Decision tree on Amazon fine food dataset

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews (https://www.kaggle.com/snap/amazon-fine-food-reviews)

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

To perform Decision tree on Avg-W2vec & Tf-idf_W2vec.

```
%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

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
```

```
C:\Users\deepak\Anaconda3\lib\site-packages\gensim\utils.py:1209: UserWarning: detected Windows; aliasing chunkize to chunk
ize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

```
#Importing Train and test dataset
train_data=pd.read_csv("E:/Applied AI assignments/Amazon_fine_train_data.csv")
test_data=pd.read_csv("E:/Applied AI assignments/Amazon_fine_test_data.csv")
```

```
train_data=train_data.astype(str)
test_data=test_data.astype(str)
```

```
train_data.shape
```

```
(80000, 13)
```

```
train_data['Score'].value_counts()
```

```
positive    70407
negative     9593
Name: Score, dtype: int64
```

```
test_data.shape
```

```
(20000, 13)
```

```
test_data['Score'].value_counts()
```

```
positive    17322
negative     2678
Name: Score, dtype: int64
```

```
#Train data
y_train = train_data['Score']
x_train = train_data['CleanedText']

#Test data
y_test = test_data['Score']
x_test = test_data['CleanedText']
```

```
#Replacing Positive score with 0 and negative score with 1
y_train.replace('negative',1,inplace=True)
y_train.replace('positive',0,inplace=True)

y_test.replace('negative',1,inplace=True)
y_test.replace('positive',0,inplace=True)
```

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import TimeSeriesSplit
from sklearn.metrics import roc_auc_score
from sklearn.metrics import recall_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import make_scorer
from sklearn.metrics import confusion_matrix
from sklearn.cross_validation import cross_val_score
from collections import Counter
from sklearn import cross_validation
from wordcloud import WordCloud
import matplotlib.pyplot as plt
```

RandomizedSearchCV

```
max_depth=list(range(1,31,1))
min_samples_split=list(range(2,31,1))
min_samples_leaf=list(range(1,31,1))
weight=[None,'balanced']
T= TimeSeriesSplit(n_splits=5)

param_distributions = dict(max_depth=max_depth,min_samples_split=min_samples_split,min_samples_leaf=min_
print(param_distributions)

# instantiate and fit the grid
grid = RandomizedSearchCV(DecisionTreeClassifier(), param_distributions, cv=T, scoring='f1', n_iter=30,
```

```
{'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 3
0], 'min_samples_split': [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 2
8, 29, 30], 'min_samples_leaf': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25,
26, 27, 28, 29, 30], 'class_weight': [None, 'balanced']}
```

Avg-W2Vec

```
#W2V List of Training data
i=0
list_of_sent_train=[]
for sent in train_data['CleanedText'].values:
    list_of_sent_train.append(sent.split())
```

```
#W2V List of Test data
i=0
list_of_sent_test=[]
for sent in test_data['CleanedText'].values:
    list_of_sent_test.append(sent.split())
```

```
#Training W2V train model
# min_count = 5 considers only words that occured atleast 5 times
w2v_model_train=Word2Vec(list_of_sent_train,min_count=5,size=200, workers=6)
```

```python
w2v_words_train = list(w2v_model_train.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words_train))
print("sample words ", w2v_words_train[0:50])
```

```
number of words that occured minimum 5 times  11361
sample words  ['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'car', 'drive', 'along', 'alway', 'sing', 'refrai
n', 'hes', 'learn', 'whale', 'india', 'droop', 'love', 'new', 'word', 'introduc', 'silli', 'classic', 'will', 'bet', 'stil
l', 'abl', 'memori', 'colleg', 'rememb', 'see', 'show', 'air', 'televis', 'year', 'ago', 'child', 'sister', 'later', 'bough
t', 'day', 'thirti', 'someth', 'use', 'seri', 'song', 'student', 'teach', 'preschool']
```

```python
#Train data
# average Word2Vec
# compute average word2vec for each review.
sent_vectors_train_avgw2v = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_train: # for each review/sentence
    sent_vec = np.zeros(200) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_train:
            vec = w2v_model_train.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train_avgw2v.append(sent_vec)
print(len(sent_vectors_train_avgw2v))
print(len(sent_vectors_train_avgw2v[0]))
```

```
80000
200
```

```
#Test data
# average Word2Vec
# compute average word2vec for each review.
sent_vectors_test_avgw2v = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_test: # for each review/sentence
    sent_vec = np.zeros(200) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_train:
            vec = w2v_model_train.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_test_avgw2v.append(sent_vec)
print(len(sent_vectors_test_avgw2v))
print(len(sent_vectors_test_avgw2v[0]))
```

```
20000
200
```

```
grid.fit(sent_vectors_train_avgw2v, y_train)

# examine the best model
print(grid.best_score_)
print(grid.best_params_)
```

```
0.4048889313128413
{'min_samples_split': 19, 'min_samples_leaf': 1, 'max_depth': 9, 'class_weight': 'balanced'}
```

```
#Plotting Max_depth v/s CV_error
a=pd.DataFrame(grid.cv_results_)[['mean_test_score', 'std_test_score', 'params']]
a['max_depth'] = [d.get('max_depth') for d in a['params']]
b=a.sort_values(['max_depth'])
CV_Error=1-b['mean_test_score']
max_depth =b['max_depth']


plt.plot(max_depth,CV_Error)
plt.xlabel('Max_depth')
plt.ylabel('Cross-Validated Error')
```

```
Text(0,0.5,'Cross-Validated Error')
```

```
#{'min_samples_split': 19, 'min_samples_leaf': 1, 'max_depth': 9, 'class_weight': 'balanced'}
dt_optimal=DecisionTreeClassifier(max_depth=9,min_samples_split=19,min_samples_leaf=1,class_weight='bala

# fitting the model
dt_optimal.fit(sent_vectors_train_avgw2v, y_train)

# predict the response
pred_avg_w2v = dt_optimal.predict(sent_vectors_test_avgw2v)

# evaluate f1_score
f1_score = f1_score(y_test, pred_avg_w2v)
```

```
# Train & Test Error
print("The overall f1_score for the Train Data is : ", metrics.f1_score(y_train,dt_optimal.predict(sent_
print("The overall f1_score for the Test Data is : ", metrics.f1_score(y_test,pred_avg_w2v))
```

```
The overall f1_score for the Train Data is :  0.50806211697507
The overall f1_score for the Test Data is :  0.43673061994011314
```

```python
#Plotting Decision tree
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(dt_optimal, out_file=dot_data,
                filled=True, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
dot: graph is too large for cairo-renderer bitmaps. Scaling by 0.353397 to fit
```

```python
# Saving DT as pdf
graph.write_pdf("Avg-W2V.pdf")
```

```
True
```

```python
#Confusion matrix
C = confusion_matrix(y_test, pred_avg_w2v)
A =(((C.T)/(C.sum(axis=1))).T)
B =(C/C.sum(axis=0))
labels = [0,1]
```

```
 print("-"*20, "Confusion matrix", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(C, annot=True, cmap="YlGnBu", fmt="g", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

print("-"*20, "Precision matrix (Columm Sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(B, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
 plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

    # representing B in heatmap format
print("-"*20, "Recall matrix (Row sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(A, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```

```
-------------------- Confusion matrix --------------------
```

```
-------------------- Precision matrix (Columm Sum=1) --------------------
```

```
-------------------- Recall matrix (Row sum=1) --------------------
```

Tfidf-W2V

Importing Pre-featurized pickle file

```
#Train
with open('train.pickle', 'rb') as f:
   tfidf_w2v_sent_vectors_train = pickle.load(f)
```

```
#Test
with open('test.pickle', 'rb') as f:
    tfidf_w2v_sent_vectors_test = pickle.load(f)
```

Fitting grid search cv on tfidf-w2vec

```
grid.fit(tfidf_w2v_sent_vectors_train, y_train)

# examine the best model
print(grid.best_score_)
print(grid.best_params_)
```

```
0.36076522546701334
{'min_samples_split': 27, 'min_samples_leaf': 2, 'max_depth': 10, 'class_weight': 'balanced'}
```

```
#Plotting Max_depth v/s CV_error
a=pd.DataFrame(grid.cv_results_)[['mean_test_score', 'std_test_score', 'params']]
a['max_depth'] = [d.get('max_depth') for d in a['params']]
b=a.sort_values(['max_depth'])
CV_Error=1-b['mean_test_score']
max_depth =b['max_depth']


plt.plot(max_depth,CV_Error)
plt.xlabel('Max_depth')
plt.ylabel('Cross-Validated Error')
```

```
Text(0,0.5,'Cross-Validated Error')
```

```
#{'min_samples_split': 27, 'min_samples_leaf': 2, 'max_depth': 10, 'class_weight': 'balanced'}
dt_optimal=DecisionTreeClassifier(max_depth=10,min_samples_split=27,min_samples_leaf=2,class_weight='ba

# fitting the model
dt_optimal.fit(tfidf_w2v_sent_vectors_train, y_train)

# predict the response
pred_tfidf_w2v_sent_vectors_test = dt_optimal.predict(tfidf_w2v_sent_vectors_test)

# evaluate f1_score
f1_score = f1_score(y_test, pred_tfidf_w2v_sent_vectors_test)
```

```
# Train & Test Error
print("The overall f1_score  for the Train Data is : ", metrics.f1_score(y_train,dt_optimal.predict(tfi
print("The overall f1_score  for the Test Data is : ", metrics.f1_score(y_test,pred_tfidf_w2v_sent_vect
```

```
The overall f1_score  for the Train Data is :  0.4841440083483101
The overall f1_score  for the Test Data is :  0.40301561658589125
```

```python
#Plotting Decision tree
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(dt_optimal, out_file=dot_data,
                filled=True, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
dot: graph is too large for cairo-renderer bitmaps. Scaling by 0.259788 to fit
```

```python
# Saving DT as pdf
graph.write_pdf("Tfidf-W2V.pdf")
```

```
True
```

```python
#Confusion matrix
C = confusion_matrix(y_test, pred_tfidf_w2v_sent_vectors_test)
A =(((C.T)/(C.sum(axis=1))).T)
B =(C/C.sum(axis=0))
labels = [0,1]
```

```
 print("-"*20, "Confusion matrix", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(C, annot=True, cmap="YlGnBu", fmt="g", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

print("-"*20, "Precision matrix (Columm Sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(B, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
 plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

    # representing B in heatmap format
print("-"*20, "Recall matrix (Row sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(A, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```

```
-------------------- Confusion matrix --------------------
```

```
-------------------- Precision matrix (Columm Sum=1) --------------------
```

```
-------------------- Recall matrix (Row sum=1) --------------------
```

0.727
0.273
0.301
0.699
Original Class
0
1
Predicted Class
0
1
0.72
0.64
0.56
0.48
0.40
0.32

Binary Bow

```
count_vect = CountVectorizer(binary=True)

#Train data
vocabulary = count_vect.fit(x_train) #in scikit-learn
Bow_x_train= count_vect.transform(x_train)
print("the type of count vectorizer ",type(Bow_x_train))
print("the shape of out text BOW vectorizer ",Bow_x_train.get_shape())
print("the number of unique words ", Bow_x_train.get_shape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (80000, 33433)
the number of unique words  33433
```

```
#Test data
Bow_x_test = count_vect.transform(x_test)
print("the type of count vectorizer ",type(Bow_x_test))
print("the shape of out text BOW vectorizer ",Bow_x_test.get_shape())
print("the number of unique words ", Bow_x_test.get_shape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (20000, 33433)
the number of unique words  33433
```

```
grid.fit(Bow_x_train, y_train)

# examine the best model
print(grid.best_score_)
print(grid.best_params_)
```

```
0.40300966363374835
{'min_samples_split': 2, 'min_samples_leaf': 7, 'max_depth': 27, 'class_weight': 'balanced'}
```

```
#Plotting Max_depth v/s CV_error
a=pd.DataFrame(grid.cv_results_)[['mean_test_score', 'std_test_score', 'params']]
a['max_depth'] = [d.get('max_depth') for d in a['params']]
b=a.sort_values(['max_depth'])
CV_Error=1-b['mean_test_score']
max_depth =b['max_depth']


plt.plot(max_depth,CV_Error)
plt.xlabel('Max_depth')
plt.ylabel('Cross-Validated Error')
```

```
Text(0,0.5,'Cross-Validated Error')
```

```
from sklearn.metrics import  f1_score
#{'min_samples_split': 2, 'min_samples_leaf': 7, 'max_depth': 27, 'class_weight': 'balanced'}
dt_optimal=DecisionTreeClassifier(max_depth=27,min_samples_split=2,min_samples_leaf=7,class_weight='bal

# fitting the model
dt_optimal.fit(Bow_x_train, y_train)

# predict the response
pred_bow = dt_optimal.predict(Bow_x_test)

# evaluate f1_score
f1_score = f1_score(y_test, pred_bow)
```

```
# Train & Test Error
print("The overall f1_score for the Train Data is : ", metrics.accuracy_score(y_train,dt_optimal.predic
print("The overall f1_score for the Test Data is : ", metrics.accuracy_score(y_test,pred_bow))
```

```
The overall f1_score for the Train Data is :  0.7992375
The overall f1_score for the Test Data is :  0.75565
```

Visualizing Decision Tree

```
feature_names = np.array(vocabulary.get_feature_names())

#Plotting Decision tree
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(dt_optimal, out_file=dot_data,
                feature_names=feature_names,
                filled=True, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
dot: graph is too large for cairo-renderer bitmaps. Scaling by 0.366493 to fit
```

```
# Saving DT as pdf
graph.write_pdf("Bow_decision_tree.pdf")
```

```
True
```

Feature importance

```
indices = np.argsort(importances)[::-1]

#Top 20 features
f=feature_names[indices[:20]]

sf = ""
for i in f:
    sf += str(i)+","

print("************ Top 20 Features ******************")
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                min_font_size = 10).generate(sf)

# plot the WordCloud image
plt.figure(figsize = (5,5), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()

```

```
************ Top 20 Features ******************
```

```
#Confusion matrix
C = confusion_matrix(y_test, pred_bow)
A =(((C.T)/(C.sum(axis=1))).T)
B =(C/C.sum(axis=0))
labels = [0,1]
```

```
 print("-"*20, "Confusion matrix", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(C, annot=True, cmap="YlGnBu", fmt="g", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

print("-"*20, "Precision matrix (Columm Sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(B, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
 plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

    # representing B in heatmap format
print("-"*20, "Recall matrix (Row sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(A, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```

```
-------------------- Confusion matrix --------------------
```

```
-------------------- Precision matrix (Columm Sum=1) --------------------
```

```
-------------------- Recall matrix (Row sum=1) --------------------
```

0.759
0.241
0.271
0.729
Original Class
Predicted Class
0
1
0
1
0.7
0.6
0.5
0.4
0.3

Tf-idf

```python
#Initiating Vectorizer
count_vect = CountVectorizer(ngram_range=(1,2))

#Train data
vocabulary = count_vect.fit(x_train)
Tfidf_x_train= count_vect.transform(x_train)
print("the type of count vectorizer ",type(Tfidf_x_train))
print("the shape of out text BOW vectorizer ",Tfidf_x_train.get_shape())
print("the number of unique words ", Tfidf_x_train.get_shape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (80000, 1013943)
the number of unique words  1013943
```

```python
#Test data
Tfidf_x_test= count_vect.transform(x_test)
print("the type of count vectorizer ",type(Tfidf_x_test))
print("the shape of out text BOW vectorizer ",Tfidf_x_test.get_shape())
print("the number of unique words ", Tfidf_x_test.get_shape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (20000, 1013943)
the number of unique words  1013943
```

```python
grid.fit(Tfidf_x_train, y_train)

# examine the best model
print(grid.best_score_)
print(grid.best_params_)
```

```
0.4291070815234228
{'min_samples_split': 16, 'min_samples_leaf': 1, 'max_depth': 26, 'class_weight': 'balanced'}
```

```
#Plotting Max_depth v/s CV_error
a=pd.DataFrame(grid.cv_results_)[['mean_test_score', 'std_test_score', 'params']]
a['max_depth'] = [d.get('max_depth') for d in a['params']]
b=a.sort_values(['max_depth'])
CV_Error=1-b['mean_test_score']
max_depth =b['max_depth']


plt.plot(max_depth,CV_Error)
plt.xlabel('Max_depth')
plt.ylabel('Cross-Validated Error')
```

```
Text(0,0.5,'Cross-Validated Error')
```

```
#{'min_samples_split': 16, 'min_samples_leaf': 1, 'max_depth': 26, 'class_weight': 'balanced'}
dt_optimal=DecisionTreeClassifier(max_depth=26,min_samples_split=16,min_samples_leaf=1,class_weight='ba

# fitting the model
dt_optimal.fit(Tfidf_x_train, y_train)

# predict the response
pred_tfidf = dt_optimal.predict(Tfidf_x_test)

# evaluate accuracy
f1_score = f1_score(y_test, pred_tfidf)
```

```
# Train & Test Error
print("The overall f1_score for the Train Data is : ", metrics.f1_score(y_train,dt_optimal.predict(Tfid
print("The overall f1_score for the Test Data is : ", metrics.f1_score(y_test,pred_tfidf))
```

```
The overall f1_score for the Train Data is :  0.5941495883692416
The overall f1_score for the Test Data is :  0.4665382145150931
```

Visualizing Decision Tree

```
feature_names = np.array(vocabulary.get_feature_names())

#Plotting Decision tree
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(dt_optimal, out_file=dot_data,
                feature_names=feature_names,
                filled=True, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
dot: graph is too large for cairo-renderer bitmaps. Scaling by 0.453642 to fit
```

```
# Saving DT as pdf
graph.write_pdf("Tfidf_decision_tree.pdf")
```

```
True
```

Feature importance

```
indices = np.argsort(importances)[::-1]

#Top 20 features
f=feature_names[indices[:20]]

sf = ""
for i in f:
    sf += str(i)+","

print("************ Top 20 Features ******************")
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                min_font_size = 10).generate(sf)

# plot the WordCloud image
plt.figure(figsize = (5,5), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()

```

```
************ Top 20 Features ******************
```

```
#Confusion matrix
C = confusion_matrix(y_test, pred_tfidf)
A =(((C.T)/(C.sum(axis=1))).T)
B =(C/C.sum(axis=0))
labels = [0,1]
```

```
 print("-"*20, "Confusion matrix", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(C, annot=True, cmap="YlGnBu", fmt="g", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

print("-"*20, "Precision matrix (Columm Sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(B, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
 plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()

    # representing B in heatmap format
print("-"*20, "Recall matrix (Row sum=1)", "-"*20)
plt.figure(figsize=(12,7))
sns.heatmap(A, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```

```
-------------------- Confusion matrix --------------------
```

```
-------------------- Precision matrix (Columm Sum=1) --------------------
```

```
-------------------- Recall matrix (Row sum=1) --------------------
```

0.810
0.190
0.322
0.678
0
1
Original Class
0
1
Predicted Class
0.75
0.60
0.45
0.30