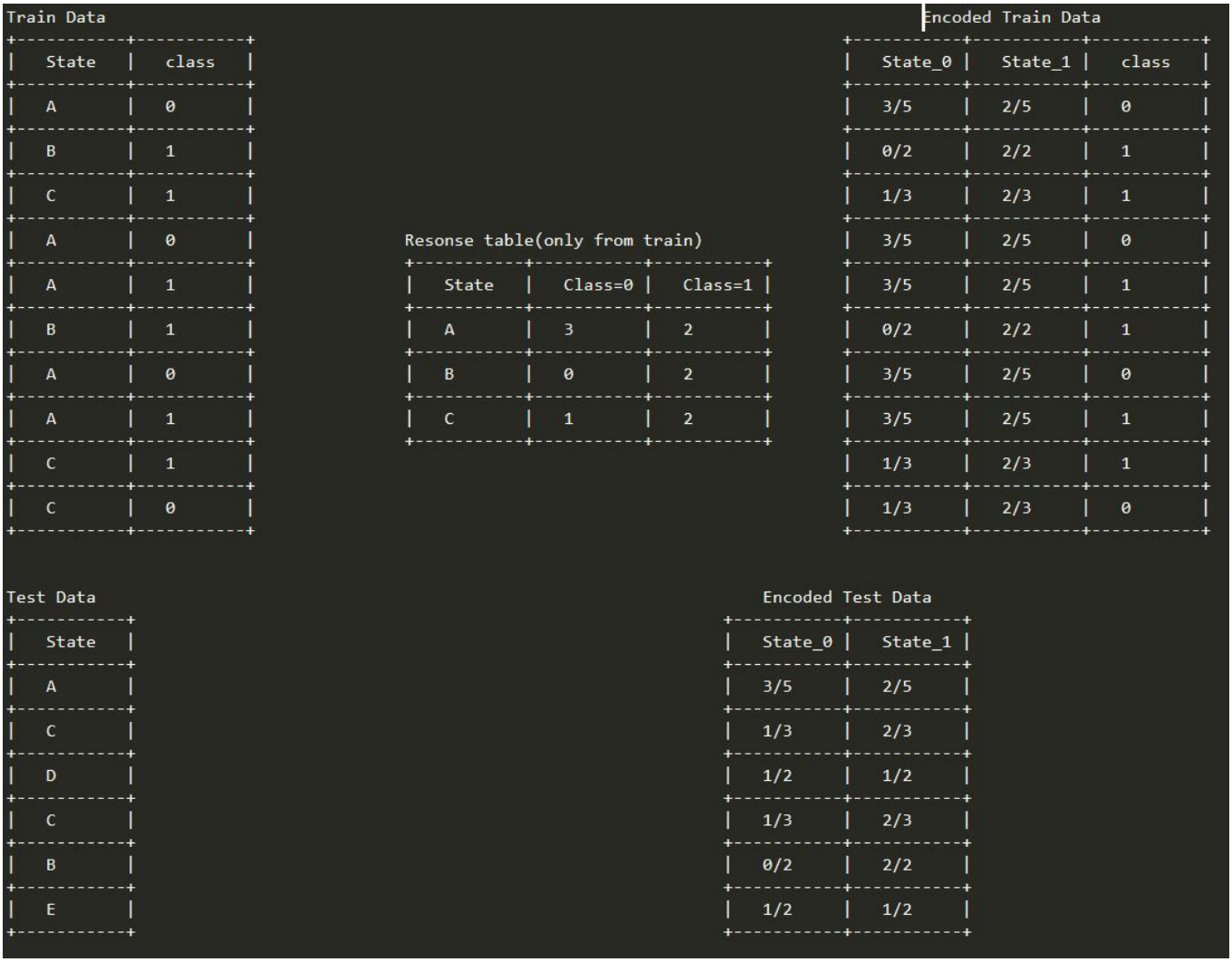
Assignment 9: GBDT

Response Coding: Example



Train Data

State	class
A	0
B	1
C	1
A	0
A	1
B	1
A	0
A	1
C	1
C	0

Resonse table(only from train)

State	Class=0	Class=1
A	3	2
B	0	2
C	1	2

Encoded Train Data

State_0	State_1	class
3/5	2/5	0
0/2	2/2	1
1/3	2/3	1
3/5	2/5	0
3/5	2/5	1
0/2	2/2	1
3/5	2/5	0
3/5	2/5	1
1/3	2/3	1
1/3	2/3	0

Test Data

State
A
C
D
C
B
E

Encoded Test Data

State_0	State_1
3/5	2/5
1/3	2/3
1/2	1/2
1/3	2/3
0/2	2/2
1/2	1/2

> 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]

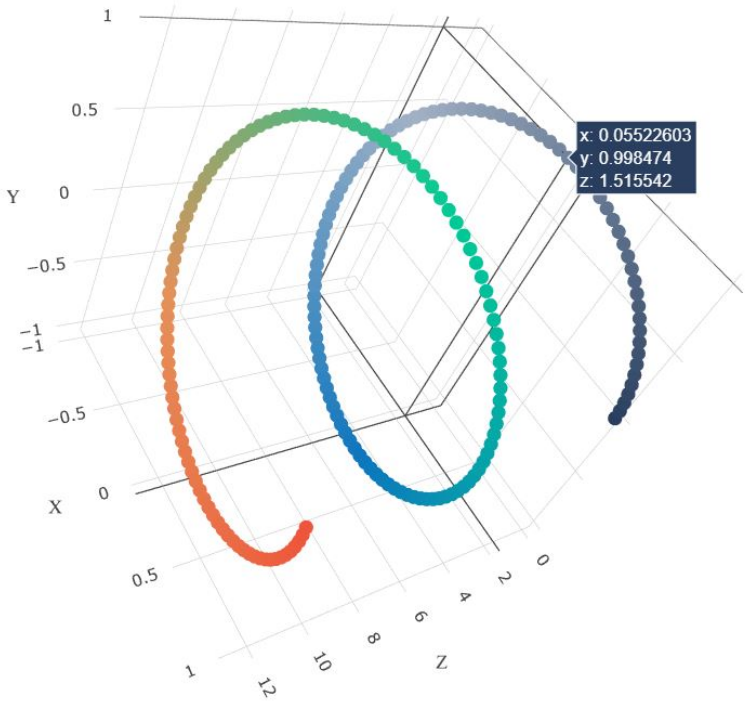
1. **Apply GBDT on these feature sets**
   - Set 1: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)+sentiment Score of eassay(check the bellow example, include all 4 values as 4 features)
   - Set 2: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **The hyper paramter tuning (Consider any two hyper parameters)**
   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-

characteristic-curve-roc-curve-and-auc-1/) value

- find the best hyper paramter using k-fold cross validation/simple cross validation data
- use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

3. **Representation of results**

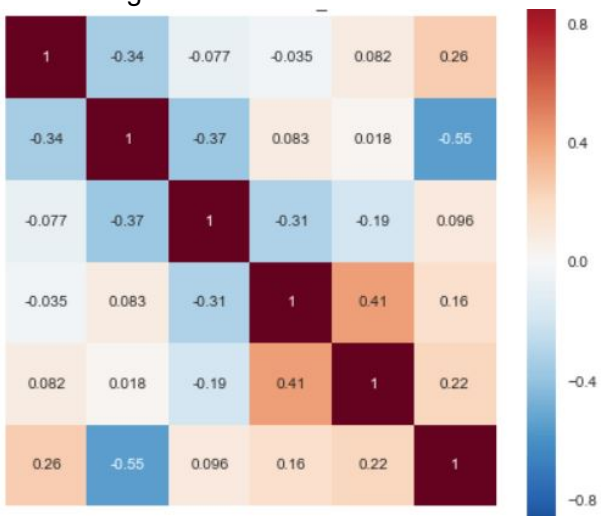
- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

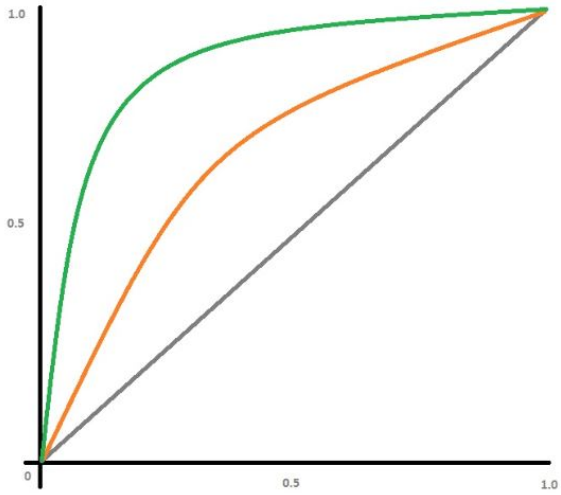
or

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



seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**

- You choose either of the plotting techniques out of 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.



- Along with plotting ROC curve, you need to print the [confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points

	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

4. You need to summarize the results at the end of the notebook, summarize it in the table format

Vectorizer	Model	Hyper parameter	AUC
BOW	Brute	7	0.78
TFIDF	Brute	12	0.79
W2V	Brute	10	0.78
TFIDFW2V	Brute	6	0.78

1. GBDT (xgboost/lightgbm)

1.1 Loading Data

In [79]:

```
import pandas as pd
data = pd.read_csv('preprocessed_data.csv')
```

In [80]:

```
data.head()
```

Out[80]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

In [81]:

```
data.shape
```

Out[81]:

```
(109248, 9)
```

calculate the sentiment scores for each review/essay

In [82]:

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

sentiment = SentimentIntensityAnalyzer()

score= []                       # it will store all the sentiment score value for all r
eview/essay
for sentence in data['essay']:
    ss = sentiment.polarity_scores(sentence)
    score.append(ss)

# these ss are in dictionary format means score will be list of dict value

# to build the newdataframe and combine with orginial dataframe we need to find the col
umn names

keys = list(ss.keys())

# now get the list of value of sentiment score
value=[]
for val in score:
    value.append(val.values())

# now built the new dataframe with value as value and keys as column names

new_df = pd.DataFrame(value,columns=keys)

new_df.head()
```

Out[82]:

	neg	neu	pos	compound
0	0.013	0.783	0.205	0.9867
1	0.072	0.680	0.248	0.9897
2	0.017	0.721	0.262	0.9860
3	0.030	0.783	0.187	0.9524
4	0.029	0.683	0.288	0.9873

In [83]:

```
new_df.shape
```

Out[83]:

```
(109248, 4)
```

combine the new_df with data

In [84]:

```
Data = pd.concat([data,new_df],axis =1)
Data.head()
```

Out[84]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

In [85]:

```
Data.shape

# now we have 13 feature after combining the sentimental score for each essay
```

Out[85]:

```
(109248, 13)
```

load the glove vector

which will be used for getting the W2v of word

In [86]:

```
import pickle

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

In [87]:

```
#glove_words
```

In [88]:

```
#model
```

if we want to get the vector for any word simply write

value = model['word name']

it will gives the vector for that word if it is present in the glove words/model

In [89]:

```
df = pd.DataFrame(Data)
```

In [90]:

```
# divide the target y from other data

X = df.drop(['project_is_approved'],axis =1)
y = df['project_is_approved']

X.head()
```

Out[90]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

In [91]:

```
y.head()
```

Out[91]:

```
0    1
1    1
2    1
3    1
4    1
Name: project_is_approved, dtype: int64
```

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

In [92]:

```
from sklearn.model_selection import train_test_split

X_train,X_test,y_train,y_test = train_test_split(X,y,test_size = 0.33,stratify=y)
```

In [93]:

```
X_train.head()

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

```
(73196, 12)
(36052, 12)
```

1.3 Make Data Model Ready: encoding eassay, and project_title

In [94]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
import numpy as np

feature_names_tfidf= []
feature_names_tfidfW2v =[]

############### apply TFidf on essay ####################

vectorizer = TfidfVectorizer(max_features=10000,ngram_range=(1,3))

vectorizer.fit(X_train['essay'].values)

dictionary = dict(zip(vectorizer.get_feature_names(),vectorizer.idf_))

feature_names_tfidf.extend(vectorizer.get_feature_names())
feature_names_tfidfW2v.extend(vectorizer.get_feature_names())

tfidf_words = set(vectorizer.get_feature_names())

X_train_essay_tfidf = vectorizer.transform(X_train['essay'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['essay'].values)

print('after vectorization\n',X_train_essay_tfidf.shape,y_train.shape)
print(X_test_essay_tfidf.shape,y_test.shape)

print('total number of feature in essay_tfdif_vector',len(feature_names_tfidf))

###################### applying TFIDF W2v on essay ###################################

X_train_tfidf_W2v_vector = [] # it will store the tfidf W2v for each review
for sentence in X_train['essay'].values: # for each review/essay
    vector = np.zeros(300) # create the 300 dimension vector for each word
    tfidf_weight = 0   # sum of all the tfidf of word for given review we will need it
 for dividing purpose
    for word in sentence.split():  # for each word in sentence
        if (word in glove_words) and (word in tfidf_words): # if the word is in glove v
ector and tfidf feature names
            vec = model.get(word)  # then get the vector of word from glove model
            tfidf = dictionary[word] * (sentence.count(word)/len(sentence.split()))  #
 find tfdif(word,sentence)= idf * tf
            vector+=(vec*tfidf)  # keep on adding the tfidf(word, sentence) * W2v(word,
sentence)
            tfidf_weight += tfidf
    X_train_tfidf_W2v_vector.append(vector/ tfidf_weight)


X_test_tfidf_W2v_vector = [] # it will store the tfidf W2v for each review
for sentence in X_test['essay'].values: # for each review/essay
    vector = np.zeros(300) # create the 300 dimension vector for each word
    tfidf_weight = 0   # sum of all the tfidf of word for given review we will need it
 for dividing purpose
    for word in sentence.split():  # for each word in sentence
        if (word in glove_words) and (word in tfidf_words): # if the word is in glove v
ector and tfidf feature names
            vec = model[word]  # then get the vector of word from glove model
            tfidf = dictionary[word] * (sentence.count(word)/len(sentence.split()))  #
 find tfdif(word,sentence)= idf * tf
            vector += (vec*tfidf)  # keep on adding the tfidf(word, sentence) * W2v(wor
d,sentence)
```

```
            tfidf_weight += tfidf
    X_test_tfidf_W2v_vector.append(vector/ tfidf_weight)

print('X_train_tfdif_W2v vector',len(X_train_tfidf_W2v_vector))
print('X_test_tfdif_W2v vector',len(X_test_tfidf_W2v_vector))
```

```
after vectorization
 (73196, 10000) (73196,)
(36052, 10000) (36052,)
total number of feature in essay_tfdif_vector 10000
X_train_tfdif_W2v vector 73196
X_test_tfdif_W2v vector 36052
```

In [96]:

```
from scipy.sparse import coo_matrix
X_train_tfidf_W2v_vector = coo_matrix(X_train_tfidf_W2v_vector)
```

In [103]:

```
X_test_tfidf_W2v_vector =coo_matrix(X_test_tfidf_W2v_vector)
```

In [97]:

```
X_train_tfidf_W2v_vector.shape
```

Out[97]:

```
(73196, 300)
```

1.4 Make Data Model Ready: encoding numerical, categorical features

In [98]:

```
list_y_train = y_train.tolist()
print(type(y_train))
print(type(list_y_train))
```

```
<class 'pandas.core.series.Series'>
<class 'list'>
```

In [99]:

```
# get all the index position for the particular word present in the list
# then for that index find update the count_pos by 1 if that index in y_train[index] ==
1 else increase count_neg by 1 if y== 0

def apply_response_encoding(column_name):
    # first get the value present in school state categorical feature
    list_of_train_category_values = []
    list_of_train_category_values.extend(X_train[column_name].values)
    #list_of_category_values

    array_of_train_category_values = np.array(list_of_train_category_values)

    list_of_test_category_values=[]
    list_of_test_category_values.extend(X_test[column_name].values)

    x_train_re = pd.DataFrame(columns=['prob_0','prob_1'])
    x_test_re = pd.DataFrame(columns=['prob_0','prob_1'])

    for cat_ele in list_of_train_category_values:
        count_pos = 0
        count_neg = 0
        # https://stackoverflow.com/questions/6294179/how-to-find-all-occurrences-of-an
-element-in-a-list
        ind_of_cat_ele = np.where(array_of_train_category_values==cat_ele)[0]
        ind_of_cat_ele = ind_of_cat_ele.tolist()

        for ind in ind_of_cat_ele:
            if (list_y_train[ind] == 1):
                count_pos += 1
            else:
                count_neg += 1


        prob_of_pos = count_pos/len(ind_of_cat_ele)
        prob_of_neg = count_neg/len(ind_of_cat_ele)

        # https://www.geeksforgeeks.org/how-to-create-an-empty-dataframe-and-append-row
s-columns-to-it-in-pandas/

        x_train_re = x_train_re.append({'values':cat_ele,'prob_0':prob_of_neg,'prob_1':
prob_of_pos},ignore_index = True)


    for cat_val in list_of_test_category_values:
        if cat_val in list_of_train_category_values:
            ind = x_train_re.loc[x_train_re['values']==cat_val].index[0]
            x_test_re = x_test_re.append(x_train_re.iloc[ind],ignore_index=True)
        else:
            x_test_re = x_test_re.append({'values':cat_val,'prob_0':0.5,'prob_1':0.5},i
gnore_index=True)


    x_train_re = x_train_re.drop(['values'],axis=1)
    x_test_re = x_test_re.drop(['values'],axis=1)


    x_train_re = pd.DataFrame(x_train_re)
    x_train_re= x_train_re.values
    #print(x_train_re)
```

```
    x_test_re = pd.DataFrame(x_test_re)
    x_test_re= x_test_re.values
    #print(x_test_re)

    return x_train_re,x_test_re
```

In [100]:

```
x_train_ss_re,x_test_ss_re = apply_response_encoding('school_state')
x_train_teacher_re,x_test_teacher_re = apply_response_encoding('teacher_prefix')
x_train_pro_grade_re,x_test_pro_grade_re = apply_response_encoding('project_grade_categ
ory')
x_train_cc_re,x_test_cc_re = apply_response_encoding('clean_categories')
x_train_cs_re,x_test_cs_re = apply_response_encoding('clean_subcategories')
```

In [101]:

```
####### normalize the numerical feature #################

################## price ###########################################################

print('\n\n normalize of price\n')



from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(1,-1))



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


x_train_price_norm = x_train_price_norm.reshape(-1,1)
x_test_price_norm = x_test_price_norm.reshape(-1,1)


print("After normalizations")
print(x_train_price_norm.shape, y_train.shape)
print(x_test_price_norm.shape, y_test.shape)



#print('\n total number of features',len(feature_names))
print("="*100)


##########  teacher_number_of_previously posted projects###################

print('\n\n normalize of teacher_number_of_previously_posted_project\n')



from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1
,-1))
```

```
x_train_teacher_project_norm = normalizer.transform(X_train['teacher_number_of_previous
ly_posted_projects'].values.reshape(1,-1))
x_test_teacher_project_norm = normalizer.transform(X_test['teacher_number_of_previously
_posted_projects'].values.reshape(1,-1))


x_train_teacher_project_norm = x_train_teacher_project_norm.reshape(-1,1)
x_test_teacher_project_norm = x_test_teacher_project_norm.reshape(-1,1)

print("After normalizations")
print(x_train_teacher_project_norm.shape, y_train.shape)
print(x_test_teacher_project_norm.shape, y_test.shape)


################## pos ############################################################

print('\n\n normalize of pos\n')



from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['pos'].values.reshape(1,-1))



x_train_pos_norm = normalizer.transform(X_train['pos'].values.reshape(1,-1))
x_test_pos_norm = normalizer.transform(X_test['pos'].values.reshape(1,-1))


x_train_pos_norm = x_train_pos_norm.reshape(-1,1)
x_test_pos_norm = x_test_pos_norm.reshape(-1,1)


print("After normalizations")
print(x_train_pos_norm.shape, y_train.shape)
print(x_test_pos_norm.shape, y_test.shape)




#print('\n total number of features',len(feature_names))
print("="*100)


##########  neg ##################

print('\n\nnormalize of neg\n')


from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
```

```
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['neg'].values.reshape(1,-1))



x_train_neg_norm = normalizer.transform(X_train['neg'].values.reshape(1,-1))
x_test_neg_norm = normalizer.transform(X_test['neg'].values.reshape(1,-1))


x_train_neg_norm = x_train_neg_norm.reshape(-1,1)
x_test_neg_norm = x_test_neg_norm.reshape(-1,1)

print("After normalizations")
print(x_train_neg_norm.shape, y_train.shape)
print(x_test_neg_norm.shape, y_test.shape)


##########  neu ##################

print('\n\nnormalize of neu\n')


from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['neu'].values.reshape(1,-1))



x_train_neu_norm = normalizer.transform(X_train['neu'].values.reshape(1,-1))
x_test_neu_norm = normalizer.transform(X_test['neu'].values.reshape(1,-1))


x_train_neu_norm = x_train_neu_norm.reshape(-1,1)
x_test_neu_norm = x_test_neu_norm.reshape(-1,1)

print("After normalizations")
print(x_train_neu_norm.shape, y_train.shape)
print(x_test_neu_norm.shape, y_test.shape)


##########  compound ##################

print('\n\n normalize of compound\n')


from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
```

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



x_train_compound_norm = normalizer.transform(X_train['neu'].values.reshape(1,-1))
x_test_compound_norm = normalizer.transform(X_test['neu'].values.reshape(1,-1))


x_train_compound_norm = x_train_compound_norm.reshape(-1,1)
x_test_compound_norm = x_test_compound_norm.reshape(-1,1)

print("After normalizations")
print(x_train_compound_norm.shape, y_train.shape)
print(x_test_compound_norm.shape, y_test.shape)
```

```
 normalize of price

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)
==========================================================================
==========================


 normalize of teacher_number_of_previously_posted_project

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)


 normalize of pos

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)
==========================================================================
==========================


normalize of neg

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)


normalize of neu

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)


 normalize of compound

After normalizations
(73196, 1) (73196,)
(36052, 1) (36052,)
```

In [104]:

```
# merge all the sparse vector of differnet feature
# concatenate all the train,test data for all feature
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039


from scipy.sparse import hstack


# set 1 => categorical feature + numerical feature + tfidf(essay)

x_tr_tfidf = hstack((X_train_essay_tfidf,x_train_ss_re,x_train_teacher_re,x_train_pro_grade_re,x_train_cc_re,x_train_cs_re,x_train_price_norm,x_train_teacher_project_norm,x_train_pos_norm,x_train_neg_norm,x_train_neu_norm,x_train_compound_norm)).tocsr()
x_te_tfidf = hstack((X_test_essay_tfidf,x_test_ss_re,x_test_teacher_re,x_test_pro_grade_re,x_test_cc_re,x_test_cs_re,x_test_price_norm,x_test_teacher_project_norm,x_test_pos_norm,x_test_neg_norm,x_test_neu_norm,x_test_compound_norm)).tocsr()

print('final shape of SET 1 -- categorical feature + numerical feature + tfidf(essay) \n')
print(x_tr_tfidf.shape,y_train.shape)
print(x_te_tfidf.shape,y_test.shape)



# set 2 => categorical feature + numerical feature + tfidf(essay)

x_tr_tfidfW2v =  hstack((X_train_tfidf_W2v_vector,x_train_ss_re,x_train_teacher_re,x_train_pro_grade_re,x_train_cc_re,x_train_cs_re,x_train_price_norm,x_train_teacher_project_norm,x_train_pos_norm,x_train_neg_norm,x_train_neu_norm,x_train_compound_norm)).tocsr()
x_te_tfidfW2v = hstack((X_test_tfidf_W2v_vector,x_test_ss_re,x_test_teacher_re,x_test_pro_grade_re,x_test_cc_re,x_test_cs_re,x_test_price_norm,x_test_teacher_project_norm,x_test_pos_norm,x_test_neg_norm,x_test_neu_norm,x_test_compound_norm)).tocsr()

print('\nfinal shape of SET 2 --  categorical feature + numerical feature + tfidf W2v(essay) \n')
print(x_tr_tfidfW2v.shape,y_train.shape)
print(x_te_tfidfW2v.shape,y_test.shape)
```

```
final shape of SET 1 -- categorical feature + numerical feature + tfidf(es
say)

(73196, 10016) (73196,)
(36052, 10016) (36052,)

final shape of SET 2 --  categorical feature + numerical feature + tfidf W
2v(essay)

(73196, 316) (73196,)
(36052, 316) (36052,)
```

1.5 Appling Models on different kind of featurization as mentioned in the instructions

SET 1

hyperparater tuning for SET 1

In [165]:

```
from pandas import DataFrame
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV
import lightgbm as lgb

learning_rate = [0.0001, 0.001, 0.01, 0.1, 0.2, 0.3]
n_estimators=[5,10,50, 75, 100]

parameter = dict(learning_rate = learning_rate,n_estimators = n_estimators)

# build gbdt xgboost model with having objective to minimze the logistic loss
dt_model = lgb.LGBMClassifier(objective='binary',max_depth=2 ,class_weight = 'balanced'
)

clf = GridSearchCV(dt_model,cv =5 ,param_grid = parameter,scoring = 'roc_auc',return_tr
ain_score =True)
clf.fit(x_tr_tfidf,y_train)
```

Out[165]:

```
GridSearchCV(cv=5, error_score='raise',
       estimator=LGBMClassifier(boosting_type='gbdt', class_weight='balanc
ed',
        colsample_bytree=1.0, importance_type='split', learning_rate=0.1,
        max_depth=2, min_child_samples=20, min_child_weight=0.001,
        min_split_gain=0.0, n_estimators=100, n_jobs=-1, num_leaves=31,
        objective='binary', random_state=None, reg_alpha=0.0,
        reg_lambda=0.0, silent=True, subsample=1.0,
        subsample_for_bin=200000, subsample_freq=0),
       fit_params=None, iid=True, n_jobs=1,
       param_grid={'learning_rate': [0.0001, 0.001, 0.01, 0.1, 0.2, 0.3],
'n_estimators': [5, 10, 50, 75, 100]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
       scoring='roc_auc', verbose=0)
```

In [166]:

```
result = pd.DataFrame.from_dict(clf.cv_results_)

result
```

Out[166]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
0	8.392136	1.997692	0.015758	2.918410e-03	0.0001	
1	7.498520	0.323810	0.013165	1.162982e-03	0.0001	
2	16.071021	0.231588	0.014761	9.774960e-04	0.0001	
3	21.555166	0.152360	0.016955	7.008046e-07	0.0001	
4	27.588622	0.425663	0.026529	6.199673e-03	0.0001	
5	6.403755	0.073794	0.014761	1.933871e-03	0.001	
6	7.604420	0.194277	0.015758	1.827627e-03	0.001	
7	16.548976	0.234716	0.019548	3.252914e-03	0.001	
8	22.529726	0.241061	0.024535	5.970552e-03	0.001	
9	28.261443	0.693993	0.023936	6.524926e-03	0.001	
10	6.795765	0.086759	0.015160	1.162974e-03	0.01	
11	7.940134	0.161555	0.015160	1.596147e-03	0.01	
12	17.668160	0.404210	0.020146	4.107009e-03	0.01	
13	23.377967	0.359253	0.020744	2.475288e-03	0.01	

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
14	29.343863	0.268177	0.029521	8.569736e-03	0.01	
15	6.233922	0.120978	0.030119	2.109400e-02	0.1	
16	7.639546	0.100888	0.017553	2.053618e-03	0.1	
17	16.060278	0.299167	0.025133	2.918224e-03	0.1	
18	20.729006	0.270950	0.025332	5.801035e-03	0.1	
19	25.777541	0.483912	0.026330	2.862515e-03	0.1	
20	6.189709	0.081923	0.017752	3.301892e-03	0.2	
21	7.621369	0.128224	0.016556	1.492948e-03	0.2	
22	15.428402	0.283042	0.022580	2.577184e-03	0.2	
23	267.329851	493.873795	0.026530	5.224428e-03	0.2	
24	24.438229	0.340924	0.026424	1.991860e-03	0.2	
25	6.176998	0.122043	0.015559	1.849365e-03	0.3	
26	7.500581	0.110673	0.016758	1.165969e-03	0.3	
27	15.340501	0.323192	0.023740	3.642195e-03	0.3	

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
28	19.351518	0.112801	0.024335	2.569971e-03	0.3	
29	23.784587	0.216659	0.027128	4.901746e-03	0.3	

30 rows × 22 columns

In [167]:

```
train_score = result['mean_train_score']
cv_score = result['mean_test_score']

learning_rate = result['param_learning_rate']
n_estimators = result['param_n_estimators']

# convert them to list

train_score = list(train_score)
cv_score = list(cv_score)
```

In [168]:

```
best_parameter = clf.best_params_
```

In [169]:

```
best_parameter
```

Out[169]:

```
{'learning_rate': 0.3, 'n_estimators': 100}
```

In [170]:

```
# build the dataframe to create the heatmap have each box filled with auc score
# https://www.geeksforgeeks.org/create-a-pandas-dataframe-from-lists/

heat_data = {'n_estimators':n_estimators,'learning_rate':learning_rate,'train_score':tr
ain_score}

heat_dataframe = pd.DataFrame(heat_data)

heat_dataframe
```

Out[170]:

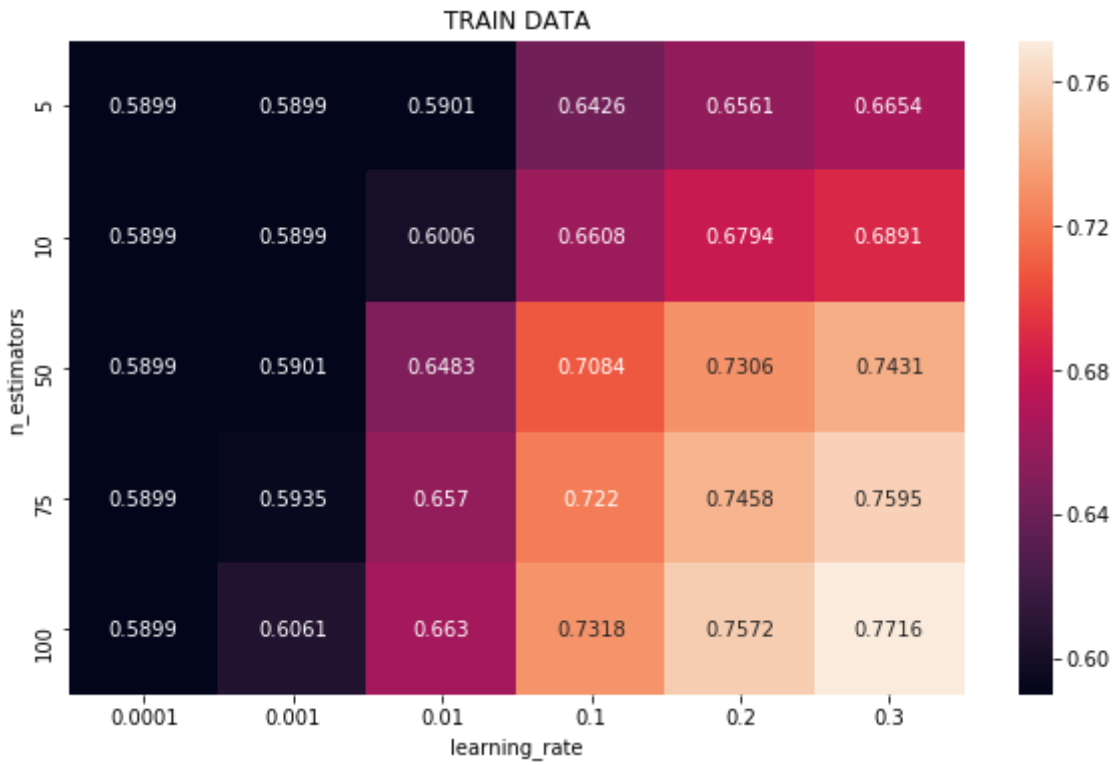
	n_estimators	learning_rate	train_score
0	5	0.0001	0.589870
1	10	0.0001	0.589870
2	50	0.0001	0.589870
3	75	0.0001	0.589870
4	100	0.0001	0.589870
5	5	0.001	0.589870
6	10	0.001	0.589870
7	50	0.001	0.590092
8	75	0.001	0.593460
9	100	0.001	0.606098
10	5	0.01	0.590092
11	10	0.01	0.600596
12	50	0.01	0.648307
13	75	0.01	0.657034
14	100	0.01	0.663033
15	5	0.1	0.642566
16	10	0.1	0.660820
17	50	0.1	0.708378
18	75	0.1	0.722015
19	100	0.1	0.731764
20	5	0.2	0.656136
21	10	0.2	0.679435
22	50	0.2	0.730580
23	75	0.2	0.745793
24	100	0.2	0.757182
25	5	0.3	0.665386
26	10	0.3	0.689110
27	50	0.3	0.743143
28	75	0.3	0.759491
29	100	0.3	0.771566

In [171]:

```
# create a heapmat with rows label as n_estimator , learning_rate as column label , auc score value in each box
# https://seaborn.pydata.org/generated/seaborn.heatmap.html
import matplotlib.pyplot as plt
import seaborn as sns


heat_map = heat_dataframe.pivot('n_estimators','learning_rate','train_score')
fig,ax = plt.subplots(figsize=(10,6))
ax = sns.heatmap(heat_map,annot=True,fmt='.4g')
ax.set_title('TRAIN DATA')
```

Out[171]:

```
Text(0.5,1,'TRAIN DATA')
```



In [172]:

```
# built the dataframe for heat map for cv data

heat_data = {'n_estimators':n_estimators,'learning_rate':learning_rate,'cv_score':cv_sc
ore}

heat_dataframe = pd.DataFrame(heat_data)

heat_dataframe
```

Out[172]:

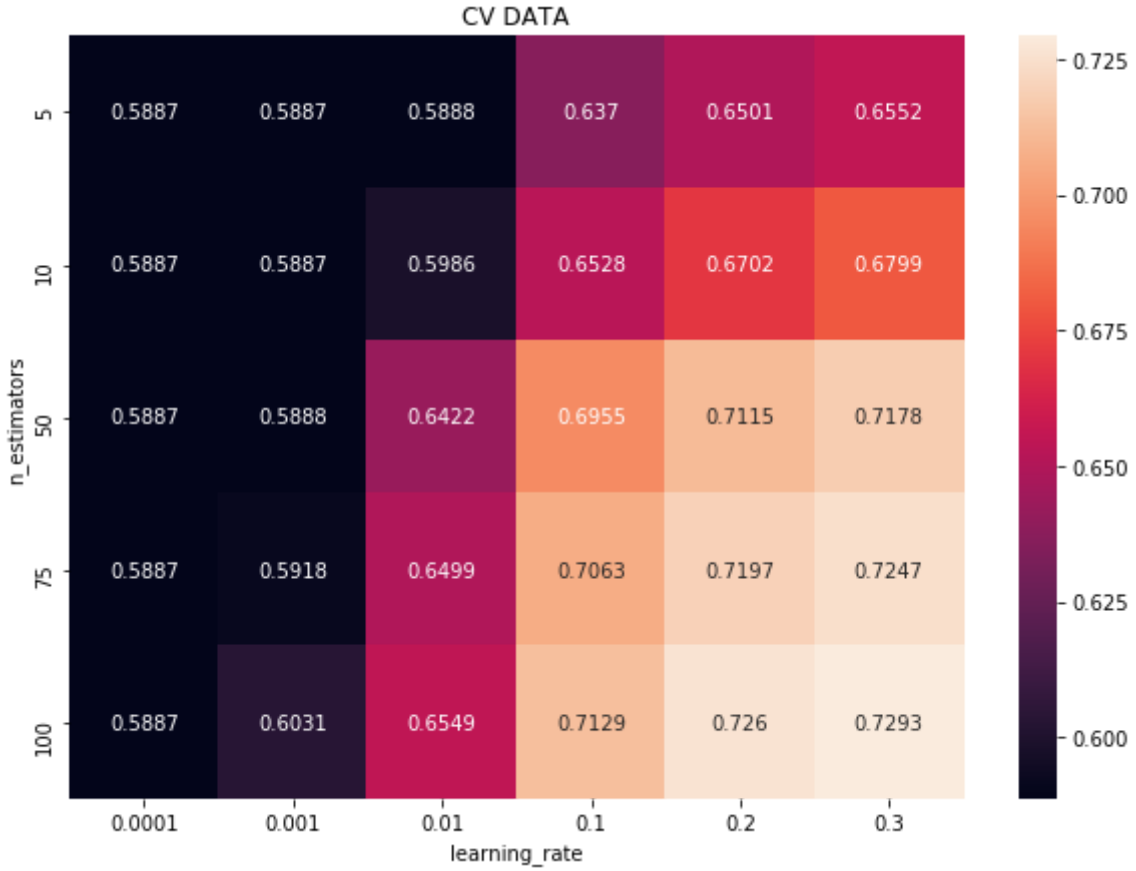
	n_estimators	learning_rate	cv_score
0	5	0.0001	0.588719
1	10	0.0001	0.588719
2	50	0.0001	0.588719
3	75	0.0001	0.588719
4	100	0.0001	0.588719
5	5	0.001	0.588719
6	10	0.001	0.588719
7	50	0.001	0.588843
8	75	0.001	0.591797
9	100	0.001	0.603118
10	5	0.01	0.588843
11	10	0.01	0.598589
12	50	0.01	0.642196
13	75	0.01	0.649923
14	100	0.01	0.654920
15	5	0.1	0.637018
16	10	0.1	0.652800
17	50	0.1	0.695492
18	75	0.1	0.706270
19	100	0.1	0.712934
20	5	0.2	0.650124
21	10	0.2	0.670216
22	50	0.2	0.711509
23	75	0.2	0.719701
24	100	0.2	0.726046
25	5	0.3	0.655183
26	10	0.3	0.679907
27	50	0.3	0.717771
28	75	0.3	0.724684
29	100	0.3	0.729255

In [173]:

```
# create a heapmat with rows label as n_estimator , learning_rate as column label , auc score value in each box

heat_map = heat_dataframe.pivot('n_estimators','learning_rate','cv_score')
fig,ax = plt.subplots(figsize=(10,7))
ax = sns.heatmap(heat_map,annot=True,fmt='.4g')
ax.set_title('CV DATA')
```

Out[173]:

```
Text(0.5,1,'CV DATA')
```



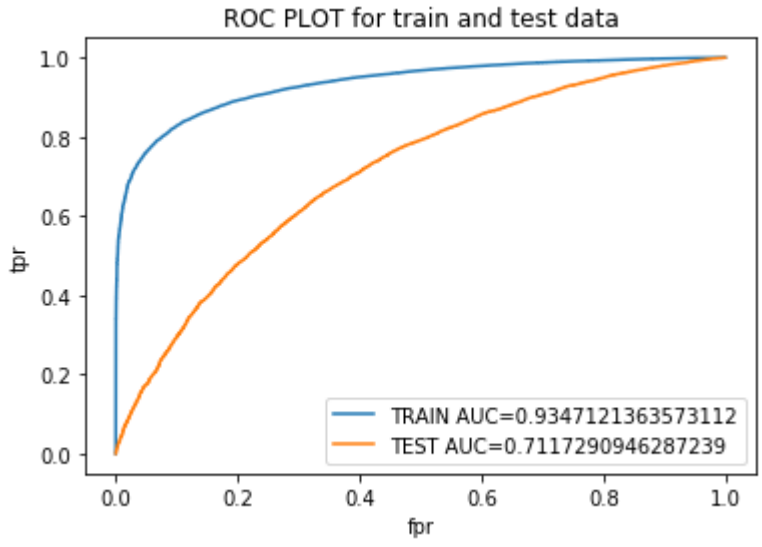
In [174]:

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

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

    return y_data_pred
```

ROC AUC plot for SET 1

In [175]:

```
# build the final model with best parameter value
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score,auc

y_train_pred = []
y_test_pred =[]


gbdt_model = lgb.LGBMClassifier(objective='binary',learning_rate = best_parameter['lear
ning_rate'],n_estimators =best_parameter['n_estimators'],class_weight='balanced')
gbdt_model=gbdt_model.fit(x_tr_tfidf,y_train)

y_train_pred = batch_predict(gbdt_model,x_tr_tfidf)
y_test_pred = batch_predict(gbdt_model,x_te_tfidf)

# by the help of of probability estimate and true_predicted we calculated the roc-auc

train_fpr,train_tpr,train_thresholds = roc_curve(y_train,y_train_pred)
test_fpr,test_tpr,test_thresholds = roc_curve(y_test,y_test_pred)

# now plot the roc_auc_curve for different value of tpr,fpr and threholds

plt.plot(train_fpr,train_tpr,label='TRAIN AUC='+str(auc(train_fpr,train_tpr)))
plt.plot(test_fpr,test_tpr,label='TEST AUC='+str(auc(test_fpr,test_tpr)))
plt.xlabel('fpr')
plt.ylabel('tpr')
plt.title('ROC PLOT for train and test data')
plt.legend()
plt.show()
```



confusion matrix for set 1

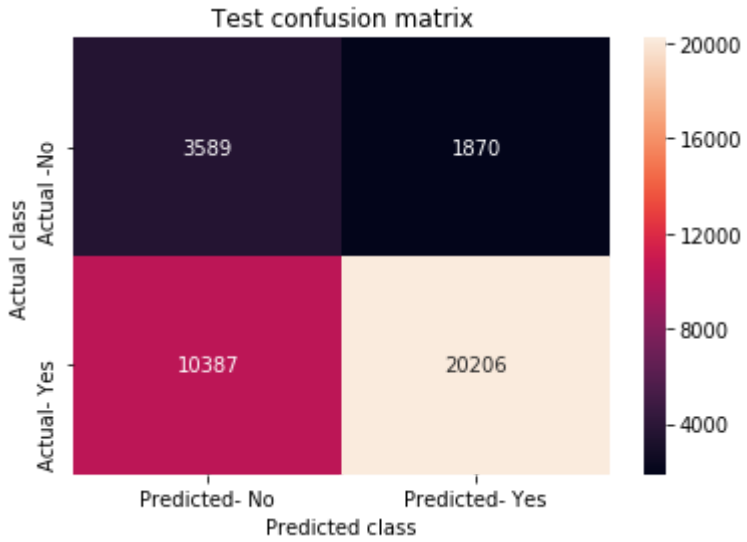
In [176]:

```
def find_best_threshold(threshold,tpr,fpr):
    t =threshold[np.argmax(tpr*(1-fpr))]
    print('max value of tpr*(1-fpr)',max(tpr*(1-fpr)),'for threshold',np.round(t,3))
    return t

def predict_with_best_t(proba,best_threshold):
    prediction=[]
    global y_pred
    for value in proba:
        if value < best_threshold:
            prediction.append(0)
        else:
            prediction.append(1)
    y_pred = prediction
    return prediction

# https://medium.com/@dtuk81/confusion-matrix-visualization-fc31e3f30fea

from sklearn.metrics import confusion_matrix


print('='*50)
best_threshold = find_best_threshold(test_thresholds,test_tpr,test_fpr)
confusion_matrix_test  = confusion_matrix(y_test,predict_with_best_t(y_test_pred,best_t
hreshold))

ax= plt.subplot()
sns.heatmap(confusion_matrix_test,xticklabels=['Predicted- No','Predicted- Yes'],ytickl
abels=['Actual -No','Actual- Yes'],annot=True,fmt='d')
ax.set_title('Test confusion matrix')
ax.set_xlabel('Predicted class')
ax.set_ylabel('Actual class')
```

```
==================================================
max value of tpr*(1-fpr) 0.43422882154167414 for threshold 0.578
```

Out[176]:

```
Text(33,0.5,'Actual class')
```



Set 2

hyperparameter tuning for SET 2

In [177]:

```
learning_rate = [0.0001, 0.001, 0.01, 0.1, 0.2, 0.3]
n_estimators=[5,10,50, 75, 100]

parameter =dict(learning_rate=learning_rate,n_estimators=n_estimators)

gbdt_model = lgb.LGBMClassifier(objective='binary',max_depth = 2,class_weight='balance
d')

clf = GridSearchCV(gbdt_model,param_grid=parameter,scoring='roc_auc',cv=5,return_train_
score =True)
clf.fit(x_tr_tfidfW2v,y_train)

results = pd.DataFrame.from_dict(clf.cv_results_)
results
```

Out[177]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
0	1.744185	0.085248	0.012168	0.001162	0.0001	
1	1.882966	0.103582	0.011968	0.000631	0.0001	
2	2.604835	0.148524	0.021543	0.002863	0.0001	
3	3.604509	0.648695	0.028583	0.009111	0.0001	
4	3.437146	0.409713	0.028942	0.008260	0.0001	
5	2.564871	0.482681	0.015558	0.002863	0.001	
6	1.979251	0.055828	0.014963	0.001678	0.001	
7	2.734336	0.561502	0.018358	0.002876	0.001	
8	3.341994	0.567941	0.025542	0.008328	0.001	
9	3.552377	0.325815	0.027726	0.005897	0.001	
10	2.096484	0.086888	0.017554	0.002327	0.01	
11	2.722814	0.563156	0.019563	0.001507	0.01	
12	3.414089	0.393374	0.025534	0.006698	0.01	
13	3.413895	0.090545	0.026872	0.001472	0.01	

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
14	3.941301	0.064901	0.031163	0.003058	0.01	
15	2.622320	0.217083	0.020358	0.006285	0.1	
16	2.437043	0.098901	0.018562	0.002784	0.1	
17	3.071850	0.063346	0.028146	0.004207	0.1	
18	3.581008	0.110661	0.034843	0.008114	0.1	
19	4.100345	0.123692	0.037590	0.006780	0.1	
20	2.482321	0.117987	0.018972	0.002088	0.2	
21	2.564187	0.304559	0.019348	0.001493	0.2	
22	3.094852	0.262628	0.028524	0.005937	0.2	
23	3.267264	0.260626	0.029323	0.005224	0.2	
24	3.687141	0.068194	0.032912	0.004804	0.2	
25	2.137882	0.131729	0.016356	0.003253	0.3	
26	2.202313	0.129462	0.021342	0.001017	0.3	
27	2.894058	0.366101	0.024136	0.001466	0.3	

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_learning_rate	paran
28	3.641864	0.398391	0.036504	0.006899	0.3	
29	3.704397	0.293112	0.030120	0.002309	0.3	

30 rows × 22 columns

In [178]:

```
train_score =results['mean_train_score']
test_score = results['mean_test_score']

n_estimators = results['param_n_estimators']
learning_rate = results['param_learning_rate']

train_score = list(train_score)
test_score = list(test_score)
```

In [179]:

```
best_parameter = clf.best_params_
best_parameter
```

Out[179]:

```
{'learning_rate': 0.3, 'n_estimators': 100}
```

In [180]:

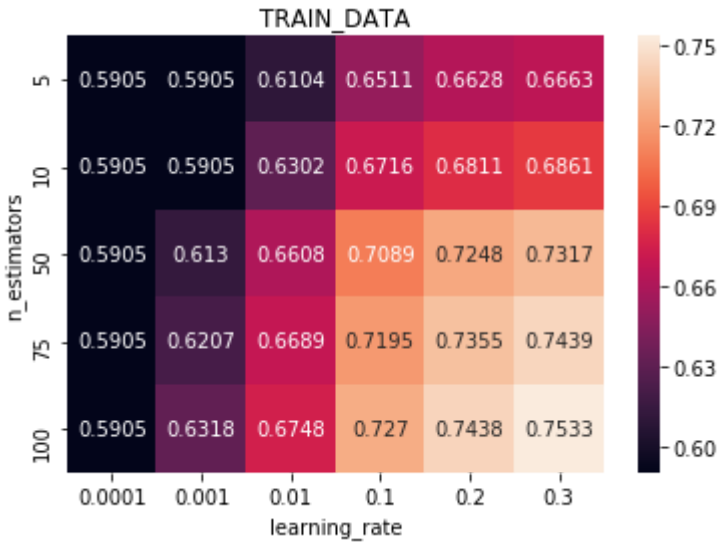
```
# create a dataframe for making heatmap with rows representing n_estimators , column re
presenting learning_rate , box containing auc score

heat_data = {'n_estimators':n_estimators,'learning_rate':learning_rate,'train_score':tr
ain_score}

heat_dataframe = pd.DataFrame(heat_data)

#heat_dataframe
```

In [181]:

```
# create a heatmap with help of dataframe

heat_dataframe = heat_dataframe.pivot('n_estimators','learning_rate','train_score')
ax = sns.heatmap(heat_dataframe,annot=True,fmt='.4g')
ax.set_title('TRAIN_DATA')
```

Out[181]:

```
Text(0.5,1,'TRAIN_DATA')
```



In [182]:

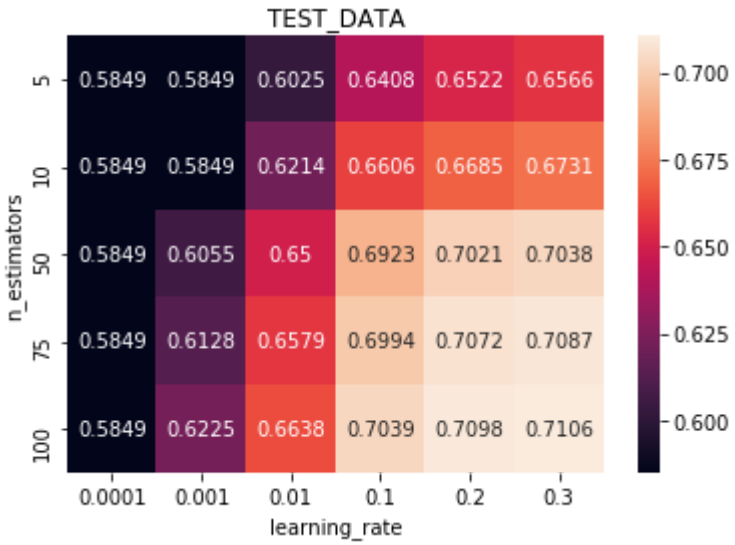
```
heat_data = {'n_estimators':n_estimators,'learning_rate':learning_rate,'test_score':tes
t_score}

heat_dataframe = pd.DataFrame(heat_data)

#heat_dataframe
```

In [183]:

```
# create a heatmap with help of dataframe

heat_dataframe = heat_dataframe.pivot('n_estimators','learning_rate','test_score')
ax = sns.heatmap(heat_dataframe,annot=True,fmt='.4g')
ax.set_title('TEST_DATA')
```

Out[183]:

```
Text(0.5,1,'TEST_DATA')
```



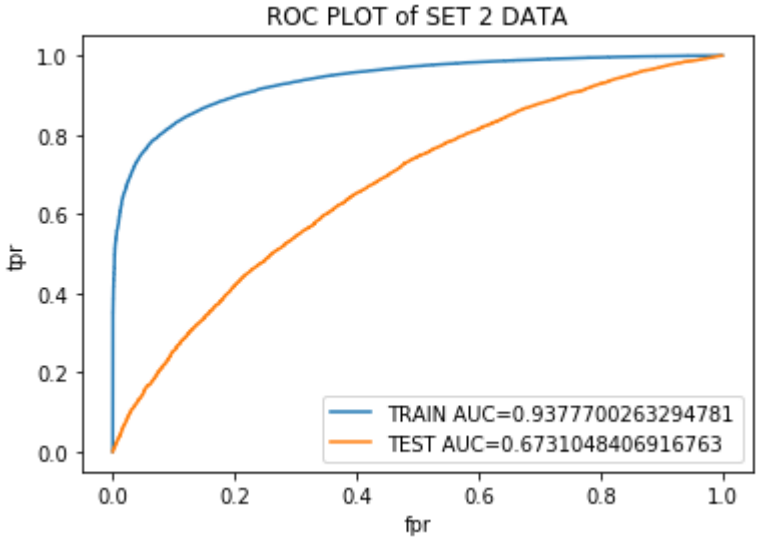
roc plot for set 2

In [184]:

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

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

    return y_data_pred
```

In [185]:

```
y_train_pred=[]
y_test_pred= []

gbdt_model = lgb.LGBMClassifier(objective='binary',n_estimators=best_parameter['n_estim
ators'],learning_rate =best_parameter['learning_rate'],class_weight='balanced')
gbdt_model=gbdt_model.fit(x_tr_tfidfW2v,y_train)

y_train_pred = batch_predict(gbdt_model,x_tr_tfidfW2v)
y_test_pred = batch_predict(gbdt_model,x_te_tfidfW2v)

# by the help of of probability estimate and true_predicted we calculated the roc-auc

train_fpr,train_tpr,train_thresholds = roc_curve(y_train,y_train_pred)
test_fpr,test_tpr,test_thresholds = roc_curve(y_test,y_test_pred)

# now plot the roc_auc_curve for different value of tpr,fpr and threholds

plt.plot(train_fpr,train_tpr,label='TRAIN AUC='+str(auc(train_fpr,train_tpr)))
plt.plot(test_fpr,test_tpr,label='TEST AUC='+str(auc(test_fpr,test_tpr)))
plt.xlabel('fpr')
plt.ylabel('tpr')
plt.title('ROC PLOT of SET 2 DATA')
plt.legend()
plt.show()
```



confusion matrix for set 2

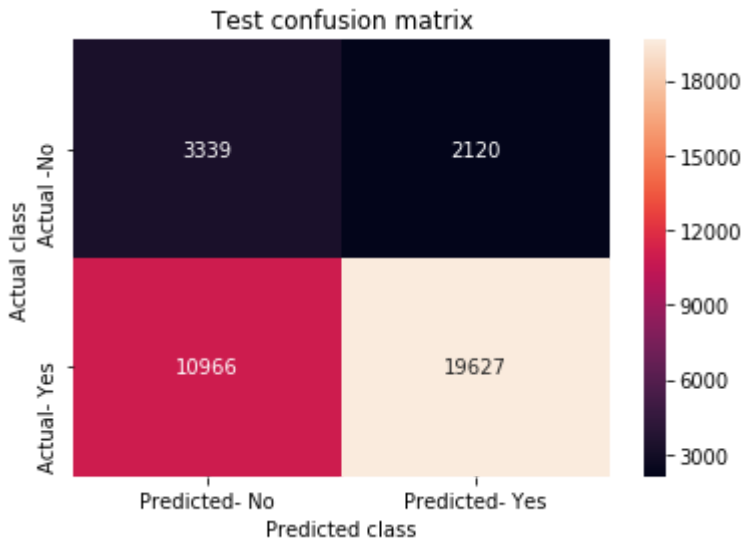
In [186]:

```
def find_best_threshold(threshold,tpr,fpr):
    t =threshold[np.argmax(tpr*(1-fpr))]
    print('max value of tpr*(1-fpr)',max(tpr*(1-fpr)),'for threshold',np.round(t,3))
    return t

def predict_with_best_t(proba,best_threshold):
    prediction=[]
    global y_pred
    for value in proba:
        if value < best_threshold:
            prediction.append(0)
        else:
            prediction.append(1)
    y_pred = prediction
    return prediction

# https://medium.com/@dtuk81/confusion-matrix-visualization-fc31e3f30fea

from sklearn.metrics import confusion_matrix


print('='*50)
best_threshold = find_best_threshold(test_thresholds,test_tpr,test_fpr)
confusion_matrix_test  = confusion_matrix(y_test,predict_with_best_t(y_test_pred,best_t
hreshold))

ax= plt.subplot()
sns.heatmap(confusion_matrix_test,xticklabels=['Predicted- No','Predicted- Yes'],ytickl
abels=['Actual -No','Actual- Yes'],annot=True,fmt='d')
ax.set_title('Test confusion matrix')
ax.set_xlabel('Predicted class')
ax.set_ylabel('Actual class')
```

```
==================================================
max value of tpr*(1-fpr) 0.39240558551531074 for threshold 0.565
```

Out[186]:

```
Text(33,0.5,'Actual class')
```



3. Summary

as mentioned in the step 4 of instructions

In [189]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names= ['vectorizer','model','hyperparameter','AUC']
x.add_row(['Tfidf','GBDT','learning rate = 0.3,n_estimator=100',0.711729094628739])
x.add_row(['TfidfW2v','GBDT','learning_rate=0.3,n_estimator=100',0.6731048406916763])

print(x)
```

```
+------------+-------+-----------------------------------+--------------
------+
| vectorizer | model |            hyperparameter           |        AUC
|
+------------+-------+-----------------------------------+--------------
------+
|   Tfidf    |  GBDT | learning rate = 0.3,n_estimator=100 | 0.71172909462
8739  |
|  TfidfW2v  |  GBDT |  learning_rate=0.3,n_estimator=100  | 0.67310484069
16763 |
+------------+-------+-----------------------------------+--------------
------+
```