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1 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

How to scale current manual processes and resources to screen 500,000 projects so that they ca
<li>How to increase the consistency of project vetting across different volunteers to improve
<li>How to focus volunteer time on the applications that need the most assistance</li>
</ul>
```

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.

1.1 About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`

`project_title` | Title of the project. **Examples:**
Art Will Make You Happy!
First Grade Fun
`project_grade_category` | Grade level of students for which the project is targeted. One of the following enumerated values:
Grades PreK-2
Grades 3-5
Grades 6-8
Grades 9-12
`project_subject_categories` | One or more (comma-separated) subject categories for the project from the following enumerated list of values:

Applied Learning
Care & Hunger
Health & Sports
History & Civics
Literacy & Language
Math & Science
Music & The Arts
Special Needs
Warmth
Examples:
Music & The Arts
Literacy & Language, Math & Science

`school_state` | State where school is located (Two-letter U.S. postal code). **Example:** `WY`

`project_subject_subcategories` | One or more (comma-separated) subject subcategories for the project. **Examples:**

Literacy
Literature & Writing, Social Sciences

`project_resource_summary` | An explanation of the resources needed for the project. **Example:**

My students need hands on literacy materials to manage sensory needs!

`project_essay_1` | First application essay

`project_essay_2` | *Second application essay* `project_essay_3` | Third application essay ***`project_essay_4`*** | *Fourth application essay* `project_submitted_datetime` | Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`

`teacher_id` | A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`

`teacher_prefix` | Teacher's title. One of the following enumerated values:

nan
Dr.
Mr.
Mrs.
Ms.
Teacher.

`teacher_number_of_previously_posted_projects` | Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

Feature	Description
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

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

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

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

1.1.1 Notes on the Essay Data

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

project_essay_1: "Introduce us to your classroom"

project_essay_2: "Tell us more about your students"

project_essay_3: "Describe how your students will use the materials you're requesting"

project_essay_3: "Close by sharing why your project will make a difference"

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

project_essay_1: "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

project_essay_2: "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

```
In [1]: %matplotlib inline
        import warnings
```

```
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os

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

1.2 1.1 Reading Data

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

```
In [3]: print("Number of data points in train data", project_data.shape)
        print('-'*50)
        print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
```

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

```
In [4]: print("Number of data points in train data", resource_data.shape)
        print(resource_data.columns.values)
        resource_data.head(2)
```

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

Out[4]:

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

```
In [5]: # join two dataframes in python:
        price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_
        price_data.head(2)
        project_data = pd.merge(project_data, price_data, on='id', how='left')
```

```
In [6]: project_data.columns
```

```
Out[6]: 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')
```

1.3 1.2 preprocessing of `project_subject_categories`

```
In [7]: catogories = list(project_data['project_subject_categories'].values)
        # remove special characters from list of strings python: https://stackoverflow.com/a/4

        # https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
        # https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-str
        # https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-pyt
        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", "Warmt
        if 'The' in j.split(): # this will split each of the catogory based on space "
            j=j.replace('The','') # if we have the words "The" we are going to replace
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing sp
        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]))
```

1.4 1.3 preprocessing of `project_subject_subcategories`

In [8]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/4

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

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", "Warmt
        if 'The' in j.split(): # this will split each of the catogory based on space "
            j=j.replace('The','') # if we have the words "The" we are going to replace
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing sp
        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/22898595/408403
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]))
```

1.5 1.3 Text preprocessing

```
In [9]: # merge two column text dataframe:
        project_data["essay"] = project_data["project_essay_1"].map(str) +\
                                project_data["project_essay_2"].map(str) + \
                                project_data["project_essay_3"].map(str) + \
                                project_data["project_essay_4"].map(str)

In [10]: project_data.head(2)

Out[10]:    Unnamed: 0       id                         teacher_id teacher_prefix  \
         0      160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc           Mrs.
         1      140945  p258326  897464ce9ddc600bced1151f324dd63a            Mr.

           school_state project_submitted_datetime project_grade_category  \
         0           IN        2016-12-05 13:43:57          Grades PreK-2
         1           FL        2016-10-25 09:22:10             Grades 6-8

                                          project_title  \
         0  Educational Support for English Learners at Home
         1            Wanted: Projector for Hungry Learners

                                         project_essay_1  \
         0  My students are English learners that are work...
         1  Our students arrive to our school eager to lea...

                                         project_essay_2 project_essay_3  \
         0  \"The limits of your language are the limits o...            NaN
         1  The projector we need for our school is very c...            NaN

           project_essay_4                         project_resource_summary  \
         0             NaN  My students need opportunities to practice beg...
         1             NaN  My students need a projector to help with view...

            teacher_number_of_previously_posted_projects  project_is_approved  price  \
         0                                             0                   0  154.6
         1                                             7                   1  299.0

            quantity             clean_categories           clean_subcategories  \
         0        23            Literacy_Language                   ESL Literacy
         1         1  History_Civics Health_Sports  Civics_Government TeamSports
```

```
                                                   essay
0  My students are English learners that are work...
1  Our students arrive to our school eager to lea...
```

In [11]:
```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [12]:
```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, a
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cogn
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The g
==================================================
```

In [13]:
```
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

```
In [14]: sent = decontracted(project_data['essay'].values[20000])
         print(sent)
         print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogn
==================================================
```

```
In [15]: # \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-p
         sent = sent.replace('\\r', ' ')
         sent = sent.replace('\\"', ' ')
         sent = sent.replace('\\n', ' ')
         print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogn
```

```
In [16]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
         print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cogni
```

```
In [17]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you'r
                     "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him'
                     'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself',
                     'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "t
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'h
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'throug
                     'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'o
                     'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'an
                     'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too
                     's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'n
                     've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't"
                     "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mig
                     "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't",
                     'won', "won't", 'wouldn', "wouldn't"]
```

```
In [18]: # Combining all the above stundents
         from tqdm import tqdm
         preprocessed_essays = []
         # tqdm is for printing the status bar
         for sentance in tqdm(project_data['essay'].values):
             sent = decontracted(sentance)
             sent = sent.replace('\\r', ' ')
```

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

```
100%|| 109248/109248 [00:44<00:00, 2454.19it/s]
```

```
In [19]: # after preprocesing
         preprocessed_essays[20000]
```

```
Out[19]: 'my kindergarten students varied disabilities ranging speech language delays cognitive
```

```
In [20]: project_data["essay"]=preprocessed_essays
```

1.4 Preprocessing of `project_title`

```
In [21]: from tqdm import tqdm
         preprocessed_project_title = []
         # tqdm is for printing the status bar
         for sentance in tqdm(project_data['project_title'].values):
             sent = decontracted(sentance)
             sent = sent.replace('\\r', ' ')
             sent = sent.replace('\\"', ' ')
             sent = sent.replace('\\n', ' ')
             sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
             # https://gist.github.com/sebleier/554280
             sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
             preprocessed_project_title.append(sent.lower().strip())
```

```
100%|| 109248/109248 [00:01<00:00, 55519.62it/s]
```

```
In [22]: print(project_data['project_title'].values[20000])
         project_data['project_title']=preprocessed_project_title
         print(project_data['project_title'].values[20000])
```

```
We Need To Move It While We Input It!
need move input
```

2 Assignment 9: RF and GBDT

Response Coding: Example

The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

```
<li><strong>Apply both Random Forrest and GBDT on these feature sets</strong>
    <ul>
        <li><font color='red'>Set 1</font>: categorical(instead of one hot encoding, try <a hre
        <li><font color='red'>Set 2</font>: categorical(instead of one hot encoding, try <a hre
        <li><font color='red'>Set 3</font>: categorical(instead of one hot encoding, try <a hre
        <li><font color='red'>Set 4</font>: categorical(instead of one hot encoding, try <a hre
</li>
<br>
<li><strong>The hyper paramter tuning (Consider any two hyper parameters preferably n_estimato
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaicou
<li>find the best hyper paramter using k-fold cross validation/simple cross validation data</li
<li>use gridsearch cv or randomsearch cv or you can write your own for loops to do this task</l
    </ul>
</li>
<br>
<li>
<strong>Representation of results</strong>
    <ul>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='3d_plot.JPG' width=500px> with X-axis as <strong>n_estimators</strong>, Y-axis as <st
        <p style="text-align:center;font-size:30px;color:red;"><strong>or</strong></p> <br>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='heat_map.JPG' width=300px> <a href='https://seaborn.pydata.org/generated/seaborn.heat
<li>You can choose either of the plotting techniques: 3d plot or heat map</li>
<li>Once after you found the best hyper parameter, you need to train your model with it, and fi
<img src='train_test_auc.JPG' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.c
<img src='confusion_matrix.png' width=300px></li>
        </ul>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table for
    <img src='summary.JPG' width=400px>
</li>
    </ul>
```

Note: Data Leakage

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

2. Random Forest and GBDT

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

```
In [23]: project_data.columns
```

```
Out[23]: Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
                'project_submitted_datetime', 'project_grade_category', 'project_title',
                'project_essay_1', 'project_essay_2', 'project_essay_3',
                'project_essay_4', 'project_resource_summary',
                'teacher_number_of_previously_posted_projects', 'project_is_approved',
                'price', 'quantity', 'clean_categories', 'clean_subcategories',
                'essay'],
               dtype='object')
```

```
In [24]: sampling=False
         undersampling=True
         if (not sampling):
             print("Total data ",project_data.shape)

         else:
             if(sampling and undersampling):
                 print("Total data ",project_data.shape)
                 project_data_negative=project_data[project_data.project_is_approved==0]
                 project_data_positive=project_data[project_data.project_is_approved==1]
                 project_data_positive=project_data_positive.sample(n=project_data_negative.sha
                 print("Positive points: ",project_data_positive.shape[0])
                 print("Negaitive points: ",project_data_negative.shape[0])
                 project_data=pd.concat([project_data_positive,project_data_negative])
             else:
                 print("Total data ",project_data.shape)
                 project_data_negative=project_data[project_data.project_is_approved==0]
                 project_data_positive=project_data[project_data.project_is_approved==1]
                 project_data_negative=project_data_negative.sample(n=project_data_positive.sha
                 print("Positive points: ",project_data_positive.shape[0])
                 print("Negaitive points: ",project_data_negative.shape[0])
                 project_data=pd.concat([project_data_positive,project_data_negative])

         #data_point_size=50000
         #project_data=project_data.sample(n=data_point_size,random_state=42,replace=True)
         print("positive and negative counts")
         print(project_data.project_is_approved.value_counts())
         project_data_Y=project_data.project_is_approved
         #project_data_X=project_data.drop(columns=['project_is_approved'])
         project_data_X=project_data
         print("After sampling: ",project_data_X.shape)
```

```
Total data  (109248, 20)
positive and negative counts
1    92706
0    16542
```

```
Name: project_is_approved, dtype: int64
After sampling:  (109248, 20)
```

```
In [25]: from sklearn.model_selection import train_test_split
         project_data_X_train,project_data_X_test,project_data_Y_train,project_data_Y_test=tra
```

2.2 Make Data Model Ready: encoding numerical, categorical features

2.2.1 Categorical features

```
In [26]: project_data.columns
```

```
Out[26]: Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
                'project_submitted_datetime', 'project_grade_category', 'project_title',
                'project_essay_1', 'project_essay_2', 'project_essay_3',
                'project_essay_4', 'project_resource_summary',
                'teacher_number_of_previously_posted_projects', 'project_is_approved',
                'price', 'quantity', 'clean_categories', 'clean_subcategories',
                'essay'],
               dtype='object')
```

```
In [27]: #print(project_data_X_train.clean_categories.value_counts())
         counts_positive=[]
         counts_negative=[]
         total_positive=project_data_X_train[project_data_X_train['project_is_approved']==1]
         total_neagtive=project_data_X_train[project_data_X_train['project_is_approved']==0]
         #print("total positive",total_positive.shape)
         #print("total_negative",total_neagtive.shape)
         for i in sorted_cat_dict.keys():
             #print(i)
             df_positive=project_data_X_train[(project_data_X_train['clean_categories'].str.co
             #print(df_positive.shape)
             counts_positive.append(df_positive.shape[0]/total_positive.shape[0])
             df_negaitive=project_data_X_train[(project_data_X_train['clean_categories'].str.c
             #print(df_negaitive.shape)
             counts_negative.append(df_negaitive.shape[0]/total_neagtive.shape[0])

         #print(counts_positive)
         #print(counts_negative)

         def feature_count_positive(x):
             final_value=0
             for i,j in enumerate(sorted_cat_dict.keys()):
                 if x.find(j):
                     final_value+=counts_positive[i]
             return final_value if final_value!=0 else 0.5

         def feature_count_negative(x):
             final_value=0
```

```
            for i,j in enumerate(sorted_cat_dict.keys()):
                if x.find(j):
                    final_value+=counts_negative[i]
            return final_value if final_value!=0 else 0.5

        #process train data
        #for positive response data
        project_data_X_train['response_clean_categories_positive'] = project_data_X_train.clea
        #print(project_data_X_train['response_clean_categories_positive'].shape)
        print(project_data_X_train['response_clean_categories_positive'].head())
        #for negative response data
        project_data_X_train['response_clean_categories_negative'] = project_data_X_train.clea
        #print(project_data_X_train['response_clean_categories_negative'].shape)
        print(project_data_X_train['response_clean_categories_negative'].head())

        #process test data
        #for positive response data
        project_data_X_test['response_clean_categories_positive'] = project_data_X_test.clean_
        #print(project_data_X_test['response_clean_categories_positive'].shape)
        print(project_data_X_test['response_clean_categories_positive'].head())

        #for negative response data
        project_data_X_test['response_clean_categories_negative'] = project_data_X_test.clean_
        #print(project_data_X_test['response_clean_categories_negative'].shape)
        print(project_data_X_test['response_clean_categories_negative'].head())
```

```
23690    1.270318
32874    1.270318
50206    1.024726
47892    0.911665
10398    1.345386
Name: response_clean_categories_positive, dtype: float64
23690    1.249509
32874    1.249509
50206    0.985105
47892    0.957281
10398    1.331544
Name: response_clean_categories_negative, dtype: float64
105447    1.024726
69262     1.277207
55966     1.345386
1860      1.306477
35390     1.024726
Name: response_clean_categories_positive, dtype: float64
105447    0.985105
69262     1.246333
55966     1.331544
1860      1.284364
```

```
35390     0.985105
Name: response_clean_categories_negative, dtype: float64
```

```
In [28]: counts_positive=[]
         counts_negative=[]
         total_positive=project_data_X_train[project_data_X_train['project_is_approved']==1]
         total_neagtive=project_data_X_train[project_data_X_train['project_is_approved']==0]
         #print("total positive",total_positive.shape)
         #print("total_negative",total_neagtive.shape)
         for i in sorted_sub_cat_dict.keys():
             #print(i)
             df_positive=project_data_X_train[(project_data_X_train['clean_subcategories'].str
             #print(df_positive.shape)
             counts_positive.append(df_positive.shape[0]/total_positive.shape[0])
             df_negaitive=project_data_X_train[(project_data_X_train['clean_subcategories'].st
             #print(df_negaitive.shape)
             counts_negative.append(df_negaitive.shape[0]/total_neagtive.shape[0])

         #print(counts_positive)
         #print(counts_negative)

         def feature_count_positive(x):
             final_value=0
             for i,j in enumerate(sorted_sub_cat_dict.keys()):
                 if x.find(j):
                     final_value+=counts_positive[i]
             return final_value if final_value!=0 else 0.5

         def feature_count_negative(x):
             final_value=0
             for i,j in enumerate(sorted_sub_cat_dict.keys()):
                 if x.find(j):
                     final_value+=counts_negative[i]
             return final_value if final_value!=0 else 0.5

         #process train data
         #for positive response data
         project_data_X_train['response_clean_subcategories_positive'] = project_data_X_train.
         print(project_data_X_train['response_clean_subcategories_positive'].shape)
         print(project_data_X_train['response_clean_subcategories_positive'].head())
         #for negative response data
         project_data_X_train['response_clean_subcategories_negative'] = project_data_X_train.
         print(project_data_X_train['response_clean_subcategories_negative'].shape)
         print(project_data_X_train['response_clean_subcategories_negative'].head())

         #process test data
         #for positive response data
```

```
        project_data_X_test['response_clean_subcategories_positive'] = project_data_X_test.cle
        print(project_data_X_test['response_clean_subcategories_positive'].shape)
        print(project_data_X_test['response_clean_subcategories_positive'].head())

        #for negative response data
        project_data_X_test['response_clean_subcategories_negative'] = project_data_X_test.cle
        print(project_data_X_test['response_clean_subcategories_negative'].shape)
        print(project_data_X_test['response_clean_subcategories_negative'].head())
```

```
(87398,)
23690    1.521679
32874    1.521679
50206    1.361538
47892    1.411409
10398    1.587742
Name: response_clean_subcategories_positive, dtype: float64
(87398,)
23690    1.525858
32874    1.525858
50206    1.349841
47892    1.420308
10398    1.583774
Name: response_clean_subcategories_negative, dtype: float64
(21850,)
105447    1.567222
69262     1.494311
55966     1.587742
1860      1.561951
35390     1.567222
Name: response_clean_subcategories_positive, dtype: float64
(21850,)
105447    1.551187
69262     1.474520
55966     1.583774
1860      1.543097
35390     1.551187
Name: response_clean_subcategories_negative, dtype: float64
```

In [29]:
```
project_data_X_train.teacher_prefix = project_data_X_train.teacher_prefix.replace(np.n
print(project_data_X_train.teacher_prefix.value_counts())
project_data_X_test.teacher_prefix = project_data_X_test.teacher_prefix.replace(np.nan
print(project_data_X_test.teacher_prefix.value_counts())
```

```
Mrs.       45800
Ms.        31168
Mr.         8519
Teacher     1898
```

```
Dr.           11
               2
Name: teacher_prefix, dtype: int64
Mrs.       11469
Ms.         7787
Mr.         2129
Teacher      462
Dr.            2
               1
Name: teacher_prefix, dtype: int64
```

```
In [30]: counts_positive=[]
         counts_negative=[]
         total_positive=project_data_X_train[project_data_X_train['project_is_approved']==1]
         total_neagtive=project_data_X_train[project_data_X_train['project_is_approved']==0]
         #print("total positive",total_positive.shape)
         #print("total_negative",total_neagtive.shape)
         for i in ['Mrs.','Ms.','Mr.','Teacher','Dr.']:
             #print(i)
             df_positive=project_data_X_train[(project_data_X_train['teacher_prefix'].str.conta
             #print(df_positive.shape)
             counts_positive.append(df_positive.shape[0]/total_positive.shape[0])
             df_negaitive=project_data_X_train[(project_data_X_train['teacher_prefix'].str.cont
             #print(df_negaitive.shape)
             counts_negative.append(df_negaitive.shape[0]/total_neagtive.shape[0])

         #print(counts_positive)
         #print(counts_negative)

         def feature_count_positive(x):
             final_value=0
             for i,j in enumerate(['Mrs.','Ms.','Mr.','Teacher','Dr.']):
                 if x==j:
                     final_value+=counts_positive[i]
             return final_value if final_value!=0 else 0.5

         def feature_count_negative(x):
             final_value=0
             for i,j in enumerate(['Mrs.','Ms.','Mr.','Teacher','Dr.']):
                 if x==j:
                     final_value+=counts_negative[i]
             return final_value if final_value!=0 else 0.5

         #process train data
         #for positive response data
         project_data_X_train['response_teacher_prefix_positive'] = project_data_X_train.teache
         #print(project_data_X_train['response_teacher_prefix_positive'].shape)
```

```
        print(project_data_X_train['response_teacher_prefix_positive'].head())
        #for negative response data
        project_data_X_train['response_teacher_prefix_negative'] = project_data_X_train.teache
        #print(project_data_X_train['response_teacher_prefix_negative'].shape)
        print(project_data_X_train['response_teacher_prefix_negative'].head())

        #process test data
        #for positive response data
        project_data_X_test['response_teacher_prefix_positive'] = project_data_X_test.teacher_
        #print(project_data_X_test['response_teacher_prefix_positive'].shape)
        print(project_data_X_test['response_teacher_prefix_positive'].head())

        #for negative response data
        project_data_X_test['response_teacher_prefix_negative'] = project_data_X_test.teacher_
        #print(project_data_X_test['response_teacher_prefix_negative'].shape)
        print(project_data_X_test['response_teacher_prefix_negative'].head())
```

```
23690    0.528488
32874    0.528488
50206    0.354568
47892    0.354568
10398    0.528488
Name: response_teacher_prefix_positive, dtype: float64
23690    0.499093
32874    0.499093
50206    0.368139
47892    0.368139
10398    0.499093
Name: response_teacher_prefix_negative, dtype: float64
105447    0.020277
69262     0.528488
55966     0.354568
1860      0.528488
35390     0.354568
Name: response_teacher_prefix_positive, dtype: float64
105447    0.029790
69262     0.499093
55966     0.368139
1860      0.499093
35390     0.368139
Name: response_teacher_prefix_negative, dtype: float64
```

```
In [31]: vocabulary=list(project_data_X_train['project_grade_category'].unique())
         counts_positive=[]
         counts_negative=[]
         total_positive=project_data_X_train[project_data_X_train['project_is_approved']==1]
         total_neagtive=project_data_X_train[project_data_X_train['project_is_approved']==0]
```

```
#print("total positive",total_positive.shape)
#print("total_negative",total_neagtive.shape)
for i in vocabulary:
    #print(i)
    df_positive=project_data_X_train[(project_data_X_train['project_grade_category'].s
    #print(df_positive.shape)
    counts_positive.append(df_positive.shape[0]/total_positive.shape[0])
    df_negaitive=project_data_X_train[(project_data_X_train['project_grade_category']
    #print(df_negaitive.shape)
    counts_negative.append(df_negaitive.shape[0]/total_neagtive.shape[0])

#print(counts_positive)
#print(counts_negative)

def feature_count_positive(x):
    final_value=0
    for i,j in enumerate(vocabulary):
        if x==j:
            final_value+=counts_positive[i]
    return final_value if final_value!=0 else 0.5

def feature_count_negative(x):
    final_value=0
    for i,j in enumerate(vocabulary):
        if x==j:
            final_value+=counts_negative[i]
    return final_value if final_value!=0 else 0.5

#process train data
#for positive response data
project_data_X_train['response_project_grade_category_positive'] = project_data_X_trai
#print(project_data_X_train['response_project_grade_category_positive'].shape)
print(project_data_X_train['response_project_grade_category_positive'].head())
#for negative response data
project_data_X_train['response_project_grade_category_negative'] = project_data_X_trai
#print(project_data_X_train['response_project_grade_category_negative'].shape)
print(project_data_X_train['response_project_grade_category_negative'].head())

#process test data
#for positive response data
project_data_X_test['response_project_grade_category_positive'] = project_data_X_test
#print(project_data_X_test['response_project_grade_category_positive'].shape)
print(project_data_X_test['response_project_grade_category_positive'].head())

#for negative response data
project_data_X_test['response_project_grade_category_negative'] = project_data_X_test
#print(project_data_X_test['response_project_grade_category_negative'].shape)
print(project_data_X_test['response_project_grade_category_negative'].head())
```

```
23690    0.406690
32874    0.406690
50206    0.406690
47892    0.341638
10398    0.153077
Name: response_project_grade_category_positive, dtype: float64
23690    0.405111
32874    0.405111
50206    0.405111
47892    0.328066
10398    0.161273
Name: response_project_grade_category_negative, dtype: float64
105447    0.098595
69262     0.341638
55966     0.098595
1860      0.341638
35390     0.153077
Name: response_project_grade_category_positive, dtype: float64
105447    0.105550
69262     0.328066
55966     0.105550
1860      0.328066
35390     0.161273
Name: response_project_grade_category_negative, dtype: float64
```

```
In [32]: vocabulary=list(project_data_X_train['school_state'].unique())
         counts_positive=[]
         counts_negative=[]
         total_positive=project_data_X_train[project_data_X_train['project_is_approved']==1]
         total_neagtive=project_data_X_train[project_data_X_train['project_is_approved']==0]
         #print("total positive",total_positive.shape)
         #print("total_negative",total_neagtive.shape)
         for i in vocabulary:
             #print(i)
             df_positive=project_data_X_train[(project_data_X_train['school_state'].str.contai
             #print(df_positive.shape)
             counts_positive.append(df_positive.shape[0]/total_positive.shape[0])
             df_negaitive=project_data_X_train[(project_data_X_train['school_state'].str.conta
             #print(df_negaitive.shape)
             counts_negative.append(df_negaitive.shape[0]/total_neagtive.shape[0])

         #print(counts_positive)
         #print(counts_negative)

         def feature_count_positive(x):
             final_value=0
             for i,j in enumerate(vocabulary):
```

```
                if x==j:
                    final_value+=counts_positive[i]
            return final_value if final_value!=0 else 0.5

        def feature_count_negative(x):
            final_value=0
            for i,j in enumerate(vocabulary):
                if x==j:
                    final_value+=counts_negative[i]
            return final_value if final_value!=0 else 0.5

        #process train data
        #for positive response data
        project_data_X_train['response_school_state_positive'] = project_data_X_train.school_s
        print(project_data_X_train['response_school_state_positive'].shape)
        print(project_data_X_train['response_school_state_positive'].head())
        #for negative response data
        project_data_X_train['response_school_state_negative'] = project_data_X_train.school_s
        print(project_data_X_train['response_school_state_negative'].shape)
        print(project_data_X_train['response_school_state_negative'].head())

        #process test data
        #for positive response data
        project_data_X_test['response_school_state_positive'] = project_data_X_test.school_sta
        print(project_data_X_test['response_school_state_positive'].shape)
        print(project_data_X_test['response_school_state_positive'].head())

        #for negative response data
        project_data_X_test['response_school_state_negative'] = project_data_X_test.school_sta
        print(project_data_X_test['response_school_state_negative'].shape)
        print(project_data_X_test['response_school_state_negative'].head())
```

```
(87398,)
23690    0.068085
32874    0.013981
50206    0.020331
47892    0.022273
10398    0.143167
Name: response_school_state_positive, dtype: float64
(87398,)
23690    0.061167
32874    0.015575
50206    0.022834
47892    0.020339
10398    0.133374
Name: response_school_state_negative, dtype: float64
(21850,)
105447    0.046851
```

```
69262     0.068085
55966     0.015491
1860      0.011352
35390     0.143167
Name: response_school_state_positive, dtype: float64
(21850,)
105447    0.043853
69262     0.061167
55966     0.016634
1860      0.011266
35390     0.133374
Name: response_school_state_negative, dtype: float64
```

2.2.2 Numerical features

```
In [33]: # check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
         # standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.
         from sklearn.preprocessing import StandardScaler

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

         price_scalar = StandardScaler()
         price_scalar.fit(project_data_X_train['price'].values.reshape(-1,1)) # finding the me
         print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.va

         # Now standardize the data with above maen and variance.
         price_standardized_train = project_data_X_train['price'].values#price_scalar.transfor
         # Now standardize the data with above maen and variance.
         price_standardized_test = project_data_X_test['price'].values#price_scalar.transform(
```

```
Mean : 298.64356770177807, Standard deviation : 368.42853396795914
```

```
In [34]: # check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
         # standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.
         from sklearn.preprocessing import StandardScaler,normalize

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

         price_scalar = StandardScaler()
         price_scalar.fit(project_data_X_train['teacher_number_of_previously_posted_projects']
         print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.va
```

```
        # Now standardize the data with above maen and variance.
        teacher_number_of_previously_posted_projects_standardized_train = project_data_X_trai

        # Now standardize the data with above maen and variance.
        teacher_number_of_previously_posted_projects_standardized_test = project_data_X_test[
```

```
Mean : 11.102897091466623, Standard deviation : 27.572082372998246
```

2.3 Make Data Model Ready: encoding eassay, and project_title

```
In [35]: vectorizer_essay_bow = CountVectorizer(min_df=10)
         vectorizer_essay_bow.fit(project_data_X_train.essay.values)

         text_bow_train=vectorizer_essay_bow.fit_transform(project_data_X_train.essay.values)
         print(text_bow_train.shape)

         text_bow_test=vectorizer_essay_bow.transform(project_data_X_test.essay.values)
         print(text_bow_test.shape)
```

```
(87398, 15254)
(21850, 15254)
```

```
In [36]: # Similarly you can vectorize for title also
         vectorizer_project_title_bow = CountVectorizer(min_df=10)
         vectorizer_project_title_bow.fit(project_data_X_train.project_title.values)

         title_text_bow_train=vectorizer_project_title_bow.fit_transform(project_data_X_train.
         print(title_text_bow_train.shape)

         title_text_bow_test=vectorizer_project_title_bow.transform(project_data_X_test.projec
         print(title_text_bow_test.shape)
```

```
(87398, 2803)
(21850, 2803)
```

```
In [37]: from sklearn.feature_extraction.text import TfidfVectorizer
         vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)
         vectorizer_essay_tfidf.fit(project_data_X_train.essay.values)

         text_tfidf_train=vectorizer_essay_tfidf.fit_transform(project_data_X_train.essay.valu
         print(text_tfidf_train.shape)

         text_tfidf_test=vectorizer_essay_tfidf.transform(project_data_X_test.essay.values)
         print(text_tfidf_test.shape)
```

```
(87398, 15254)
(21850, 15254)
```

In [38]:
```
# Similarly you can vectorize for title also
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_project_title_tfidf = TfidfVectorizer(min_df=10)
vectorizer_project_title_tfidf.fit(project_data_X_train.project_title.values)

title_text_tfidf_train=vectorizer_project_title_tfidf.fit_transform(project_data_X_tra
print(title_text_tfidf_train.shape)

title_text_tfidf_test=vectorizer_project_title_tfidf.transform(project_data_X_test.pro
print(title_text_tfidf_test.shape)
```

```
(87398, 2803)
(21850, 2803)
```

In [39]:
```
# 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
# borrowed from https://therenegadecoder.com/code/how-to-check-if-a-file-exists-in-py
import os
exists = os.path.isfile('./glove_vectors')
if(not exists):
    model = loadGloveModel('glove.42B.300d.txt')

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

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

    # ============================'''

    words = []
    for i in preproced_texts:
```

```
            words.extend(i.split(' '))

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

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

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


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

        import pickle
        with open('glove_vectors', 'wb') as f:
            pickle.dump(words_courpus, f)
    else:
        print("glove already exists. No need to compute")
```

```
glove already exists. No need to compute
```

```
In [40]: with open('glove_vectors', 'rb') as f:
             model = pickle.load(f)
             glove_words =  set(model.keys())
```

```
In [41]: # average Word2Vec
         # compute average word2vec for each review.
         avg_w2v_vectors_essay_train = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_train.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
             avg_w2v_vectors_essay_train.append(vector)
```

```
        print(len(avg_w2v_vectors_essay_train))
        print(len(avg_w2v_vectors_essay_train[0]))
```

```
100%|| 87398/87398 [00:21<00:00, 4161.04it/s]


87398
300
```

```
In [42]: # average Word2Vec
         # compute average word2vec for each review.
         avg_w2v_vectors_essay_test = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_test.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
             avg_w2v_vectors_essay_test.append(vector)

         print(len(avg_w2v_vectors_essay_test))
         print(len(avg_w2v_vectors_essay_test[0]))
```

```
100%|| 21850/21850 [00:05<00:00, 4065.38it/s]


21850
300
```

```
In [43]: # average Word2Vec
         # compute average word2vec for each title.
         title_avg_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(project_data_X_train.project_title.values): # for each review/se
             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
             title_avg_w2v_vectors_train.append(vector)
```

```
        print(len(title_avg_w2v_vectors_train))
        print(len(title_avg_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [00:00<00:00, 91953.56it/s]


87398
300
```

In [44]:
```
        # average Word2Vec
        # compute average word2vec for each title.
        title_avg_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in
        for sentence in tqdm(project_data_X_test.project_title.values): # for each review/sen
            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
            title_avg_w2v_vectors_test.append(vector)

        print(len(title_avg_w2v_vectors_test))
        print(len(title_avg_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:00<00:00, 89789.33it/s]


21850
300
```

In [45]:
```
        # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
        tfidf_model = TfidfVectorizer()
        tfidf_model.fit(project_data_X_train.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_)))
        essay_tfidf_words = set(tfidf_model.get_feature_names())
```

In [46]:
```
        # average Word2Vec
        # compute average word2vec for each review.
        essay_tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored
        for sentence in tqdm(project_data_X_train.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 essay_tfidf_words):
```

```
                    vec = model[word] # getting the vector for each word
                    # here we are multiplying idf value(dictionary[word]) and the tf value((s
                    tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                    vector += (vec * tf_idf) # calculating tfidf weighted w2v
                    tf_idf_weight += tf_idf
            if tf_idf_weight != 0:
                vector /= tf_idf_weight
            essay_tfidf_w2v_vectors_train.append(vector)

        print(len(essay_tfidf_w2v_vectors_train))
        print(len(essay_tfidf_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [02:21<00:00, 617.47it/s]


87398
300
```

In [47]:
```
# average Word2Vec
# compute average word2vec for each review.
essay_tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored i
for sentence in tqdm(project_data_X_test.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 essay_tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((s
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    essay_tfidf_w2v_vectors_test.append(vector)

print(len(essay_tfidf_w2v_vectors_test))
print(len(essay_tfidf_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:35<00:00, 622.45it/s]


21850
300
```

In [48]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(project_data_X_train.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_)))
        essay_tfidf_words = set(tfidf_model.get_feature_names())
```

In [49]:
```
# average Word2Vec
# compute average word2vec for each review.
title_tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored
for sentence in tqdm(project_data_X_train.project_title.values): # for each review/se
    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 essay_tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((s
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    title_tfidf_w2v_vectors_train.append(vector)

print(len(title_tfidf_w2v_vectors_train))
print(len(title_tfidf_w2v_vectors_train[0]))
```

```
100%|| 87398/87398 [00:01<00:00, 44437.37it/s]


87398
300
```

In [50]:
```
# average Word2Vec
# compute average word2vec for each review.
title_tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored i
for sentence in tqdm(project_data_X_test.project_title.values): # for each review/sen
    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 essay_tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((s
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    title_tfidf_w2v_vectors_test.append(vector)
```

```
        print(len(title_tfidf_w2v_vectors_test))
        print(len(title_tfidf_w2v_vectors_test[0]))
```

```
100%|| 21850/21850 [00:00<00:00, 44259.46it/s]


21850
300
```

2.4 Applying Random Forest

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

2.0.1 2.4.0 Define method to predict based on threshold of AUC

```
In [51]: # we are writing our own function for predict, with defined thresould
         # we will pick a threshold that will give the least fpr
         def predict(proba, threshould, fpr, tpr):

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

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

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

2.0.2 2.4.1 Applying Random Forests on BOW, SET 1

```
In [52]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         BOW = hstack((project_data_X_train.response_clean_categories_negative.values.reshape(
         print(BOW.shape)
         BOW_test= hstack((project_data_X_test.response_clean_categories_negative.values.resha
         print(BOW_test.shape)
```

```
(87398, 18067)
(21850, 18067)
```

```
In [52]: from sklearn.ensemble import RandomForestClassifier
         from sklearn.model_selection import GridSearchCV
```

```
model=RandomForestClassifier(class_weight='balanced')
number_of_base_models=[20,35,50,100,150,200]
depth=[1,3,5,7]
parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
clf1 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
clf1.fit(BOW,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:    5.2s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:    9.7s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:   19.0s
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:   24.2s
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:   36.0s
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:   43.6s
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed:   59.4s
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed:  1.2min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed:  1.5min finished


Out[52]: GridSearchCV(cv='warn', error_score='raise-deprecating',
               estimator=RandomForestClassifier(bootstrap=True, class_weight='balanced',
                    criterion='gini', max_depth=None, max_features='auto',
                    max_leaf_nodes=None, min_impurity_decrease=0.0,
                    min_impurity_split=None, min_samples_leaf=1,
                    min_samples_split=2, min_weight_fraction_leaf=0.0,
                    n_estimators='warn', n_jobs=None, oob_score=False,
                    random_state=None, verbose=0, warm_start=False),
               fit_params=None, iid='warn', n_jobs=4,
               param_grid={'n_estimators': [20, 35, 50, 100, 150, 200], 'max_depth': [1, 3, 5
               pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
               scoring='roc_auc', verbose=10)
```

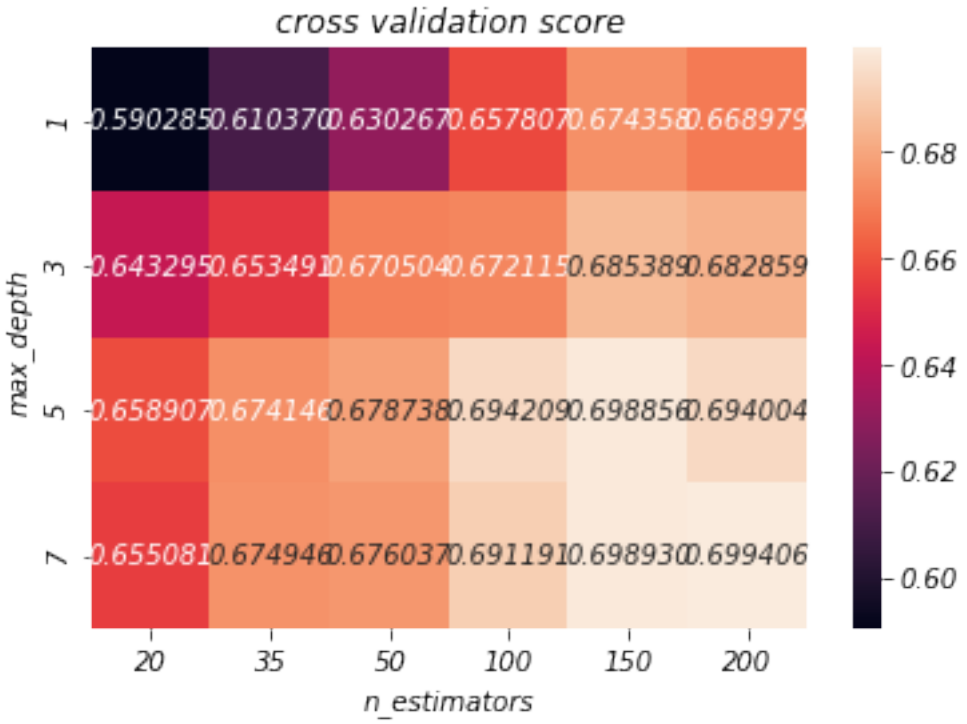
```
In [54]: clf=clf1
         clf.best_params_
```

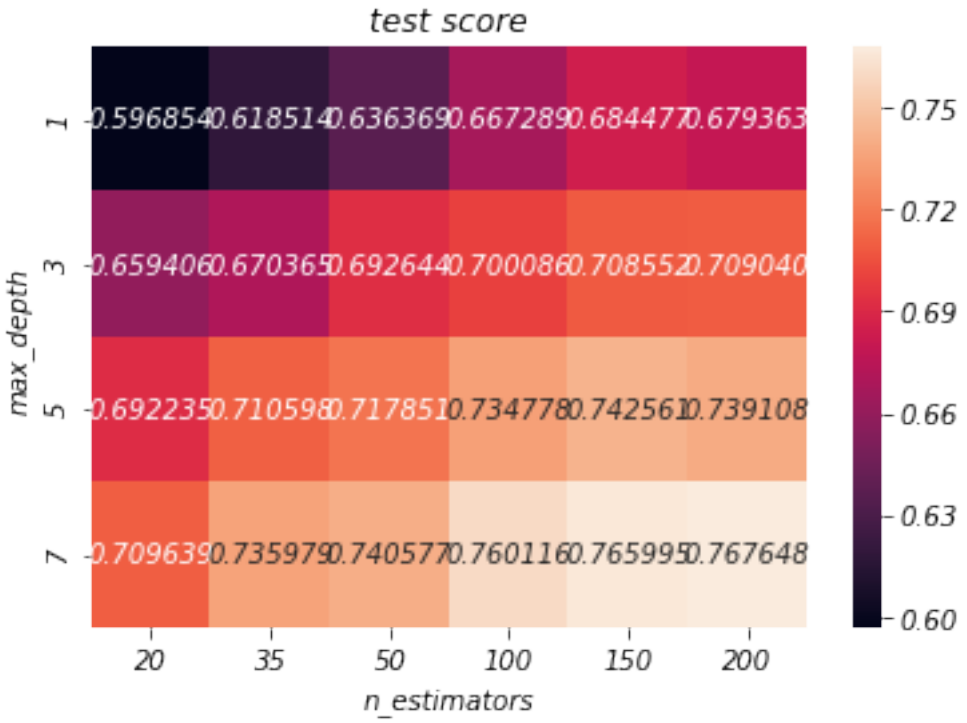
```
Out[54]: {'max_depth': 7, 'n_estimators': 200}
```

```
In [56]: #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
         #https://seaborn.pydata.org/generated/seaborn.heatmap.html
         max_depth_all=[]
         min_samples_split_all=[]
         for i in range (0,len(clf.cv_results_['params'])):
             max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
             min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
         #print(max_depth_all)
         #print(min_samples_split_all)
```

```
cv_score_all=clf.cv_results_['mean_test_score']
#print(cv_score_all)
cv_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'cv_auc': cv_score_all
    })
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 10}, fmt="f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 10}, fmt="f")
```

Out[56]: <matplotlib.axes._subplots.AxesSubplot at 0x297043f7a58>





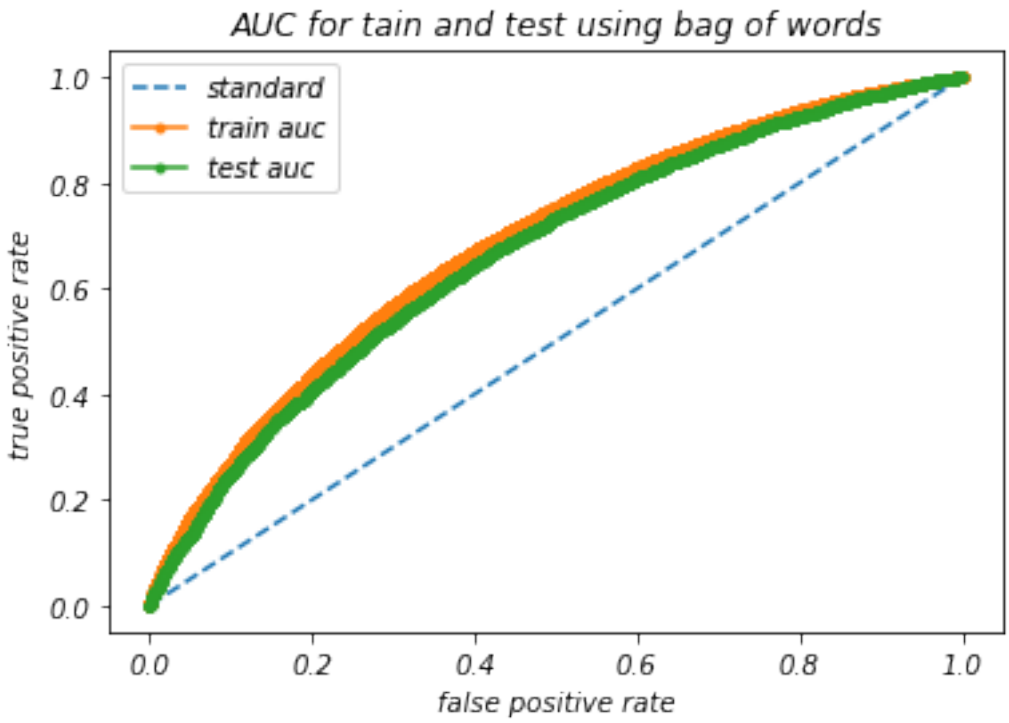
In [53]:
```
from sklearn.ensemble import RandomForestClassifier
#model=RandomForestClassifier(class_weight='balanced',max_depth= 25, n_estimators=150
model=RandomForestClassifier(class_weight='balanced',max_depth= 3, n_estimators=150)
model.fit(BOW,project_data_Y_train)
```

Out[53]:
```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
                       criterion='gini', max_depth=3, max_features='auto',
                       max_leaf_nodes=None, min_impurity_decrease=0.0,
                       min_impurity_split=None, min_samples_leaf=1,
                       min_samples_split=2, min_weight_fraction_leaf=0.0,
                       n_estimators=150, n_jobs=None, oob_score=False,
                       random_state=None, verbose=0, warm_start=False)
```

In [54]:
```
#https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score
from tqdm import tqdm

probs_test = model.predict_proba(BOW_test)
# keep probabilities for the positive outcome only
probs_test = probs_test[:, 1]
auc_test = roc_auc_score(project_data_Y_test, probs_test)
```

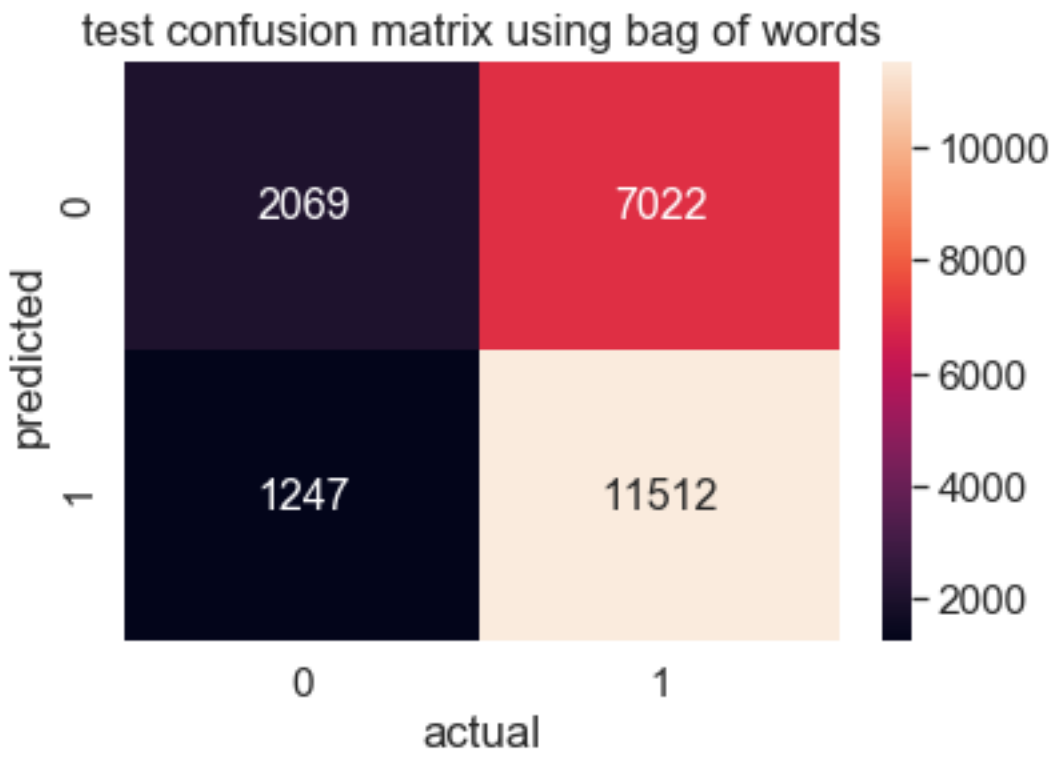
```
print('AUC: %.3f' % auc_test)
fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

probs_train = model.predict_proba(BOW)
# keep probabilities for the positive outcome only
probs_train = probs_train[:, 1]
auc_train = roc_auc_score(project_data_Y_train, probs_train)
print('AUC: %.3f' % auc_train)
fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr1, tpr1, marker='.')
plt.plot(fpr, tpr, marker='.')

plt.legend({"standard":"","train auc":"","test auc":""})
plt.title("AUC for tain and test using bag of words")
plt.xlabel("false positive rate")
plt.ylabel("true positive rate")
plt.show()
```

```
AUC: 0.667
AUC: 0.686
```



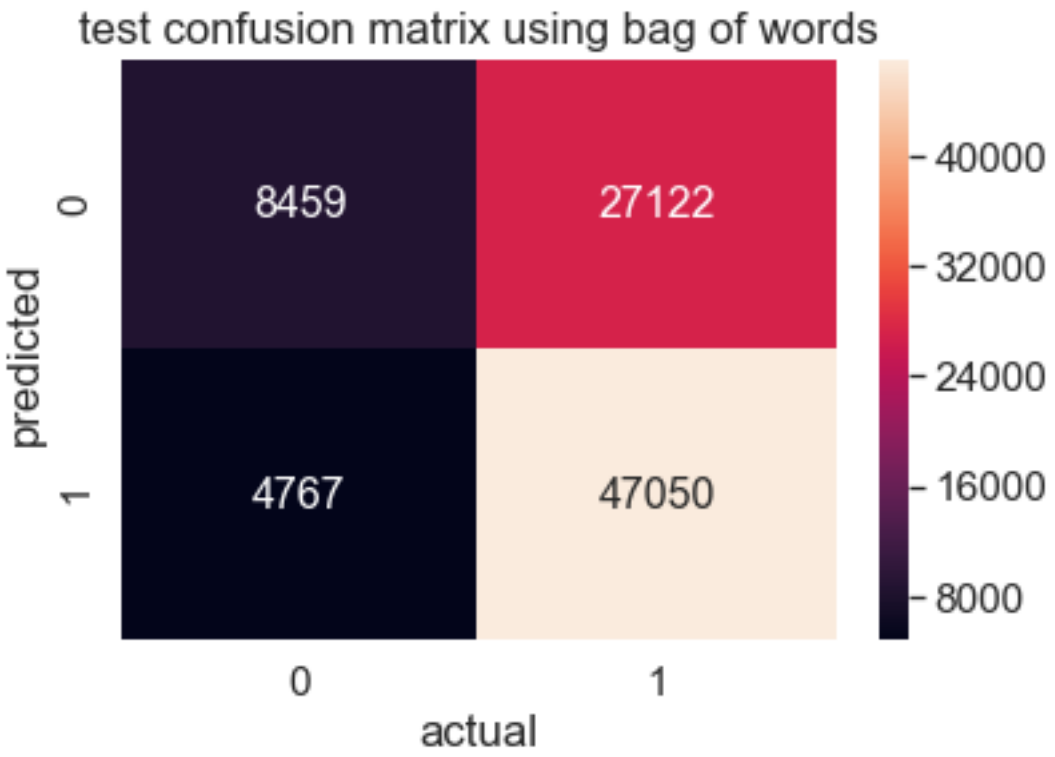
In [55]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(BOW_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.3875498659718786 for threshold 0.499
2069 1247 7022 11512
true positive rate 0.6211287363763893
true negaitive rate 0.6239445114595898
[[2069, 7022], [1247, 11512]]
```



In [56]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(BOW)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
#tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, threshold
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.40570479881244964 for threshold 0.499
8459 4767 27122 47050
true positive rate 0.6343364072695896
true negaitive rate 0.6395735672160895
[[8459, 27122], [4767, 47050]]
```



2.0.3 2.4.2 Applying Random Forests on TFIDF, SET 2

In [57]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense mati

TFIDF = hstack((project_data_X_train.response_clean_categories_negative.values.reshape
print(TFIDF.shape)

TFIDF_test = hstack((project_data_X_test.response_clean_categories_negative.values.res
print(TFIDF_test.shape)
```

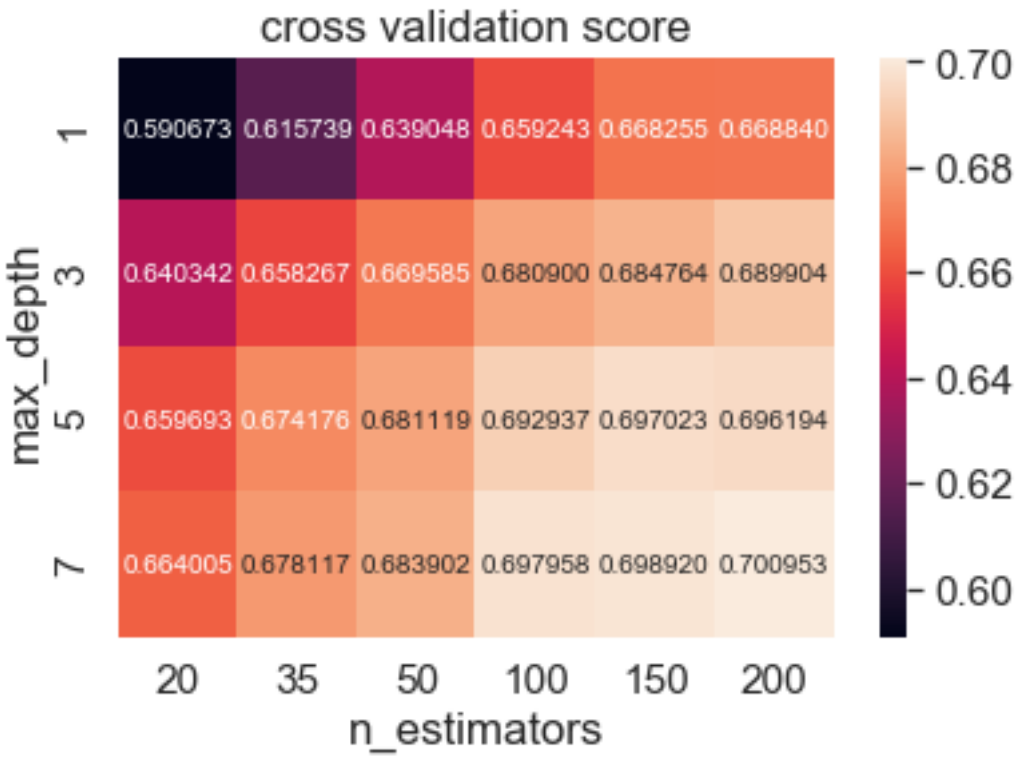
```
(87398, 36124)
(21850, 36124)
```

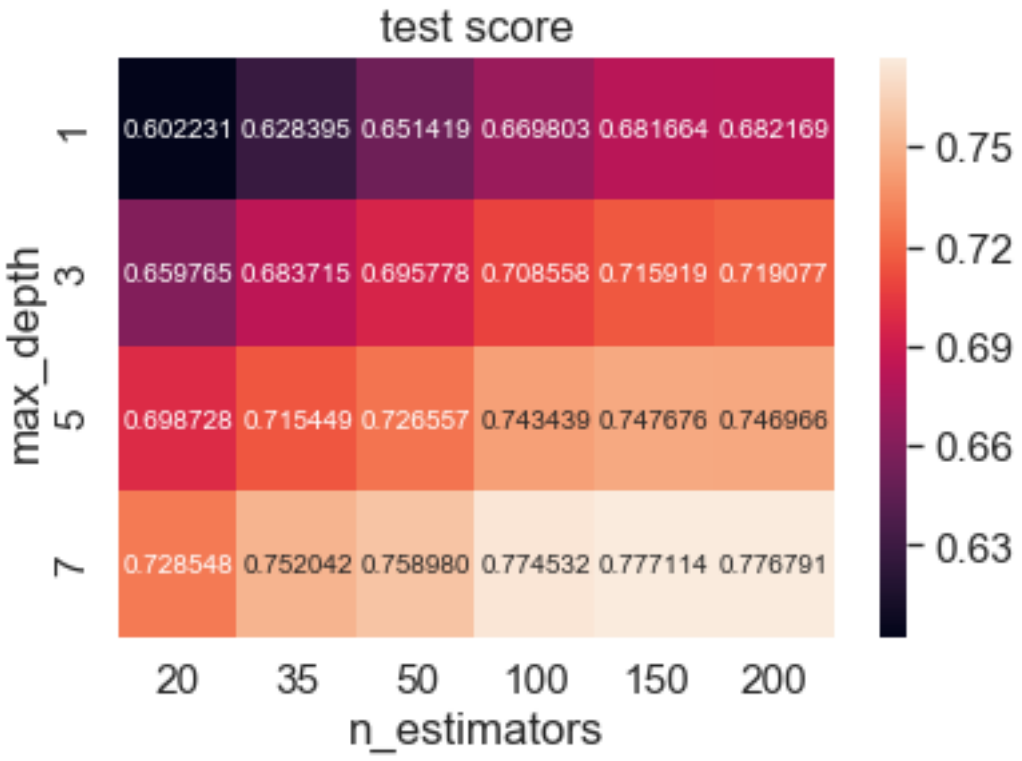
In [61]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
model=RandomForestClassifier(class_weight='balanced')
number_of_base_models=[20,35,50,100,150,200]
depth=[1,3,5,7]
parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
clf2 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
clf2.fit(TFIDF,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:    9.0s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   18.0s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:   36.4s
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:   46.9s
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:  1.2min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  1.4min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed:  2.0min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed:  2.4min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed:  3.0min finished


Out[61]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=None, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators='warn', n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [20, 35, 50, 100, 150, 200], 'max_depth': [1, 3, 5
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)

In [62]: clf=clf2
         clf.best_params_

Out[62]: {'max_depth': 7, 'n_estimators': 200}

In [63]: #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
         #https://seaborn.pydata.org/generated/seaborn.heatmap.html
         max_depth_all=[]
         min_samples_split_all=[]
         for i in range (0,len(clf.cv_results_['params'])):
             max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
             min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
         #print(max_depth_all)
         #print(min_samples_split_all)
         cv_score_all=clf.cv_results_['mean_test_score']
         #print(cv_score_all)
         cv_data=pd.DataFrame(
             {'max_depth': max_depth_all,
              'n_estimators': min_samples_split_all,
              'cv_auc': cv_score_all
             })
```

```
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 10}, fmt="f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 10}, fmt="f")
```

Out[63]: <matplotlib.axes._subplots.AxesSubplot at 0x2974eaafe10>





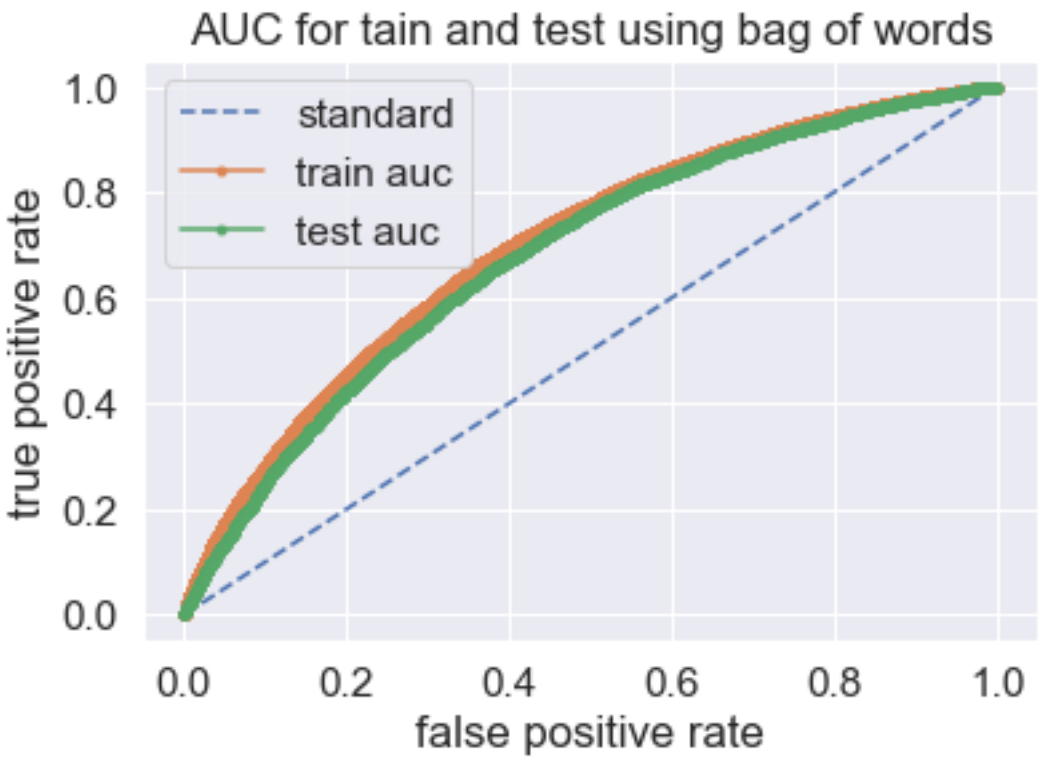

```
In [58]: from sklearn.ensemble import RandomForestClassifier
         model=RandomForestClassifier(class_weight='balanced',max_depth= 3, n_estimators=150)
         model.fit(TFIDF,project_data_Y_train)
```

```
Out[58]: RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=3, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators=150, n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False)
```

```
In [59]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)
```

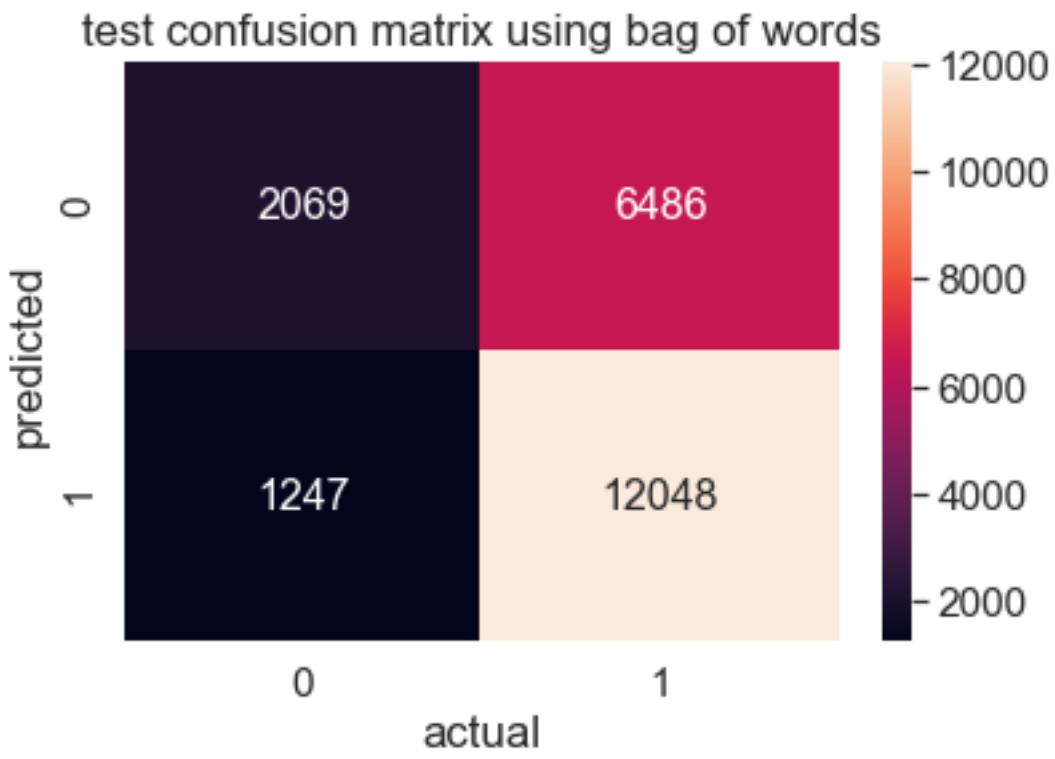
```
probs_train = model.predict_proba(TFIDF)
# keep probabilities for the positive outcome only
probs_train = probs_train[:, 1]
auc_train = roc_auc_score(project_data_Y_train, probs_train)
print('AUC: %.3f' % auc_train)
fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr1, tpr1, marker='.')
plt.plot(fpr, tpr, marker='.')

plt.legend({"standard":"","train auc":"","test auc":""})
plt.title("AUC for tain and test using bag of words")
plt.xlabel("false positive rate")
plt.ylabel("true positive rate")
plt.show()
```

```
AUC: 0.683
AUC: 0.701
```



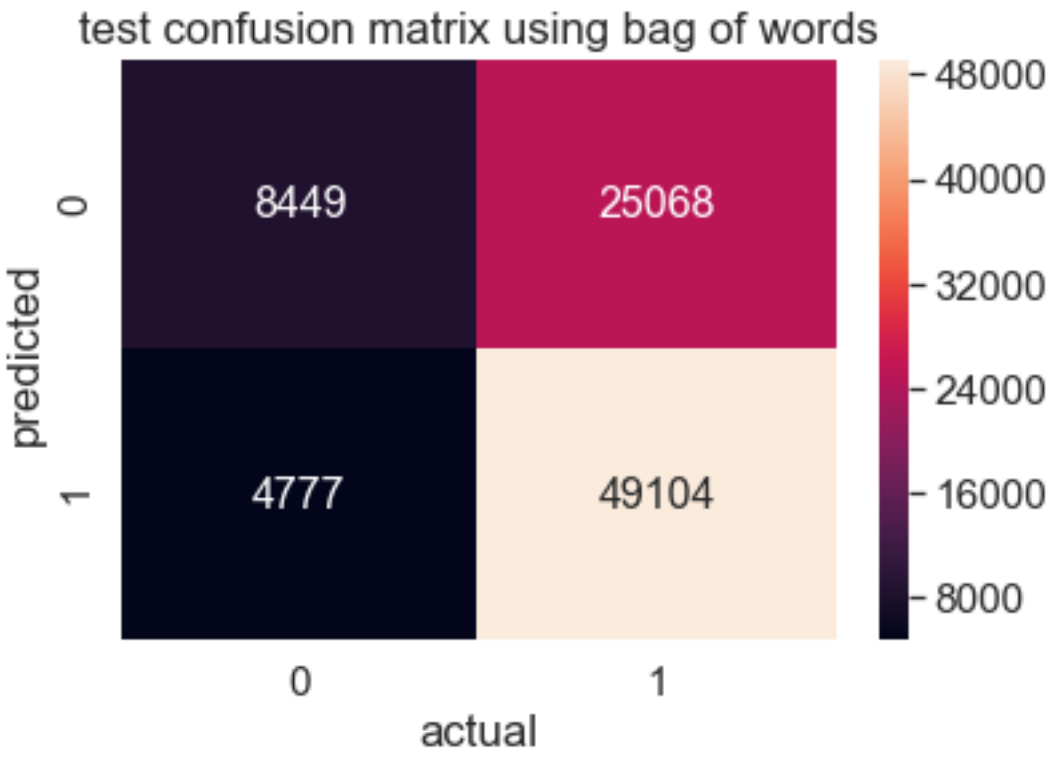
In [60]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4055942308225498 for threshold 0.499
2069 1247 6486 12048
true positive rate 0.6500485594043379
true negaitive rate 0.6239445114595898
[[2069, 6486], [1247, 12048]]
```



In [61]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.42291556885704557 for threshold 0.499
8449 4777 25068 49104
true positive rate 0.6620287979291377
true negaitive rate 0.6388174807197944
[[8449, 25068], [4777, 49104]]
```



2.0.4 2.4.3 Applying Random Forests on AVG W2V, SET 3

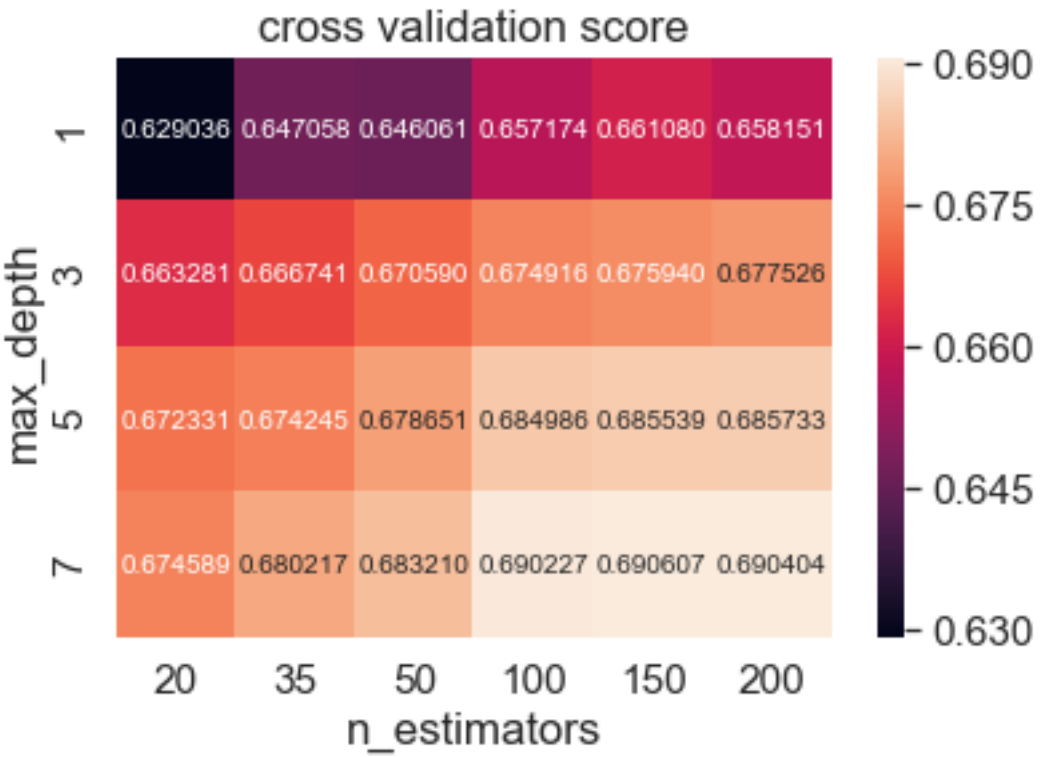
```
In [62]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         # conver list of lists to sparse matrix https://docs.scipy.org/doc/scipy/reference/ge
         from scipy.sparse import hstack,csr_matrix
         # with same hstack function we are concatinating a sparse matrix and a dense matirx :
         a=csr_matrix(avg_w2v_vectors_essay_train)
         #print(a.shape)
         b=csr_matrix(avg_w2v_vectors_essay_test)
         #print(b.shape)
         c=csr_matrix(title_avg_w2v_vectors_train)
         #print(c.shape)
         d=csr_matrix(title_avg_w2v_vectors_test)
         #print(d.shape)

         AVG_W2V = hstack((project_data_X_train.response_clean_categories_negative.values.resha
         print(AVG_W2V.shape)
         AVG_W2V_test = hstack((project_data_X_test.response_clean_categories_negative.values.
         print(AVG_W2V_test.shape)
```

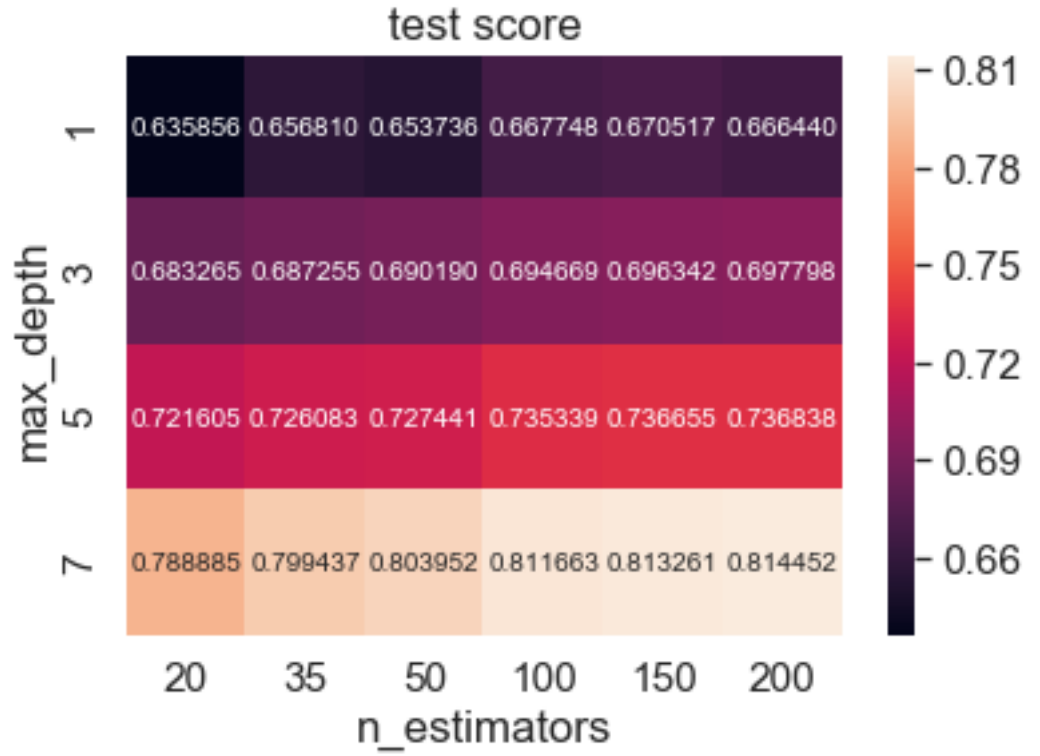
```
(87398, 610)
(21850, 610)
```

```
In [68]: from sklearn.ensemble import RandomForestClassifier
         from sklearn.model_selection import GridSearchCV
         model=RandomForestClassifier(class_weight='balanced')
         number_of_base_models=[20,35,50,100,150,200]
         depth=[1,3,5,7]
         parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
         clf3 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
         clf3.fit(AVG_W2V,project_data_Y_train)

Fitting 3 folds for each of 24 candidates, totalling 72 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   29.2s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   53.9s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  1.7min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  2.3min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:  4.3min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  5.5min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed:  9.6min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed: 13.0min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 19.7min finished


Out[68]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=None, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators='warn', n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [20, 35, 50, 100, 150, 200], 'max_depth': [1, 3, 5
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)

In [69]: clf=clf3
         clf.best_params_

Out[69]: {'max_depth': 7, 'n_estimators': 150}

In [70]: #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
         #https://seaborn.pydata.org/generated/seaborn.heatmap.html
         max_depth_all=[]
         min_samples_split_all=[]
         for i in range (0,len(clf.cv_results_['params'])):
             max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
             min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
```

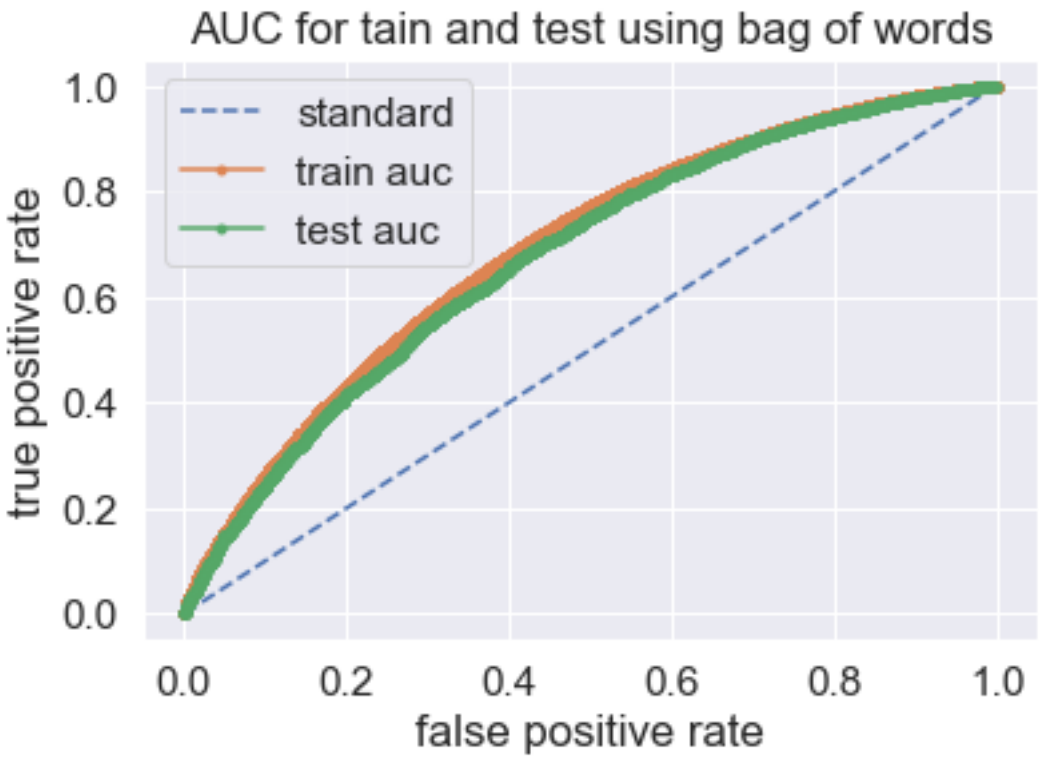
```
        #print(max_depth_all)
        #print(min_samples_split_all)
        cv_score_all=clf.cv_results_['mean_test_score']
        #print(cv_score_all)
        cv_data=pd.DataFrame(
            {'max_depth': max_depth_all,
             'n_estimators': min_samples_split_all,
             'cv_auc': cv_score_all
            })
        cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
        plt.figure(112)
        plt.title("cross validation score")
        sns.heatmap(cv_data, annot=True,annot_kws={"size": 10}, fmt="f")

        train_score_all=clf.cv_results_['mean_train_score']
        #print(train_score_all)
        tain_data=pd.DataFrame(
            {'max_depth': max_depth_all,
             'n_estimators': min_samples_split_all,
             'train_auc': train_score_all
            })
        tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
        plt.figure(122)
        plt.title("test score")
        sns.heatmap(tain_data, annot=True,annot_kws={"size": 10}, fmt="f")
```

```
Out[70]: <matplotlib.axes._subplots.AxesSubplot at 0x29705227048>
```


cross validation score
max_depth
1
3
5
7
0.629036 0.647058 0.646061 0.657174 0.661080 0.658151
0.663281 0.666741 0.670590 0.674916 0.675940 0.677526
0.672331 0.674245 0.678651 0.684986 0.685539 0.685733
0.674589 0.680217 0.683210 0.690227 0.690607 0.690404
20 35 50 100 150 200
n_estimators
0.690
0.675
0.660
0.645
0.630


test score
max_depth
1
3
5
7
0.635856 0.656810 0.653736 0.667748 0.670517 0.666440
0.683265 0.687255 0.690190 0.694669 0.696342 0.697798
0.721605 0.726083 0.727441 0.735339 0.736655 0.736838
0.788885 0.799437 0.803952 0.811663 0.813261 0.814452
20 35 50 100 150 200
n_estimators
0.81
0.78
0.75
0.72
0.69
0.66

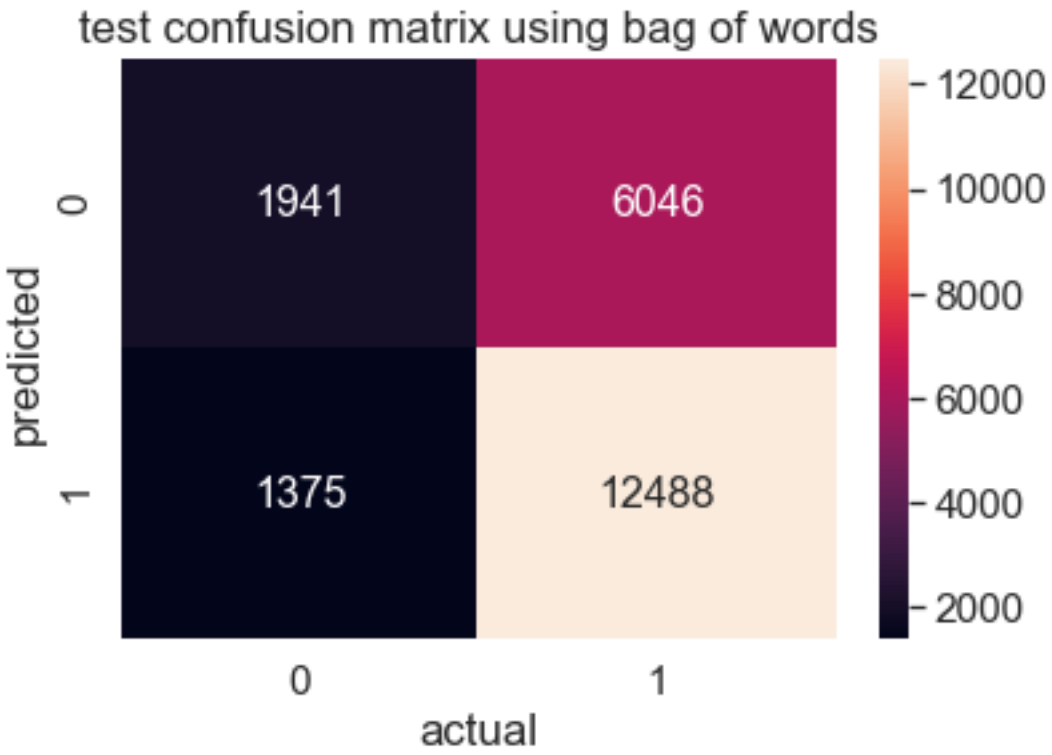
```
In [63]: from sklearn.ensemble import RandomForestClassifier
         model=RandomForestClassifier(class_weight='balanced',max_depth= 3, n_estimators=200)
         model.fit(AVG_W2V,project_data_Y_train)

Out[63]: RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=3, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators=200, n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False)

In [64]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(AVG_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(AVG_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.677
AUC: 0.691
```



In [65]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(AVG_W2V_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.3943980371613191 for threshold 0.498
1941 1375 6046 12488
true positive rate 0.6737887126362361
```

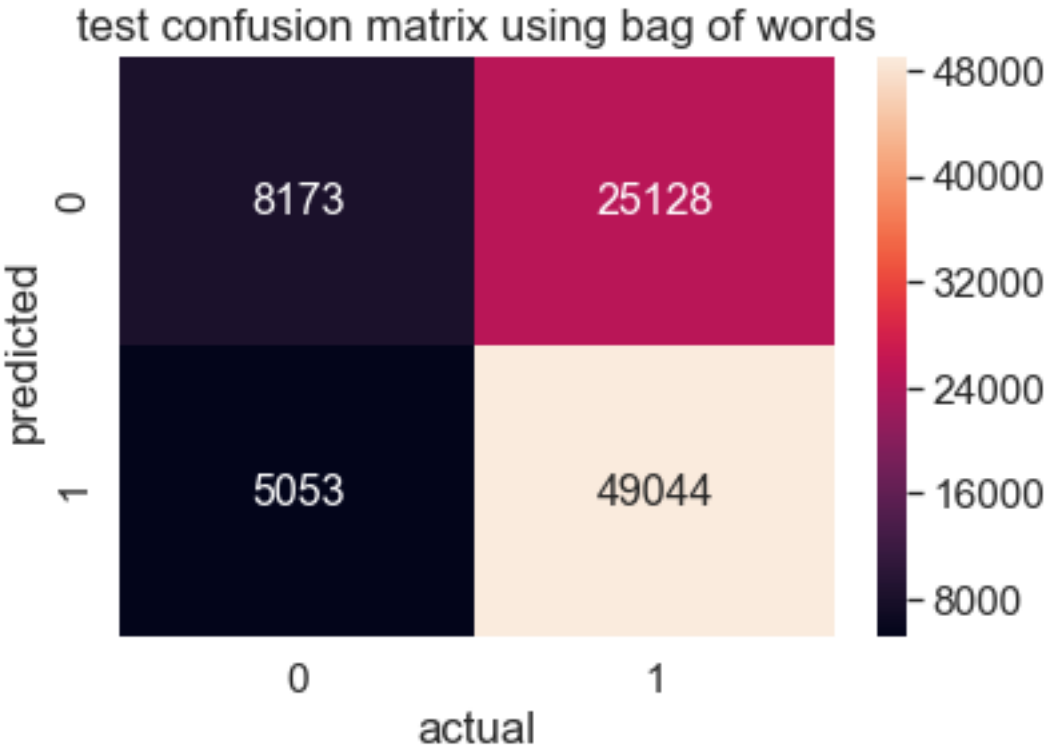
```
true negaitive rate 0.5853437876960192
[[1941, 6046], [1375, 12488]]
```



In [66]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(AVG_W2V)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
#tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, threshold
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
```

```
        plt.ylabel("predicted")
        plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.40860048206049315 for threshold 0.499
8173 5053 25128 49044
true positive rate 0.6612198673353826
true negaitive rate 0.6179494934220475
[[8173, 25128], [5053, 49044]]
```



2.0.5 2.4.4 Applying Random Forests on TFIDF W2V, SET 4

```
In [67]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         # conver list of lists to sparse matrix https://docs.scipy.org/doc/scipy/reference/ge
         from scipy.sparse import hstack,csr_matrix
         a=csr_matrix(essay_tfidf_w2v_vectors_train)
         #print(a.shape)
         b=csr_matrix(essay_tfidf_w2v_vectors_test)
         #print(b.shape)
         c=csr_matrix(title_tfidf_w2v_vectors_train)
         #print(c.shape)
         d=csr_matrix(title_tfidf_w2v_vectors_test)
         #print(d.shape)
```

```
        # with the same hstack function we are concatinating a sparse matrix and a dense mati
        TFIDF_W2V = hstack((project_data_X_train.response_clean_categories_negative.values.res
        print(TFIDF_W2V.shape)
        TFIDF_W2V_test = hstack((project_data_X_test.response_clean_categories_negative.values
        print(TFIDF_W2V_test.shape)
```

```
(87398, 610)
(21850, 610)
```

```
In [76]: from sklearn.ensemble import RandomForestClassifier
         from sklearn.model_selection import GridSearchCV
         model=RandomForestClassifier(class_weight='balanced')
         number_of_base_models=[20,35,50,100,200,250]
         depth=[1,2,3,5]
         parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
         clf4 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
         clf4.fit(TFIDF_W2V,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits
```

```
[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   23.9s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   46.1s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  1.7min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  2.3min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:  4.0min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  5.1min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed:  7.6min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed: 10.1min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 15.3min finished
```

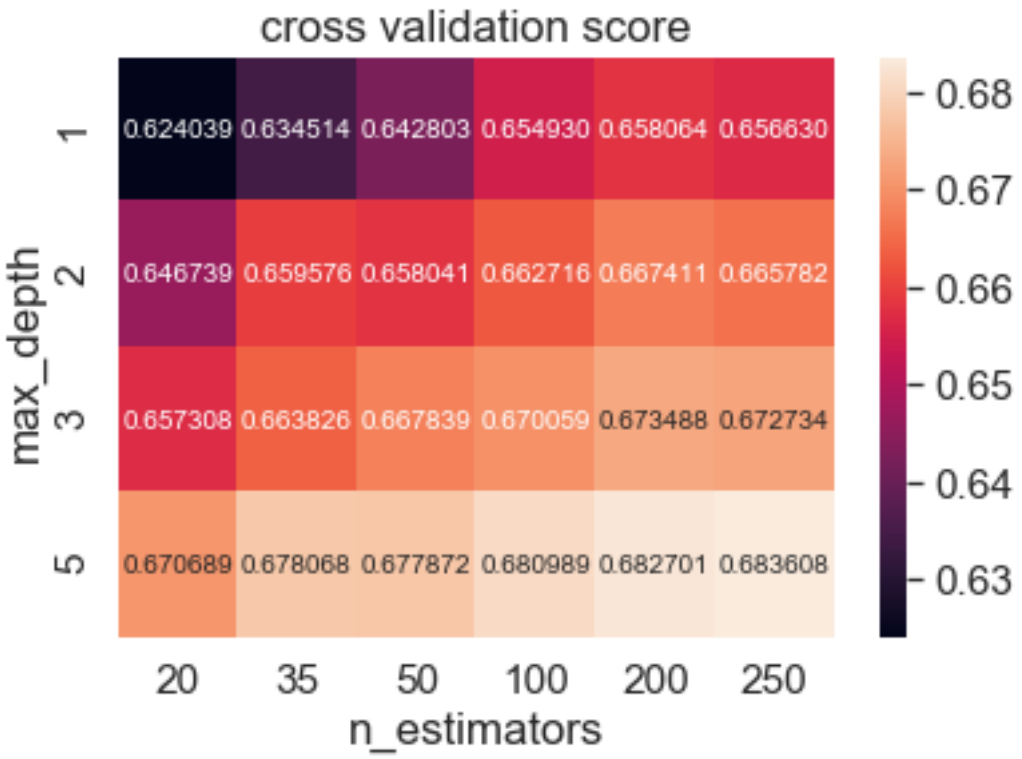
```
Out[76]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=None, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators='warn', n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [20, 35, 50, 100, 200, 250], 'max_depth': [1, 2, 3
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

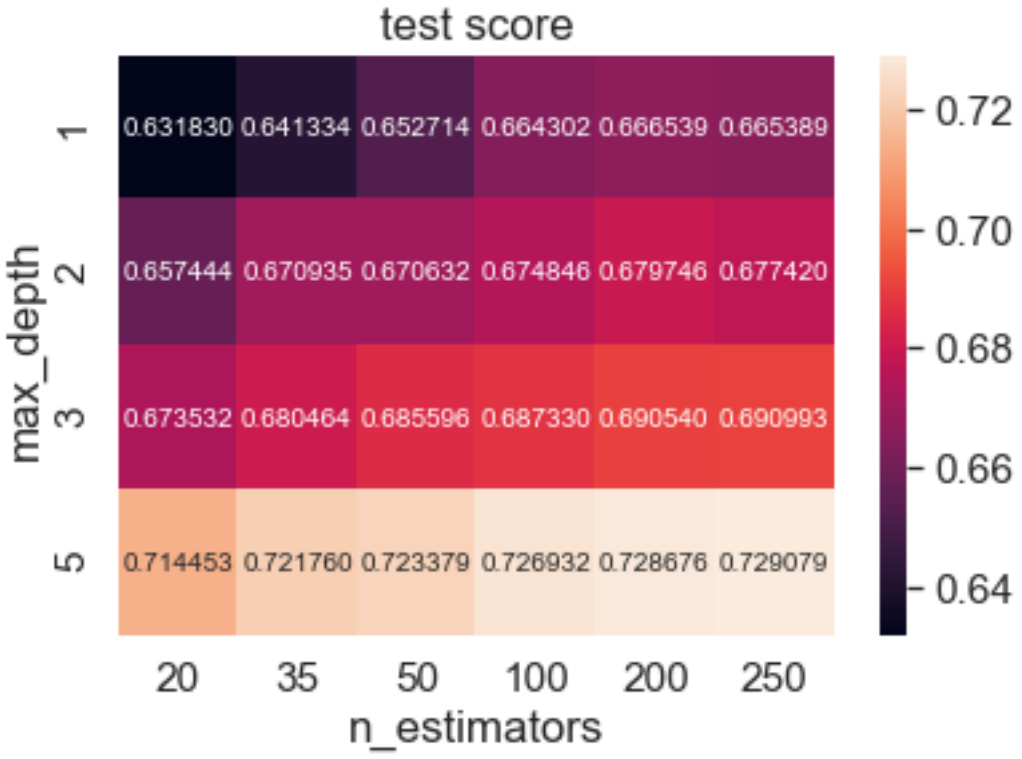
```
In [79]: clf=clf4
         clf.best_params_
```

Out[79]: {'max_depth': 5, 'n_estimators': 250}

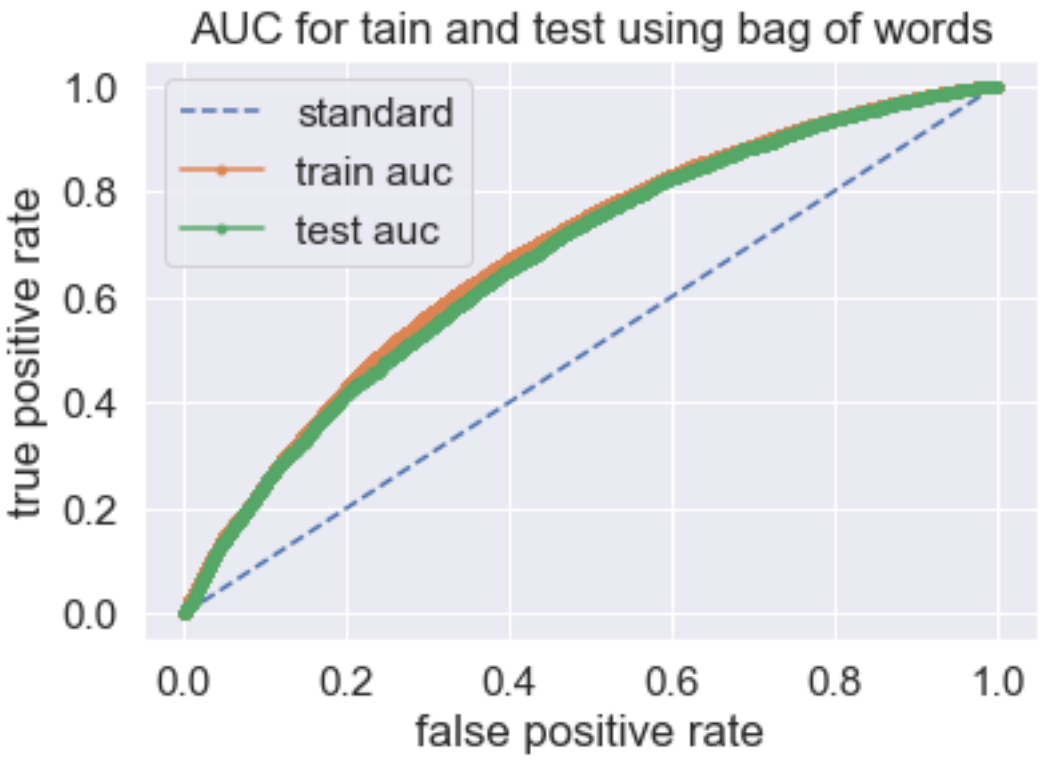
In [80]:
```
#https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
max_depth_all=[]
min_samples_split_all=[]
for i in range (0,len(clf.cv_results_['params'])):
    max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
    min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
#print(max_depth_all)
#print(min_samples_split_all)
cv_score_all=clf.cv_results_['mean_test_score']
#print(cv_score_all)
cv_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'cv_auc': cv_score_all
    })
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 10}, fmt="f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 10}, fmt="f")
```

Out[80]: <matplotlib.axes._subplots.AxesSubplot at 0x297046b5048>


cross validation score
max_depth
1
2
3
5
0.624039 0.634514 0.642803 0.654930 0.658064 0.656630
0.646739 0.659576 0.658041 0.662716 0.667411 0.665782
0.657308 0.663826 0.667839 0.670059 0.673488 0.672734
0.670689 0.678068 0.677872 0.680989 0.682701 0.683608
20 35 50 100 200 250
n_estimators
0.68
0.67
0.66
0.65
0.64
0.63


test score
max_depth
1
2
3
5
0.631830 0.641334 0.652714 0.664302 0.666539 0.665389
0.657444 0.670935 0.670632 0.674846 0.679746 0.677420
0.673532 0.680464 0.685596 0.687330 0.690540 0.690993
0.714453 0.721760 0.723379 0.726932 0.728676 0.729079
20 35 50 100 200 250
n_estimators
0.72
0.70
0.68
0.66
0.64

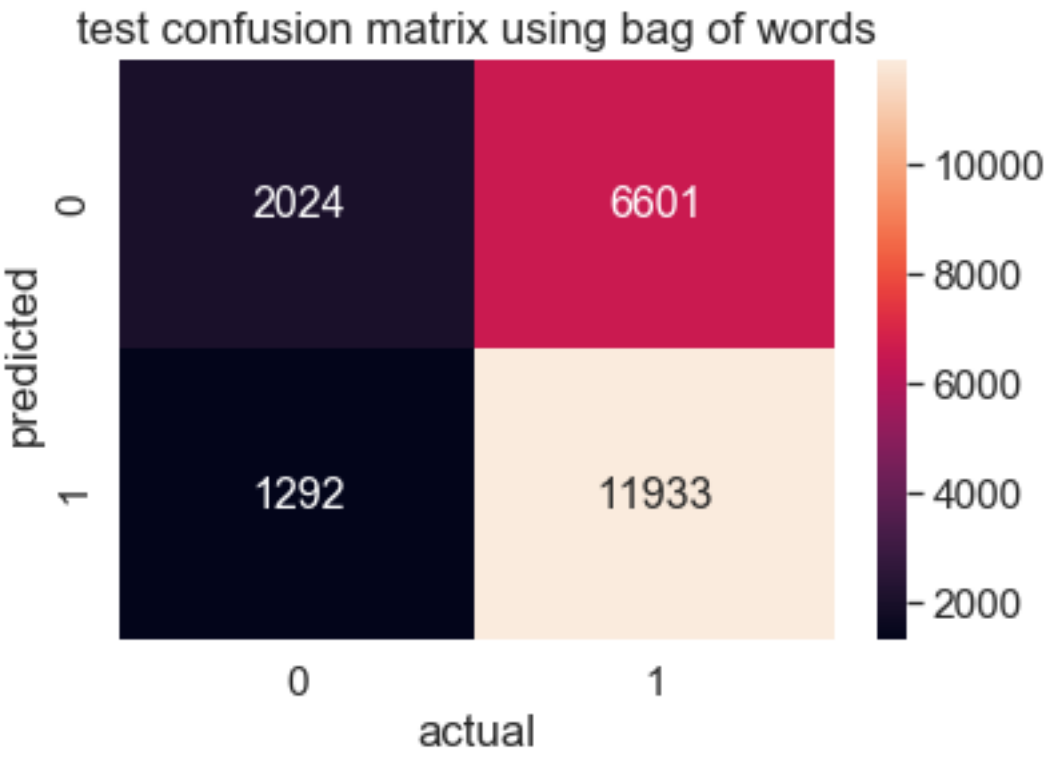
```
In [77]: from sklearn.ensemble import RandomForestClassifier
         model=RandomForestClassifier(class_weight='balanced',max_depth= 3, n_estimators=200)
         model.fit(TFIDF_W2V,project_data_Y_train)

Out[77]: RandomForestClassifier(bootstrap=True, class_weight='balanced',
                     criterion='gini', max_depth=3, max_features='auto',
                     max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators=200, n_jobs=None, oob_score=False,
                     random_state=None, verbose=0, warm_start=False)

In [78]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(TFIDF_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.673
AUC: 0.683
```



In [79]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_W2V_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

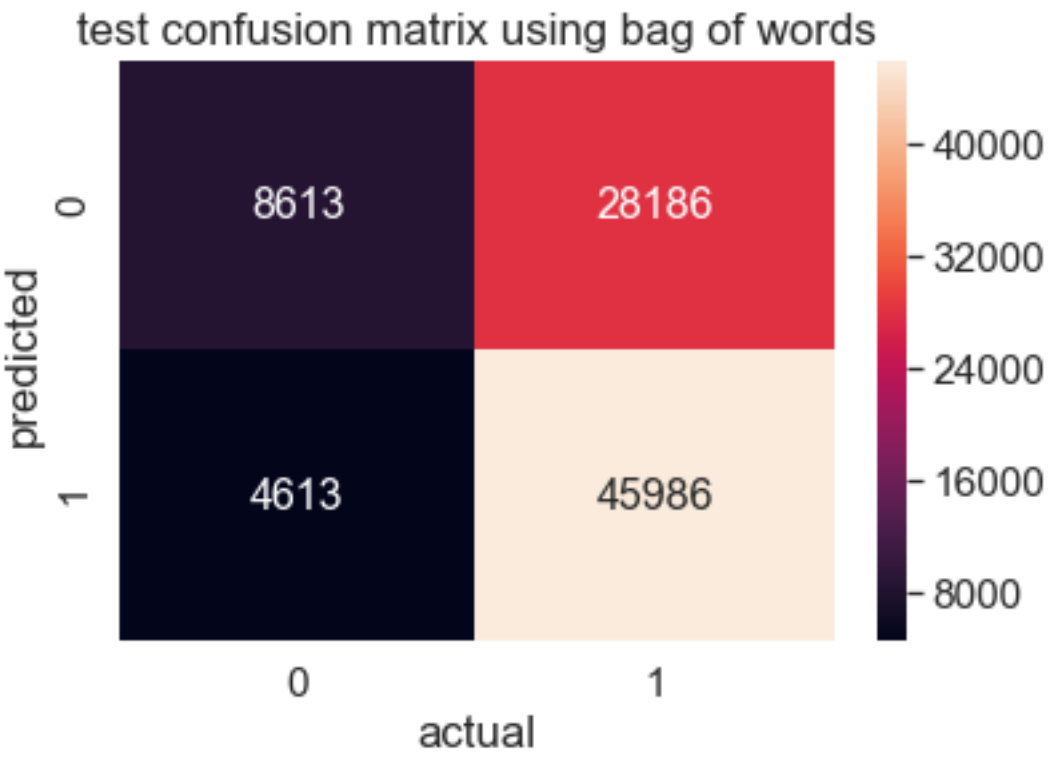
```
the maximum value of tpr*(1-fpr) 0.39298544727825874 for threshold 0.496
2024 1292 6601 11933
true positive rate 0.6438437466278192
```

```
true negaitive rate 0.6103739445114595
[[2024, 6601], [1292, 11933]]
```



In [80]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_W2V)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4037491064515719 for threshold 0.499
8613 4613 28186 45986
true positive rate 0.6199913714069999
true negaitive rate 0.6512172992590353
[[8613, 28186], [4613, 45986]]
```



2.5 Applying GBDT

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

2.0.6 2.5.1 Applying XGBOOST on BOW, SET 1

```
In [81]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         BOW = hstack((project_data_X_train.response_clean_categories_negative.values.reshape(
         print(BOW.shape)
         BOW_test= hstack((project_data_X_test.response_clean_categories_negative.values.resha
         print(BOW_test.shape)
```

```
(87398, 18067)
(21850, 18067)
```

```
In [85]: from xgboost import XGBClassifier
         from sklearn.model_selection import GridSearchCV
         model=XGBClassifier(class_weight='balanced')
         number_of_base_models=[5,10,20,35,50,100,200,500]
         depth=[1,2,3]
         parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
         clf1 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
         clf1.fit(BOW,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   13.8s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   20.3s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:   38.8s
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  1.2min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:  1.7min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  2.2min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed:  3.6min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed:  4.6min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 11.8min finished
```

```
Out[85]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balance
                colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
                n_estimators=100, n_jobs=1, nthread=None,
                objective='binary:logistic', random_state=0, reg_alpha=0,
                reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                subsample=1),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [5, 10, 20, 35, 50, 100, 200, 500], 'max_depth': [
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

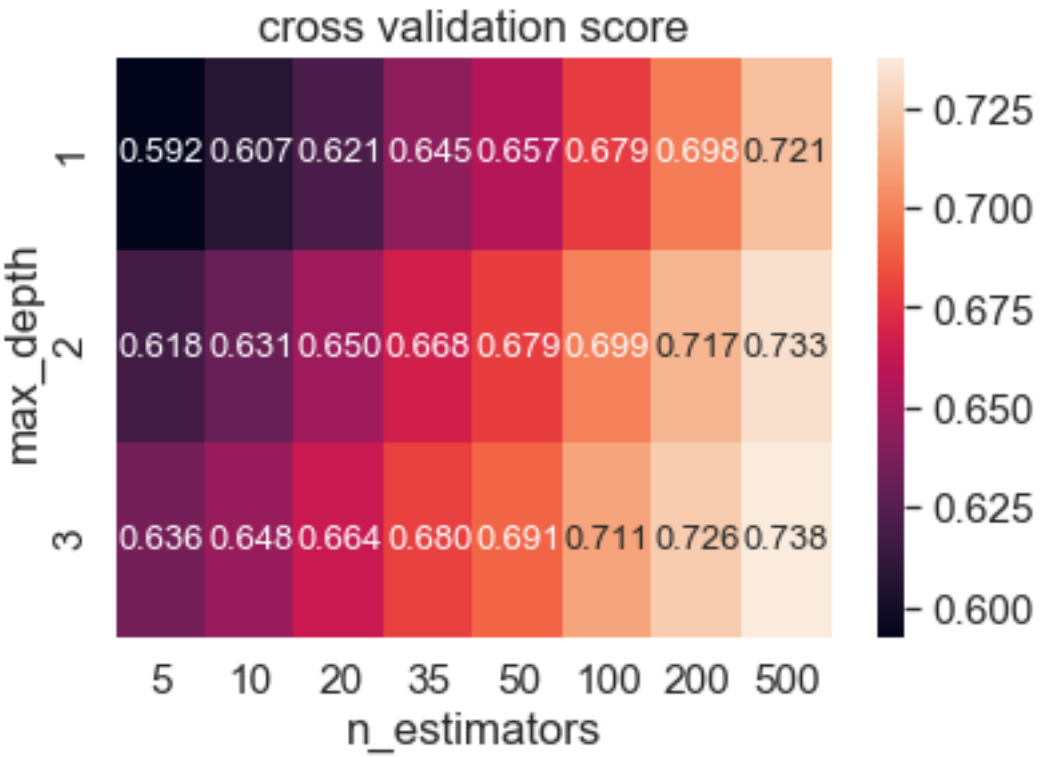
```
In [86]: clf=clf1
         clf.best_params_
```

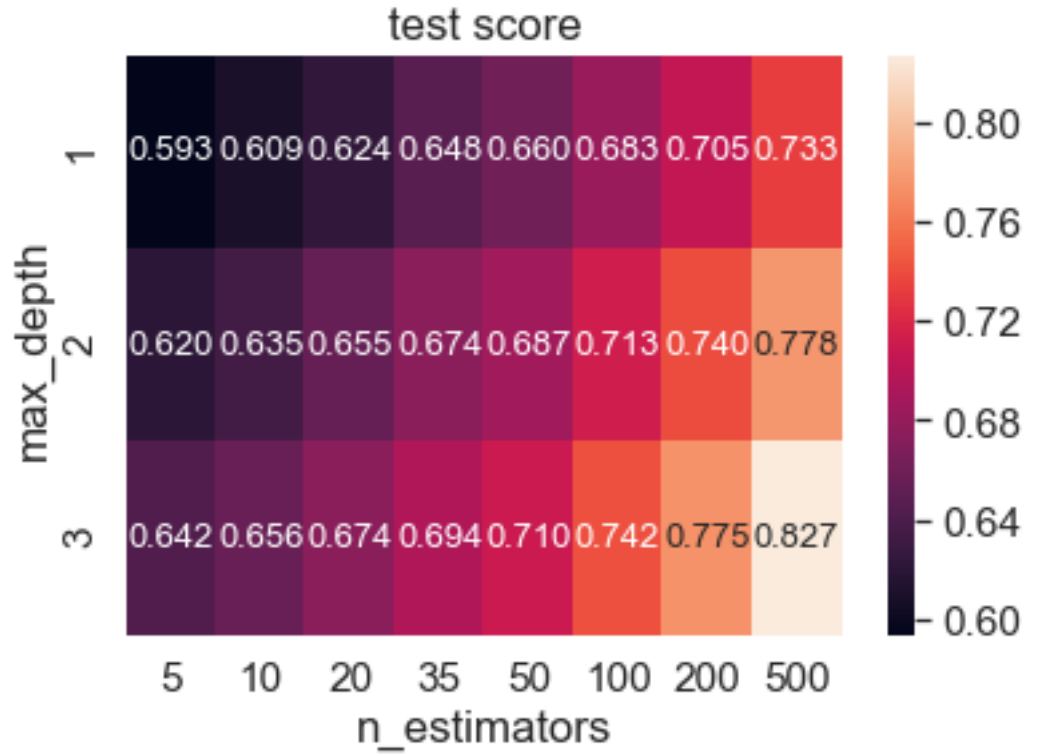
```
Out[86]: {'max_depth': 3, 'n_estimators': 500}
```

```
In [92]: #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
         #https://seaborn.pydata.org/generated/seaborn.heatmap.html
         max_depth_all=[]
         min_samples_split_all=[]
         for i in range (0,len(clf.cv_results_['params'])):
             max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
             min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
```

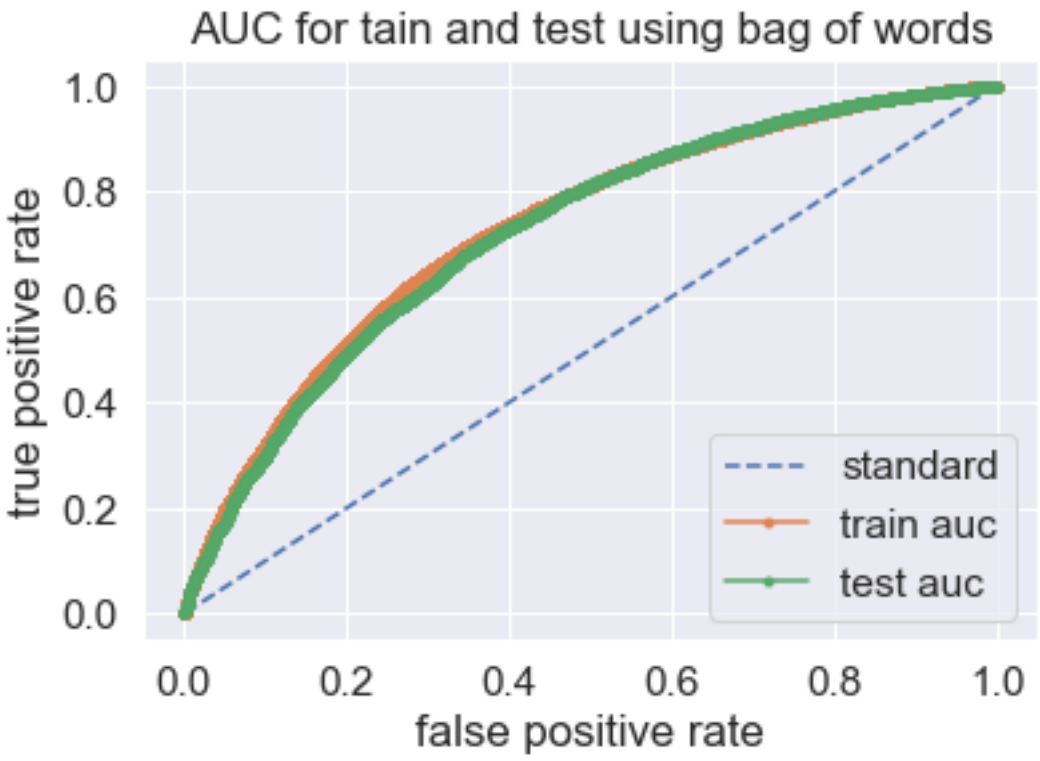
```
        #print(max_depth_all)
        #print(min_samples_split_all)
        cv_score_all=clf.cv_results_['mean_test_score']
        #print(cv_score_all)
        cv_data=pd.DataFrame(
            {'max_depth': max_depth_all,
             'n_estimators': min_samples_split_all,
             'cv_auc': cv_score_all
            })
        cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
        plt.figure(112)
        plt.title("cross validation score")
        sns.heatmap(cv_data, annot=True,annot_kws={"size": 13}, fmt=".3f")

        train_score_all=clf.cv_results_['mean_train_score']
        #print(train_score_all)
        tain_data=pd.DataFrame(
            {'max_depth': max_depth_all,
             'n_estimators': min_samples_split_all,
             'train_auc': train_score_all
            })
        tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
        plt.figure(122)
        plt.title("test score")
        sns.heatmap(tain_data, annot=True,annot_kws={"size": 13}, fmt=".3f")
```

```
Out[92]: <matplotlib.axes._subplots.AxesSubplot at 0x2970a050b70>
```


cross validation score
max_depth
1
2
3
0.592 0.607 0.621 0.645 0.657 0.679 0.698 0.721
0.618 0.631 0.650 0.668 0.679 0.699 0.717 0.733
0.636 0.648 0.664 0.680 0.691 0.711 0.726 0.738
5 10 20 35 50 100 200 500
n_estimators
0.725
0.700
0.675
0.650
0.625
0.600


test score
max_depth
1
2
3
0.593 0.609 0.624 0.648 0.660 0.683 0.705 0.733
0.620 0.635 0.655 0.674 0.687 0.713 0.740 0.778
0.642 0.656 0.674 0.694 0.710 0.742 0.775 0.827
5 10 20 35 50 100 200 500
n_estimators
0.80
0.76
0.72
0.68
0.64
0.60

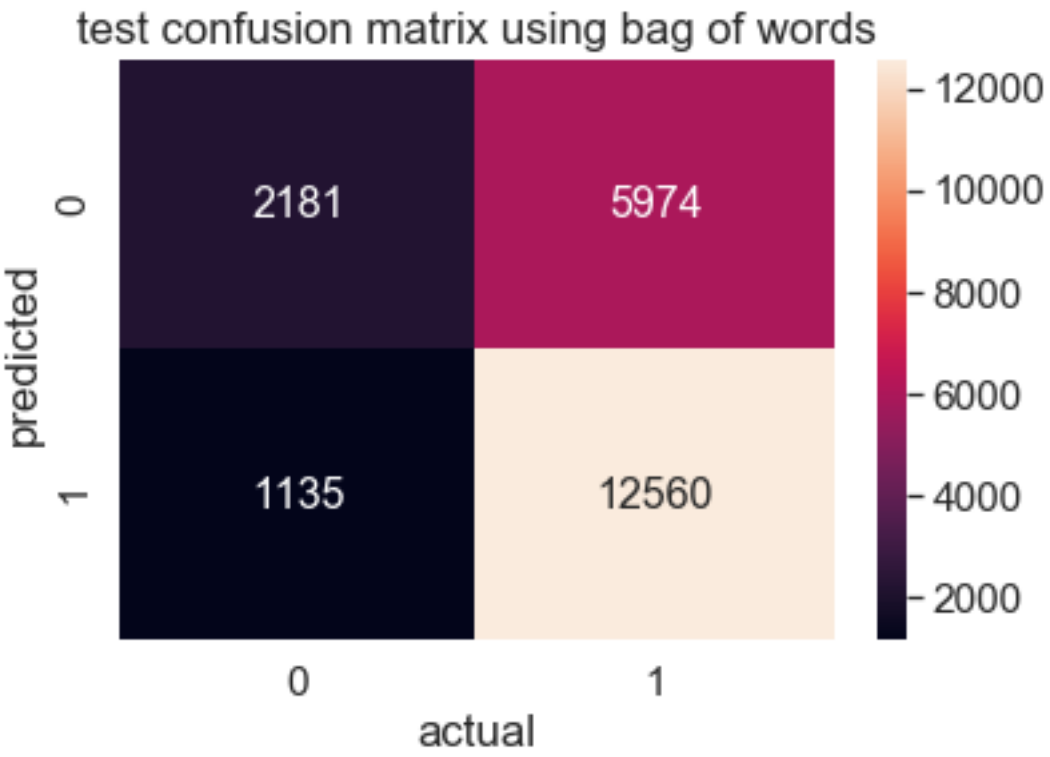
```
In [82]: from xgboost import XGBClassifier
         model=XGBClassifier(max_depth= 1, n_estimators=500,random_state=42)
         model.fit(BOW,project_data_Y_train)

Out[82]: XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
                colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
                max_depth=1, min_child_weight=1, missing=None, n_estimators=500,
                n_jobs=1, nthread=None, objective='binary:logistic',
                random_state=42, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
                seed=None, silent=True, subsample=1)

In [83]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(BOW_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(BOW)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.723
AUC: 0.730
```



In [84]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(BOW_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

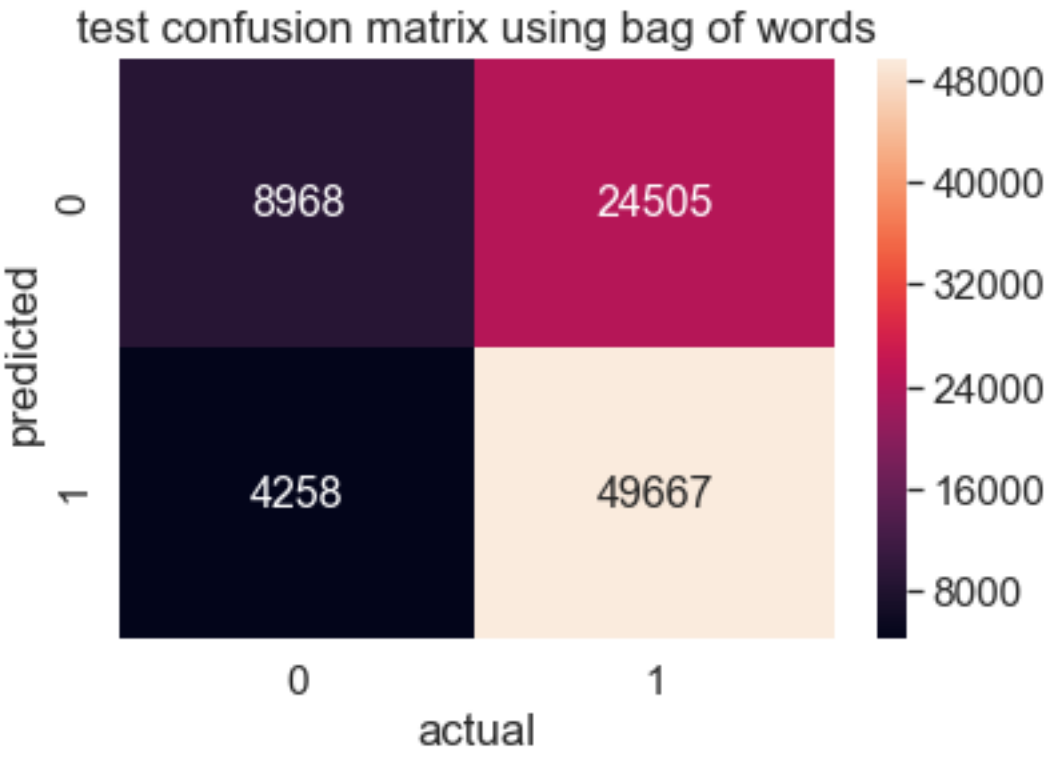
```
the maximum value of tpr*(1-fpr) 0.4457194894838723 for threshold 0.832
2181 1135 5974 12560
true positive rate 0.677673464983274
```

```
true negaitive rate 0.6577201447527141
[[2181, 5974], [1135, 12560]]
```



In [85]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(BOW)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4540409461347475 for threshold 0.834
8968 4258 24505 49667
true positive rate 0.6696192633338727
true negaitive rate 0.678058369877514
[[8968, 24505], [4258, 49667]]
```



2.0.7 2.5.2 Applying XGBOOST on TFIDF, SET 2

In [86]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense mati

TFIDF = hstack((project_data_X_train.response_clean_categories_negative.values.reshape
print(TFIDF.shape)

TFIDF_test = hstack((project_data_X_test.response_clean_categories_negative.values.res
print(TFIDF_test.shape)
```

```
(87398, 36124)
(21850, 36124)
```

```
In [102]: from xgboost import XGBClassifier
          from sklearn.model_selection import GridSearchCV
          model=XGBClassifier(class_weight='balanced')
          number_of_base_models=[5,10,20,35,50,100,200,500]
          depth=[1,2,3]
          parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
          clf2 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
          clf2.fit(TFIDF,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits


[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   21.2s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:   41.1s
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  1.5min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  3.1min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:  4.7min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed:  6.4min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed: 10.2min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed: 13.6min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 22.7min finished
```

```
Out[102]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balanc
                colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
                n_estimators=100, n_jobs=1, nthread=None,
                objective='binary:logistic', random_state=0, reg_alpha=0,
                reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                subsample=1),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [5, 10, 20, 35, 50, 100, 200, 500], 'max_depth':
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

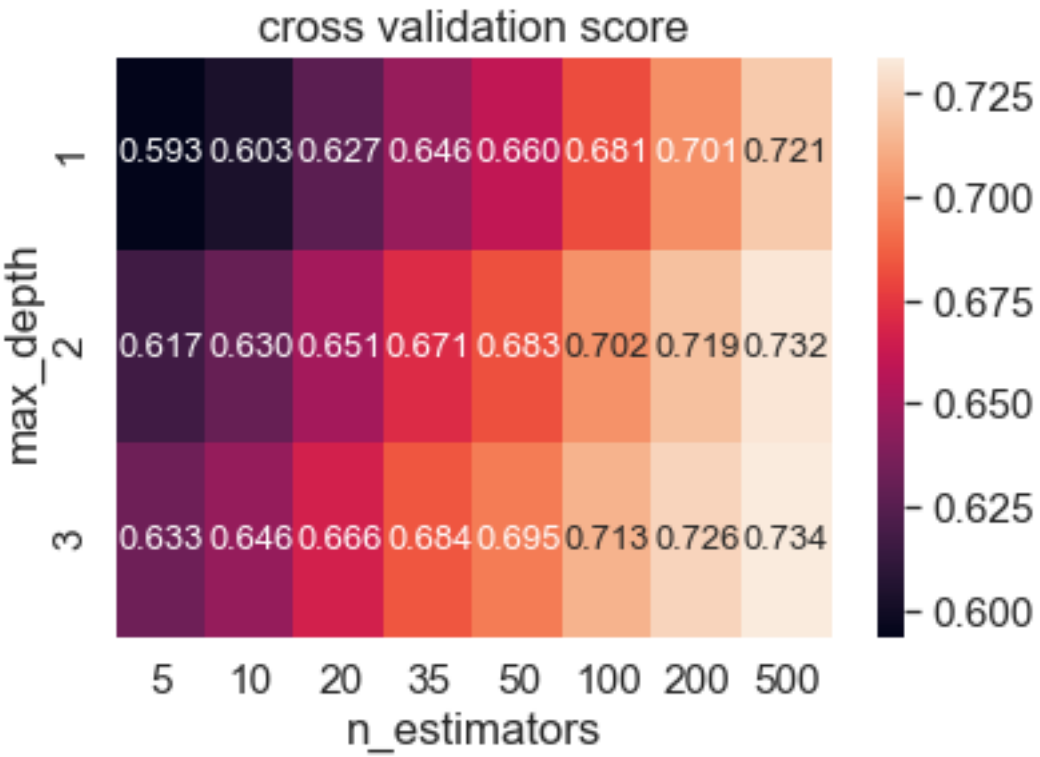
```
In [103]: clf=clf2
          clf.best_params_
```

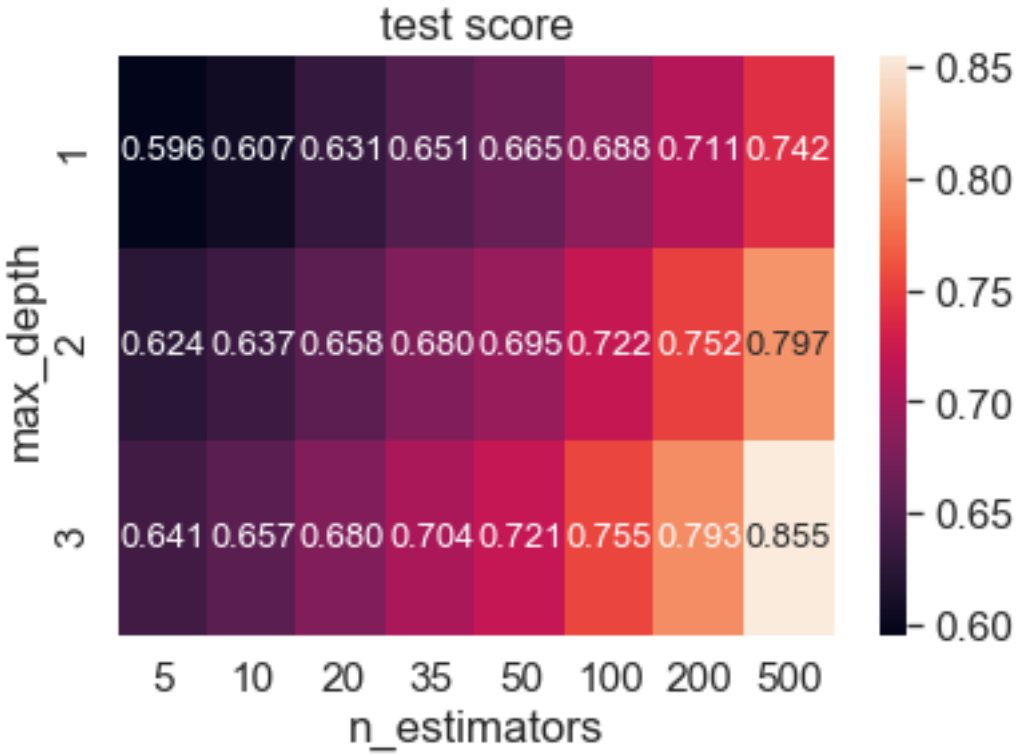
```
Out[103]: {'max_depth': 3, 'n_estimators': 500}
```

```
In [104]: #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
          #https://seaborn.pydata.org/generated/seaborn.heatmap.html
          max_depth_all=[]
          min_samples_split_all=[]
          for i in range (0,len(clf.cv_results_['params'])):
              max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
              min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
```

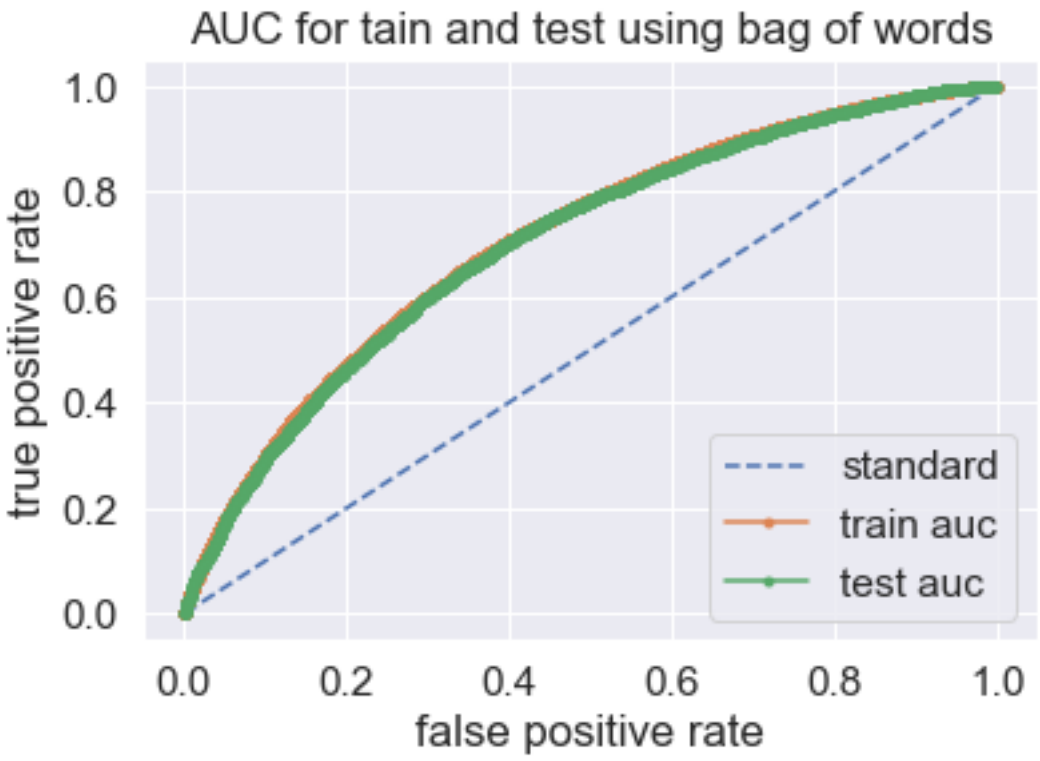
```
#print(max_depth_all)
#print(min_samples_split_all)
cv_score_all=clf.cv_results_['mean_test_score']
#print(cv_score_all)
cv_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'cv_auc': cv_score_all
    })
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 13}, fmt=".3f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 13}, fmt=".3f")
```

```
Out[104]: <matplotlib.axes._subplots.AxesSubplot at 0x297540f24e0>
```


cross validation score
max_depth
1
2
3
0.593 0.603 0.627 0.646 0.660 0.681 0.701 0.721
0.617 0.630 0.651 0.671 0.683 0.702 0.719 0.732
0.633 0.646 0.666 0.684 0.695 0.713 0.726 0.734
5 10 20 35 50 100 200 500
n_estimators
0.725
0.700
0.675
0.650
0.625
0.600


test score
max_depth
1
2
3
0.596 0.607 0.631 0.651 0.665 0.688 0.711 0.742
0.624 0.637 0.658 0.680 0.695 0.722 0.752 0.797
0.641 0.657 0.680 0.704 0.721 0.755 0.793 0.855
5 10 20 35 50 100 200 500
n_estimators
0.85
0.80
0.75
0.70
0.65
0.60

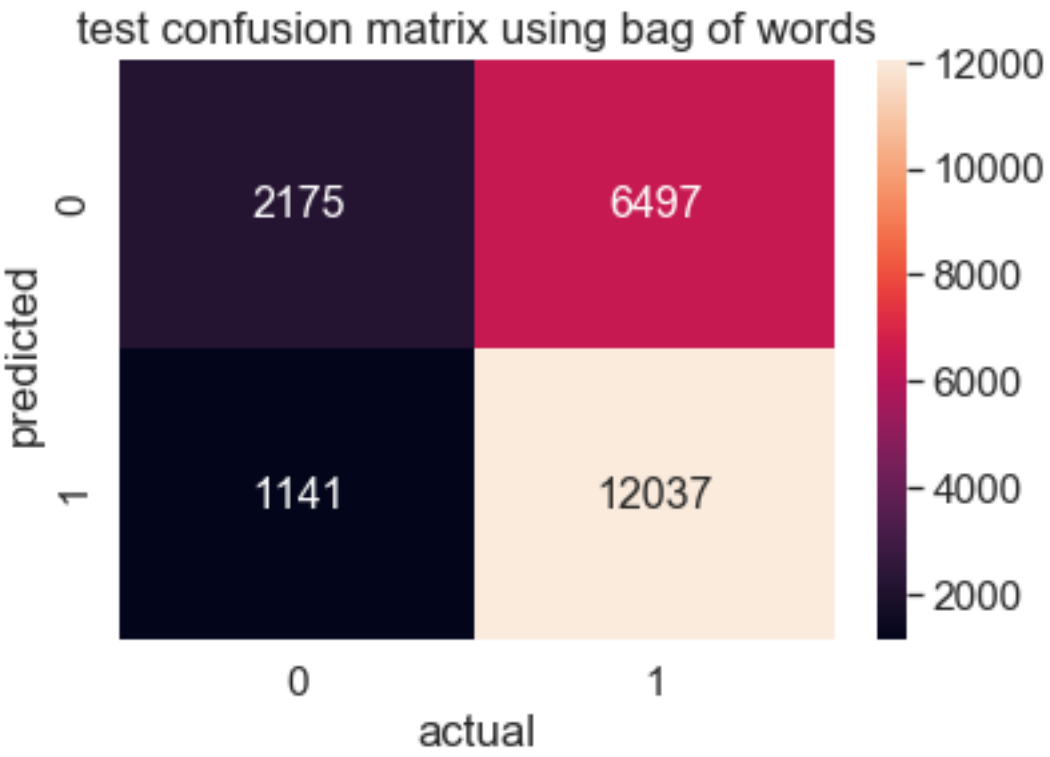
```
In [87]: from sklearn.ensemble import RandomForestClassifier
         model=XGBClassifier(max_depth= 1, n_estimators=200,random_state=42)
         model.fit(TFIDF,project_data_Y_train)

Out[87]: XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
                colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
                max_depth=1, min_child_weight=1, missing=None, n_estimators=200,
                n_jobs=1, nthread=None, objective='binary:logistic',
                random_state=42, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
                seed=None, silent=True, subsample=1)

In [88]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(TFIDF)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.704
AUC: 0.708
```



In [89]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

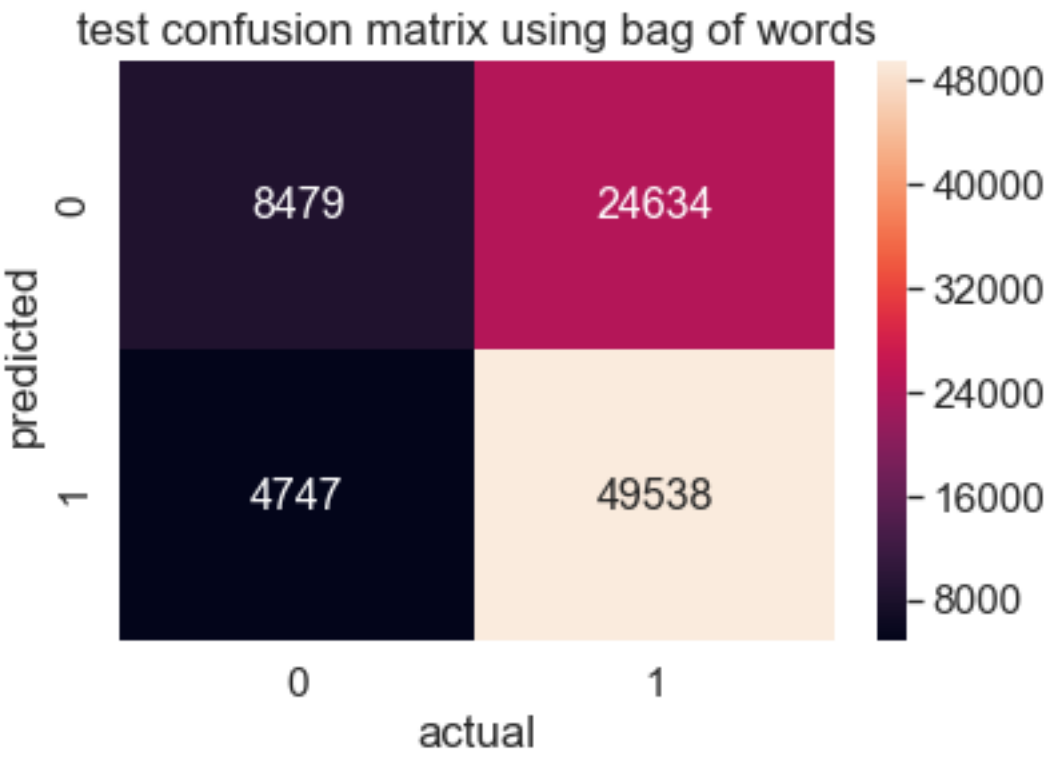
```
the maximum value of tpr*(1-fpr) 0.4259845433873494 for threshold 0.839
2175 1141 6497 12037
true positive rate 0.6494550555735406
```

```
true negaitive rate 0.6559107358262968
[[2175, 6497], [1141, 12037]]
```



In [90]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.42816838427516557 for threshold 0.836
8479 4747 24634 49538
true positive rate 0.6678800625572993
true negaitive rate 0.6410857402086799
[[8479, 24634], [4747, 49538]]
```



2.0.8 2.5.3 Applying XGBOOST on AVG W2V, SET 3

```
In [91]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         # conver list of lists to sparse matrix https://docs.scipy.org/doc/scipy/reference/ge
         from scipy.sparse import hstack,csr_matrix
         # with same hstack function we are concatinating a sparse matrix and a dense matirx :
         a=csr_matrix(avg_w2v_vectors_essay_train)
         #print(a.shape)
         b=csr_matrix(avg_w2v_vectors_essay_test)
         #print(b.shape)
         c=csr_matrix(title_avg_w2v_vectors_train)
         #print(c.shape)
         d=csr_matrix(title_avg_w2v_vectors_test)
         #print(d.shape)

         AVG_W2V = hstack((project_data_X_train.response_clean_categories_negative.values.resha
```

```
print(AVG_W2V.shape)
AVG_W2V_test = hstack((project_data_X_test.response_clean_categories_negative.values.
print(AVG_W2V_test.shape)
```

```
(87398, 610)
(21850, 610)
```

```
In [106]: from xgboost import XGBClassifier
          from sklearn.model_selection import GridSearchCV
          model=XGBClassifier(class_weight='balanced')
          number_of_base_models=[5,10,20,35,50,100,200,500]
          depth=[1,2,3]
          parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
          clf3 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
          clf3.fit(AVG_W2V,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits
```

```
[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:   58.8s
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:  1.8min
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  4.1min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed:  9.1min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed: 15.4min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed: 33.0min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed: 62.6min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed: 72.5min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 112.0min finished
```

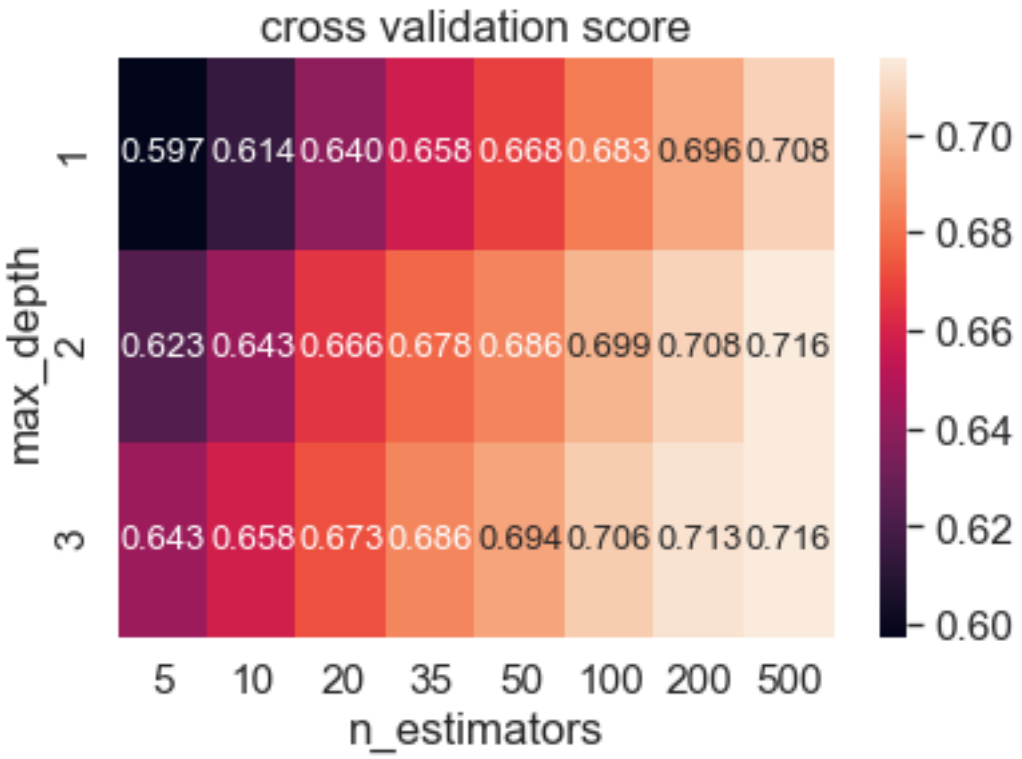
```
Out[106]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                  estimator=XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balanc
                  colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                  max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
                  n_estimators=100, n_jobs=1, nthread=None,
                  objective='binary:logistic', random_state=0, reg_alpha=0,
                  reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                  subsample=1),
                  fit_params=None, iid='warn', n_jobs=4,
                  param_grid={'n_estimators': [5, 10, 20, 35, 50, 100, 200, 500], 'max_depth':
                  pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                  scoring='roc_auc', verbose=10)
```

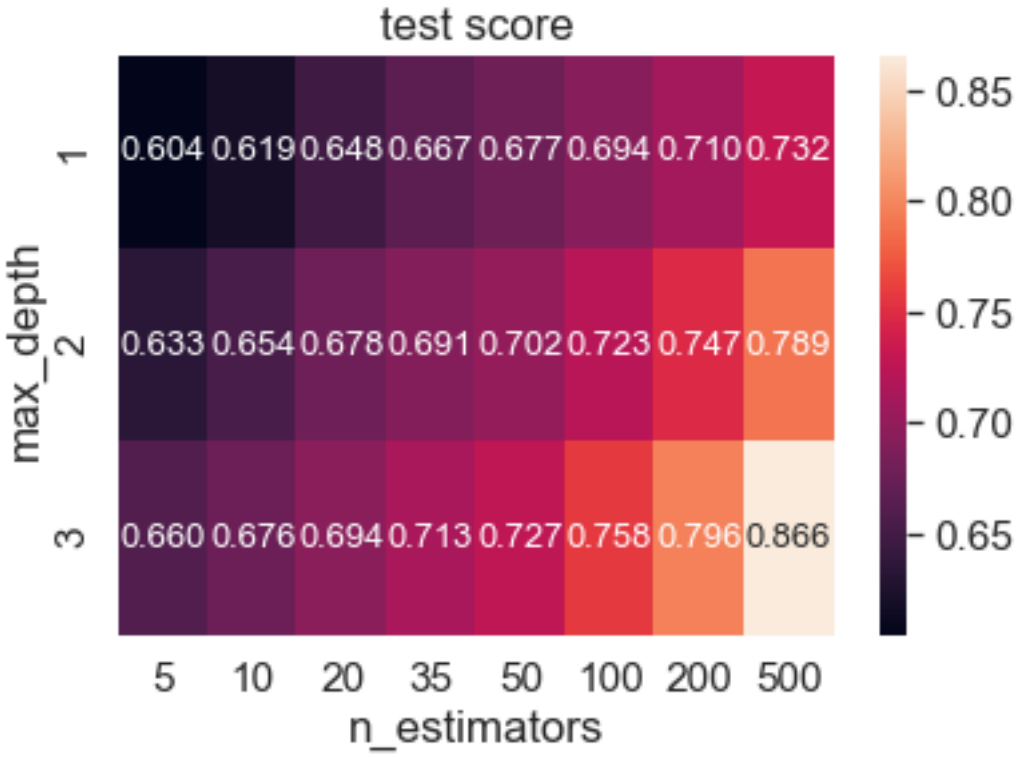
```
In [107]: clf=clf3
          clf.best_params_
```

```
Out[107]: {'max_depth': 2, 'n_estimators': 500}
```

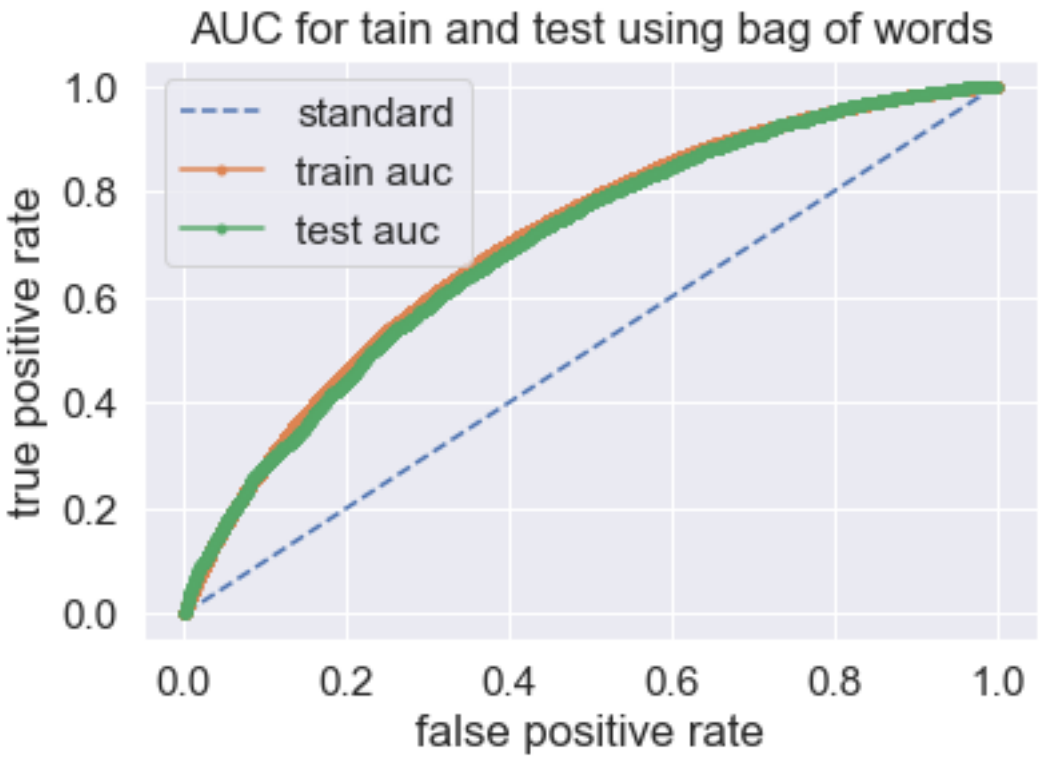
In [108]:
```
#https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
max_depth_all=[]
min_samples_split_all=[]
for i in range (0,len(clf.cv_results_['params'])):
    max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
    min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
#print(max_depth_all)
#print(min_samples_split_all)
cv_score_all=clf.cv_results_['mean_test_score']
#print(cv_score_all)
cv_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'cv_auc': cv_score_all
    })
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 13}, fmt=".3f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 13}, fmt=".3f")
```

Out[108]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x297537a0f98>
```


cross validation score
max_depth
1
2
3
0.597 0.614 0.640 0.658 0.668 0.683 0.696 0.708
0.623 0.643 0.666 0.678 0.686 0.699 0.708 0.716
0.643 0.658 0.673 0.686 0.694 0.706 0.713 0.716
5 10 20 35 50 100 200 500
n_estimators
0.70
0.68
0.66
0.64
0.62
0.60


test score
max_depth
1
2
3
0.604 0.619 0.648 0.667 0.677 0.694 0.710 0.732
0.633 0.654 0.678 0.691 0.702 0.723 0.747 0.789
0.660 0.676 0.694 0.713 0.727 0.758 0.796 0.866
5 10 20 35 50 100 200 500
n_estimators
0.85
0.80
0.75
0.70
0.65

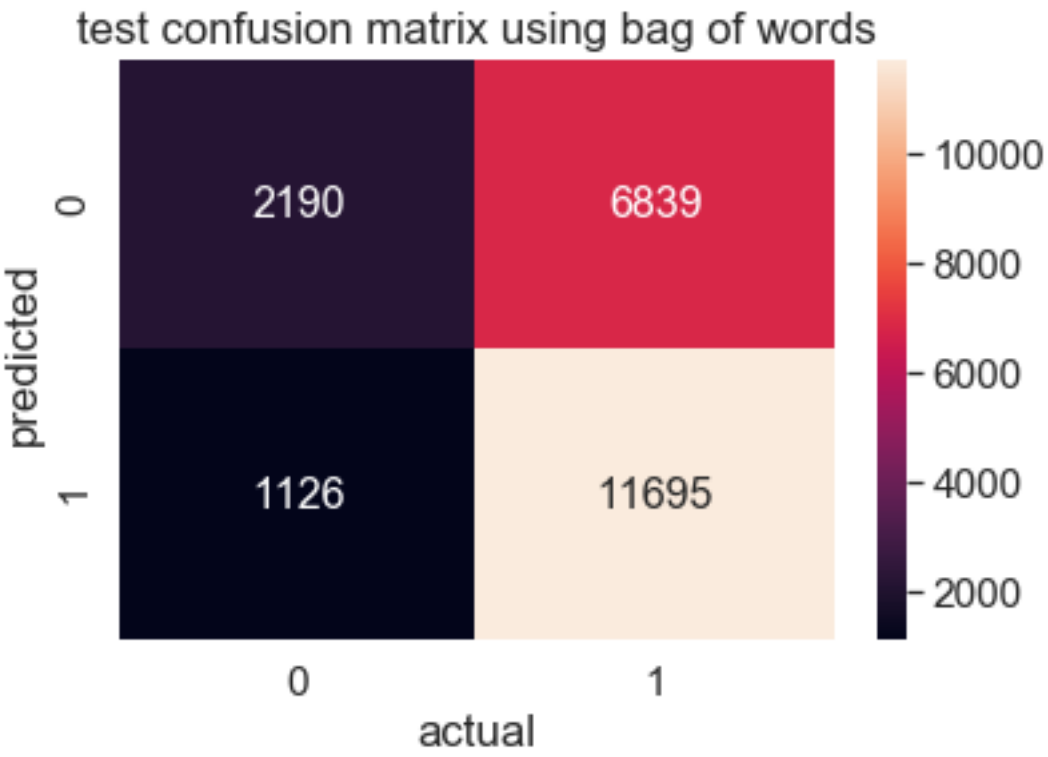
```
In [92]: from sklearn.ensemble import RandomForestClassifier
         model=XGBClassifier(class_weight='balanced',max_depth= 1, n_estimators=200,random_sta
         model.fit(AVG_W2V,project_data_Y_train)

Out[92]: XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balanced',
                colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                max_delta_step=0, max_depth=1, min_child_weight=1, missing=None,
                n_estimators=200, n_jobs=1, nthread=None,
                objective='binary:logistic', random_state=42, reg_alpha=0,
                reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                subsample=1)

In [93]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(AVG_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(AVG_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.700
AUC: 0.707
```



In [95]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(AVG_W2V_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

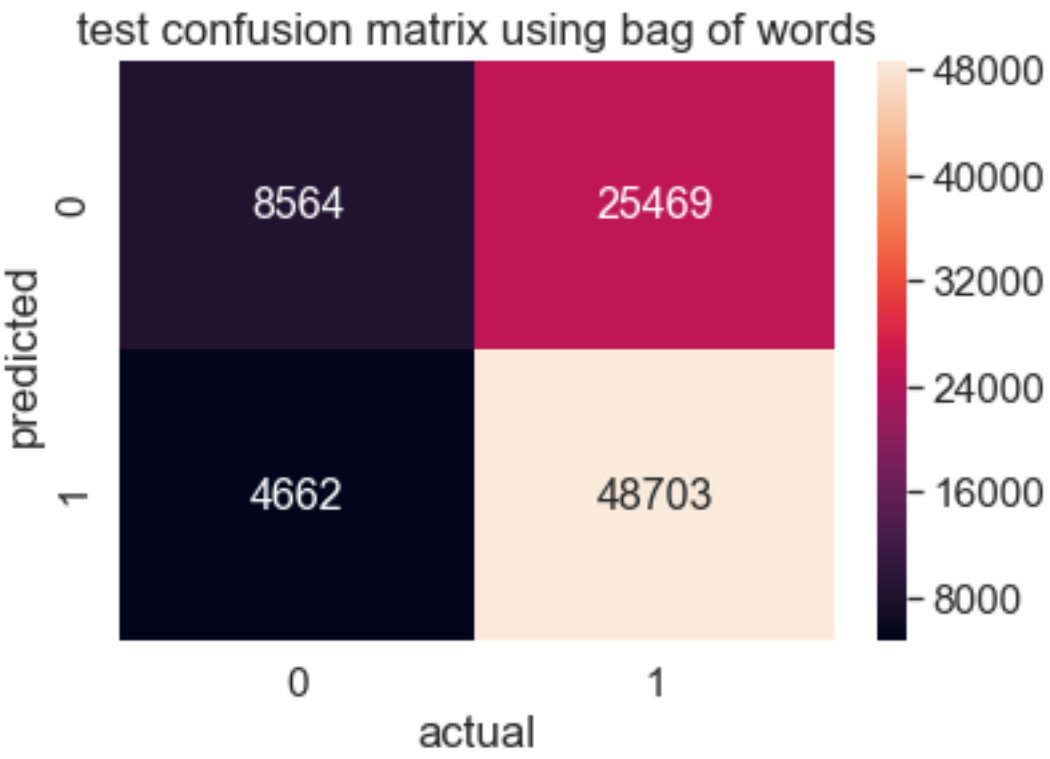
```
the maximum value of tpr*(1-fpr) 0.41673565603618584 for threshold 0.845
2190 1126 6839 11695
true positive rate 0.6310024819251107
```

```
true negaitive rate 0.6604342581423401
[[2190, 6839], [1126, 11695]]
```



In [96]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(AVG_W2V)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, threshol
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4251712248655878 for threshold 0.841
8564 4662 25469 48703
true positive rate 0.6566224451275414
true negaitive rate 0.6475124754271888
[[8564, 25469], [4662, 48703]]
```



2.0.9 2.5.4 Applying XGBOOST on TFIDF W2V, SET 4

```
In [97]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         # conver list of lists to sparse matrix https://docs.scipy.org/doc/scipy/reference/ge
         from scipy.sparse import hstack,csr_matrix
         a=csr_matrix(essay_tfidf_w2v_vectors_train)
         #print(a.shape)
         b=csr_matrix(essay_tfidf_w2v_vectors_test)
         #print(b.shape)
         c=csr_matrix(title_tfidf_w2v_vectors_train)
         #print(c.shape)
         d=csr_matrix(title_tfidf_w2v_vectors_test)
         #print(d.shape)
         # with the same hstack function we are concatinating a sparse matrix and a dense mati
         TFIDF_W2V = hstack((project_data_X_train.response_clean_categories_negative.values.re
         print(TFIDF_W2V.shape)
```

```
        TFIDF_W2V_test = hstack((project_data_X_test.response_clean_categories_negative.values
        print(TFIDF_W2V_test.shape)
```

```
(87398, 610)
(21850, 610)
```

```
In [110]: from xgboost import XGBClassifier
          from sklearn.model_selection import GridSearchCV
          model=XGBClassifier(class_weight='balanced')
          number_of_base_models=[5,10,20,35,50,100,200,500]
          depth=[1,2,3]
          parameters = {'n_estimators': number_of_base_models, 'max_depth':depth}
          clf4 = GridSearchCV(model, parameters,scoring='roc_auc',n_jobs=4,verbose=10)
          clf4.fit(TFIDF_W2V,project_data_Y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits
```

```
[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done   5 tasks      | elapsed:  2.4min
[Parallel(n_jobs=4)]: Done  10 tasks      | elapsed:  4.5min
[Parallel(n_jobs=4)]: Done  17 tasks      | elapsed:  8.6min
[Parallel(n_jobs=4)]: Done  24 tasks      | elapsed: 12.5min
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed: 16.7min
[Parallel(n_jobs=4)]: Done  42 tasks      | elapsed: 21.1min
[Parallel(n_jobs=4)]: Done  53 tasks      | elapsed: 31.2min
[Parallel(n_jobs=4)]: Done  64 tasks      | elapsed: 40.5min
[Parallel(n_jobs=4)]: Done  72 out of  72 | elapsed: 66.0min finished
```

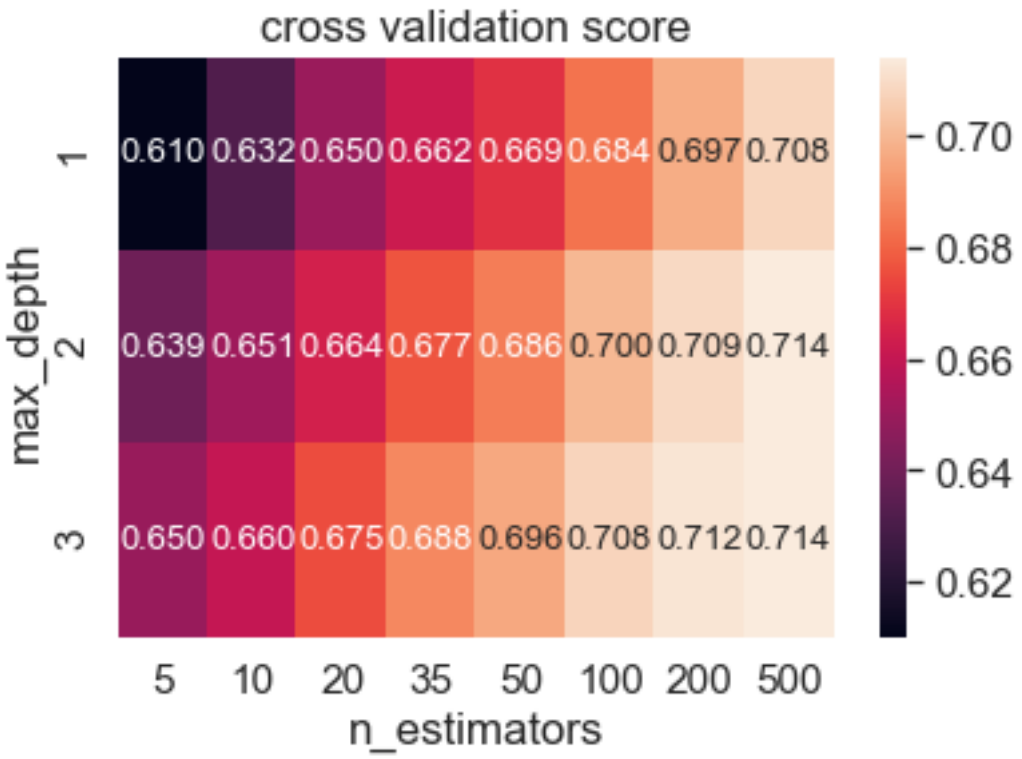
```
Out[110]: GridSearchCV(cv='warn', error_score='raise-deprecating',
                estimator=XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balanc
                colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
                n_estimators=100, n_jobs=1, nthread=None,
                objective='binary:logistic', random_state=0, reg_alpha=0,
                reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                subsample=1),
                fit_params=None, iid='warn', n_jobs=4,
                param_grid={'n_estimators': [5, 10, 20, 35, 50, 100, 200, 500], 'max_depth':
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring='roc_auc', verbose=10)
```

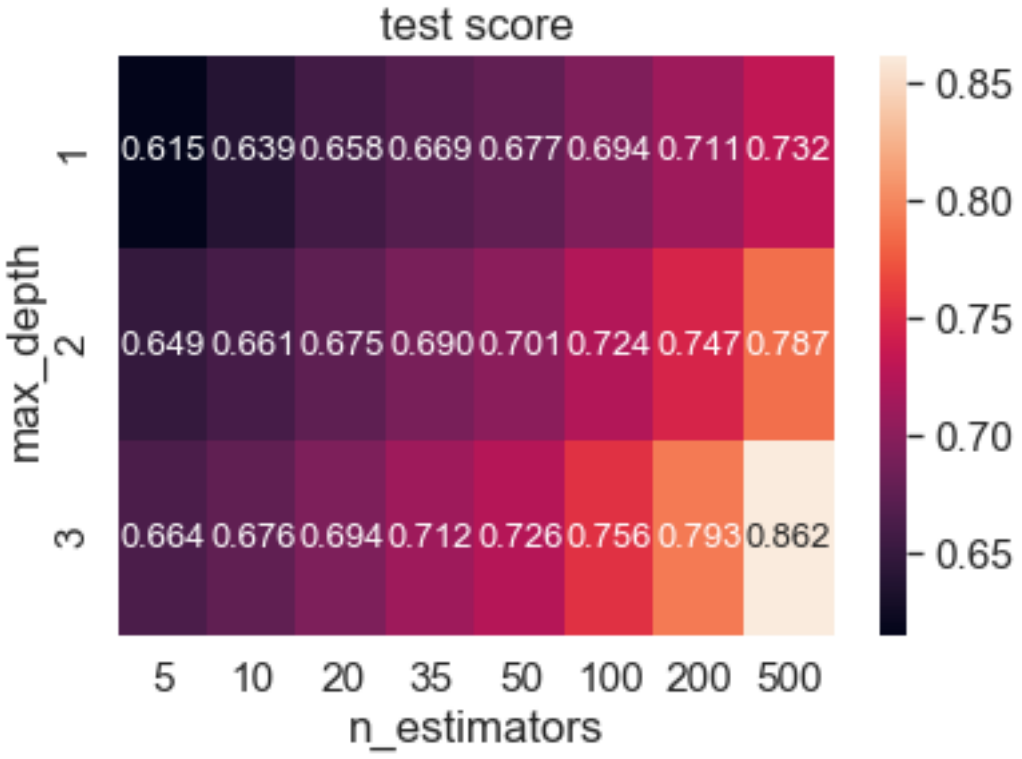
```
In [111]: clf=clf4
          clf.best_params_
```

```
Out[111]: {'max_depth': 3, 'n_estimators': 500}
```

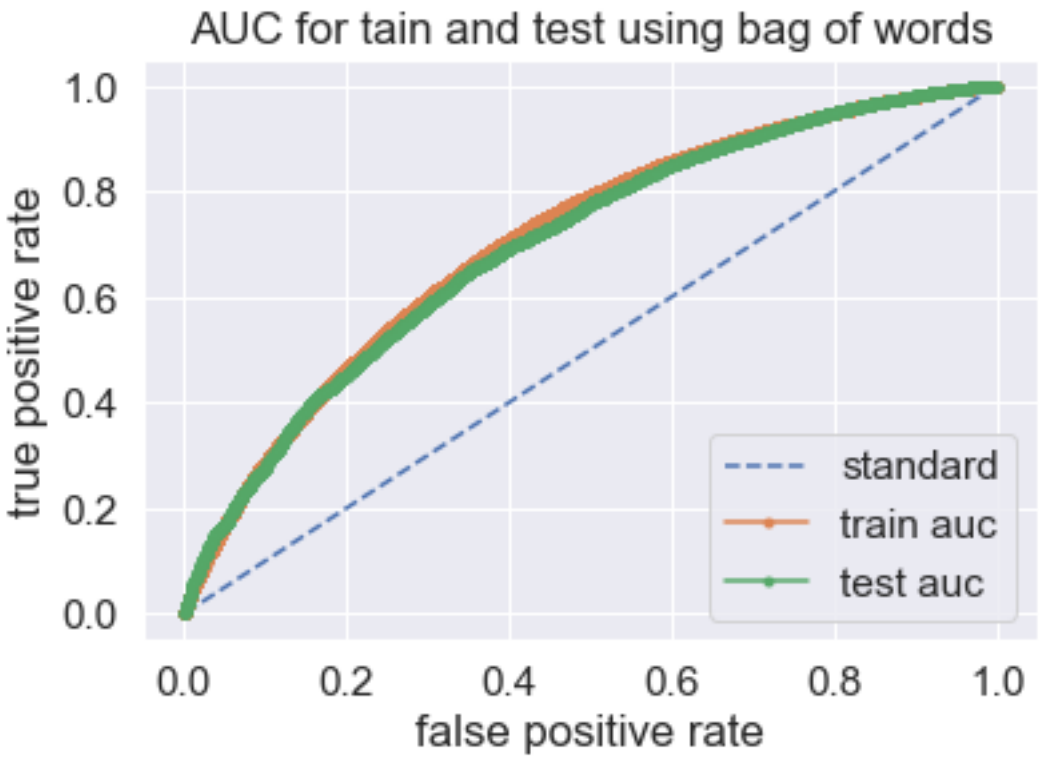
In [112]:
```
#https://stackoverflow.com/questions/30522724/take-multiple-lists-into-dataframe
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
max_depth_all=[]
min_samples_split_all=[]
for i in range (0,len(clf.cv_results_['params'])):
    max_depth_all.append(clf.cv_results_['params'][i]['max_depth'])
    min_samples_split_all.append(clf.cv_results_['params'][i]['n_estimators'])
#print(max_depth_all)
#print(min_samples_split_all)
cv_score_all=clf.cv_results_['mean_test_score']
#print(cv_score_all)
cv_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'cv_auc': cv_score_all
    })
cv_data=cv_data.pivot('max_depth','n_estimators','cv_auc')
plt.figure(112)
plt.title("cross validation score")
sns.heatmap(cv_data, annot=True,annot_kws={"size": 13}, fmt=".3f")

train_score_all=clf.cv_results_['mean_train_score']
#print(train_score_all)
tain_data=pd.DataFrame(
    {'max_depth': max_depth_all,
     'n_estimators': min_samples_split_all,
     'train_auc': train_score_all
    })
tain_data=tain_data.pivot('max_depth','n_estimators','train_auc')
plt.figure(122)
plt.title("test score")
sns.heatmap(tain_data, annot=True,annot_kws={"size": 13}, fmt=".3f")
```

Out[112]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x29763e60b70>
```


cross validation score
max_depth
1
2
3
0.610 0.632 0.650 0.662 0.669 0.684 0.697 0.708
0.639 0.651 0.664 0.677 0.686 0.700 0.709 0.714
0.650 0.660 0.675 0.688 0.696 0.708 0.712 0.714
5 10 20 35 50 100 200 500
n_estimators
0.70
0.68
0.66
0.64
0.62


test score
max_depth
1
2
3
0.615 0.639 0.658 0.669 0.677 0.694 0.711 0.732
0.649 0.661 0.675 0.690 0.701 0.724 0.747 0.787
0.664 0.676 0.694 0.712 0.726 0.756 0.793 0.862
5 10 20 35 50 100 200 500
n_estimators
0.85
0.80
0.75
0.70
0.65

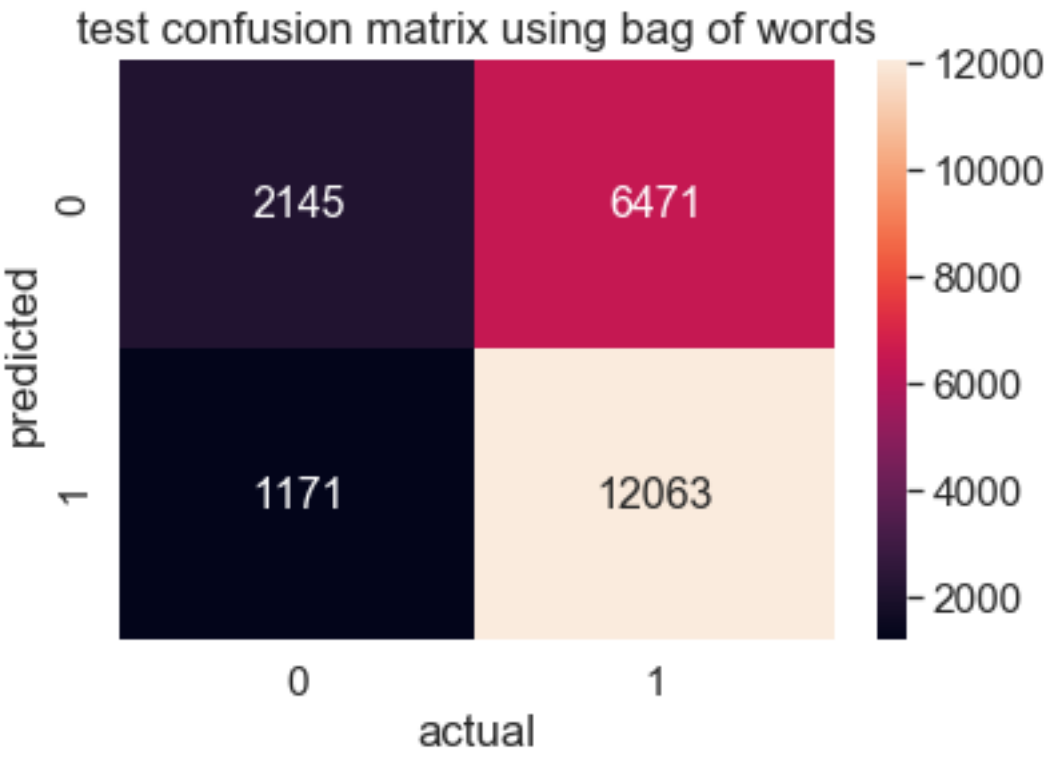
```
In [98]: from sklearn.ensemble import RandomForestClassifier
         model=XGBClassifier(class_weight='balanced',max_depth= 1, n_estimators=200,random_sta
         model.fit(TFIDF_W2V,project_data_Y_train)

Out[98]: XGBClassifier(base_score=0.5, booster='gbtree', class_weight='balanced',
                colsample_bylevel=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
                max_delta_step=0, max_depth=1, min_child_weight=1, missing=None,
                n_estimators=200, n_jobs=1, nthread=None,
                objective='binary:logistic', random_state=42, reg_alpha=0,
                reg_lambda=1, scale_pos_weight=1, seed=None, silent=True,
                subsample=1)

In [99]: #https://machinelearningmastery.com/roc-curves-and-precision-recall-curves-for-classi
         from sklearn.metrics import roc_curve
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm

         probs_test = model.predict_proba(TFIDF_W2V_test)
         # keep probabilities for the positive outcome only
         probs_test = probs_test[:, 1]
         auc_test = roc_auc_score(project_data_Y_test, probs_test)
         print('AUC: %.3f' % auc_test)
         fpr, tpr, thresholds = roc_curve(project_data_Y_test, probs_test)

         probs_train = model.predict_proba(TFIDF_W2V)
         # keep probabilities for the positive outcome only
         probs_train = probs_train[:, 1]
         auc_train = roc_auc_score(project_data_Y_train, probs_train)
         print('AUC: %.3f' % auc_train)
         fpr1, tpr1, thresholds1 = roc_curve(project_data_Y_train, probs_train)


         plt.plot([0, 1], [0, 1], linestyle='--')
         plt.plot(fpr1, tpr1, marker='.')
         plt.plot(fpr, tpr, marker='.')

         plt.legend({"standard":"","train auc":"","test auc":""})
         plt.title("AUC for tain and test using bag of words")
         plt.xlabel("false positive rate")
         plt.ylabel("true positive rate")
         plt.show()

AUC: 0.701
AUC: 0.708
```



In [100]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_W2V_test)
tn, fp, fn, tp = confusion_matrix(project_data_Y_test, predict(probs_test, thresholds
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

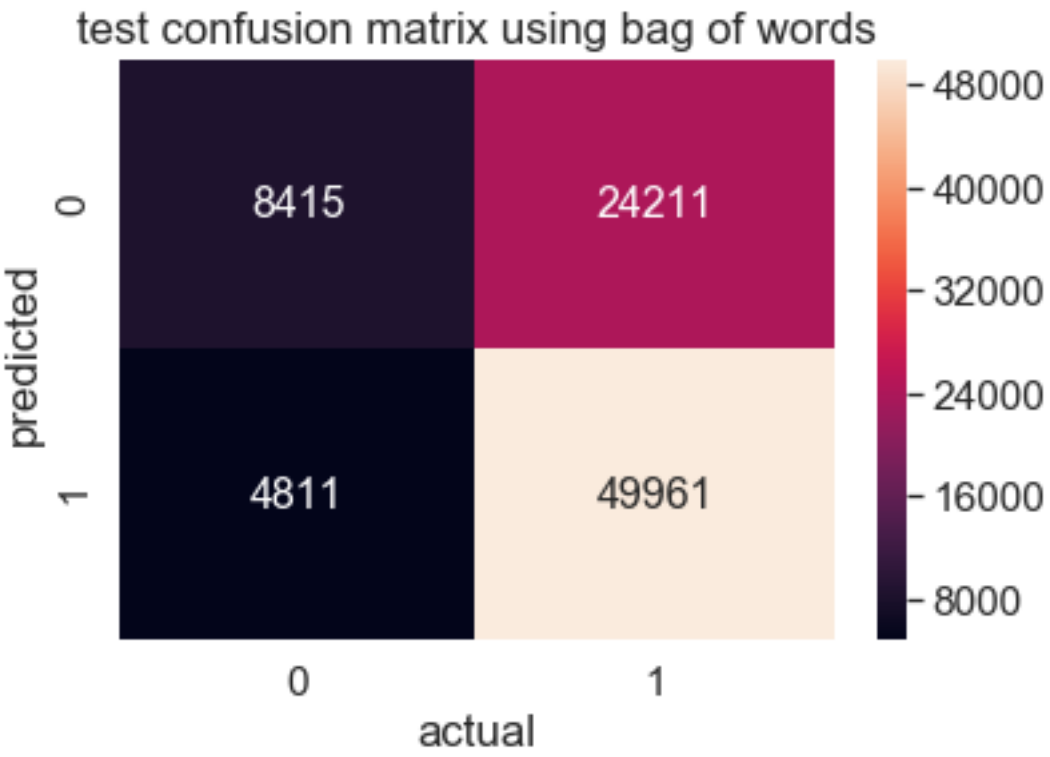
```
the maximum value of tpr*(1-fpr) 0.4210163325173062 for threshold 0.84
2145 1171 6471 12063
true positive rate 0.6508578828099708
```

```
true negaitive rate 0.6468636911942099
[[2145, 6471], [1171, 12063]]
```



In [101]:
```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
#compute confudion matrix values and plot
from sklearn.metrics import confusion_matrix
predicted_bow_test=model.predict(TFIDF_W2V)
tn, fp, fn, tp = confusion_matrix(project_data_Y_train, predict(probs_train, thresho
print(tn, fp, fn, tp)
print("true positive rate",(tp/(tp+fn)))
print("true negaitive rate",(tn/(tn+fp)))
matrix=[[tn,fn],[fp,tp]]
print(matrix)
df_cm = pd.DataFrame(matrix, range(2),
                     range(2))
#plt.figure(figsize = (10,7))
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')# font size
plt.title("test confusion matrix using bag of words")
plt.xlabel("actual")
plt.ylabel("predicted")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.42856503406866303 for threshold 0.836
8415 4811 24211 49961
true positive rate 0.6735830232432723
true negaitive rate 0.6362467866323908
[[8415, 24211], [4811, 49961]]
```



3. Conclusion

```
In [119]: from prettytable import PrettyTable
          x = PrettyTable()
          x.field_names = ["Vectorizer", "Model","n_estimators", "max_depth", "AUC"]
          x.add_row(["BAG of words", "Random Forest", 150, 3, 0.667])
          x.add_row(["TFIDF", "Random Forest" , 150, 3, 0.683])
          x.add_row(["Average W2V", "Random Forest",200, 3, 0.677])
          x.add_row(["TFIDF W2V", "Random Forest" ,200,  3, 0.673])
          x.add_row(["------------", "-------------" ,"---","-","-----"])
          x.add_row(["BAG of words", "XGBOOST", 500, 1, 0.723])
          x.add_row(["TFIDF", "XGBOOST" , 200, 1, 0.704])
          x.add_row(["Average W2V", "XGBOOST", 200, 1, 0.700])
          x.add_row(["TFIDF W2V", "XGBOOST" , 200,  1, 0.701])
          x.border=True
          print(x)
```

Vectorizer	Model	n_estimators	max_depth	AUC
BAG of words	Random Forest	150	3	0.667
TFIDF	Random Forest	150	3	0.683
Average W2V	Random Forest	200	3	0.677
TFIDF W2V	Random Forest	200	3	0.673
---	---	---	-	-----
BAG of words	XGBOOST	500	1	0.723
TFIDF	XGBOOST	200	1	0.704
Average W2V	XGBOOST	200	1	0.7
TFIDF W2V	XGBOOST	200	1	0.701

In [ ]: