]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'price', 'quantity', 'essay', 'cleaned_essay', 'cleaned_project_title',
       'clean_categories', 'clean_subcategories', 'totalwords_title',
       'totalwords_essay', 'neg', 'neu', 'pos', 'compound'],
      dtype='object')
```

2.6 Categories with response coding

In [56]:

```
def Responsetable(table, col) :
    cat = table[col].unique()
    alpha=1
    freq_Pos = []
    for i in cat :
        freq_Pos.append(len(table.loc[(table[col] == i) & (table['project_is_approved'] == 1)]))


    freq_Neg = []
    for i in cat :
        freq_Neg.append(len(table.loc[(table[col] == i) & (table['project_is_approved'] == 0)]))


    encoded_Pos = []
    for i in range(len(cat)) :
        encoded_Pos.append(((freq_Pos[i]+alpha)/(freq_Pos[i] + freq_Neg[i]+alpha)))

    encoded_Neg = []
    encoded_Neg[:] = [1 - x for x in encoded_Pos]

    encoded_Pos_val = dict(zip(cat, encoded_Pos))
    encoded_Neg_val = dict(zip(cat, encoded_Neg))

    return encoded_Pos_val, encoded_Neg_val
```

In [57]:

```
def Responsecode(table) :
    pos_cleancat, neg_cleancat = Responsetable(table,'clean_categories')
    pos_cleansubcat, neg_cleansubcat = Responsetable(table,'clean_subcategories')
    pos_schoolstate, neg_schoolstate = Responsetable(table, 'school_state')
    pos_teacherprefix, neg_teacherprefix = Responsetable(table, 'teacher_prefix')
    pos_projgradecat, neg_projgradecat = Responsetable(table, 'project_grade_category')

    df = pd.DataFrame()
    df['clean_cat_pos'] = table['clean_categories'].map(pos_cleancat)
    df['clean_cat_neg'] = table['clean_categories'].map(neg_cleancat)
    df['clean_subcat_pos'] = table['clean_subcategories'].map(pos_cleansubcat)
    df['clean_subcat_neg'] = table['clean_subcategories'].map(neg_cleansubcat)
    df['school_state_pos'] = table['school_state'].map(pos_schoolstate)
    df['school_state_neg'] = table['school_state'].map(neg_schoolstate)
    df['teacher_prefix_pos'] = table['teacher_prefix'].map(pos_teacherprefix)
    df['teacher_prefix_neg'] = table['teacher_prefix'].map(neg_teacherprefix)
    df['proj_grade_cat_pos'] = table['project_grade_category'].map(pos_projgradecat)
    df['proj_grade_cat_neg'] = table['project_grade_category'].map(neg_projgradecat)

    return df
```

In [59]:

```
newTrain = Responsecode(X_train)
newTest = Responsecode(X_test)
#newCv=Responsecode(X_cv)
```

In [60]:

```
def mergeEncoding(table, p, n) :
    lstPos = table[p].values.tolist()
    lstNeg = table[n].values.tolist()
    frame = pd.DataFrame(list(zip(lstNeg, lstPos)))

    return frame
```

2.7 response code of clean_categories

In [61]:

```
X_train_clean_cat_resposecode = mergeEncoding(newTrain, 'clean_cat_pos', 'clean_cat_neg')
X_test_clean_cat_resposecode = mergeEncoding(newTest, 'clean_cat_pos', 'clean_cat_neg')
#X_cv_clean_cat_resposecode=mergeEncoding(newCv, 'clean_cat_pos', 'clean_cat_neg')
print(X_train_clean_cat_resposecode.shape)
```

```
(22445, 2)
```

2.8 response code of clean_sub_categories

In [63]:

```
X_train_clean_subcat_resposecode = mergeEncoding(newTrain, 'clean_subcat_pos', 'clean_subcat_neg')
X_test_clean_subcat_resposecode = mergeEncoding(newTest, 'clean_subcat_pos', 'clean_subcat_neg')
#X_cv_clean_subcat_resposecode = mergeEncoding(newCv, 'clean_subcat_pos', 'clean_subcat_neg')
print(X_train_clean_subcat_resposecode.shape)
print(X_test_clean_subcat_resposecode.shape)
#print(X_cv_clean_subcat_resposecode.shape)
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

2.9 response code of project grade

In [64]:

```
X_train_grade_resposecode = mergeEncoding(newTrain, 'proj_grade_cat_pos', 'proj_grade_cat_neg')
X_test_grade_resposecode = mergeEncoding(newTest, 'proj_grade_cat_pos', 'proj_grade_cat_neg')
#X_cv_grade_resposecode = mergeEncoding(newCv, 'proj_grade_cat_pos', 'proj_grade_cat_neg')
print(X_train_grade_resposecode.shape)
print(X_test_grade_resposecode.shape)
#print(X_cv_grade_resposecode.shape)
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

2.10 response code of school state

In [66]:

```
X_train_state_resposecode = mergeEncoding(newTrain, 'school_state_pos', 'school_state_neg')
X_test_state_resposecode = mergeEncoding(newTest, 'school_state_pos', 'school_state_neg')
#X_cv_state_resposecode = mergeEncoding(newCv, 'school_state_pos', 'school_state_neg')
print(X_train_state_resposecode.shape)
print(X_test_state_resposecode.shape)
#print(X_cv_state_resposecode.shape)
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

2.11 response code of teacher prefix

In [65]:

```
X_train_teacher_resposecode = mergeEncoding(newTrain, 'teacher_prefix_pos', 'teacher_prefix_neg')
X_test_teacher_resposecode = mergeEncoding(newTest, 'teacher_prefix_pos', 'teacher_prefix_neg')
#X_cv_teacher_resposecode = mergeEncoding(newCv, 'teacher_prefix_pos', 'teacher_prefix_neg')
print(X_train_teacher_resposecode.shape)
print(X_test_teacher_resposecode.shape)
#print(X_cv_teacher_resposecode.shape)
```

```
(22445, 2)
(16500, 2)
(11055, 2)
```

2.12 Normalizing the numerical features: Price

In [68]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['price'].values.reshape(-1,1))

X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))

X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))

#X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_norm.shape, Y_train.shape)
#print(X_cv_price_norm.shape, Y_cv.shape)
print(X_test_price_norm.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.13 Normalizing the numerical features:teacher_number_of_previously_posted_projects

In [69]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

X_train_TPPP_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.r
#X_cv_TPPP_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.resha
X_test_TPPP_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.res

print("After vectorizations")
print(X_train_TPPP_norm.shape, Y_train.shape)
#print(X_cv_TPPP_norm.shape, Y_cv.shape)
print(X_test_TPPP_norm.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.14 Normalizing the numerical features: quantity

In [70]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['quantity'].values.reshape(-1,1))

X_train_quantity_norm = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
#X_cv_quantity_norm = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quantity_norm = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_quantity_norm.shape, Y_train.shape)
#print(X_cv_quantity_norm.shape, Y_cv.shape)
print(X_test_quantity_norm.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.15 Normalizing the numerical features: totalwords_title

In [71]:

```python
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['totalwords_title'].values.reshape(-1,1))

X_train_totalwords_title_norm = normalizer.transform(X_train['totalwords_title'].values.reshape(-1,1))

X_test_totalwords_title_norm = normalizer.transform(X_test['totalwords_title'].values.reshape(-1,1))
#X_cv_totalwords_title_norm = normalizer.transform(X_cv['totalwords_title'].values.reshape(-1,1))
print("After vectorizations")
print(X_train_totalwords_title_norm.shape, Y_train.shape)
#print(X_cv_totalwords_title_norm.shape, Y_cv.shape)
print(X_test_totalwords_title_norm.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.17 Normalizing the numerical features: totalwords_essay

In [72]:

```python
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['totalwords_essay'].values.reshape(-1,1))

X_train_totalwords_essay_norm = normalizer.transform(X_train['totalwords_essay'].values.reshape(-1,1))
#X_cv_totalwords_essay_norm = normalizer.transform(X_cv['totalwords_essay'].values.reshape(-1,1))
X_test_totalwords_essay_norm = normalizer.transform(X_test['totalwords_essay'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_totalwords_essay_norm.shape, Y_train.shape)
#print(X_cv_totalwords_essay_norm.shape, Y_cv.shape)
print(X_test_totalwords_essay_norm.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

3. Random Forest on BOW

In [76]:

```python
def predict(proba, threshould, fpr, tpr):

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


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

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

In [77]:

```python
def myplot_matrix1(data):
    plt.clf()
    plt.imshow(data, interpolation='nearest', cmap=plt.cm.Wistia)
    classNames = ['Negative','Positive']
    plt.title('Approved not approved matrix')
    tick_marks = np.arange(len(classNames))

    plt.xticks(tick_marks, classNames, rotation=45)
    plt.yticks(tick_marks, classNames)
    s = [['TN','FN'], ['FP', 'TP']]
    for i in range(2):
        for j in range(2):
```

```
            plt.text(j,i, str(s[i][j])+" = "+str(data[i][j]))
    plt.show()
```

3.1 BOW:Concatinating all the features

In [89]:

```
from scipy.sparse import hstack
X_tr_bow = hstack((X_train_essay_bow,X_train_title_bow,X_train_clean_cat_resposecode,X_train_clean_subcat
#X_cr_bow = hstack((X_cv_essay_bow,X_cv_title_bow,X_cv_clean_cat_resposecode,X_cv_clean_subcat_resposeco

X_te_bow = hstack((X_test_essay_bow,X_test_title_bow,X_test_clean_cat_resposecode,X_test_clean_subcat_res

print("Final Data matrix")
print(X_tr_bow.shape, Y_train.shape)
#print(X_cr_bow.shape, Y_cv.shape)
print(X_te_bow.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 7017) (22445,)
(11055, 7017) (11055,)
(16500, 7017) (16500,)
====================================================================================================
```

In [97]:

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier

RF = RandomForestClassifier(class_weight='balanced',min_samples_split=5)
parameters = {'n_estimators': [5, 10, 50, 100, 200, 500, 1000], 'max_depth':[2, 3, 4, 5, 7, 8, 10]}
model = GridSearchCV(RF, parameters, cv=3, scoring='roc_auc',return_train_score=True)
bow= model.fit(X_tr_bow, Y_train)

bow.cv_results_.keys()

print(bow.best_estimator_)
#Mean cross-validated score of the best_estimator
print(bow.score(X_tr_bow,Y_train))
print(bow.score(X_te_bow,Y_test))
```

```
RandomForestClassifier(class_weight='balanced', max_depth=10,
                       min_samples_split=5, n_estimators=1000)
0.8656591637660408
0.6992449154842851
```

In [98]:

```
bow.cv_results_.keys()
```

Out[98]:

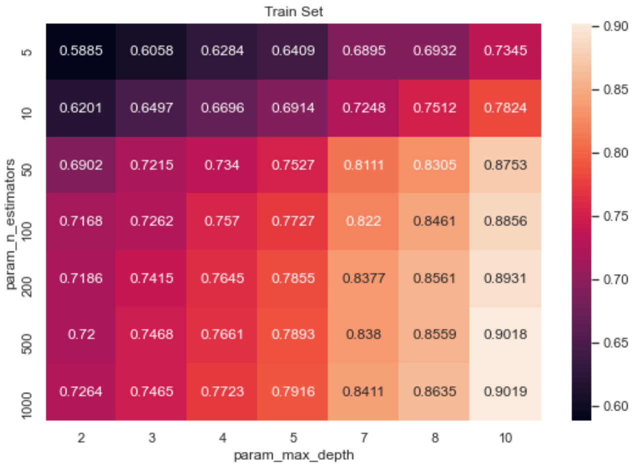
```
dict_keys(['mean_fit_time', 'std_fit_time', 'mean_score_time', 'std_score_time', 'param_max_depth', 'para
m_n_estimators', 'params', 'split0_test_score', 'split1_test_score', 'split2_test_score', 'mean_test_scor
e', 'std_test_score', 'rank_test_score', 'split0_train_score', 'split1_train_score',
'split2_train_score', 'mean_train_score', 'std_train_score'])
```

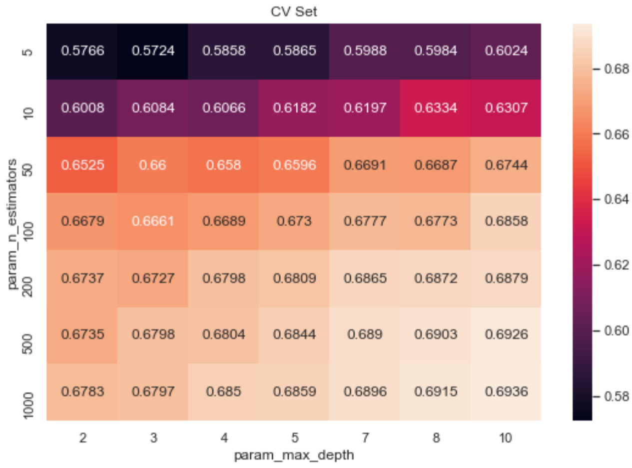
In [104]:

```
best_parameters=[{'n_estimators': [1000], 'max_depth':[10]}]
```

In [102]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(bow.cv_results_).groupby(['param_n_estimators', 'param_max_depth']).max().unst
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```





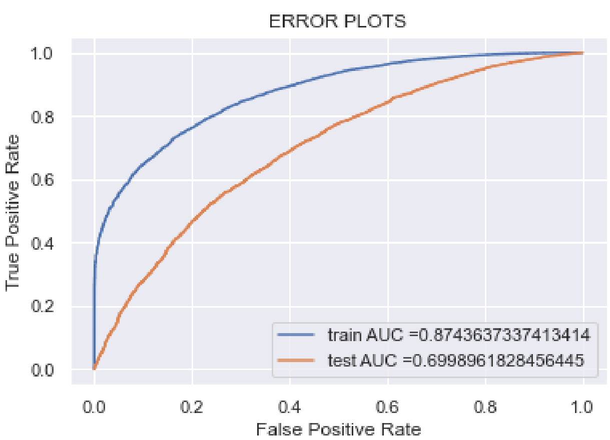
observations

1.Good corelation between max depth 10 and sn_estimators 1000

2.Good corelation between max depth 10 and sample split 1000

In [105]:

```
from sklearn.metrics import roc_curve, auc
clf11 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_parameters)
clf11.fit(X_tr_bow, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = clf11.predict_proba(X_tr_bow) [:,1]
y_test_pred = clf11.predict_proba(X_te_bow) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
```



observation

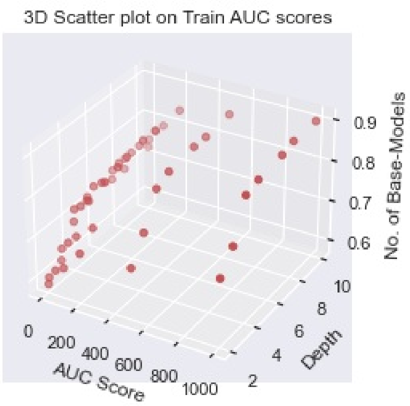
1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [106]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,5,5,10,10,10,10,10,10,10,50,50,50,50,50,50,50,100,100,100,100,100,100,100,200,200,200,2
second = [2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7,
```

```
third = list(bow.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [107]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_bow=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_bow)
print("="*100)
```

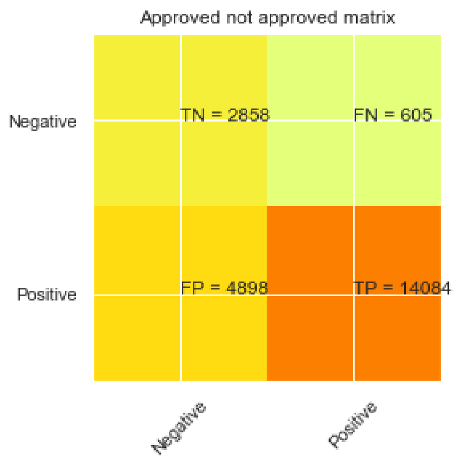
```
====================================================================================================
Train confusion matrix
[[ 2858   605]
 [ 4898 14084]]
====================================================================================================
Accuracy score  for Train
0.7548229004232568
====================================================================================================
Test confusion matrix
[[ 1159  1387]
 [ 2741 11213]]
====================================================================================================
Accuracy score  for Test
0.7498181818181818
====================================================================================================
```

In [108]:

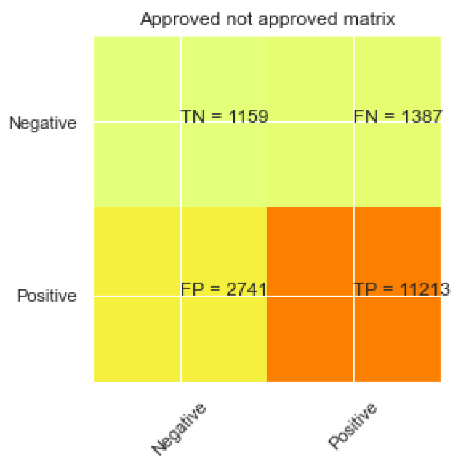
```
print("confusion matrix for train data")
print("="*100)
```

```
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 75% and test data is 74%.

3.2 TFIDF:Concatinating all the features

In [109]:

```
X_tr_tfidf = hstack((X_train_essay_tfidf,X_train_title_tfidf,X_train_clean_cat_resposecode,X_train_clean_

X_te_tfidf = hstack((X_test_essay_tfidf,X_test_title_tfidf,X_test_clean_cat_resposecode,X_test_clean_subc

print("Final Data matrix")
print(X_tr_tfidf.shape, Y_train.shape)

print(X_te_tfidf.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 10111) (22445,)
(16500, 10111) (16500,)
====================================================================================================
```

In [110]:

```
model = RandomForestClassifier(class_weight='balanced',min_samples_split=5)
parameters = {'n_estimators': [5, 10, 50, 100, 200, 500, 1000], 'max_depth':[2, 3, 4, 5, 7, 8, 10]}
clf2 = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
tfidf = clf2.fit(X_tr_tfidf, Y_train)

print(tfidf.best_score_)
print(tfidf.best_estimator_)
```

```
print(tfidf.best_params_)
```

```
0.6949762987674836
RandomForestClassifier(class_weight='balanced', max_depth=8,
                       min_samples_split=5, n_estimators=1000)
{'max_depth': 8, 'n_estimators': 1000}
```

In [111]:

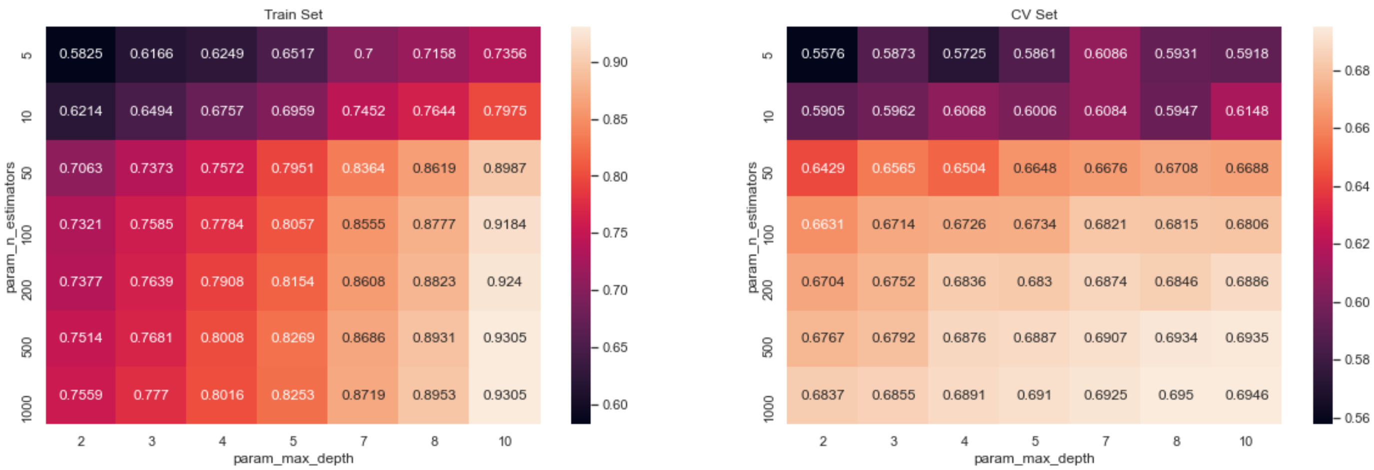
```
clf2.cv_results_.keys()
```

Out[111]:

```
dict_keys(['mean_fit_time', 'std_fit_time', 'mean_score_time', 'std_score_time', 'param_max_depth', 'para
m_n_estimators', 'params', 'split0_test_score', 'split1_test_score', 'split2_test_score', 'mean_test_scor
e', 'std_test_score', 'rank_test_score', 'split0_train_score', 'split1_train_score',
'split2_train_score', 'mean_train_score', 'std_train_score'])
```

In [112]:

```
max_scores1 = pd.DataFrame(clf2.cv_results_).groupby(['param_n_estimators', 'param_max_depth']).max().uns
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



observations

1.Good corelation between max depth 10 and sn_estimators 1000

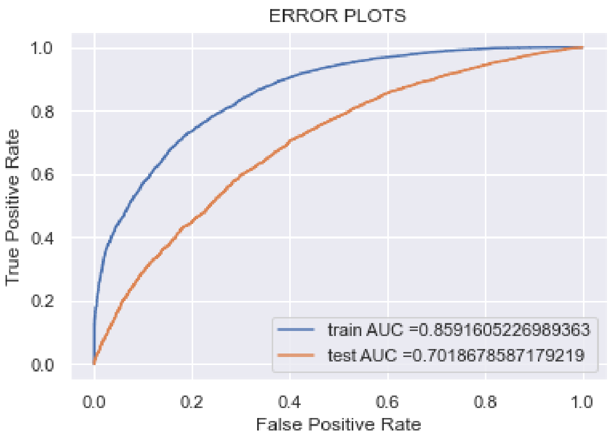
2.Good corelation between max depth 10 and sample split 1000

In [113]:

```
best_parameters=[{'n_estimators': [1000], 'max_depth':[8]}]
```

In [114]:

```
from sklearn.metrics import roc_curve, auc
clf2 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_parameters)
clf2.fit(X_tr_tfidf, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = clf2.predict_proba(X_tr_tfidf) [:,1]
y_test_pred = clf2.predict_proba(X_te_tfidf) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
```



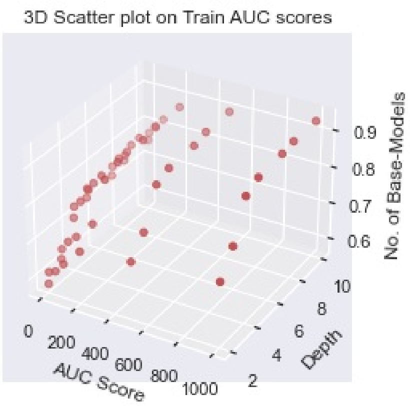
observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [115]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,5,5,10,10,10,10,10,10,10,50,50,50,50,50,50,50,100,100,100,100,100,100,100,200,200,200,2
second = [2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7,
third = list(tfidf.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [116]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
```

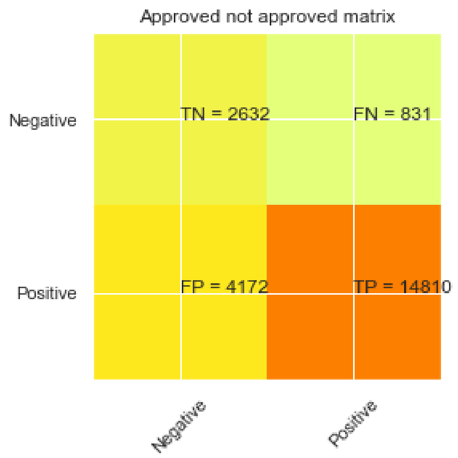
```
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidf=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidf)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2632   831]
 [ 4172 14810]]
====================================================================================================
Accuracy score  for Train
0.7770995767431499
====================================================================================================
Test confusion matrix
[[ 1228  1318]
 [ 2870 11084]]
====================================================================================================
Accuracy score  for Test
0.7461818181818182
====================================================================================================
```

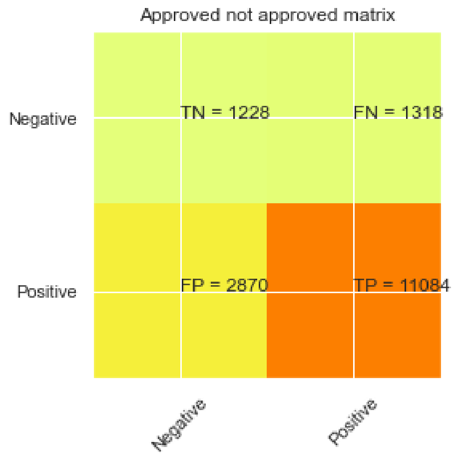
In [117]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 77% and test data is 74%.

3.3 avgw2v:Concatinating all the features

In [118]:

```
X_tr_avgw2v = np.hstack((Text_avg_w2v_train_essay,Text_avg_w2v_train_title,X_train_clean_cat_resposecode,

X_te_avgw2v = np.hstack((Text_avg_w2v_test_essay,Text_avg_w2v_test_title,X_test_clean_cat_resposecode,X_t

print("Final Data matrix")
print(X_tr_avgw2v.shape, Y_train.shape)

print(X_te_avgw2v.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 613) (22445,)
(16500, 613) (16500,)
====================================================================================================
```

In [119]:

```
model = RandomForestClassifier(class_weight='balanced',min_samples_split=5)
parameters = {'n_estimators': [5, 10, 50, 100, 200, 500, 1000], 'max_depth':[2, 3, 4, 5, 7, 8, 10]}
clf1 = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
avgw2v = clf1.fit(X_tr_avgw2v, Y_train)

print(avgw2v.best_score_)
print(avgw2v.best_estimator_)
print(avgw2v.best_params_)
```

```
0.6842236912759052
RandomForestClassifier(class_weight='balanced', max_depth=7,
                       min_samples_split=5, n_estimators=1000)
{'max_depth': 7, 'n_estimators': 1000}
```

In [120]:

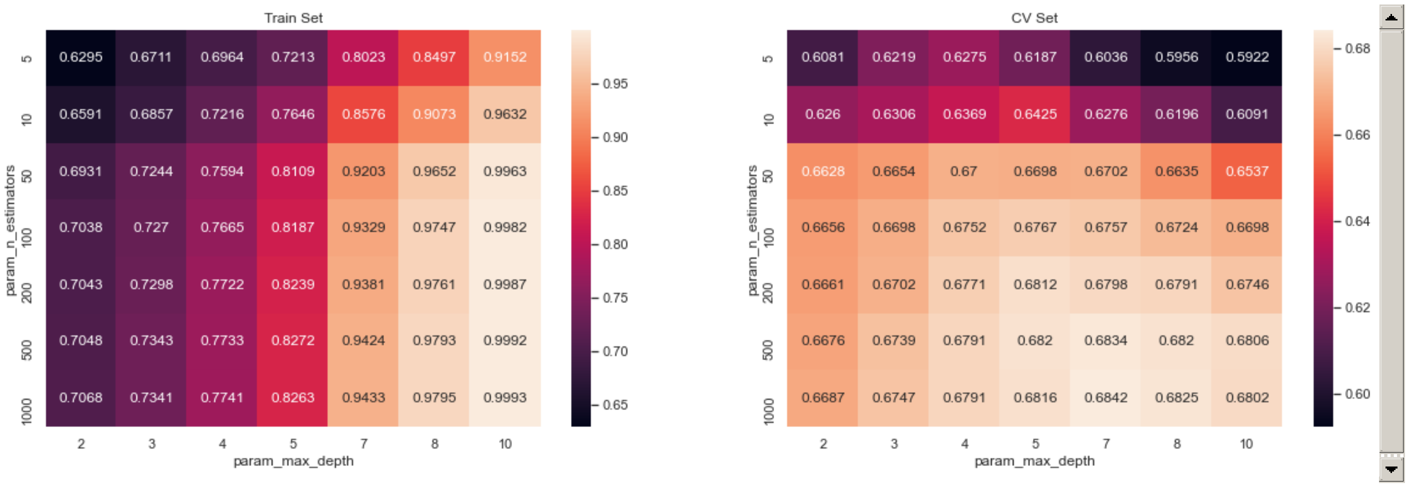
```
clf1.cv_results_.keys()
```

Out[120]:

```
dict_keys(['mean_fit_time', 'std_fit_time', 'mean_score_time', 'std_score_time', 'param_max_depth', 'para
m_n_estimators', 'params', 'split0_test_score', 'split1_test_score', 'split2_test_score', 'mean_test_scor
e', 'std_test_score', 'rank_test_score', 'split0_train_score', 'split1_train_score',
'split2_train_score', 'mean_train_score', 'std_train_score'])
```

In [121]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf1.cv_results_).groupby(['param_n_estimators', 'param_max_depth']).max().uns
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



observations

1.Good corelation between max depth 10 and sn_estimators 1000

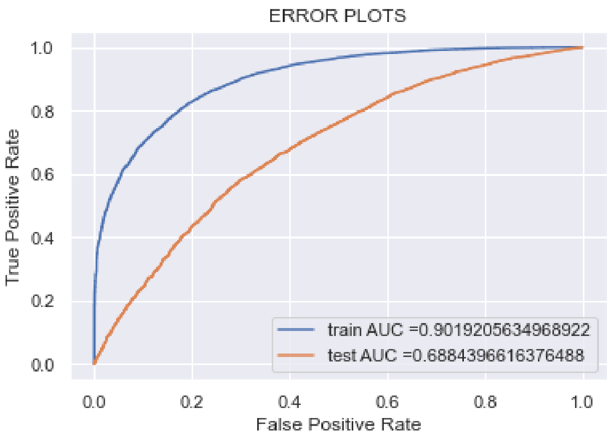
2.Good corelation between max depth 7 and sample split 1000

In [124]:

```
best_parameters=[{'n_estimators': [1000], 'max_depth':[7]}]
```

In [125]:

```
from sklearn.metrics import roc_curve, auc
clf2 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_parameters)
clf2.fit(X_tr_avgw2v, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = clf2.predict_proba(X_tr_avgw2v) [:,1]
y_test_pred = clf2.predict_proba(X_te_avgw2v) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
```



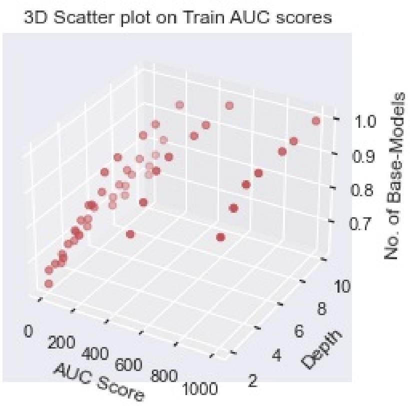
observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [126]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,5,5,10,10,10,10,10,10,10,50,50,50,50,50,50,50,100,100,100,100,100,100,100,200,200,200,2
second = [2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7,
third = list(avgw2v.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [127]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
```

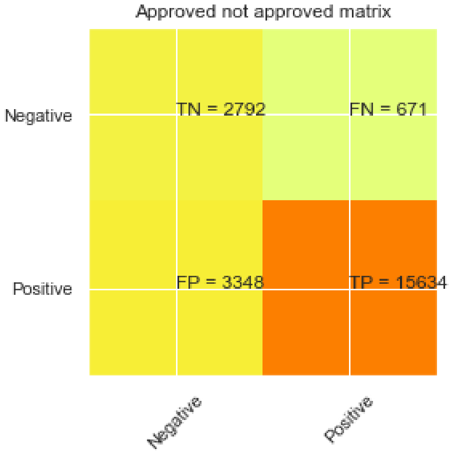
```
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidf=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidf)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2792   671]
 [ 3348 15634]]
====================================================================================================
Accuracy score  for Train
0.8209400757406995
====================================================================================================
Test confusion matrix
[[  988  1558]
 [ 2070 11884]]
====================================================================================================
Accuracy score  for Test
0.7801212121212121
====================================================================================================
```

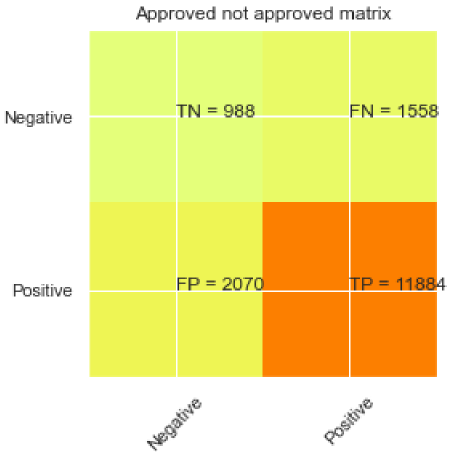
In [128]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 82% and test data is 78%.

3.4 TFIDFw2v

In [129]:

```
X_tr_tfidfw2v = np.hstack((Text_tfidf_w2v_train_essay,Text_tfidf_w2v_train_title,X_train_clean_cat_respos

X_te_tfidfw2v = np.hstack((Text_tfidf_w2v_test_essay,Text_tfidf_w2v_test_title,X_test_clean_cat_resposecc

print("Final Data matrix")
print(X_tr_tfidfw2v.shape, Y_train.shape)

print(X_te_tfidfw2v.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
(22445, 613) (22445,)
(16500, 613) (16500,)
====================================================================================================
```

In [130]:

```
model = RandomForestClassifier(class_weight='balanced',min_samples_split=5)
parameters = {'n_estimators': [5, 10, 50, 100, 200, 500, 1000], 'max_depth':[2, 3, 4, 5, 7, 8, 10]}
clf3 = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
tfidfw2v = clf3.fit(X_tr_tfidfw2v, Y_train)

print(tfidfw2v.best_score_)
print(tfidfw2v.best_estimator_)
print(tfidfw2v.best_params_)
```

```
0.6787674568567095
RandomForestClassifier(class_weight='balanced', max_depth=7,
                       min_samples_split=5, n_estimators=1000)
{'max_depth': 7, 'n_estimators': 1000}
```

In [131]:

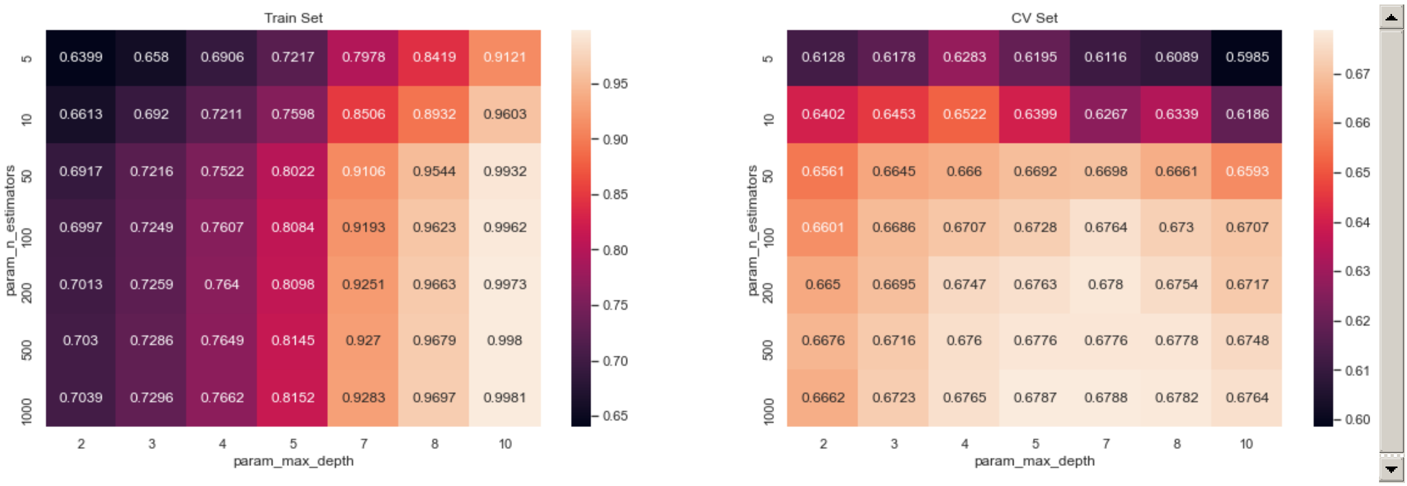
```
clf3.cv_results_.keys()
```

Out[131]:

```
dict_keys(['mean_fit_time', 'std_fit_time', 'mean_score_time', 'std_score_time', 'param_max_depth', 'para
m_n_estimators', 'params', 'split0_test_score', 'split1_test_score', 'split2_test_score', 'mean_test_scor
e', 'std_test_score', 'rank_test_score', 'split0_train_score', 'split1_train_score',
'split2_train_score', 'mean_train_score', 'std_train_score'])
```

In [132]:

```
import seaborn as sns; sns.set()
max_scores1 = pd.DataFrame(clf3.cv_results_).groupby(['param_n_estimators', 'param_max_depth']).max().uns
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



observations

1.Good corelation between max depth 10 and sn_estimators 1000

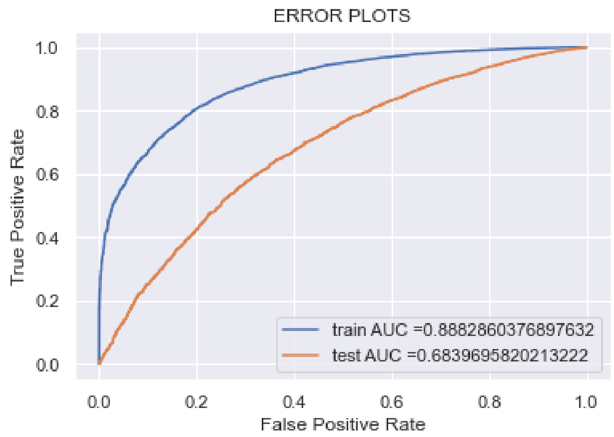
2.Good corelation between max depth 7 and sample split 1000

In [ ]:

```
best_parameters=[{'n_estimators': [1000], 'max_depth':[7]}]
```

In [133]:

```
from sklearn.metrics import roc_curve, auc
clf2 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_parameters)
clf2.fit(X_tr_tfidfw2v, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = clf2.predict_proba(X_tr_tfidfw2v) [:,1]
y_test_pred = clf2.predict_proba(X_te_tfidfw2v) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
```



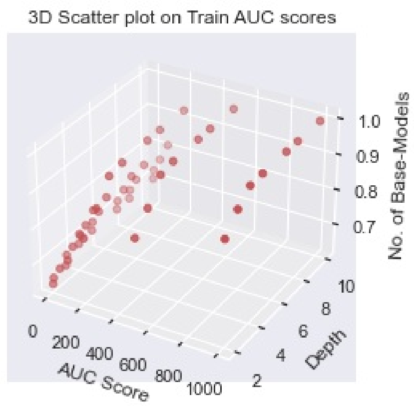
observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [134]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,5,5,10,10,10,10,10,10,10,50,50,50,50,50,50,50,100,100,100,100,100,100,100,200,200,200,2
second = [2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7, 8, 10,2, 3, 4, 5, 7,
third = list(tfidfw2v.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [135]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
```

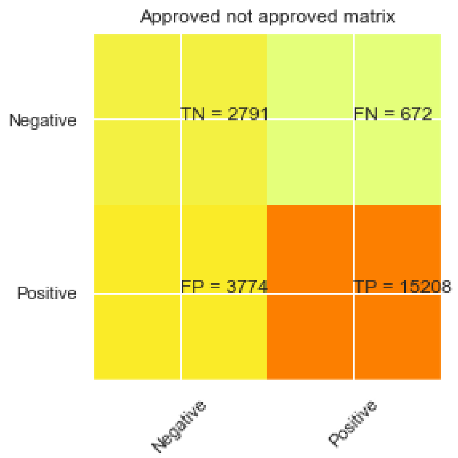
```
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidfw2v=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidfw2v)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2791   672]
 [ 3774 15208]]
====================================================================================================
Accuracy score  for Train
0.8019157941635108
====================================================================================================
Test confusion matrix
[[ 1045  1501]
 [ 2435 11519]]
====================================================================================================
Accuracy score  for Test
0.7614545454545455
====================================================================================================
```

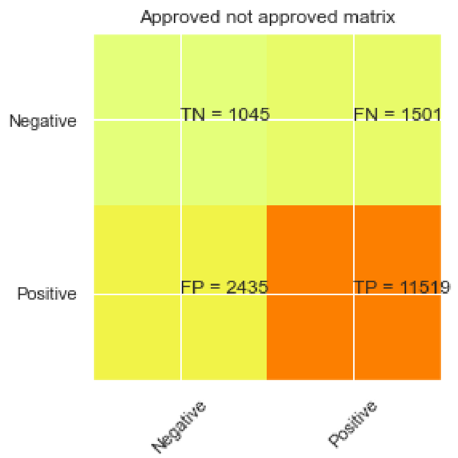
In [136]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
===========================================================================================
```




```
confusion matrix for Test data
===========================================================================================
```



observations

1.TN and TP of train data and test data is higher.

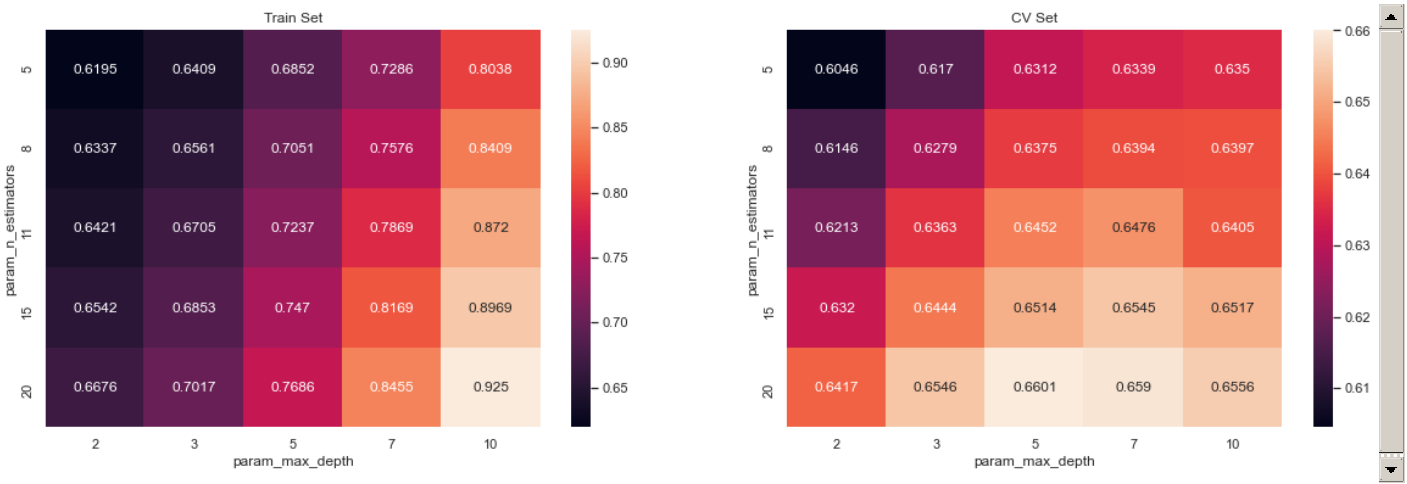
2.Accuracy score on train data is 80% and test data is 76%.

4.GBDT on all vectors.

4.1 GBDT on Bow

In [137]:

```
from sklearn.ensemble import GradientBoostingClassifier

model = GradientBoostingClassifier(min_samples_split=15)
parameters = {'n_estimators': [5, 8,11,15,20], 'max_depth':[2, 3, 5, 7, 10] }
bow_gbdt = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
bow_gbdt .fit(X_tr_bow, Y_train)



max_scores1 = pd.DataFrame(bow_gbdt .cv_results_).groupby(['param_n_estimators', 'param_max_depth']).max(
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



observations

1.Good corelation between max depth 10 and sn_estimators 20

2.Good corelation between max depth 5 and sample split 20

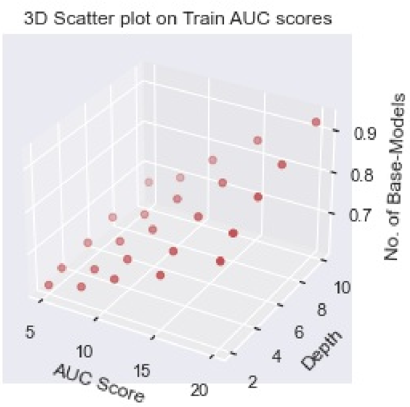
In [140]:

```
print(bow_gbdt.best_estimator_)
#Mean cross-validated score of the best_estimator
print(bow_gbdt.score(X_tr_bow,Y_train))
print(bow_gbdt.score(X_te_bow,Y_test))
```

```
GradientBoostingClassifier(max_depth=5, min_samples_split=15, n_estimators=20)
0.7534518468535307
0.6739213464372502
```

In [146]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,8,8,8,8,8,11,11,11,11,11,15,15,15,15,15,20,20,20,20,20]
second = [2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10]
third = list(bow_gbdt.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```

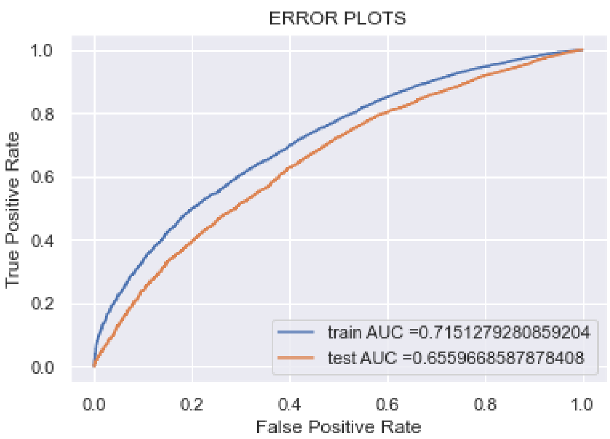


In [166]:

```
best_tune_parameters=[{'n_estimators': [20], 'max_depth':[5] } ]
```

In [167]:

```
model1 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_tune_parameters)
model1.fit(X_tr_bow, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = model1.predict_proba(X_tr_bow) [:,1]
y_test_pred = model1.predict_proba(X_te_bow) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [168]:

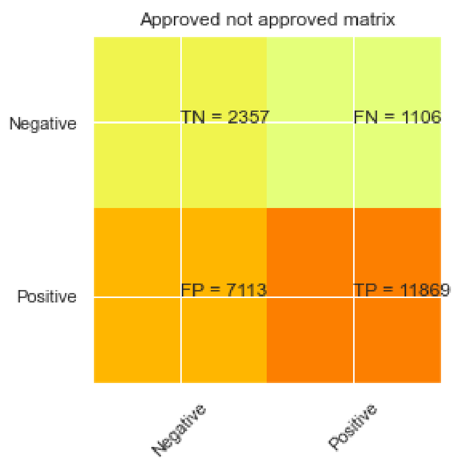
```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidfw2v=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidfw2v)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2357  1106]
 [ 7113 11869]]
====================================================================================================
Accuracy score  for Train
0.6338159946535977
====================================================================================================
Test confusion matrix
[[1660  886]
 [6135 7819]]
====================================================================================================
Accuracy score  for Test
0.5744848484848485
====================================================================================================
```

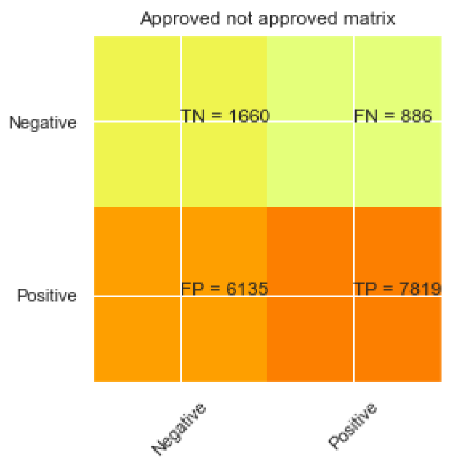
In [169]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

1.TN and TP of train data and test data is higher.

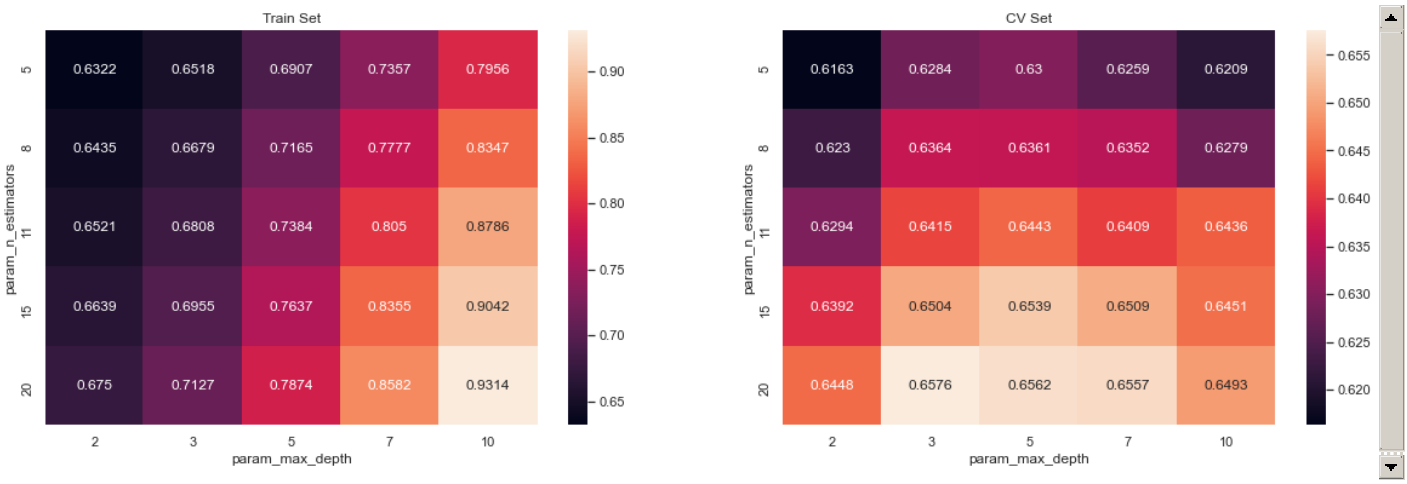
2.Accuracy score on train data is 63% and test data is 57%.

4.2 GBDT on TFIDF

In [149]:

```
from sklearn.ensemble import GradientBoostingClassifier

model = GradientBoostingClassifier(min_samples_split=15)
```

```
parameters = {'n_estimators': [5, 8,11,15,20], 'max_depth':[2, 3, 5, 7, 10] }
tfidf_gbdt = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
tfidf_gbdt .fit(X_tr_tfidf, Y_train)



max_scores1 = pd.DataFrame(tfidf_gbdt .cv_results_).groupby(['param_n_estimators', 'param_max_depth']).ma
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



observations

1.Good corelation between max depth 20 and sn_estimators 10

2.Good corelation between max depth 20 and sample split 5

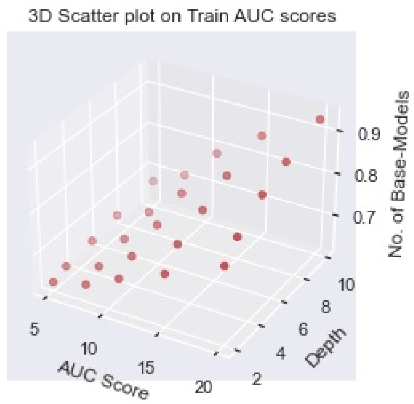
In [155]:

```
print(tfidf_gbdt.best_estimator_)
#Mean cross-validated score of the best_estimator
print(tfidf_gbdt.score(X_tr_tfidf,Y_train))
print(tfidf_gbdt.score(X_te_tfidf,Y_test))
```

```
GradientBoostingClassifier(min_samples_split=15, n_estimators=20)
0.6978973392821376
0.6666342170622113
```

In [152]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,8,8,8,8,8,11,11,11,11,11,15,15,15,15,15,20,20,20,20,20]
second = [2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10]
third = list(tfidf_gbdt.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```

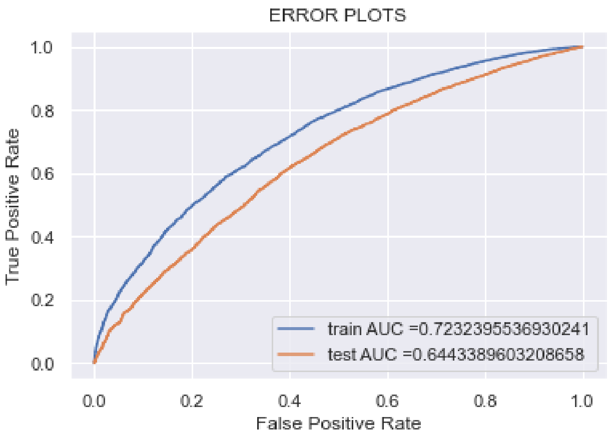


In [170]:

```
best_tune_parameters=[{'n_estimators': [20], 'max_depth':[5] } ]
```

In [171]:

```
model1 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_tune_parameters)
model1.fit(X_tr_tfidf, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = model1.predict_proba(X_tr_tfidf) [:,1]
y_test_pred = model1.predict_proba(X_te_tfidf) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [172]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
```

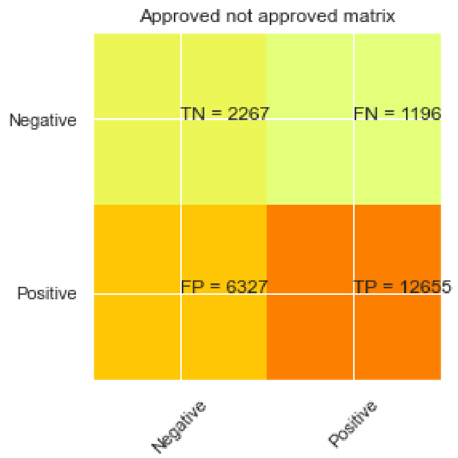
```
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidfw2v=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidfw2v)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2267  1196]
 [ 6327 12655]]
====================================================================================================
Accuracy score  for Train
0.6648251280908888
====================================================================================================
Test confusion matrix
[[1639  907]
 [6057 7897]]
====================================================================================================
Accuracy score  for Test
0.577939393939394
====================================================================================================
```

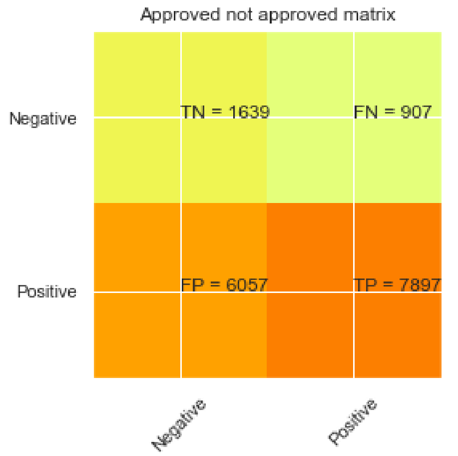
In [173]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

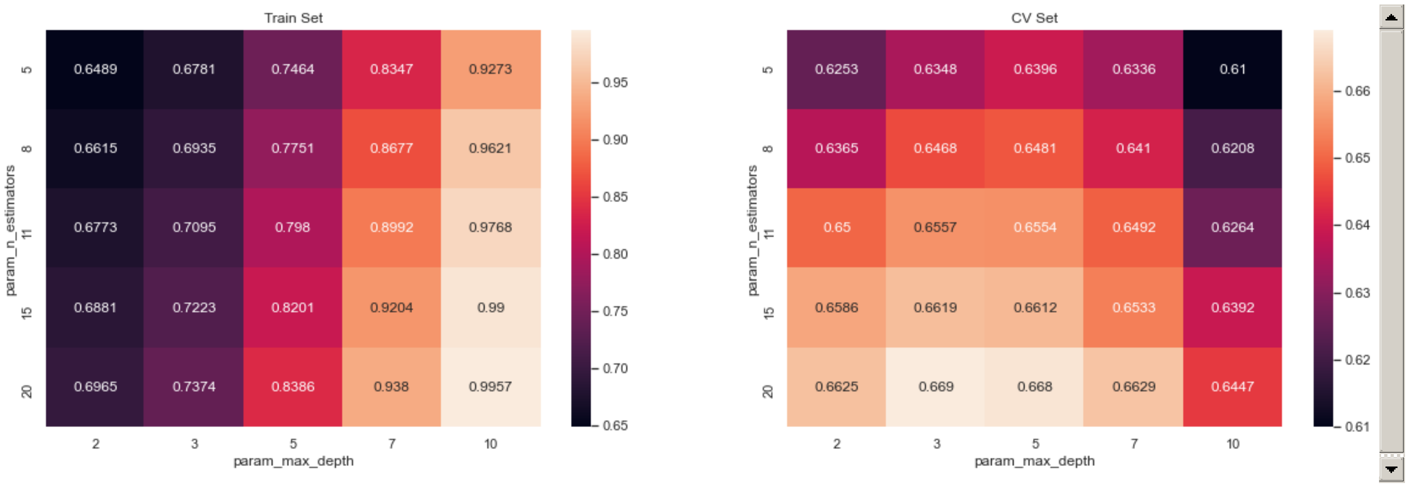
1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 66% and test data is 57%.

4.3 GBDT on avgw2v

In [162]:

```
from sklearn.ensemble import GradientBoostingClassifier

model = GradientBoostingClassifier(min_samples_split=15)
parameters = {'n_estimators': [5, 8,11,15,20], 'max_depth':[2, 3, 5, 7, 10] }
avgw2v_gbdt = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
avgw2v_gbdt .fit(X_tr_avgw2v, Y_train)



max_scores1 = pd.DataFrame(avgw2v_gbdt .cv_results_).groupby(['param_n_estimators', 'param_max_depth']).m
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



param_n_estimators \ param_max_depth (Train Set)	2	3	5	7	10
5	0.6489	0.6781	0.7464	0.8347	0.9273
8	0.6615	0.6935	0.7751	0.8677	0.9621
11	0.6773	0.7095	0.798	0.8992	0.9768
15	0.6881	0.7223	0.8201	0.9204	0.99
20	0.6965	0.7374	0.8386	0.938	0.9957

param_n_estimators \ param_max_depth (CV Set)	2	3	5	7	10
5	0.6253	0.6348	0.6396	0.6336	0.61
8	0.6365	0.6468	0.6481	0.641	0.6208
11	0.65	0.6557	0.6554	0.6492	0.6264
15	0.6586	0.6619	0.6612	0.6533	0.6392
20	0.6625	0.669	0.668	0.6629	0.6447

observations

1.Good corelation between max depth 10 and sn_estimators 20

2.Good corelation between max depth 5 and sample split 20

In [163]:

```
print(avgw2v_gbdt.best_estimator_)
#Mean cross-validated score of the best_estimator
print(avgw2v_gbdt.score(X_tr_avgw2v,Y_train))
print(avgw2v_gbdt.score(X_te_avgw2v,Y_test))
```

```
GradientBoostingClassifier(min_samples_split=15, n_estimators=20)
0.7201905003974616
0.6719697961690083
```

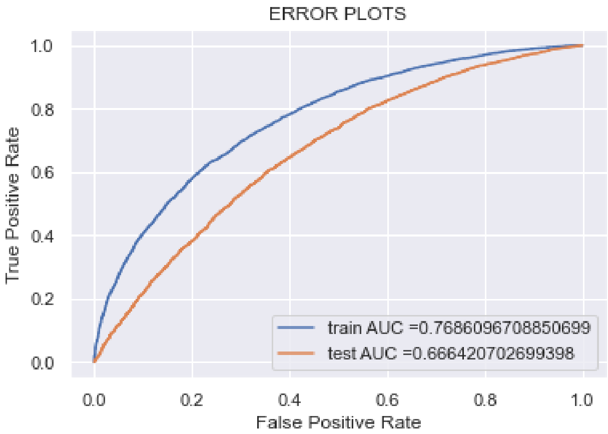
In [174]:

```
best_tune_parameters=[{'n_estimators': [20], 'max_depth':[5] } ]
```

In [176]:

```
model1 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_tune_parameters)
model1.fit(X_tr_avgw2v, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = model1.predict_proba(X_tr_avgw2v) [:,1]
y_test_pred = model1.predict_proba(X_te_avgw2v) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
```

```
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



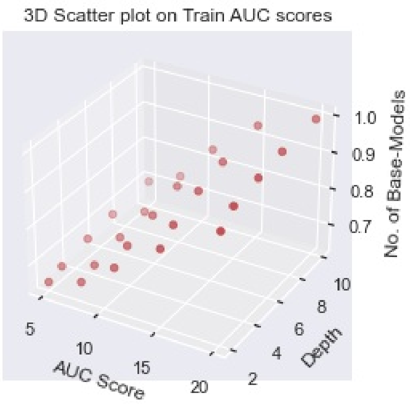
observations

1.By looking ROC curve of Training FPR and TPR it looks sensible as it is greater than diagonal line

2.By looking ROC curve of Test FPR and TPR is sensible .Model is generalize model

In [179]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,8,8,8,8,8,11,11,11,11,11,15,15,15,15,15,20,20,20,20,20]
second = [2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10]
third = list(avgw2v_gbdt.cv_results_['mean_train_score'])



ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [180]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthreshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthreshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthreshold,labels=[0, 1])
```

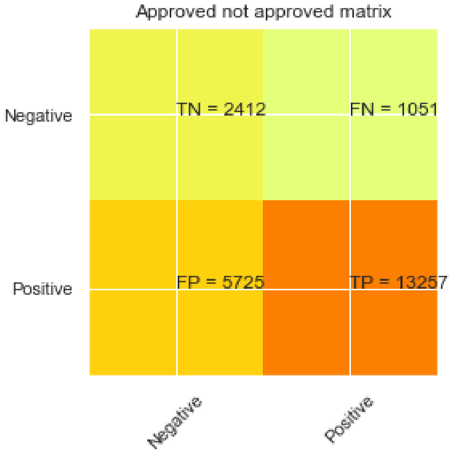
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidfw2v=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidfw2v)
print("="*100)
```

```
====================================================================================================
Train confusion matrix
[[ 2412  1051]
 [ 5725 13257]]
====================================================================================================
Accuracy score  for Train
0.698106482512809
====================================================================================================
Test confusion matrix
[[1566  980]
 [5162 8792]]
====================================================================================================
Accuracy score  for Test
0.6277575757575757
====================================================================================================
```

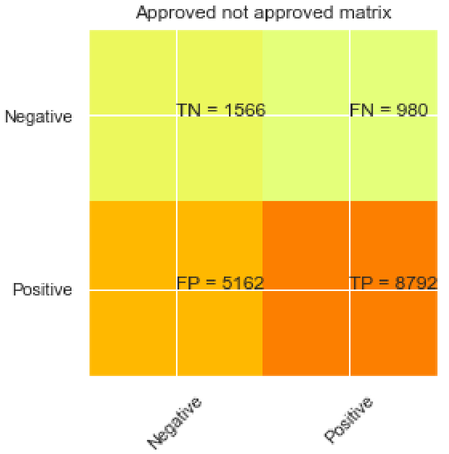
In [181]:

```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
==========================================================================================
```




```
confusion matrix for Test data
==========================================================================================
```



observations

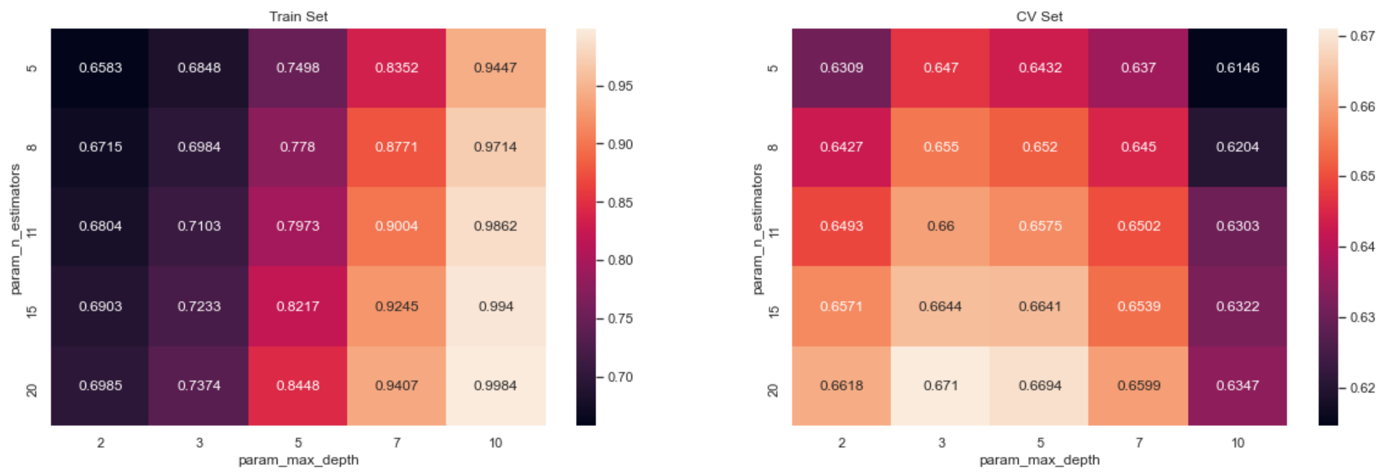
1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 69% and test data is 62%.

4.4 TFIDFW2v

In [182]:

```
from sklearn.ensemble import GradientBoostingClassifier

model = GradientBoostingClassifier(min_samples_split=15)
parameters = {'n_estimators': [5, 8,11,15,20], 'max_depth':[2, 3, 5, 7, 10] }
tfidfw2v_gbdt = GridSearchCV(model, parameters, cv=3, scoring='roc_auc',return_train_score=True)
tfidfw2v_gbdt .fit(X_tr_tfidfw2v, Y_train)



max_scores1 = pd.DataFrame(tfidfw2v_gbdt .cv_results_).groupby(['param_n_estimators', 'param_max_depth'])
fig, ax = plt.subplots(1,2, figsize=(20,6))
sns.heatmap(max_scores1.mean_train_score, annot = True, fmt='.4g', ax=ax[0])
sns.heatmap(max_scores1.mean_test_score, annot = True, fmt='.4g', ax=ax[1])
ax[0].set_title('Train Set')
ax[1].set_title('CV Set')
plt.show()
```



In [185]:

```
print(tfidfw2v_gbdt.best_estimator_)
#Mean cross-validated score of the best_estimator
print(tfidfw2v_gbdt.score(X_tr_tfidfw2v,Y_train))
print(tfidfw2v_gbdt.score(X_te_tfidfw2v,Y_test))
```

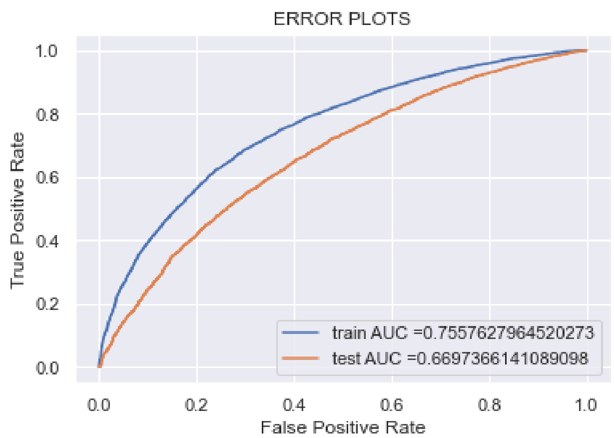
```
GradientBoostingClassifier(min_samples_split=15, n_estimators=20)
0.7207962462302615
0.6732162043820111
```

In [186]:

```
best_tune_parameters=[{'n_estimators': [20], 'max_depth':[5] } ]
```

In [187]:

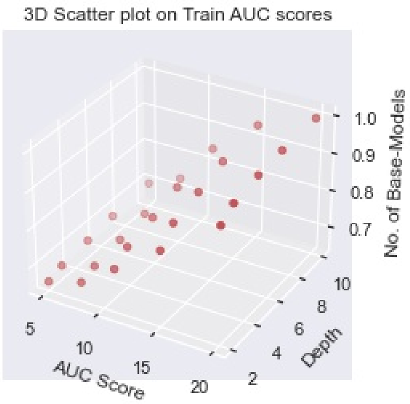
```
model1 = GridSearchCV(RandomForestClassifier(class_weight='balanced'),best_tune_parameters)
model1.fit(X_tr_tfidfw2v, Y_train)
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
#sklearn.linear_model.SGDClassifier.decision_function
y_train_pred = model1.predict_proba(X_tr_tfidfw2v) [:,1]
y_test_pred = model1.predict_proba(X_te_tfidfw2v) [:,1]
train_fpr, train_tpr, tr_thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(Y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



In [192]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt



fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

first = [5,5,5,5,5,8,8,8,8,8,11,11,11,11,11,15,15,15,15,15,20,20,20,20,20]
second = [2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10,2,3,5,7,10]
third = list(tfidfw2v_gbdt .cv_results_['mean_train_score'])
```

```
ax.scatter(first,second,third, c='r', marker='o')

ax.set_zlabel('No. of Base-Models')
ax.set_ylabel('Depth')
ax.set_xlabel('AUC Score')

plt.title('3D Scatter plot on Train AUC scores')
plt.show()
```



In [193]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

y_train_predicted_withthroshold=predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)
y_test_predicted_withthroshold=predict(y_test_pred, tr_thresholds, test_fpr, test_tpr)

cm_train=confusion_matrix(Y_train,y_train_predicted_withthroshold,labels=[0, 1])



print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(cm_train)
print("="*100)
print("Accuracy score  for Train")
print(accuracy_score(Y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*100)

cm_test=confusion_matrix(Y_test,y_test_predicted_withthroshold,labels=[0, 1])

print("Test confusion matrix")
print(cm_test)
print("="*100)
print("Accuracy score  for Test")
accuracy_score_tfidfw2v=accuracy_score(Y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_tpr))
print(accuracy_score_tfidfw2v)
print("="*100)
```

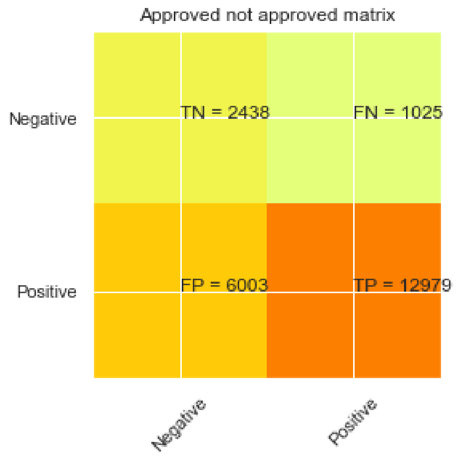
```
====================================================================================================
Train confusion matrix
[[ 2438  1025]
 [ 6003 12979]]
====================================================================================================
Accuracy score  for Train
0.686879037647583
====================================================================================================
Test confusion matrix
[[1500 1046]
 [4773 9181]]
====================================================================================================
Accuracy score  for Test
0.6473333333333333
====================================================================================================
```

In [194]:

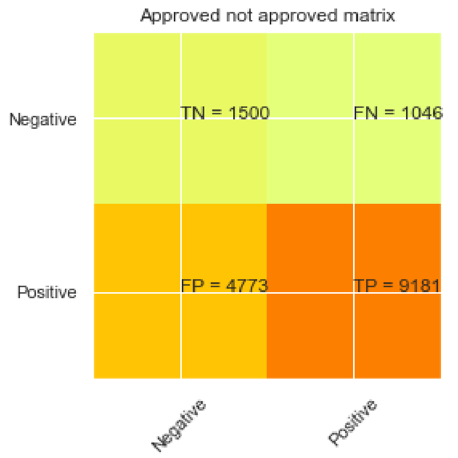
```
print("confusion matrix for train data")
print("="*100)
myplot_matrix1(cm_train)
```

```
print("confusion matrix for Test data")

print("="*100)
myplot_matrix1(cm_test)
```

```
confusion matrix for train data
====================================================================================================
```




```
confusion matrix for Test data
====================================================================================================
```



observations

1.TN and TP of train data and test data is higher.

2.Accuracy score on train data is 68% and test data is 64%

5.Performance

In [183]:

```
from prettytable import PrettyTable
tb = PrettyTable()
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= (" Model ", " Vectorizer ", " n_estimators", " max_depth "," Test -AUC")
tb.add_row([ "Random Forest", " BOW ", 1000,10, 69 ])
tb.add_row([ "Random Forest", " Tf - Idf",1000, 8, 70.3 ])
tb.add_row([ "Random Forest", " AVG-W2V", 1000, 7 , 68 ])
tb.add_row([ "Random Forest", " A VG-TfIdf",1000 , 7 , 68.2 ])
tb.add_row([ "Gradient Boosting DT", " Bow ",20 , 5 , 65 ])
tb.add_row([ "Gradient Boosting DT", " Tf-Idf",20 , 5 , 64.2 ])
tb.add_row([ "Gradient Boosting DT", " AVG-W2V", 20 , 5 , 66])
tb.add_row([ "Gradient Boosting DT", "A VG-TfIdf", 20 , 5 , 67 ])
```

observation

1.Random forest gives best performance for n_estimators=1000 max_depth=8 using TFIDF

2.GBDT gives best performance for n_estimators=20 max_depth=5 using bow