# Assignment_DT_Instructions

April 20, 2022

## 1 Assignment : DT

Glove vectors

In this assignment you will be working with glove vectors , please check this and this for more details.

Download glove vectors from this link

## 2 Task - 1

Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets

Set 1: categorical, numerical features + preprocessed_essay (TFIDF) + Sentiment scores(preprocessed_essay)

Set 2: categorical, numerical features + preprocessed_essay (TFIDF W2V) + Sentiment scores(preprocessed_essay)

```
</li>
<li><strong>The hyper paramter tuning (best `depth` in range [1, 3, 10, 30], and the best `min_
    <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(use gridsearch cv or randomsearc
    </ul>
</li>
<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='https://i.imgur.com/Gp2DQmh.jpg' width=500px> with X-axis as <strong>min_sample_split
        <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='https://i.imgur.com/fgN9aUP.jpg' width=300px> <a href='https://seaborn.pydata.org/ger
<li>You choose either of the plotting techniques out of 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
    Make sure that you are using predict_proba method to calculate AUC curves, because AUC is c
<img src='https://i.imgur.com/wMQDTFe.jpg' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.c
<img src='https://i.imgur.com/IdN5Ctv.png' width=300px></li>
```

```
<li>Once after you plot the confusion matrix with the test data, get all the `false positive da
    <ul>
        <li> Plot the WordCloud(https://www.geeksforgeeks.org/generating-word-cloud-python/) wi
        <li> Plot the box plot with the `price` of these `false positive data points`</li>
        <li> Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `fal
    </ul>
    </ul>
</li>
```

## 3 Task - 2

For this task consider **set-1** features.

- Select all the features which are having non-zero feature importance.You can get the feature importance using 'feature_importances_' (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard the all other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic Regression, Linear SVM).
- You need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3 **Note**: when you want to find the feature importance make sure you don't use max_depth parameter keep it None.
  You need to summarize the results at the end of the notebook, summarize it in the table format

Hint for calculating Sentiment scores

[1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np
import math as m
import matplotlib.pyplot as plt
import seaborn as sns
import nltk
import re

from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.preprocessing import Normalizer
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from tqdm import tqdm
import nltk
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\sarve\AppData\Roaming\nltk_data…
[nltk_data]   Package vader_lexicon is already up-to-date!
```

[1]:
```
True
```

[2]:
```
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

sample_sentence_1='I am happy.'
ss_1 = sid.polarity_scores(sample_sentence_1)
print('sentiment score for sentence 1',ss_1)

sample_sentence_2='I am sad.'
ss_2 = sid.polarity_scores(sample_sentence_2)
print('sentiment score for sentence 2',ss_2)

sample_sentence_3='I am going to New Delhi tommorow.'
ss_3 = sid.polarity_scores(sample_sentence_3)
print('sentiment score for sentence 3',ss_3)
```

```
sentiment score for sentence 1 {'neg': 0.0, 'neu': 0.213, 'pos': 0.787,
'compound': 0.5719}
sentiment score for sentence 2 {'neg': 0.756, 'neu': 0.244, 'pos': 0.0,
'compound': -0.4767}
sentiment score for sentence 3 {'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound':
0.0}
```

### 3.1 Making Data Ready

[3]:
```
import pandas
data = pandas.read_csv('preprocessed_data.csv')
data.head()
```

[3]:

| | school_state | teacher_prefix | project_grade_category | \ |
|---|---|---|---|---|
| 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 | |

| | teacher_number_of_previously_posted_projects | project_is_approved | \ |
|---|---|---|---|
| 0 | 53 | 1 | |
| 1 | 4 | 1 | |
| 2 | 10 | 1 | |
| 3 | 2 | 1 | |

```
4                                          2                    1

    clean_categories                clean_subcategories  \
0       math_science  appliedsciences health_lifescience
1       specialneeds                        specialneeds
2  literacy_language                            literacy
3    appliedlearning                  earlydevelopment
4  literacy_language                            literacy

                                                 essay   price
0  i fortunate enough use fairy tale stem kits cl…  725.05
1  imagine 8 9 years old you third grade classroo…  213.03
2  having class 24 students comes diverse learner…  329.00
3  i recently read article giving students choice…  481.04
4  my students crave challenge eat obstacles brea…   17.74
```

[4]:
```
neg = []
pos = []
neu = []
comp = []

def update_sentiments(values):           # Calculating sentiment scores

    neg.append(values["neg"])
    pos.append(values["pos"])
    neu.append(values["neu"])
    comp.append(values["compound"])
```

[5]:
```
for essay in tqdm(data["essay"]):
    update_sentiments(sid.polarity_scores(essay))
```

```
100%|                                          |
109248/109248 [02:53<00:00, 629.31it/s]
```

[6]:
```
data["neg"] = neg   # adding new features based on Sentiment scores
data["pos"] = pos
data["neu"] = neu
data["compound"] = comp

data.head()
```

[6]:
```
  school_state teacher_prefix project_grade_category  \
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
```

```
   teacher_number_of_previously_posted_projects  project_is_approved  \
0                                            53                    1
1                                             4                    1
2                                            10                    1
3                                             2                    1
4                                             2                    1

    clean_categories                clean_subcategories  \
0       math_science  appliedsciences health_lifescience
1       specialneeds                        specialneeds
2  literacy_language                             literacy
3    appliedlearning                   earlydevelopment
4  literacy_language                             literacy

                                               essay   price    neg    pos  \
0  i fortunate enough use fairy tale stem kits cl…  725.05  0.013  0.205
1  imagine 8 9 years old you third grade classroo…  213.03  0.072  0.248
2  having class 24 students comes diverse learner…  329.00  0.017  0.262
3  i recently read article giving students choice…  481.04  0.030  0.187
4  my students crave challenge eat obstacles brea…   17.74  0.029  0.288

     neu  compound
0  0.783    0.9867
1  0.680    0.9897
2  0.721    0.9860
3  0.783    0.9524
4  0.683    0.9873
```

### 3.1.1 Splitting Data Into Train And test: Stratified Sampling

[7]:
```
X = data.drop(['project_is_approved'], axis=1)
y = data['project_is_approved'].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,␣
 ↪stratify=y,random_state=42)

print(len(y_train))
print(len(y_test))
```

```
73196
36052
```

### 3.1.2 Encoding text feature : Essay (TFIDF Vectorizer)

[8]:
```
tfidf = TfidfVectorizer(min_df=10,max_features=5000)
text_tfidf = tfidf.fit(X_train['essay'].values)

X_train_tfidf =tfidf.transform(X_train['essay'].values)
X_test_tfidf =tfidf.transform(X_test['essay'].values)

print("After vectorization :")
print(X_train_tfidf.shape, y_train.shape)
print(X_test_tfidf.shape, y_test.shape)
```

```
After vectorization :
(73196, 5000) (73196,)
(36052, 5000) (36052,)
```

### 3.1.3 Encoding text feature : Essay (TFIDF W2V Vectorizer)

[9]:
```
import pickle
with open (r'glove_vectors', "rb") as f:
    model = pickle.load(f)
    glove_words = set(model.keys())
```

[10]:
```
tfidf1 = TfidfVectorizer()
tfidf1.fit(X_train["essay"])     # Creating a dictionary with features(words)␣
 ↪as a key, and the idf as a value
features = set(tfidf1.get_feature_names())
dictionary = dict(zip(features, list(tfidf1.idf_)))
```

[11]:
```
#encoding the training dataset

X_train_w2v = []                                    # the tfidf-w2v for each␣
 ↪essay will be stored in this
for sentence in tqdm(X_train["essay"]):
    null = np.zeros(300)
    tfidf_wt =0;
    for word in sentence.split():
        if (word in glove_words) and (word in features):
            vec = model[word]
            tfidf_value = dictionary[word]*(sentence.count(word)/len(sentence.
 ↪split()))
            tfidf_wt += tfidf_value
    if tfidf_wt != 0:
        null /= tfidf_wt
    X_train_w2v.append(null)
X_train_w2v=np.array(X_train_w2v)
```

```
print("After vectorization :")
print(X_train_w2v.shape, y_train.shape)
```

```
100%|
| 73196/73196 [01:43<00:00, 705.64it/s]
```

```
After vectorization :
(73196, 300) (73196,)
```

[12]:
```
#encoding the test dataset

X_test_w2v = []                                    # the tfidf-w2v for each essay␣
 ↪will be stored in this
for sentence in tqdm(X_test["essay"]):
    null = np.zeros(300)
    tfidf_wt =0;
    for word in sentence.split():
        if (word in glove_words) and (word in features):
            vec = model[word]
            tfidf_value = dictionary[word]*(sentence.count(word)/len(sentence.
 ↪split()))
            tfidf_wt += tfidf_value
    if tfidf_wt != 0:
        null /= tfidf_wt
    X_test_w2v.append(null)
X_test_w2v=np.array(X_test_w2v)

print("After vectorization :")
print(X_test_w2v.shape, y_test.shape)
```

```
100%|
| 36052/36052 [00:50<00:00, 707.00it/s]
```

```
After vectorization :
(36052, 300) (36052,)
```

### 3.1.4 Encoding Categorical Features

**School State**

[13]:
```
state = CountVectorizer()
state.fit(X_train['school_state'].values)

X_train_state = state.transform(X_train['school_state'].values)
X_test_state = state.transform(X_test['school_state'].values)

print("After vectorization:")
print(X_train_state.shape, y_train.shape)
print(X_test_state.shape, y_test.shape)
```

```
After vectorization:
(73196, 51) (73196,)
(36052, 51) (36052,)
```

**teacher_prefix**

[14]:
```
prefix = CountVectorizer()
prefix.fit(X_train['teacher_prefix'].values)

X_train_teacher = prefix.transform(X_train['teacher_prefix'].values)
X_test_teacher = prefix.transform(X_test['teacher_prefix'].values)

print("After vectorization:")
print(X_train_teacher.shape, y_train.shape)
print(X_test_teacher.shape, y_test.shape)
```

```
After vectorization:
(73196, 5) (73196,)
(36052, 5) (36052,)
```

**project_grade_category**

[15]:
```
grade = CountVectorizer()
grade.fit(X_train['project_grade_category'].values)

X_train_grade = grade.transform(X_train['project_grade_category'].values)
X_test_grade = grade.transform(X_test['project_grade_category'].values)

print("After vectorization :")
print(X_train_grade.shape, y_train.shape)
print(X_test_grade.shape, y_test.shape)
```

```
After vectorization :
(73196, 4) (73196,)
(36052, 4) (36052,)
```

**clean_categories**

[16]:
```
category = CountVectorizer()
category.fit(X_train['clean_categories'].values)

X_train_category = category.transform(X_train['clean_categories'].values)
X_test_category = category.transform(X_test['clean_categories'].values)

print("After vectorization :")
print(X_train_category.shape, y_train.shape)
print(X_test_category.shape, y_test.shape)
```

```
After vectorization :
(73196, 9) (73196,)
```

```
(36052, 9) (36052,)
```

**clean_subcategories**

[17]:
```
sub = CountVectorizer()
sub.fit(X_train['clean_subcategories'].values)

X_train_subcategory = sub.transform(X_train['clean_subcategories'].values)
X_test_subcategory = sub.transform(X_test['clean_subcategories'].values)

print("After vectorization :")
print(X_train_subcategory.shape, y_train.shape)
print(X_test_subcategory.shape, y_test.shape)
```

```
After vectorization :
(73196, 30) (73196,)
(36052, 30) (36052,)
```

### 3.1.5 Encoding Numerical Features

[18]:
```
# Combining all the numerical features into single DF and then encoding that DF

abc = X_train.
 ↪drop(['school_state','teacher_prefix','project_grade_category','clean_categories','clean_su
 ↪axis=1)
abc1 = X_test.
 ↪drop(['school_state','teacher_prefix','project_grade_category','clean_categories','clean_su
 ↪axis=1)
abc1.head(1)
```

[18]:

| | teacher_number_of_previously_posted_projects | price | neg | pos | neu | compound |
|---|---|---|---|---|---|---|
| 32248 | 1 | 67.22 | 0.048 | 0.376 | 0.576 | 0.9946 |

[19]:
```
# normalizer.fit(abc) will rise an error Expected XX array, got 1D array␣
 ↪instead:
# we can give columns as a list to resolve this problem

a = abc.values.tolist()
b = abc1.values.tolist()
```

[20]:
```
normalizer = Normalizer()
normalizer.fit(a)

X_train_num = normalizer.transform(a)
X_test_num = normalizer.transform(b)
```

```
#X_train_price_norm =X_train_price_norm.reshape(-1,1)
#X_test_price_norm=X_test_price_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_num.shape, y_train.shape)
print(X_test_num.shape, y_test.shape)
```

```
After vectorizations
(73196, 6) (73196,)
(36052, 6) (36052,)
```

#### 3.1.6 Concatinating All The Features

**SET-1**

[21]:
```
from scipy.sparse import hstack
X_tr_1 = hstack((X_train_tfidf, X_train_state, X_train_teacher, X_train_grade,␣
 ↪X_train_category, X_train_subcategory,X_train_num)).tocsr()
X_te_1 = hstack((X_test_tfidf, X_test_state, X_test_teacher, X_test_grade,␣
 ↪X_test_category, X_test_subcategory,X_test_num)).tocsr()

print(X_tr_1.shape)
print(X_te_1.shape)
```

```
(73196, 5105)
(36052, 5105)
```

**SET-2**

[22]:
```
X_tr_2 = hstack((X_train_w2v, X_train_state, X_train_teacher, X_train_grade,␣
 ↪X_train_category, X_train_subcategory,X_train_num)).tocsr()
X_te_2 = hstack((X_test_w2v, X_test_state, X_test_teacher, X_test_grade,␣
 ↪X_test_category, X_test_subcategory,X_test_num)).tocsr()

print(X_tr_2.shape)
print(X_te_2.shape)
```

```
(73196, 405)
(36052, 405)
```

## 4 Task - 1

#### 4.0.1 DECISION TREE USING GRID SEARCH CV (SET - 1)

[23]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
param = {'max_depth': [1, 5, 10, 50],
         'min_samples_split': [5, 10, 100, 500]}
```

```
dtc = DecisionTreeClassifier(class_weight='balanced',random_state = 0)
clf = GridSearchCV(dtc, param, cv=5, scoring='roc_auc',␣
 ↪return_train_score=True, n_jobs=-1)
clf.fit(X_tr_1,y_train)
```

[23]:
```
GridSearchCV(cv=5,
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              random_state=0),
             n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             return_train_score=True, scoring='roc_auc')
```

[24]:
```
tr_auc_1 = clf.cv_results_['mean_train_score']
tr_auc_std1 = clf.cv_results_['std_train_score']
te_auc_1 = clf.cv_results_['mean_test_score']
te_auc_std1 = clf.cv_results_['std_test_score']

best_max_depth1 = clf.best_params_["max_depth"]
best_min_samples_split1 = clf.best_params_["min_samples_split"]

print('Best score for set 1: ',clf.best_score_)
print('Best max_depth for set 1: ',best_max_depth1)
print('Best min_samples_split for set 1: ',best_min_samples_split1)
```

```
Best score for set 1:  0.6519568925953961
Best max_depth for set 1:  10
Best min_samples_split for set 1:  500
```

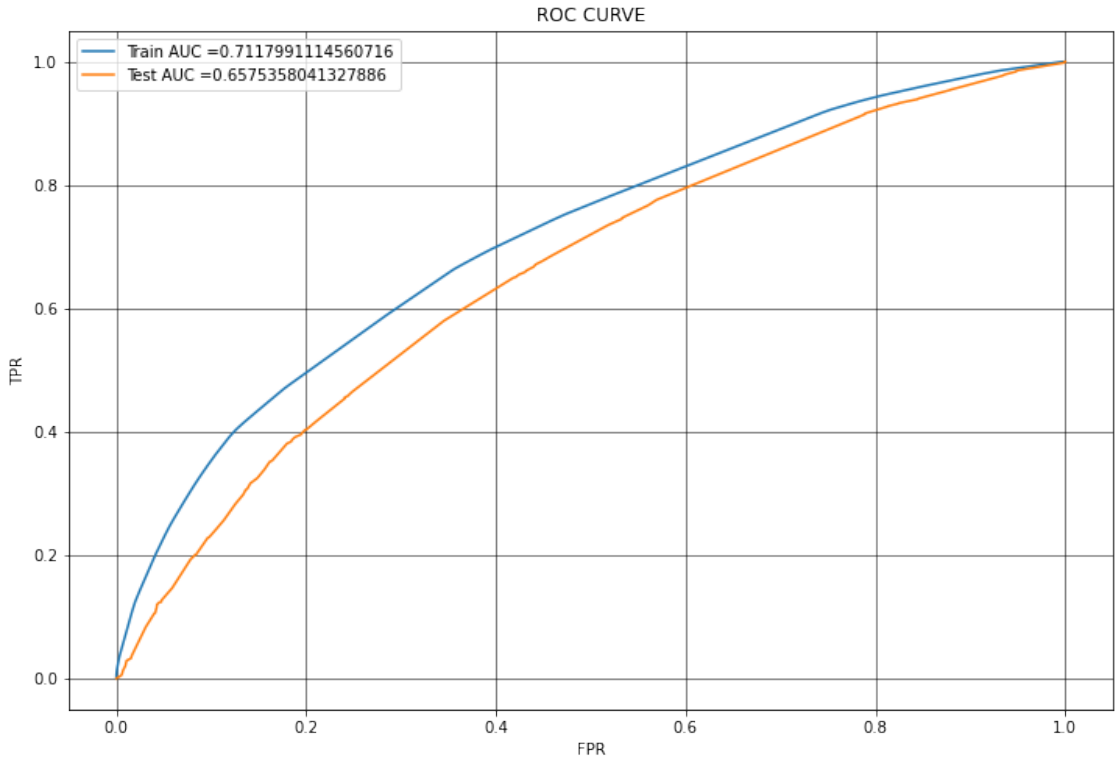
### 4.0.2 Plotting Hyperparameter v AUC

[25]:
```
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from itertools import repeat

max_depth = [1, 5, 10, 50]
min_samples_split = [5, 10, 100, 500]

x1= max_depth
y1= min_samples_split
z1= tr_auc_1
z2= te_auc_1

trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name="tr_auc_1")
trace2 = go.Scatter3d(x=x1,y=y1,z=z2, name="te_auc_1")
```

```
values = [trace1, trace2]

lay = go.Layout(scene = dict(
        xaxis = dict(title='max_depth'),
        yaxis = dict(title='min_samples_split'),
        zaxis = dict(title='AUC SCORE'),))

fig = go.Figure(data=values, layout=lay)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

#### 4.0.3 ROC : Train And Test Data

[26]:
```
model1 = DecisionTreeClassifier(class_weight='balanced',max_depth =␣
↪best_max_depth1,min_samples_split = best_min_samples_split1,random_state = 0)
model1.fit(X_tr_1,y_train)
y_tr_prob = clf.predict_proba(X_tr_1)[:,1]     # getting probability scores
y_te_prob = clf.predict_proba(X_te_1 )[:,1]

tr_fpr, tr_tpr, tr_thresh = roc_curve(y_train, y_tr_prob)       # getting fpr␣
↪and tpr values
te_fpr, te_tpr, te_thresh = roc_curve(y_test, y_te_prob)

plt.figure(figsize=(12,8))
plt.plot(tr_fpr, tr_tpr, label="Train AUC ="+str(auc(tr_fpr, tr_tpr)))
plt.plot(te_fpr, te_tpr, label="Test AUC ="+str(auc(te_fpr, te_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC CURVE")
plt.grid(color='black',lw=0.5)
```




#### 4.0.4 Confusion Matrix

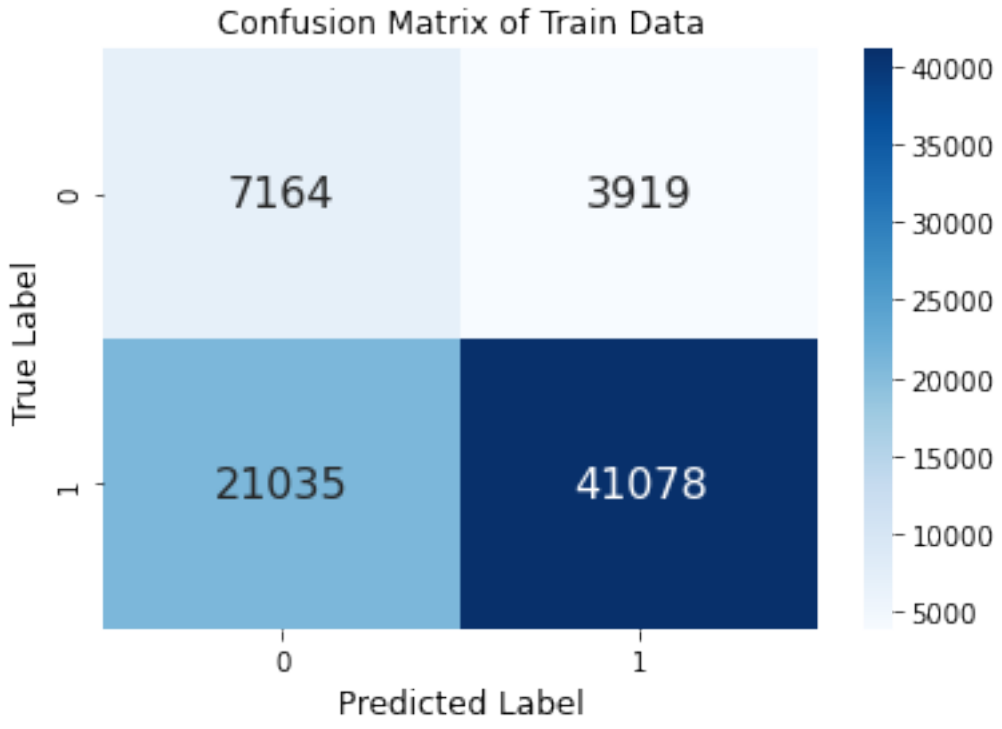
[27]:
```
def calc_best_threshold(thresh, fpr, tpr):

    t = thresh[np.argmax(tpr*(1-fpr))]  # it will be maximum when fpr is very␣
 ↪low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for␣
 ↪threshold", np.round(t,3), "\n")
    return t

def calc_predictions(prob, thresh):
    predictions = []
    for p in prob:
        if p>=thresh:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

[28]:
```
# For Train Data

best_t = calc_best_threshold(tr_thresh, tr_fpr, tr_tpr)
```

```
cm = metrics.confusion_matrix(y_train,calc_predictions(y_tr_prob, best_t))  #␣
 ↪https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix

print("Confusion Matrix of Train Data :\n",cm)
sns.heatmap(cm, annot=True, fmt='d',cmap='Blues',annot_kws = {"size":16})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.42748908332336444 for threshold 0.512

Confusion Matrix of Train Data :
 [[ 7164  3919]
 [21035 41078]]
```

[28]: `Text(0.5, 1.0, 'Confusion Matrix of Train Data')`

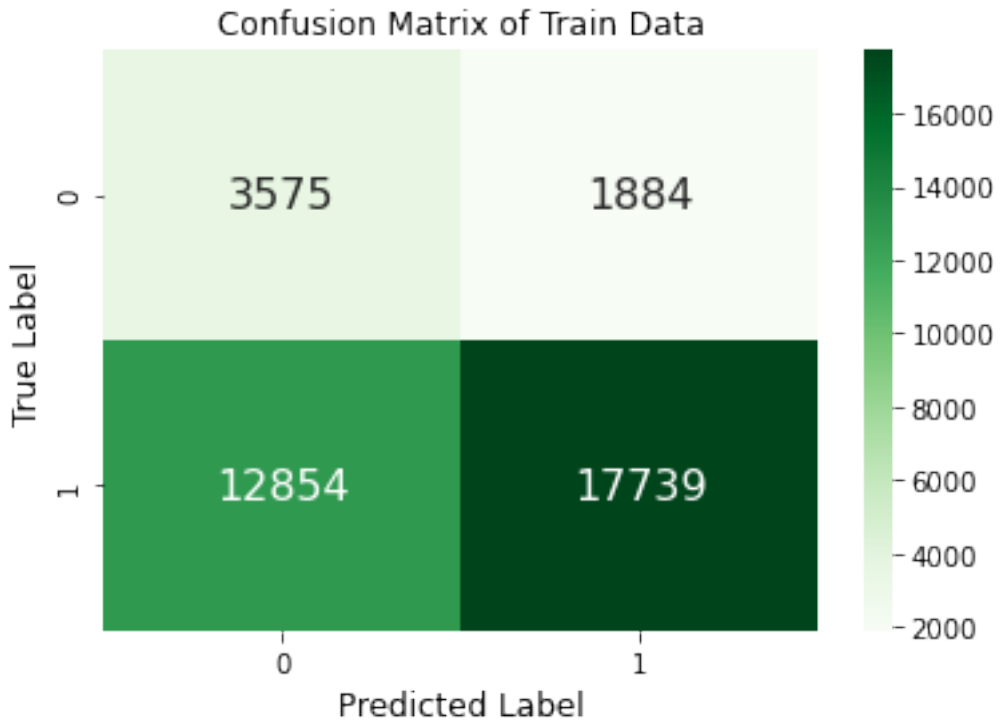



[29]:
```
# For Test Data

best_t = calc_best_threshold(te_thresh, te_fpr, te_tpr)
```

```
cm = metrics.confusion_matrix(y_test,calc_predictions(y_te_prob, best_t))  #␣
↪https://stackoverflow.com/questions/35572000/
↪how-can-i-plot-a-confusion-matrix

print("Confusion Matrix of Test Data :\n",cm)
#print(cm)
sns.heatmap(cm, annot=True, fmt='d',cmap='Greens',annot_kws = {"size":16})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.3797257240192903 for threshold 0.524

Confusion Matrix of Test Data :
 [[ 3575  1884]
 [12854 17739]]
```

[29]: Text(0.5, 1.0, 'Confusion Matrix of Train Data')



#### 4.0.5 Getting All the False Positive Data Points

[30]:
```
pred = calc_predictions(y_te_prob,best_t)

fp_count = []
for i in range(len(y_test)):
    if(y_test[i]==0) & (pred[i] == 1):
        fp_count.append(i)                    # GETTING THE ALL FALSE POSITIVE␣
↪INDICES
len(fp_count)
```

[30]:
```
1884
```

[31]:
```
col = X_test.columns
X_test_fp = pd.DataFrame(columns=col)         # creating FALSE POSITIVE DF
X_test_fp = X_test.iloc[fp_count]
print(X_test_fp.shape)

X_test_fp.head(1)
```

```
(1884, 12)
```

[31]:

| | school_state | teacher_prefix | project_grade_category | \ |
|---|---|---|---|---|
| 69487 | sc | mrs | grades_3_5 | |

| | teacher_number_of_previously_posted_projects | \ |
|---|---|---|
| 69487 | 10 | |

| | clean_categories | clean_subcategories | \ |
|---|---|---|---|
| 69487 | literacy_language math_science | literacy mathematics | |

| | essay | price | neg | \ |
|---|---|---|---|---|
| 69487 | many students english language learners hard w… | 228.89 | 0.039 | |

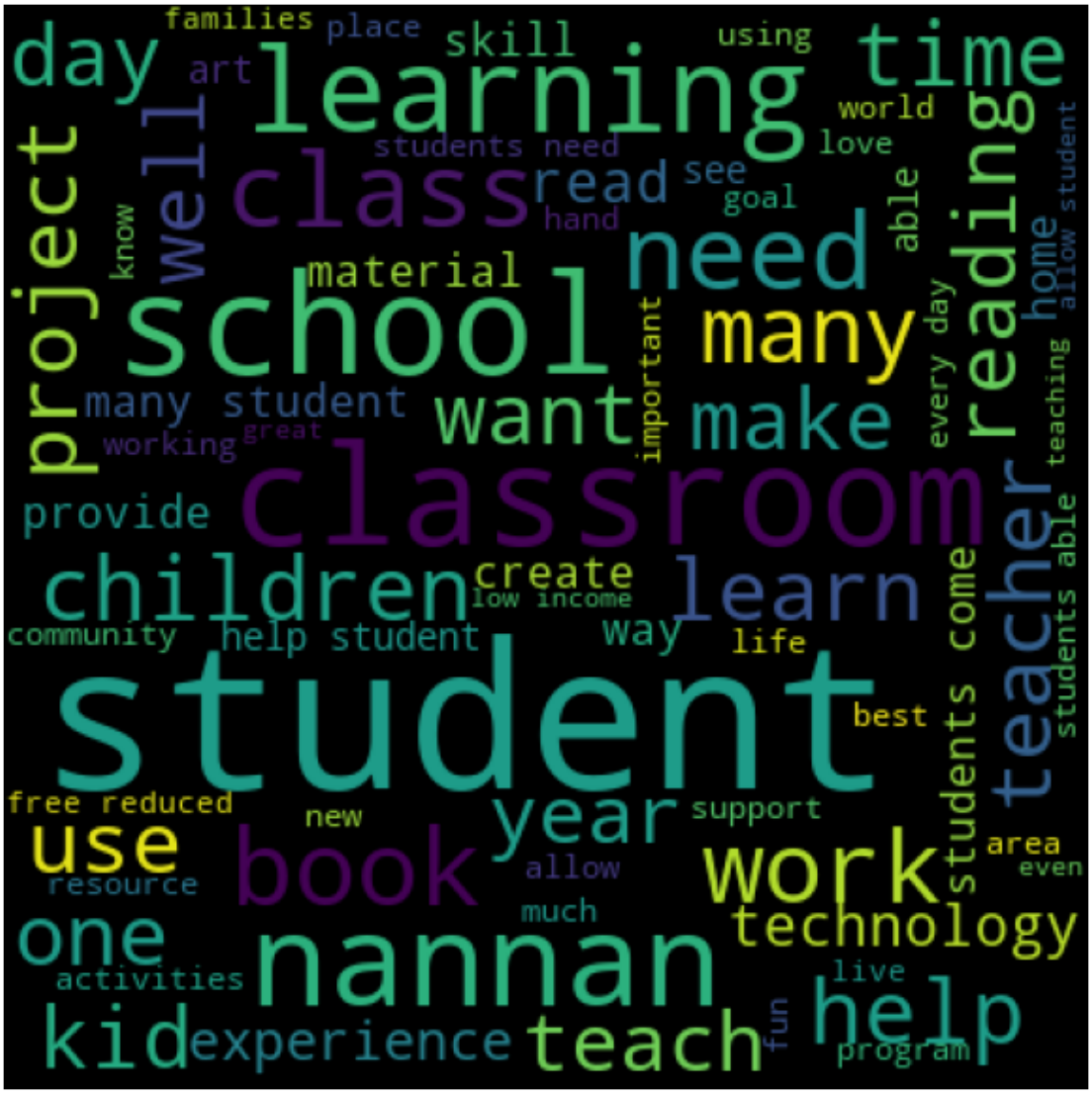
| | pos | neu | compound |
|---|---|---|---|
| 69487 | 0.242 | 0.719 | 0.9794 |

#### 4.0.6 WordCloud for Essay for False Positive Dataset

[32]:
```
#https://www.geeksforgeeks.org/generating-word-cloud-python

from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
sw = set(STOPWORDS)
for e in X_test_fp['essay']:
    val = str(e)
    tokens = val.split()
```

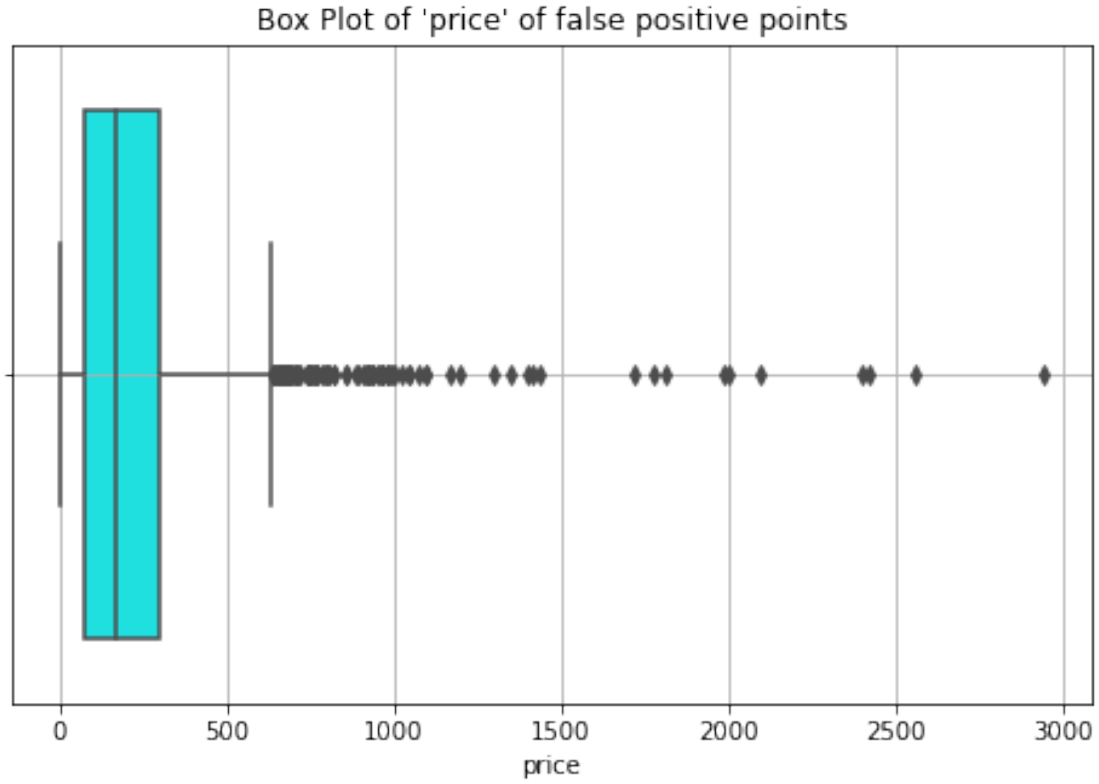
```
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()
    for words in tokens:
        comment_words = comment_words + words + ' '
```

[33]:
```
wrdcld = WordCloud(width = 400, height = 400, background_color ='black',␣
↪stopwords = sw, min_font_size = 10).generate(comment_words)

plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wrdcld)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



#### 4.0.7 Box Plot for 'price' Of these False Positive Points

[34]:
```
plt.figure(figsize=(8,5))
sns.boxplot('price',data=X_test_fp,color='cyan').set_title("Box Plot of 'price' of false positive points")
plt.grid()
```



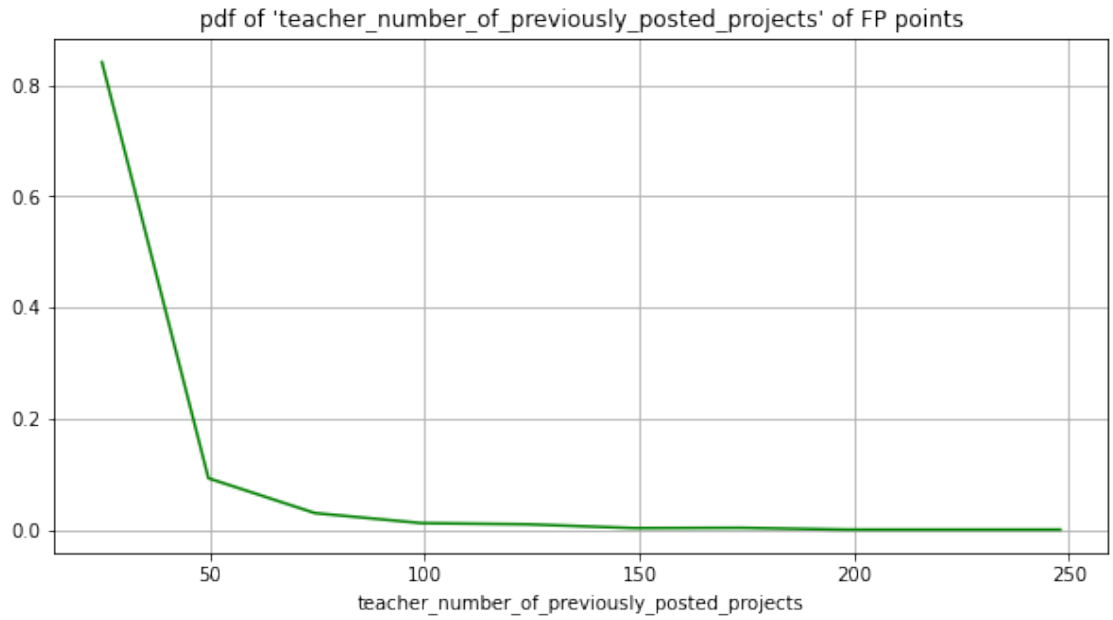

#### 4.0.8 Pdf Plot for 'teacher_number_of_previously_posted_projects' Of these False Positive Points

[35]:
```
plt.figure(figsize=(10,5))
plt.grid()
counts, bin_edges = np.histogram(X_test_fp['teacher_number_of_previously_posted_projects'], bins=10,
                                 density = True)
pdf = counts/(sum(counts))
print("PDFs : ",pdf);
print("\nbins : ",bin_edges)
plt.plot(bin_edges[1:],pdf,color="green")
```

```
plt.title("pdf of 'teacher_number_of_previously_posted_projects' of FP points")
plt.xlabel('teacher_number_of_previously_posted_projects')
```

```
PDFs :  [0.84129512 0.09341826 0.03078556 0.01273885 0.01061571 0.0037155
 0.00424628 0.00106157 0.00106157 0.00106157]

bins :  [  0.   24.8  49.6  74.4  99.2 124.  148.8 173.6 198.4 223.2 248. ]
```

[35]:
```
Text(0.5, 0, 'teacher_number_of_previously_posted_projects')
```




#### 4.0.9 DECISION TREE USING GRID SEARCH CV (SET - 2)

[36]:
```
param = {'max_depth': [1, 5, 10, 50],
         'min_samples_split': [5, 10, 100, 500]}

dtc = DecisionTreeClassifier(class_weight='balanced', random_state = 0)
clf2 = GridSearchCV(dtc, param, cv=5, scoring='roc_auc',␣
 ↪return_train_score=True, n_jobs=-1)
clf2.fit(X_tr_2,y_train)
```

[36]:
```
GridSearchCV(cv=5,
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              random_state=0),
             n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
```

```
                return_train_score=True, scoring='roc_auc')
```

[37]:
```
tr_auc_2 = clf2.cv_results_['mean_train_score']
tr_auc_std2 = clf2.cv_results_['std_train_score']
te_auc_2 = clf2.cv_results_['mean_test_score']
te_auc_std2 = clf2.cv_results_['std_test_score']

best_max_depth2 = clf2.best_params_["max_depth"]
best_min_samples_split2 = clf2.best_params_["min_samples_split"]

print('Best score for set 2: ',clf2.best_score_)
print('Best max_depth for set 2: ',best_max_depth1)
print('Best min_samples_split for set 2: ',best_min_samples_split1)
```

```
Best score for set 2:  0.614839181083529
Best max_depth for set 2:  10
Best min_samples_split for set 2:  500
```

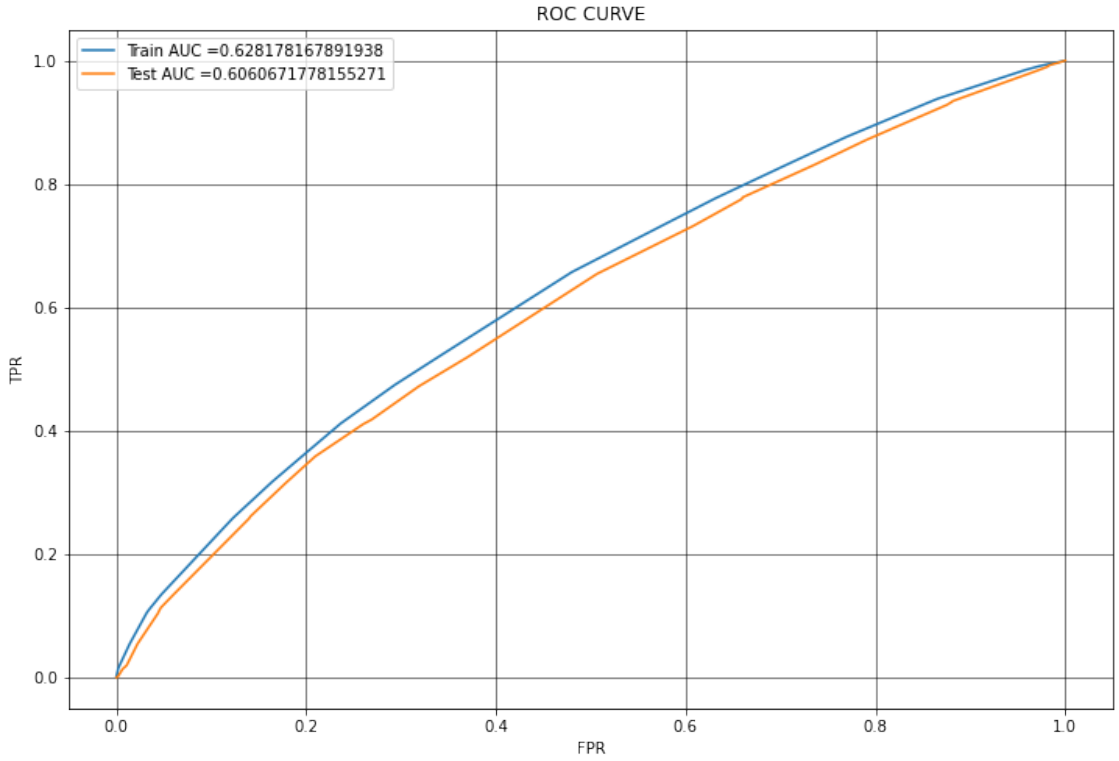
#### 4.0.10 Plotting Hyperparameter v AUC

[38]:
```
max_depth = [1, 5, 10, 50]
min_samples_split = [5, 10, 100, 500]

x1= max_depth
y1= min_samples_split
z1= tr_auc_2
z2= te_auc_2

trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name="tr_auc_2")
trace2 = go.Scatter3d(x=x1,y=y1,z=z2, name="te_auc_2")
values = [trace1, trace2]

lay = go.Layout(scene = dict(
        xaxis = dict(title='max_depth'),
        yaxis = dict(title='min_samples_split'),
        zaxis = dict(title='AUC SCORE'),))

fig = go.Figure(data=values, layout=lay)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

#### 4.0.11 ROC : Train And Test Data

[39]:
```
model2 = DecisionTreeClassifier(class_weight='balanced',max_depth =␣
↪best_max_depth2,min_samples_split = best_min_samples_split2, random_state =␣
↪0)
model2.fit(X_tr_2,y_train)
y_tr_prob2 = clf2.predict_proba(X_tr_2)[:,1]     # getting probability scores
```

```
y_te_prob2 = clf2.predict_proba(X_te_2 )[:,1]

tr_fpr2, tr_tpr2, tr_thresh2 = roc_curve(y_train, y_tr_prob2)       # getting␣
↪fpr and tpr values
te_fpr2, te_tpr2, te_thresh2 = roc_curve(y_test, y_te_prob2)

plt.figure(figsize=(12,8))
plt.plot(tr_fpr2, tr_tpr2, label="Train AUC ="+str(auc(tr_fpr2, tr_tpr2)))
plt.plot(te_fpr2, te_tpr2, label="Test AUC ="+str(auc(te_fpr2, te_tpr2)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC CURVE")
plt.grid(color='black',lw=0.5)
```



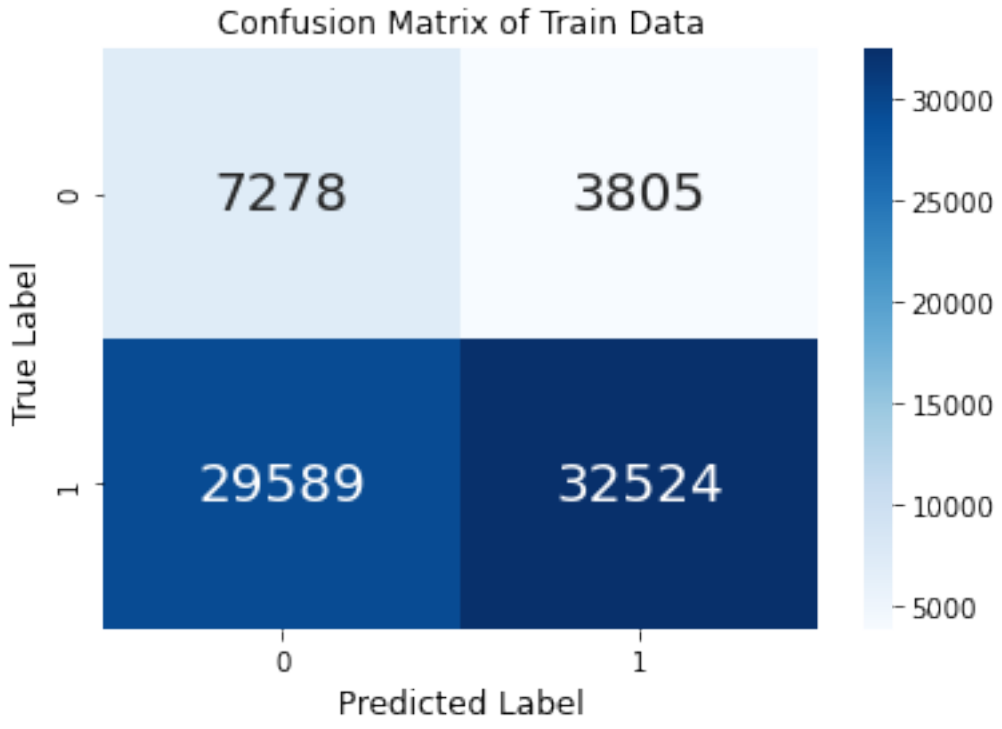

#### 4.0.12 Confusion Matrix

[40]:
```
# For Train Data

best_t2 = calc_best_threshold(tr_thresh2, tr_fpr2, tr_tpr2)
```

```
cm2 = metrics.confusion_matrix(y_train,calc_predictions(y_tr_prob2, best_t2))
 ↪# https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix

print("Confusion Matrix of Train Data of set 2 :\n",cm2)
sns.heatmap(cm2, annot=True, fmt='d',cmap='Blues',annot_kws = {"size":20})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.3438556498983273 for threshold 0.497

Confusion Matrix of Train Data of set 2 :
 [[ 7278  3805]
 [29589 32524]]
```

[40]: `Text(0.5, 1.0, 'Confusion Matrix of Train Data')`

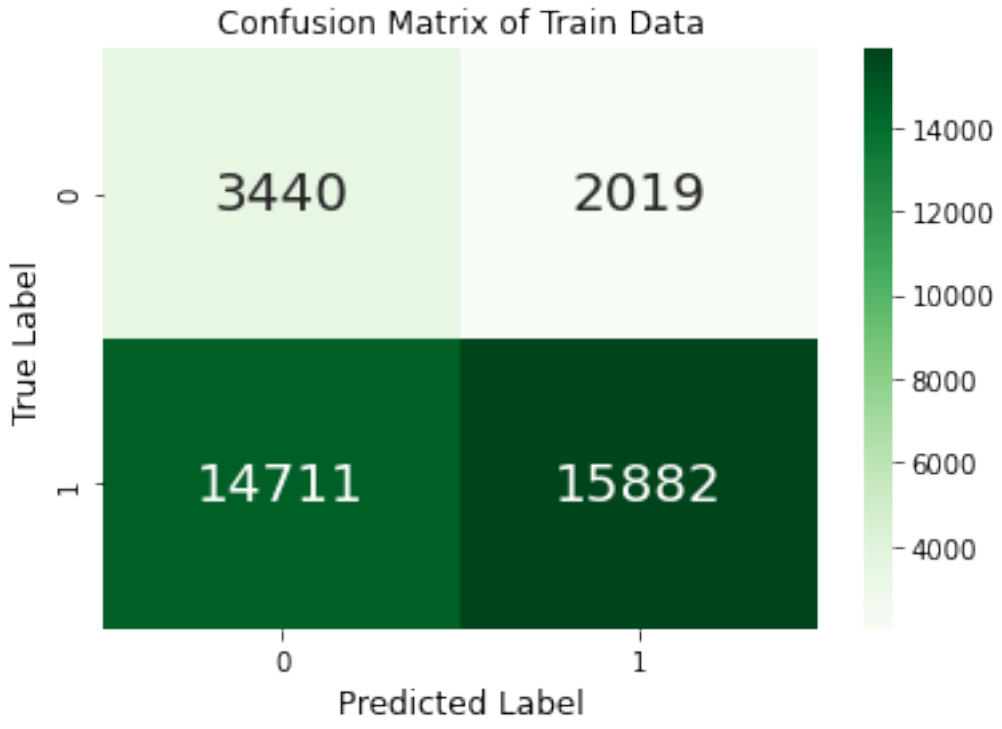



[41]:
```
# For Test data

best_t2 = calc_best_threshold(te_thresh2, te_fpr2, te_tpr2)
```

```
cm2 = metrics.confusion_matrix(y_test,calc_predictions(y_te_prob2, best_t2))  #␣
 ↪https://stackoverflow.com/questions/35572000/
 ↪how-can-i-plot-a-confusion-matrix

print("Confusion Matrix of Train Data of set 2 :\n",cm2)
sns.heatmap(cm2, annot=True, fmt='d',cmap='Greens',annot_kws = {"size":20})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.3271361010349812 for threshold 0.497

Confusion Matrix of Train Data of set 2 :
 [[ 3440  2019]
 [14711 15882]]
```

[41]: Text(0.5, 1.0, 'Confusion Matrix of Train Data')



#### 4.0.13 Getting All the False Positive Data Points

[42]:
```
pred = calc_predictions(y_te_prob2,best_t2)

fp_count = []
for i in range(len(y_test)):
    if(y_test[i]==0) & (pred[i] == 1):
        fp_count.append(i)
len(fp_count)
```

[42]: 2019

[43]:
```
col = X_test.columns
X_test_fp2 = pd.DataFrame(columns=col)          # creating FALSE POSITIVE DF
X_test_fp2 = X_test.iloc[fp_count]
print(X_test_fp2.shape)

X_test_fp2.head(1)
```

(2019, 12)

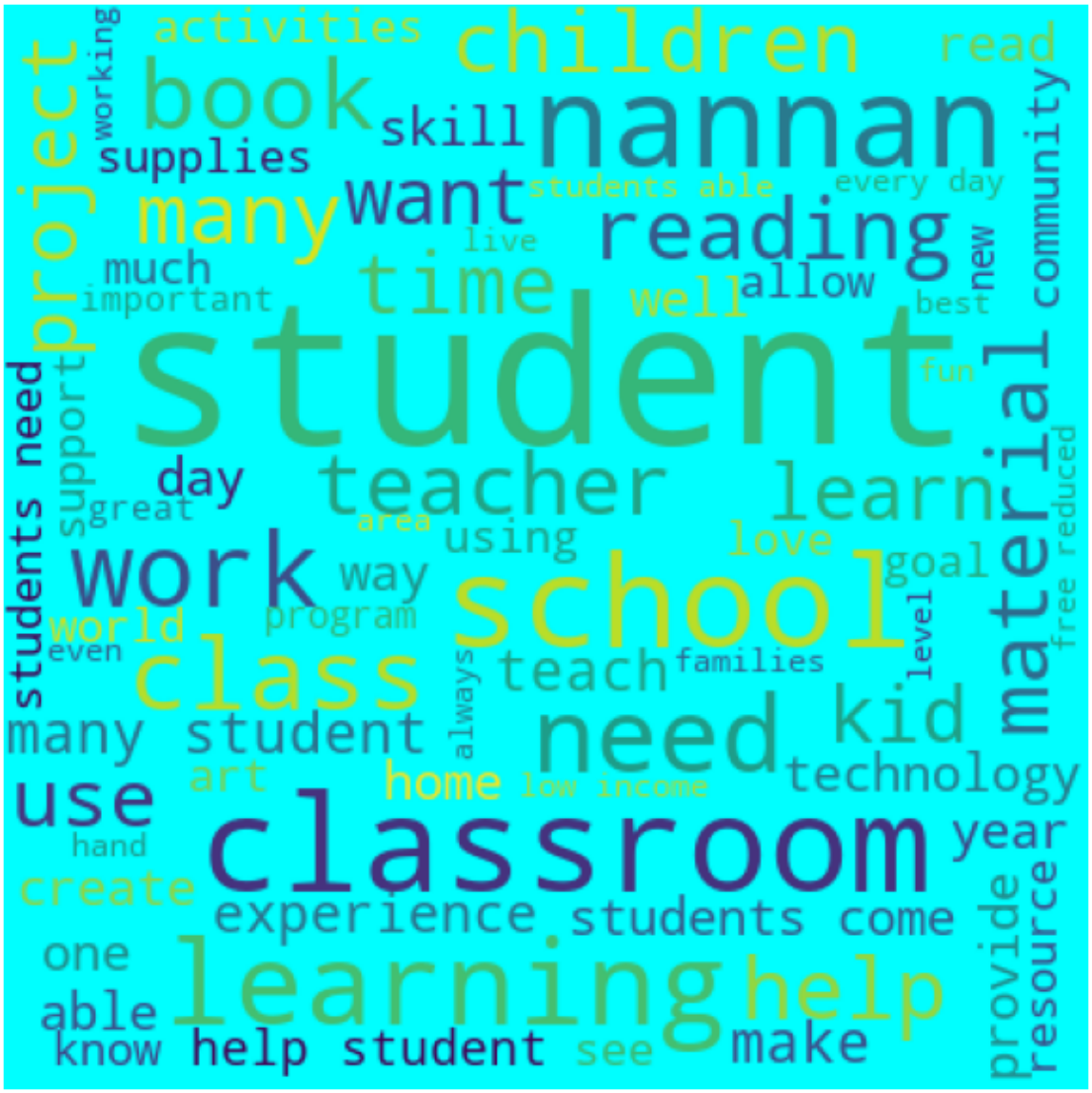
[43]:
```
      school_state teacher_prefix project_grade_category  \
69487           sc            mrs              grades_3_5

       teacher_number_of_previously_posted_projects  \
69487                                            10

                     clean_categories   clean_subcategories  \
69487  literacy_language math_science  literacy mathematics

                                                  essay   price    neg  \
69487  many students english language learners hard w…  228.89  0.039

         pos    neu  compound
69487  0.242  0.719    0.9794
```

#### 4.0.14 WordCloud for Essay for False Positive Dataset

[44]:
```
# https://www.geeksforgeeks.org/generating-word-cloud-python/

from wordcloud import WordCloud, STOPWORDS
comment_words = ' '
sw = set(STOPWORDS)
for e in X_test_fp2['essay']:
    val = str(e)
    tokens = val.split()
    for i in range(len(tokens)):
```

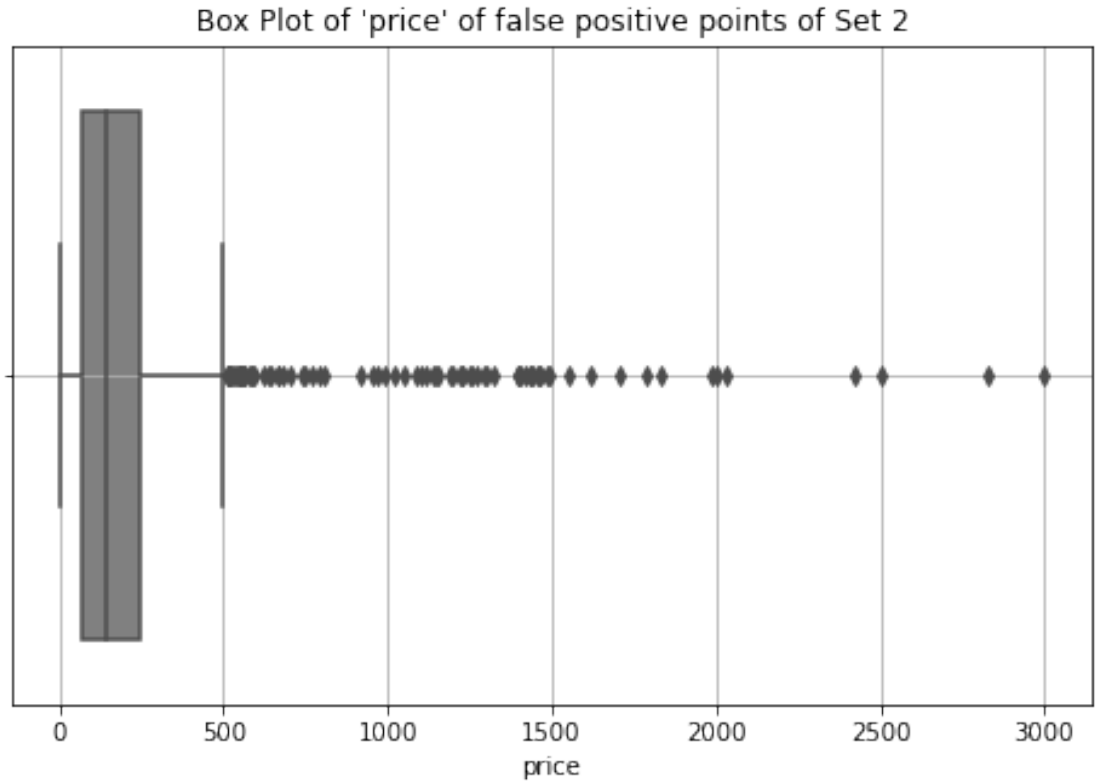
```
        tokens[i] = tokens[i].lower()
    for words in tokens:
        comment_words = comment_words + words + ' '
```

[45]:
```
wrdcld = WordCloud(width = 400, height = 400, background_color ='cyan',␣
↪stopwords = sw, min_font_size = 10).generate(comment_words)

plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wrdcld)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



#### 4.0.15 Box Plot for 'price' Of these False Positive Points

[46]:
```
plt.figure(figsize=(8,5))
sns.boxplot('price',data=X_test_fp2,color='grey').set_title("Box Plot of␣
↪'price' of false positive points of Set 2")
plt.grid()
```

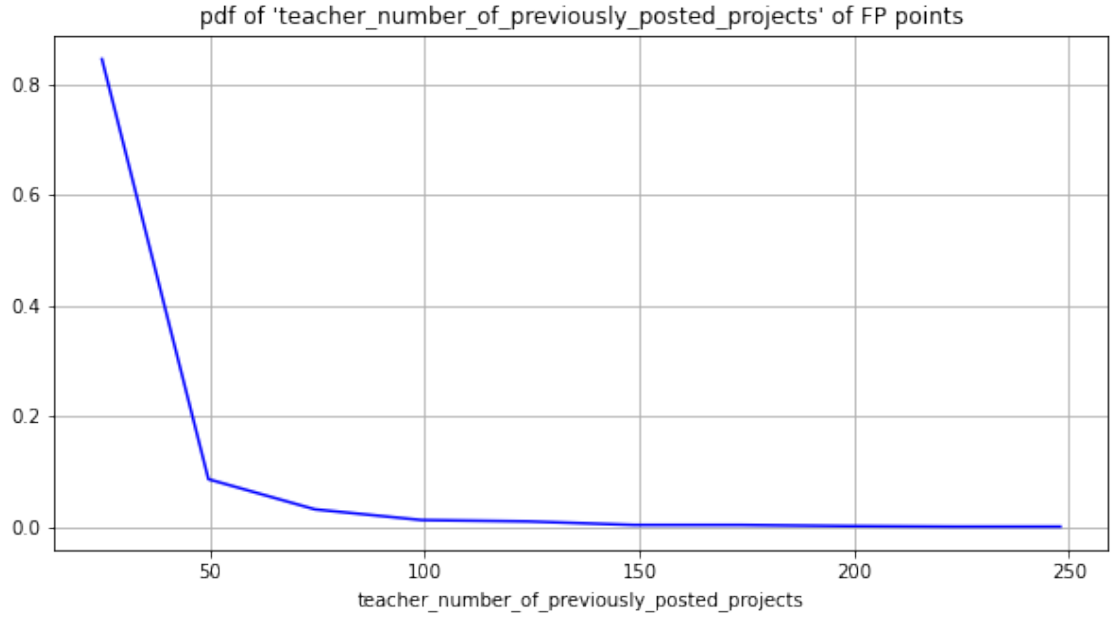



#### 4.0.16 PDF Plot for 'teacher_number_of_previously_posted_projects' Of these False Positive Points

[47]:
```
plt.figure(figsize=(10,5))
plt.grid()
counts, bin_edges = np.
↪histogram(X_test_fp2['teacher_number_of_previously_posted_projects'],␣
↪bins=10,
                                    density = True)
pdf = counts/(sum(counts))
print("PDFs : ",pdf);
print("\nbins : ",bin_edges)
plt.plot(bin_edges[1:],pdf,color="blue")
plt.title("pdf of 'teacher_number_of_previously_posted_projects' of FP points")
plt.xlabel('teacher_number_of_previously_posted_projects')
```

```
PDFs :  [0.84596335 0.08667657 0.03219416 0.01287766 0.01040119 0.00396236
 0.00396236 0.00198118 0.00099059 0.00099059]

bins :  [  0.   24.8  49.6  74.4  99.2 124.  148.8 173.6 198.4 223.2 248. ]
```

[47]:
```
Text(0.5, 0, 'teacher_number_of_previously_posted_projects')
```




# 5 Task - 2

### 5.0.1 Features with Non-Zero Feature Importance

[48]:
```
print(X_tr_1.shape)
print(X_te_1.shape)
```

```
(73196, 5105)
(36052, 5105)
```

[49]:
```
clf_feat = DecisionTreeClassifier(class_weight='balanced', max_depth=None,␣
 ↪min_samples_split=500, random_state = 0)
clf_feat.fit(X_tr_1,y_train)

features = clf_feat.feature_importances_
len(features)
```

[49]:
```
5105
```

[50]:
```
non_0_feat = []
for i in range(len(features)):
    if features[i]>0:
        non_0_feat.append(i)

print("Number of non-zero importance features : " ,len(non_0_feat))
```

```
Number of non-zero importance features :  1207
```

[51]:
```
X_tr_new = X_tr_1[:,non_0_feat]
X_te_new = X_te_1[:,non_0_feat]

print("Shape of non-zero importance training data : ", X_tr_new.shape)
print("Shape of non-zero importance test data : ", X_te_new.shape)
```

```
Shape of non-zero importance training data :  (73196, 1207)
Shape of non-zero importance test data :  (36052, 1207)
```

### 5.0.2 Fitting Modified Data

[52]:
```
dct_new = DecisionTreeClassifier(class_weight='balanced', random_state = 0)
clf_new = GridSearchCV(dct_new, param, cv=5, scoring='roc_auc',␣
 ↪return_train_score=True, n_jobs=-1)
clf_new.fit(X_tr_new,y_train)
```

[52]:
```
GridSearchCV(cv=5,
             estimator=DecisionTreeClassifier(class_weight='balanced',
                                              random_state=0),
             n_jobs=-1,
             param_grid={'max_depth': [1, 5, 10, 50],
                         'min_samples_split': [5, 10, 100, 500]},
             return_train_score=True, scoring='roc_auc')
```

[53]:
```
train_auc_new = clf_new.cv_results_['mean_train_score']
train_auc_std_new = clf_new.cv_results_['std_train_score']
test_auc_new = clf_new.cv_results_['mean_test_score']
test_auc_std_new = clf_new.cv_results_['std_test_score']

max_depth_new = clf.best_params_['max_depth']
min_samples_split_new = clf.best_params_['min_samples_split']

print('Best score for modified dataset: ',clf_new.best_score_)
print('Best max_depth for modified dataset: ',max_depth_new)
print('Best min_samples_split for modified dataset: ',min_samples_split_new)
```

```
Best score for modified dataset:  0.653742158026761
Best max_depth for modified dataset:  10
Best min_samples_split for modified dataset:  500
```

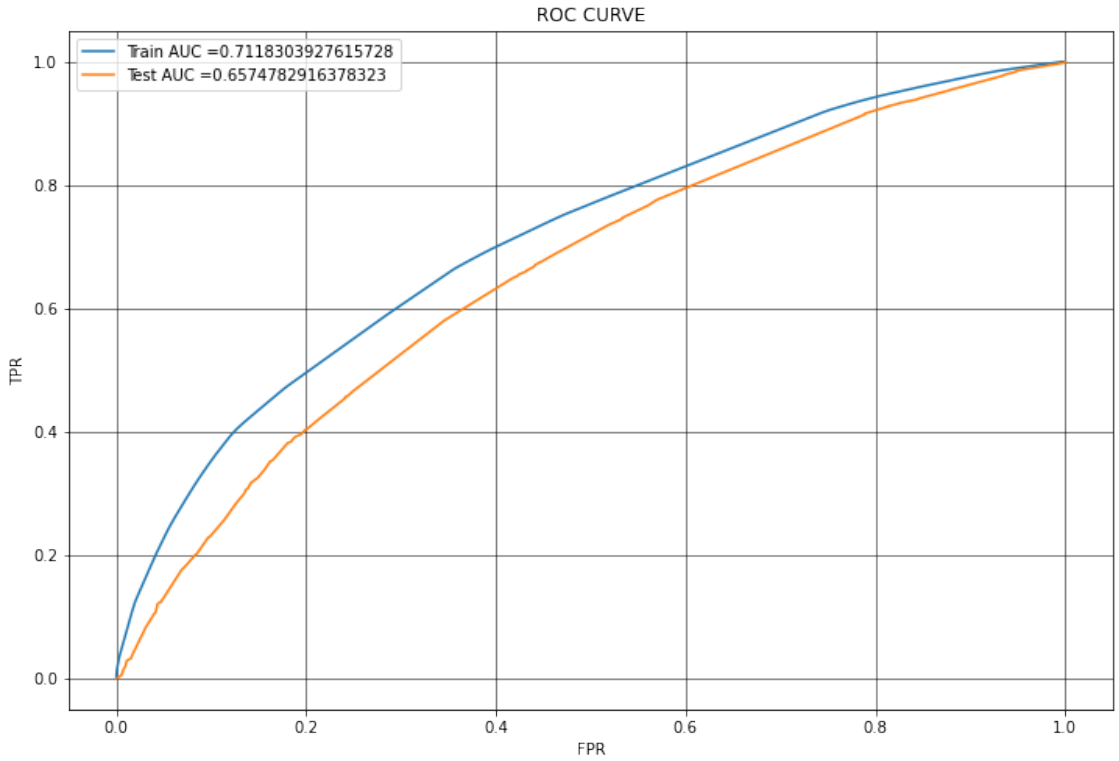
### 5.0.3 Hyperparameter v/s Auc Plot

[54]:
```
from itertools import repeat

x1= max_depth
y1= min_samples_split
z1= train_auc_new
z2= test_auc_new
```

[55]:
```
trace1 = go.Scatter3d(x=x1,y=y1,z=z1, name="train_auc")
trace2 = go.Scatter3d(x=x1,y=y1,z=z2, name="test_auc")
values = [trace1, trace2]

lay = go.Layout(scene = dict(
        xaxis = dict(title='max_depth'),
        yaxis = dict(title='min_samples_split'),
        zaxis = dict(title='AUC SCORE'),))

fig = go.Figure(data=values, layout=lay)
offline.iplot(fig, filename='3d-scatter-colorscale')
```

### 5.0.4 ROC Plot : Train And Test Data

[56]:
```
model = DecisionTreeClassifier(class_weight='balanced',max_depth =␣
 ↪max_depth_new, min_samples_split = min_samples_split_new, random_state = 0)
model.fit(X_tr_new,y_train)

y_tr_prob_new = clf_new.predict_proba(X_tr_new)[:,1]
y_te_prob_new = clf_new.predict_proba(X_te_new )[:,1]

tr_fpr_new, tr_tpr_new, tr_thres_new = roc_curve(y_train, y_tr_prob_new)
te_fpr_new, te_tpr_new, te_thres_new = roc_curve(y_test, y_te_prob_new)

plt.figure(figsize=(12,8))
plt.plot(tr_fpr_new, tr_tpr_new, label="Train AUC ="+str(auc(tr_fpr_new,␣
 ↪tr_tpr_new)))
plt.plot(te_fpr_new, te_tpr_new, label="Test AUC ="+str(auc(te_fpr_new,␣
 ↪te_tpr_new)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC CURVE")
plt.grid(color='black',lw=0.5)
```

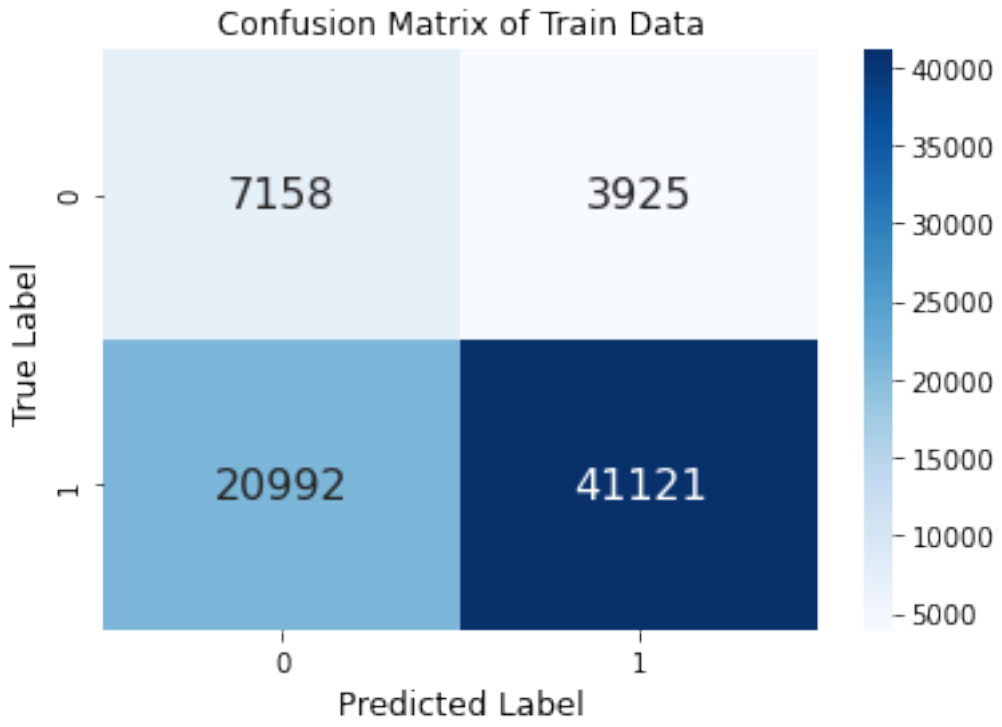



### 5.0.5 Confusion Matrix

[57]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

# Train Data

best_t_new = calc_best_threshold(tr_thres_new, tr_fpr_new, tr_tpr_new)
cm_new = metrics.confusion_matrix(y_train,calc_predictions(y_tr_prob_new,␣
 ↪best_t_new))

print("Confusion Matrix of modified Train Data :\n",cm_new)
sns.heatmap(cm_new, annot=True, fmt='d',cmap='Blues',annot_kws = {"size":16})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.4275781683675348 for threshold 0.512

Confusion Matrix of modified Train Data :
 [[ 7158  3925]
 [20992 41121]]
```

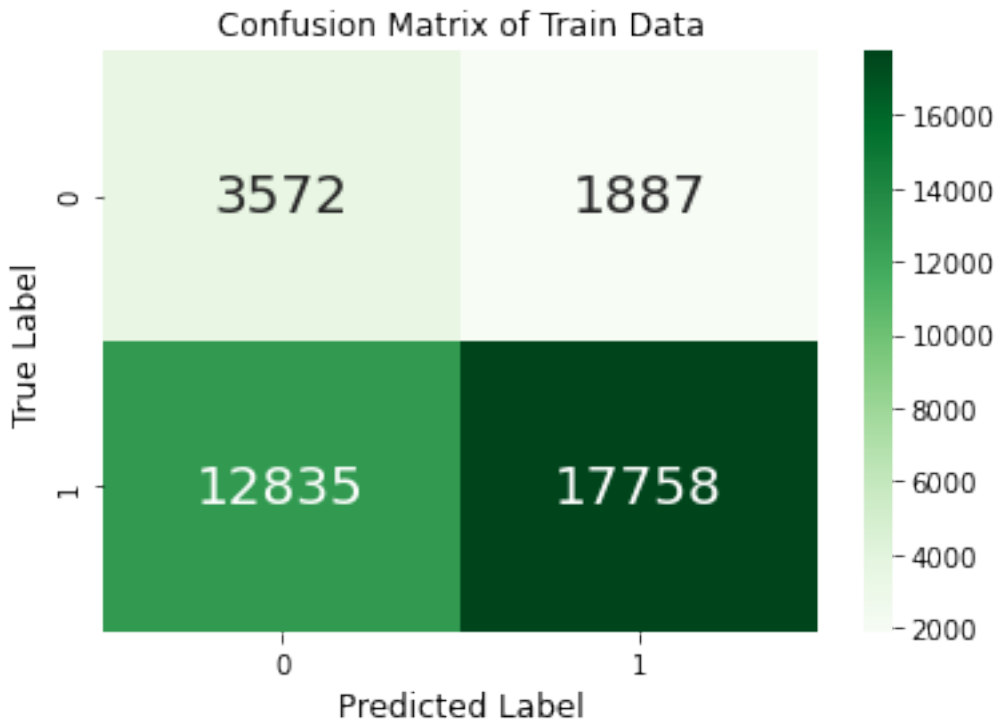
[57]: Text(0.5, 1.0, 'Confusion Matrix of Train Data')




[58]:
```
# For Test data

best_t_new = calc_best_threshold(te_thres_new, te_fpr_new, te_tpr_new)
cm_new = metrics.confusion_matrix(y_test,calc_predictions(y_te_prob_new,␣
 ↪best_t_new))

print("Confusion Matrix of modified Test Data:\n",cm_new)
sns.heatmap(cm_new, annot=True, fmt='d',cmap='Greens',annot_kws = {"size":20})
plt.ylabel('True Label',size=12)
plt.xlabel('Predicted Label',size=12)
plt.title('Confusion Matrix of Train Data',size=12)
```

```
the maximum value of tpr*(1-fpr) 0.37981345078280976 for threshold 0.524

Confusion Matrix of modified Test Data:
 [[ 3572  1887]
 [12835 17758]]
```

[58]: Text(0.5, 1.0, 'Confusion Matrix of Train Data')




### 5.0.6 False Positive Data Points

[59]:
```
pred_new = calc_predictions(y_te_prob_new,best_t_new)

fp_count_new = []

for i in range(len(y_test)):
    if(y_test[i]==0) & (pred_new[i] == 1):
        fp_count_new.append(i)

len(fp_count_new)
```

[59]: 1887

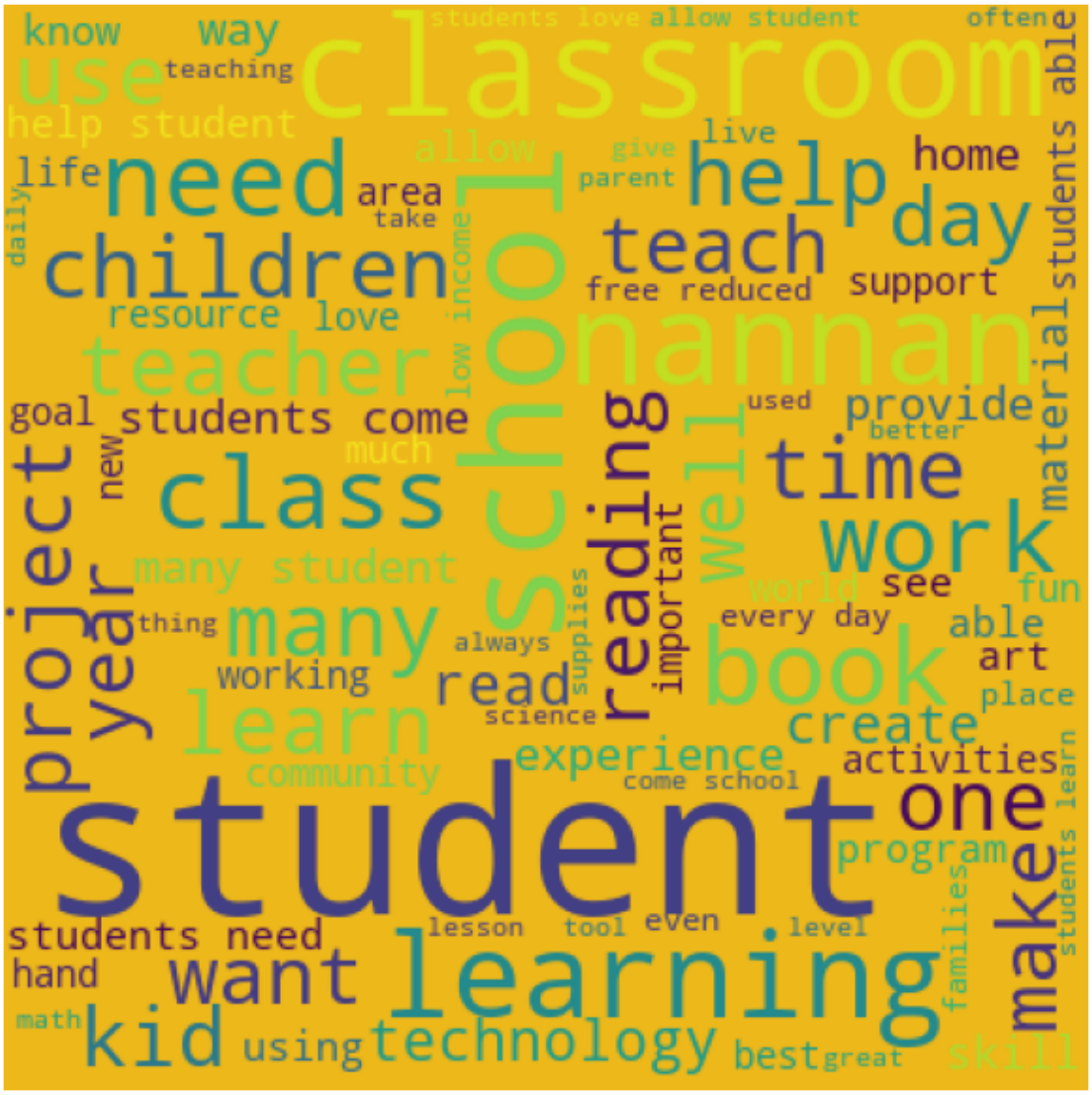
[60]:
```
cols_new = X_test.columns
X_te_fp_new = pd.DataFrame(columns=cols_new) # MAKING THE FALSE POSITIVE␣
↪DATAFRAME
X_te_fp_new = X_test.iloc[fp_count_new]
print(X_te_fp_new.shape)
```

```
(1887, 12)
```

### 5.0.7 WordCloud for Essay False Positive Dataset

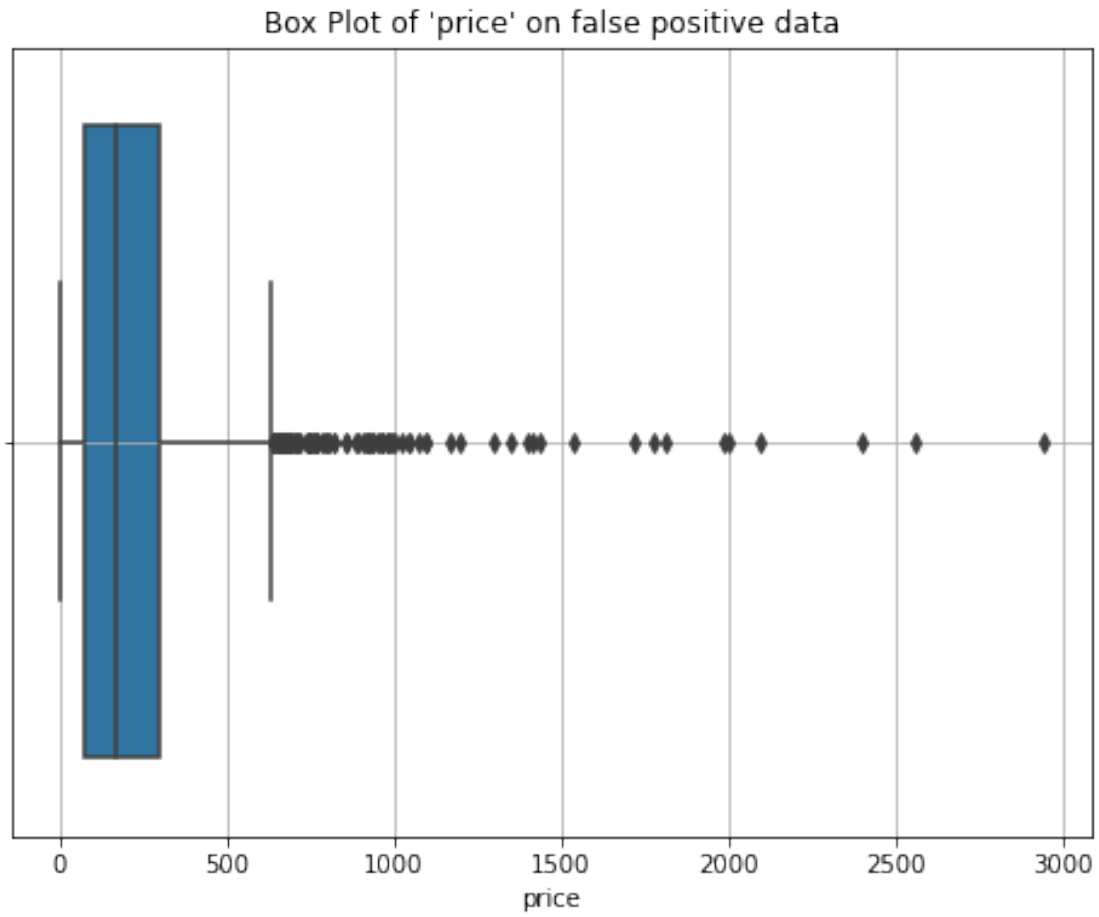
[61]:
```
# https://www.geeksforgeeks.org/generating-word-cloud-python/

comment_words = ' '
sw = set(STOPWORDS)
for e in X_te_fp_new['essay']:
    val = str(e)
    tokens = val.split()
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()
    for words in tokens:
        comment_words = comment_words + words + ' '
```

[62]:
```
wrdcld = WordCloud(width = 400, height = 400, background_color ='#edb81a',␣
 ↪stopwords = sw, min_font_size = 10).generate(comment_words)
# For more color options Google hex color picker

plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wrdcld)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```




### 5.0.8 Box Plot for 'price' of False Positive Data Points

[63]:
```
plt.figure(figsize=(8,6))
sns.boxplot('price',data=X_te_fp_new,orient="v").set_title("Box Plot of 'price' on false positive data")
plt.grid()
```



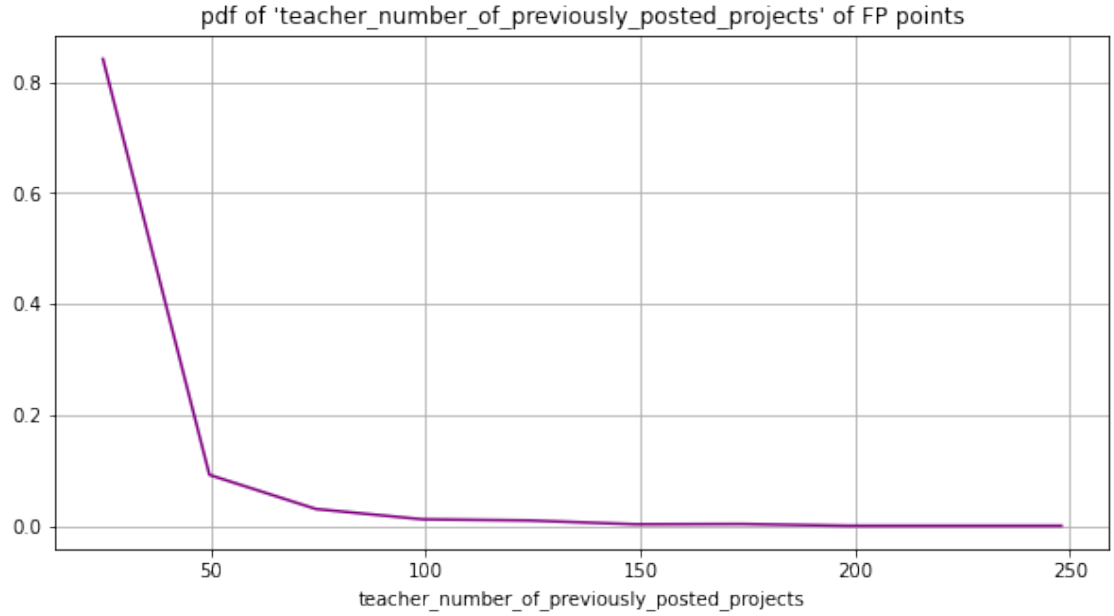

### 5.0.9 PDF Plot for 'teacher_number_of_previously_posted_projects' Of these False Positive Points

[64]:
```
plt.figure(figsize=(10,5))
plt.grid()
counts, bin_edges = np.
 ↪histogram(X_te_fp_new['teacher_number_of_previously_posted_projects'],␣
 ↪bins=10,
                                  density = True)
pdf = counts/(sum(counts))
print("PDFs : ",pdf);
print("\nbins : ",bin_edges)
plt.plot(bin_edges[1:],pdf,color="purple")
plt.title("pdf of 'teacher_number_of_previously_posted_projects' of FP points")
plt.xlabel('teacher_number_of_previously_posted_projects')
```

```
PDFs :  [0.84154743 0.0927398  0.03126656 0.0127186  0.01059883 0.00370959
 0.00423953 0.00105988 0.00105988 0.00105988]
```

```
bins :  [  0.   24.8  49.6  74.4  99.2 124.  148.8 173.6 198.4 223.2 248. ]
```

[64]:
```
Text(0.5, 0, 'teacher_number_of_previously_posted_projects')
```




### 5.1 Summary

[67]:
```
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable
from prettytable import ALL as ALL
table = PrettyTable(hrules=ALL)
table.field_names = ["S.No.","Vectorizer", "Model", "Hyper-Parameter",␣
 ↪"Test-AUC Score"]
table.add_row([1,"TF-IDF", "DECSION TREE", "max_depth =10,␣
 ↪min_samples_split=500", np.round(clf.best_score_,3)])
table.add_row([2,"TF-IDF W2V", "DECSION TREE"," max_depth =10 ,␣
 ↪min_samples_split=500", np.round(clf2.best_score_,3)])
table.add_row([3,"TF-IDF NON ZERO FEATURES", "DECSION TREE", "max_depth =10 ,␣
 ↪min_samples_split=500", np.round(clf_new.best_score_,3)])
print(table)
```

```
+-------+--------------------------+-------------+-----------------------------
-----------+----------------+
| S.No. |        Vectorizer        |    Model    |            Hyper-Parameter
| Test-AUC Score |
+-------+--------------------------+-------------+-----------------------------
```

```
-----------+---------------+
|   1   |          TF-IDF          | DECSION TREE |  max_depth =10,
min_samples_split=500  |     0.652      |
+-------+--------------------------+--------------+----------------------------
-----------+---------------+
|   2   |        TF-IDF W2V        | DECSION TREE |  max_depth =10 ,
min_samples_split=500 |     0.615      |
+-------+--------------------------+--------------+----------------------------
-----------+---------------+
|   3   | TF-IDF NON ZERO FEATURES | DECSION TREE | max_depth =10 ,
min_samples_split=500  |     0.654      |
+-------+--------------------------+--------------+----------------------------
-----------+---------------+
```

[ ]: