2_Hitsong_prediction

December 3, 2020

In [1]:
```
import pandas as pd
import warnings
warnings.filterwarnings('ignore')
from scipy.io import arff
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score, f1_score
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import LogisticRegressionCV
from sklearn.model_selection import cross_val_predict
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import accuracy_score
from sklearn.metrics import accuracy_score,recall_score,f1_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import RandomizedSearchCV
```

In [3]:
```
#Load dataset and divide them into train : test =8:2
#df1=pd.read_csv('C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/dataset-of
#df2=pd.read_csv('C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/dataset-of
#DATA=pd.concat([df1,df2])
#print(df1.shape)
#print(df2.shape)
#print(DATA.shape)
#DATA.reset_index(drop=True, inplace=True)
#DATA
#DATA=DATA.sample(frac=1.0)
#DATA.reset_index(drop=True, inplace=True)#shuffle the dataset
#DATA
#train_set=DATA.loc[0:9816]
#test_set=DATA.loc[9817:12270]
#test_set.reset_index(drop=True, inplace=True)
#print("split the dataset into the proportion train:test=8:2 ")
#print("size of train set=",train_set.shape)
#print("size of test set=",test_set.shape)
#df=test_set.loc[test_set['target'].isin(['1'])]
```

```
        #print("the target is 1 in test",df.shape)
        #test_set.to_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/test_set.c
        #train_set.to_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/train_set
        #print("Save train and test dataset successfully!")
```

```
(5872, 19)
(6398, 19)
(12270, 19)
split the dataset into the proportion train:test=8:2
size of train set= (9817, 19)
size of test set= (2453, 19)
the target is 1 in test (1205, 19)
Save train and test dataset successfully!
```

```
In [2]: train_set=pd.read_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/train_
                              encoding='unicode_escape')
        train_set=train_set.drop(["Unnamed: 0"],axis=1)
        test_set=pd.read_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/test_se
                             encoding='unicode_escape').drop(["Unnamed: 0"],axis=1)
        print("size of train set=",train_set.shape)
        print("size of test set=",test_set.shape)
        #train_set
```

```
size of train set= (9817, 19)
size of test set= (2453, 19)
```

```
In [4]: DATA_miss=pd.read_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/data s
                              encoding='unicode_escape')
        DATA_miss.shape

Out[4]: (12254, 20)

In [5]: DATA_miss.isnull().sum()

Out[5]: Unnamed: 0              0
        track                   0
        artist                 77
        uri                    98
        danceability         1492
        energy                  0
        key                     0
        loudness                0
        mode                    0
        speechiness            46
        acousticness          648
        instrumentalness       50
        liveness                0
```

```
valence              0
tempo                0
duration_ms          0
time_signature       0
chorus_hit           0
sections             0
target               0
dtype: int64
```

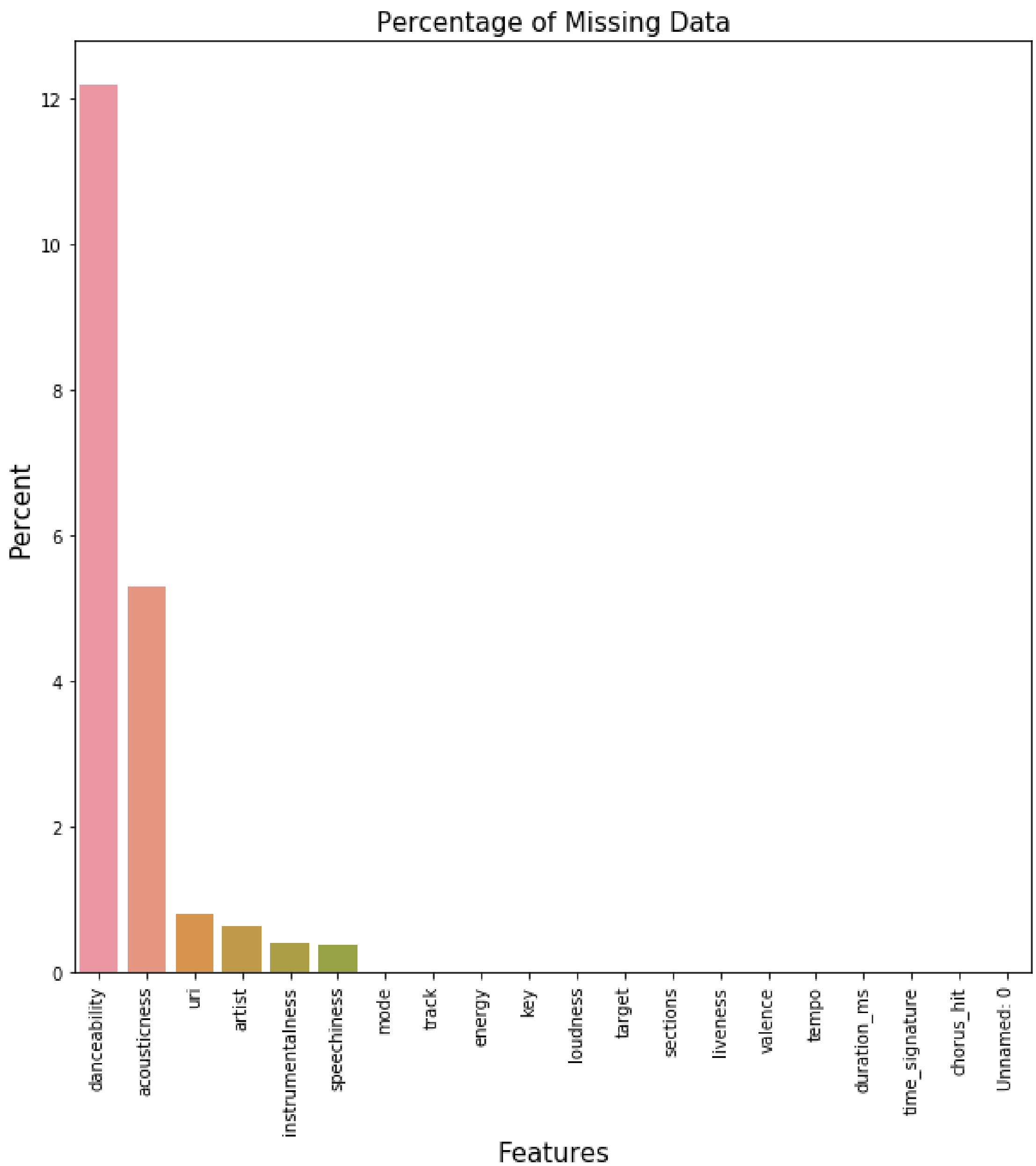
```
In [6]: train_set_miss=pd.read_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/t
                              encoding='unicode_escape')
        train_set_miss=train_set_miss.drop(["Unnamed: 0"],axis=1)
        test_set_miss=pd.read_csv("C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/te
                             encoding='unicode_escape').drop(["Unnamed: 0"],axis=1)
        print("size of train set=",train_set_miss.shape)
        print("size of test set=",test_set_miss.shape)
        #train_set
```

```
size of train set= (9817, 20)
size of test set= (2437, 20)
```

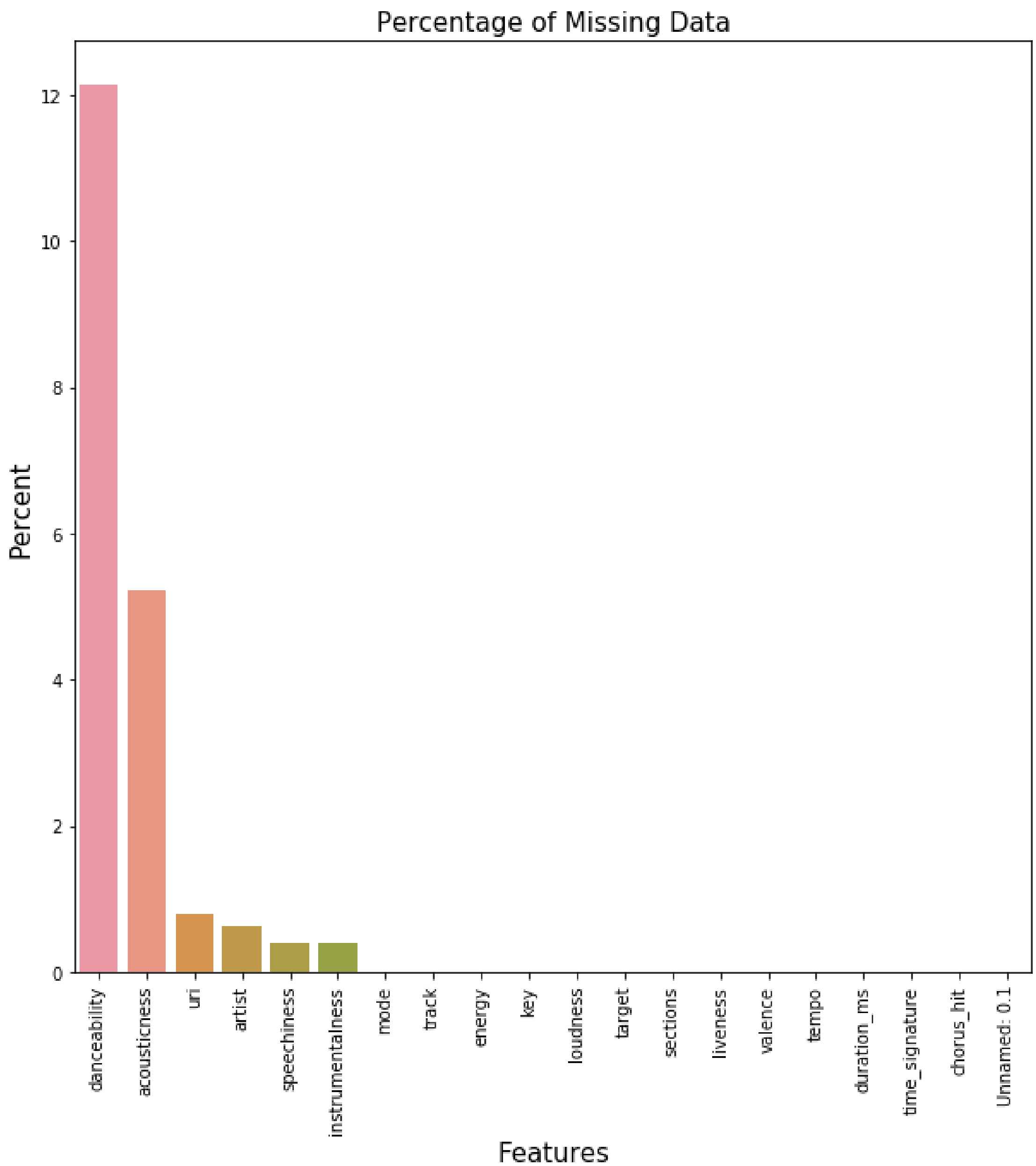
```
In [71]: def MissValue(data):
             miss_ratio = (data.isnull().sum() / len(data)) * 100
             miss_ratio = miss_ratio.sort_values(ascending=False)
             AllNull_train_ratio = miss_ratio.drop(miss_ratio[miss_ratio == 0].index)
             missing_train_ratio = pd.DataFrame({'Missing train data ratio': AllNull_train_rati
             print(missing_train_ratio)

             f, ax = plt.subplots(figsize=(10, 10))
             plt.xticks(rotation='90')  # ratate direction of words for each feature
             sns.barplot(x=miss_ratio.index, y=miss_ratio)
             plt.xlabel('Features', fontsize=15)
             plt.ylabel('Percent', fontsize=15)
             plt.title('Percentage of Missing Data', fontsize=15)
             plt.show()
```

```
In [72]: MissValue(DATA_miss)
```

```
                  Missing train data ratio
danceability                     12.175616
acousticness                      5.288069
uri                               0.799739
artist                            0.628366
instrumentalness                  0.408030
speechiness                       0.375388
```




```
In [73]: MissValue(train_set_miss)

                     Missing train data ratio
danceability                        12.132016
acousticness                         5.225629
uri                                  0.784354
artist                               0.621371
speechiness                          0.407456
instrumentalness                     0.397270
```




```
In [15]: #delete "uri and artist"
         train_miss_numerical=train_set_miss.drop(['track'], axis=1)
         train_miss_numerical=train_miss_numerical.drop(['artist','uri','Unnamed: 0.1'], axis=
         train_miss_numerical.shape

Out[15]: (9817, 16)

In [16]: test_miss_numerical=test_set_miss.drop(['track'], axis=1)
         test_miss_numerical=test_miss_numerical.drop(['artist','uri','Unnamed: 0.1'], axis=1)
         test_miss_numerical.shape
```

Out[16]: (2437, 16)

In [17]: test_miss_numerical.isnull().sum()

Out[17]:
```
danceability        301
energy                0
key                   0
loudness              0
mode                  0
speechiness           6
acousticness        135
instrumentalness     11
liveness              0
valence               0
tempo                 0
duration_ms           0
time_signature        0
chorus_hit            0
sections              0
target                0
dtype: int64
```

In [18]:
```
#for missing value in instrumentalness and acousticness - delete the datapoint
train_miss_numerical=train_miss_numerical.dropna(subset=['instrumentalness',
                                                          'speechiness'], how='any')
print(train_miss_numerical.shape)
test_miss_numerical=test_miss_numerical.dropna(subset=['instrumentalness',
                                                          'speechiness'], how='any')
print(test_miss_numerical.shape)
```

```
(9743, 16)
(2421, 16)
```

In [19]:
```
from sklearn.impute import KNNImputer
impute_knn=KNNImputer(n_neighbors=2)
impute_knn.fit(train_miss_numerical)
impute_knn_=impute_knn.transform(train_miss_numerical)
df_train=pd.DataFrame(impute_knn_)

df_train.columns = ['danceability','energy','key','loudness','mode','speechiness','ac
                    'instrumentalness','liveness','valence','tempo','duration_ms','tim
                     'sections','target']
df_train.shape
```

Out[19]: (9743, 16)

In [20]:
```
#impute_knn_test=KNNImputer(n_neighbors=2)
#impute_knn_test.fit(test_miss_numerical)
```

```
impute_knn_test=impute_knn.transform(test_miss_numerical)
df_test=pd.DataFrame(impute_knn_test)

df_test.columns = ['danceability','energy','key','loudness','mode','speechiness','acou
                   'instrumentalness','liveness','valence','tempo','duration_ms','time
                    'sections','target']
df_test.shape
```

Out[20]: (2421, 16)

In [21]:
```
df_test.isnull().sum()
```

Out[21]:
```
danceability        0
energy              0
key                 0
loudness            0
mode                0
speechiness         0
acousticness        0
instrumentalness    0
liveness            0
valence             0
tempo               0
duration_ms         0
time_signature      0
chorus_hit          0
sections            0
target              0
dtype: int64
```

In [75]:
```
#Preprocessing & feature extraction
#delete missing data because only 16 which is a very small number
#the featuretrack, artist, uri are not usable features, so delete them.
#outlier
train_set_numerical=train_set.drop(['track'], axis=1)
train_set_numerical=train_set_numerical.drop(['artist','uri'], axis=1)
#train_set_numerical
for column,row in train_set_numerical.iteritems():
    #print(index) #
    df_column=train_set[column].describe()
    IQR=df_column["75%"]-df_column["25%"]
    if (df_column["min"]>df_column["25%"]-1.5*IQR)&(df_column["max"]<df_column["75%"]+
        print("No outlier for column", column)
    else:
        print("Have outlier of ",column)
```

```
No outlier for column danceability
Have outlier of  energy
No outlier for column key
```

```
Have outlier of  loudness
No outlier for column mode
Have outlier of  speechiness
Have outlier of  acousticness
Have outlier of  instrumentalness
Have outlier of  liveness
No outlier for column valence
Have outlier of  tempo
Have outlier of  duration_ms
Have outlier of  time_signature
Have outlier of  chorus_hit
Have outlier of  sections
No outlier for column target
```

In [82]:
```
x_train_outlier=train_set_numerical.drop(['target'],axis=1)
y_train_outlier=train_set_numerical['target']
model_log_outlier=LogisticRegression(penalty="l2")
model_log_noutlier=model_log_outlier.fit(x_train_outlier, y_train_outlier)

pred_train_log_outlier=model_log_outlier.predict(x_train_outlier)

acc_train_logistic_outlier = accuracy_score(pred_train_log_outlier, y_train_outlier)


print("the train accuracy =", acc_train_logistic_outlier)
print('REC of training set = ',recall_score(y_train_outlier,pred_train_log_outlier,ave
print('F1-Score of training set = ',f1_score(y_train_outlier,pred_train_log_outlier,av
print("")
```

```
the train accuracy = 0.5310176224915962
REC of training set =  0.5310176224915962
F1-Score of training set =  0.5310176224915962
```

In [22]:
```
for column,row in df_train.iteritems():
    #print(index) #
    df_column=df_train[column].describe()
    IQR=df_column["75%"]-df_column["25%"]
    if (df_column["min"]>df_column["25%"]-1.5*IQR)&(df_column["max"]<df_column["75%"]
        print("No outlier for column", column)
    else:
        print("Have outlier of ",column)
```

```
Have outlier of  danceability
Have outlier of  energy
No outlier for column key
Have outlier of  loudness
```

```
No outlier for column mode
Have outlier of  speechiness
Have outlier of  acousticness
Have outlier of  instrumentalness
Have outlier of  liveness
No outlier for column valence
Have outlier of  tempo
Have outlier of  duration_ms
Have outlier of  time_signature
Have outlier of  chorus_hit
Have outlier of  sections
No outlier for column target
```

In [23]:
```
#deal with the outlier
df_energy=train_set["energy"].describe()
IQR_energy=df_energy["75%"]-df_energy["25%"]
train_set_numerical["energy"][train_set_numerical.energy>df_energy["75%"]+1.5*IQR_ene
train_set_numerical["energy"][train_set_numerical.energy<df_energy["25%"]-1.5*IQR_ene

df_loudness=train_set["loudness"].describe()
IQR_loudness=df_loudness["75%"]-df_loudness["25%"]
train_set_numerical["loudness"][train_set_numerical.loudness>df_energy["75%"]+1.5*IQR_
train_set_numerical["loudness"][train_set_numerical.loudness<df_energy["25%"]-1.5*IQR_

df_speechiness=train_set["speechiness"].describe()
IQR_speechiness=df_speechiness["75%"]-df_speechiness["25%"]
train_set_numerical["speechiness"][train_set_numerical.speechiness
                                   >df_speechiness["75%"]+1.5*IQR_speechiness]=df_spee
train_set_numerical["speechiness"][train_set_numerical.speechiness
                                   <df_speechiness["25%"]-1.5*IQR_speechiness]=df_spee

df_acousticness=train_set["acousticness"].describe()
IQR_acousticness=df_acousticness["75%"]-df_acousticness["25%"]
train_set_numerical["acousticness"][train_set_numerical.acousticness
                                    >df_acousticness["75%"]+1.5*IQR_acousticness]=df_a
train_set_numerical["acousticness"][train_set_numerical.acousticness
                                    <df_acousticness["25%"]-1.5*IQR_acousticness]=df_a

df_instrumentalness=train_set["instrumentalness"].describe()
IQR_instrumentalness=df_instrumentalness["75%"]-df_instrumentalness["25%"]
train_set_numerical["instrumentalness"][train_set_numerical.instrumentalness
                              >df_instrumentalness["75%"]+1.5*IQR_instrumentalness]=di
train_set_numerical["instrumentalness"][train_set_numerical.instrumentalness
                              <df_instrumentalness["25%"]-1.5*IQR_instrumentalness]=di

df_liveness=train_set["liveness"].describe()
IQR_liveness=df_liveness["75%"]-df_liveness["25%"]
```

```python
train_set_numerical["liveness"][train_set_numerical.liveness>df_liveness["75%"]+1.5*I
train_set_numerical["liveness"][train_set_numerical.liveness<df_liveness["25%"]-1.5*I

df_tempo=train_set["tempo"].describe()
IQR_tempo=df_tempo["75%"]-df_tempo["25%"]
train_set_numerical["tempo"][train_set_numerical.tempo>df_tempo["75%"]+1.5*IQR_tempo]
train_set_numerical["tempo"][train_set_numerical.tempo<df_tempo["25%"]-1.5*IQR_tempo]

df_duration_ms=train_set["duration_ms"].describe()
IQR_duration_ms=df_duration_ms["75%"]-df_duration_ms["25%"]
train_set_numerical["duration_ms"][train_set_numerical.duration_ms
                                   >df_duration_ms["75%"]+1.5*IQR_duration_ms]=df_dura
train_set_numerical["duration_ms"][train_set_numerical.duration_ms
                                   <df_duration_ms["25%"]-1.5*IQR_duration_ms]=df_dura

df_time_signature=train_set["time_signature"].describe()
IQR_time_signature=df_time_signature["75%"]-df_time_signature["25%"]
train_set_numerical["time_signature"][train_set_numerical.time_signature
                                      >df_time_signature["75%"]+1.5*IQR_time_signature
train_set_numerical["time_signature"][train_set_numerical.time_signature
                                      <df_time_signature["25%"]-1.5*IQR_time_signature

df_chorus_hit=train_set["chorus_hit"].describe()
IQR_chorus_hit=df_chorus_hit["75%"]-df_chorus_hit["25%"]
train_set_numerical["chorus_hit"][train_set_numerical.chorus_hit
                                  >df_chorus_hit["75%"]+1.5*IQR_chorus_hit]=df_chorus_
train_set_numerical["chorus_hit"][train_set_numerical.chorus_hit
                                  <df_chorus_hit["25%"]-1.5*IQR_chorus_hit]=df_chorus_

df_sections=train_set["sections"].describe()
IQR_sections=df_sections["75%"]-df_sections["25%"]
train_set_numerical["sections"][train_set_numerical.sections>df_sections["75%"]+1.5*I
train_set_numerical["sections"][train_set_numerical.sections<df_sections["25%"]-1.5*I


for column,row in train_set_numerical.iteritems():
    #print(index) #output the index of column
    df_column=train_set_numerical[column].describe()
    IQR=df_column["75%"]-df_column["25%"]
    if (df_column["min"]>= df_column["25%"]-1.5*IQR)&(df_column["max"]<= df_column["7
        print("no outlier for column", column)
    else:
        print("process for the outlier of",column)

print("")
print("Process all the outlier successfully! ")
```

```
no outlier for column danceability
```

```
no outlier for column energy
no outlier for column key
no outlier for column loudness
no outlier for column mode
no outlier for column speechiness
no outlier for column acousticness
no outlier for column instrumentalness
no outlier for column liveness
no outlier for column valence
no outlier for column tempo
no outlier for column duration_ms
no outlier for column time_signature
no outlier for column chorus_hit
no outlier for column sections
no outlier for column target

Process all the outlier successfully!
```

In [24]:
```
#deal with the outlier
df_danceability=df_train["danceability"].describe()
IQR_danceability=df_danceability["75%"]-df_danceability["25%"]
df_train["danceability"][df_train.danceability>df_danceability["75%"]+1.5*IQR_danceabi
df_train["danceability"][df_train.danceability<df_danceability["25%"]-1.5*IQR_danceabi

df_energy=df_train["energy"].describe()
IQR_energy=df_energy["75%"]-df_energy["25%"]
df_train["energy"][df_train.energy>df_energy["75%"]+1.5*IQR_energy]=df_energy["75%"]+
df_train["energy"][df_train.energy<df_energy["25%"]-1.5*IQR_energy]=df_energy["25%"]-

df_loudness=df_train["loudness"].describe()
IQR_loudness=df_loudness["75%"]-df_loudness["25%"]
df_train["loudness"][df_train.loudness>df_energy["75%"]+1.5*IQR_loudness]=df_loudness
df_train["loudness"][df_train.loudness<df_energy["25%"]-1.5*IQR_loudness]=df_loudness

df_speechiness=df_train["speechiness"].describe()
IQR_speechiness=df_speechiness["75%"]-df_speechiness["25%"]
df_train["speechiness"][df_train.speechiness
                                   >df_speechiness["75%"]+1.5*IQR_speechiness]=df_spee
df_train["speechiness"][df_train.speechiness
                                   <df_speechiness["25%"]-1.5*IQR_speechiness]=df_spee

df_acousticness=df_train["acousticness"].describe()
IQR_acousticness=df_acousticness["75%"]-df_acousticness["25%"]
df_train["acousticness"][df_train.acousticness
                                    >df_acousticness["75%"]+1.5*IQR_acousticness]=df_a
df_train["acousticness"][df_train.acousticness
                                    <df_acousticness["25%"]-1.5*IQR_acousticness]=df_a
```

```
df_instrumentalness=df_train["instrumentalness"].describe()
IQR_instrumentalness=df_instrumentalness["75%"]-df_instrumentalness["25%"]
df_train["instrumentalness"][df_train.instrumentalness
                              >df_instrumentalness["75%"]+1.5*IQR_instrumentalness]=di
df_train["instrumentalness"][df_train.instrumentalness
                              <df_instrumentalness["25%"]-1.5*IQR_instrumentalness]=di

df_liveness=df_train["liveness"].describe()
IQR_liveness=df_liveness["75%"]-df_liveness["25%"]
df_train["liveness"][df_train.liveness>df_liveness["75%"]+1.5*IQR_liveness]=df_livene
df_train["liveness"][df_train.liveness<df_liveness["25%"]-1.5*IQR_liveness]=df_livene

df_tempo=df_train["tempo"].describe()
IQR_tempo=df_tempo["75%"]-df_tempo["25%"]
df_train["tempo"][df_train.tempo>df_tempo["75%"]+1.5*IQR_tempo]=df_tempo["75%"]+1.5*I
df_train["tempo"][df_train.tempo<df_tempo["25%"]-1.5*IQR_tempo]=df_tempo["25%"]-1.5*I

df_duration_ms=df_train["duration_ms"].describe()
IQR_duration_ms=df_duration_ms["75%"]-df_duration_ms["25%"]
df_train["duration_ms"][df_train.duration_ms
                                   >df_duration_ms["75%"]+1.5*IQR_duration_ms]=df_dura
df_train["duration_ms"][df_train.duration_ms
                                   <df_duration_ms["25%"]-1.5*IQR_duration_ms]=df_dura

df_time_signature=df_train["time_signature"].describe()
IQR_time_signature=df_time_signature["75%"]-df_time_signature["25%"]
df_train["time_signature"][df_train.time_signature
                                      >df_time_signature["75%"]+1.5*IQR_time_signature
df_train["time_signature"][df_train.time_signature
                                      <df_time_signature["25%"]-1.5*IQR_time_signature

df_chorus_hit=df_train["chorus_hit"].describe()
IQR_chorus_hit=df_chorus_hit["75%"]-df_chorus_hit["25%"]
df_train["chorus_hit"][df_train.chorus_hit
                                 >df_chorus_hit["75%"]+1.5*IQR_chorus_hit]=df_chorus_
df_train["chorus_hit"][df_train.chorus_hit
                                 <df_chorus_hit["25%"]-1.5*IQR_chorus_hit]=df_chorus_

df_sections=df_train["sections"].describe()
IQR_sections=df_sections["75%"]-df_sections["25%"]
df_train["sections"][df_train.sections>df_sections["75%"]+1.5*IQR_sections]=df_sectio
df_train["sections"][df_train.sections<df_sections["25%"]-1.5*IQR_sections]=df_sectio


for column,row in df_train.iteritems():
    #print(index) #output the index of column
    df_column=df_train[column].describe()
```

```
            IQR=df_column["75%"]-df_column["25%"]
            if (df_column["min"]>= df_column["25%"]-1.5*IQR)&(df_column["max"]<= df_column["75
                print("no outlier for column", column)
            else:
                print("process for the outlier of",column)

        print("")
        print("Process all the outlier successfully! ")
```

```
no outlier for column danceability
no outlier for column energy
no outlier for column key
no outlier for column loudness
no outlier for column mode
no outlier for column speechiness
no outlier for column acousticness
no outlier for column instrumentalness
no outlier for column liveness
no outlier for column valence
no outlier for column tempo
no outlier for column duration_ms
no outlier for column time_signature
no outlier for column chorus_hit
no outlier for column sections
no outlier for column target

Process all the outlier successfully!
```

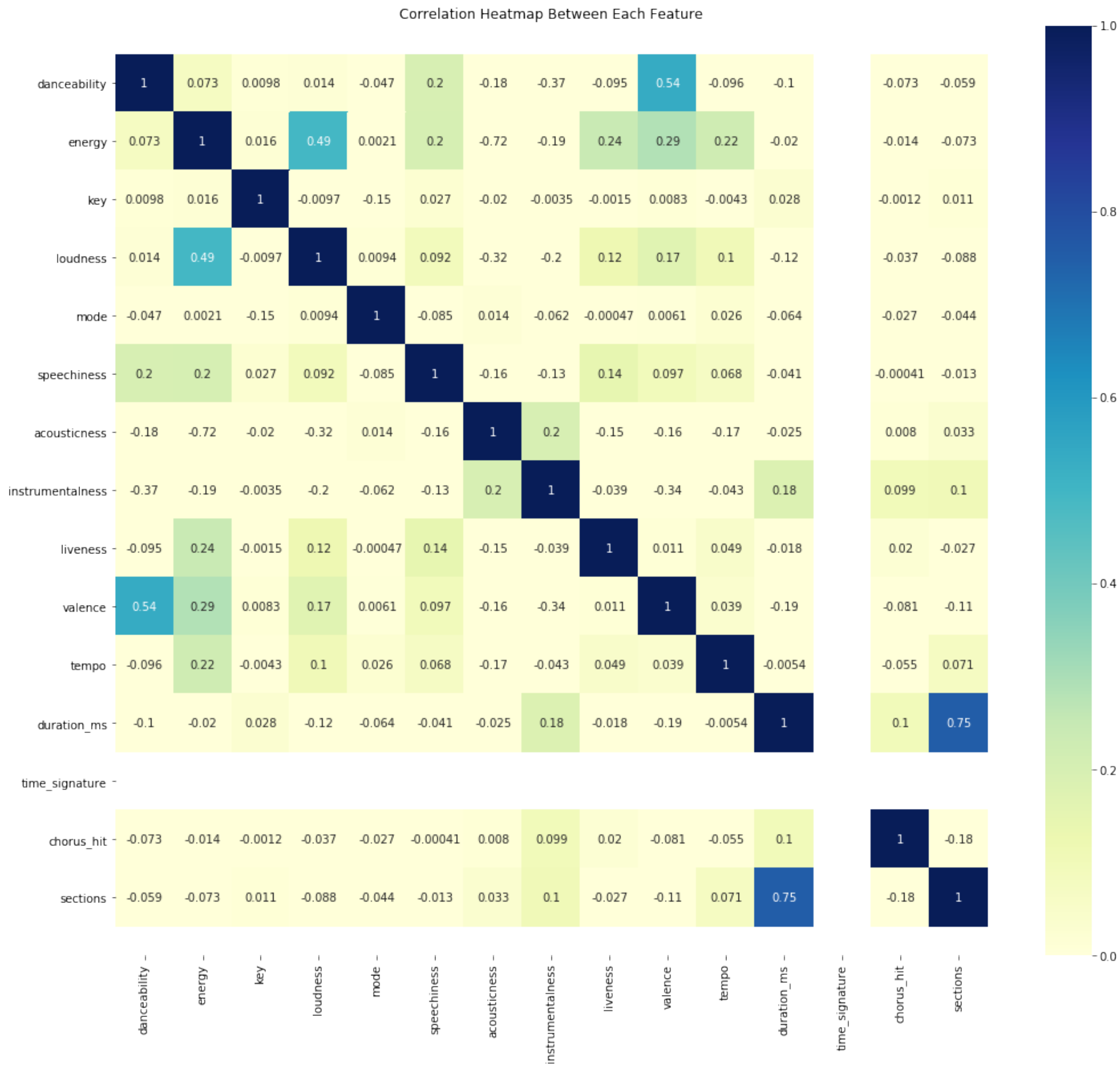
In [38]:
```
#stdandarization
#self.mean, self.std = X_train.mean(), X_train.std()
#self.feature_num = len(X_train.columns.tolist())
X_train=train_set_numerical.drop(['target'], axis=1)
std_X_train = (X_train - X_train.mean()) / X_train.std()
test_set_n=test_set.drop(['track','artist','uri'],axis=1)
#test_set_numerical=
#applied the std of X_train to the test setb
std_X_test= (test_set_n.drop(['target'],axis=1)- X_train.mean()) / X_train.std()
std_x_test=std_X_test.drop(['time_signature'],axis=1)
std_x_test

#std_X_test = (X_test - X_train.mean()) / X_train.std()

#find out the time_signature are almostly the same so drop it.
std_X_train=std_X_train.drop(['time_signature'],axis=1)
std_X_train.shape
```

Out[38]: (9817, 14)

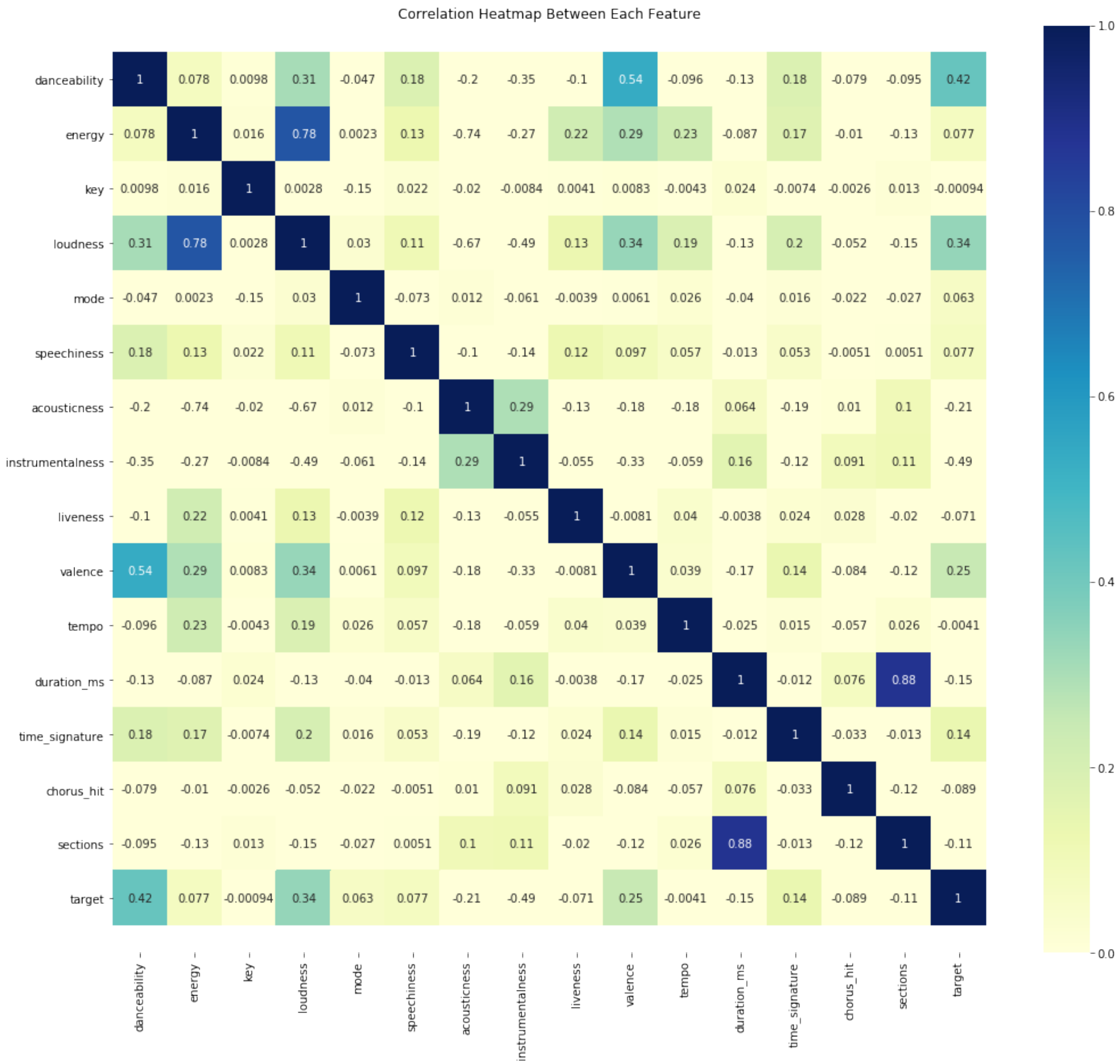
In [39]:
```
#stdandarization for missing data
X_train_miss=df_train.drop(['target'], axis=1)
std_X_train_miss = (X_train_miss - X_train_miss.mean()) / X_train_miss.std()
test_set_n_miss=df_test
#applied the std of X_train to the test setb
std_X_test_miss= (test_set_n_miss.drop(['target'],axis=1)- X_train_miss.mean()) / X_t
std_x_test_miss=std_X_test_miss.drop(['time_signature'],axis=1)
std_x_test_miss

#find out the time_signature are almostly the same so drop it.
std_X_train_miss=std_X_train_miss.drop(['time_signature'],axis=1)
std_X_train_miss.shape
```

Out[39]: (9743, 14)

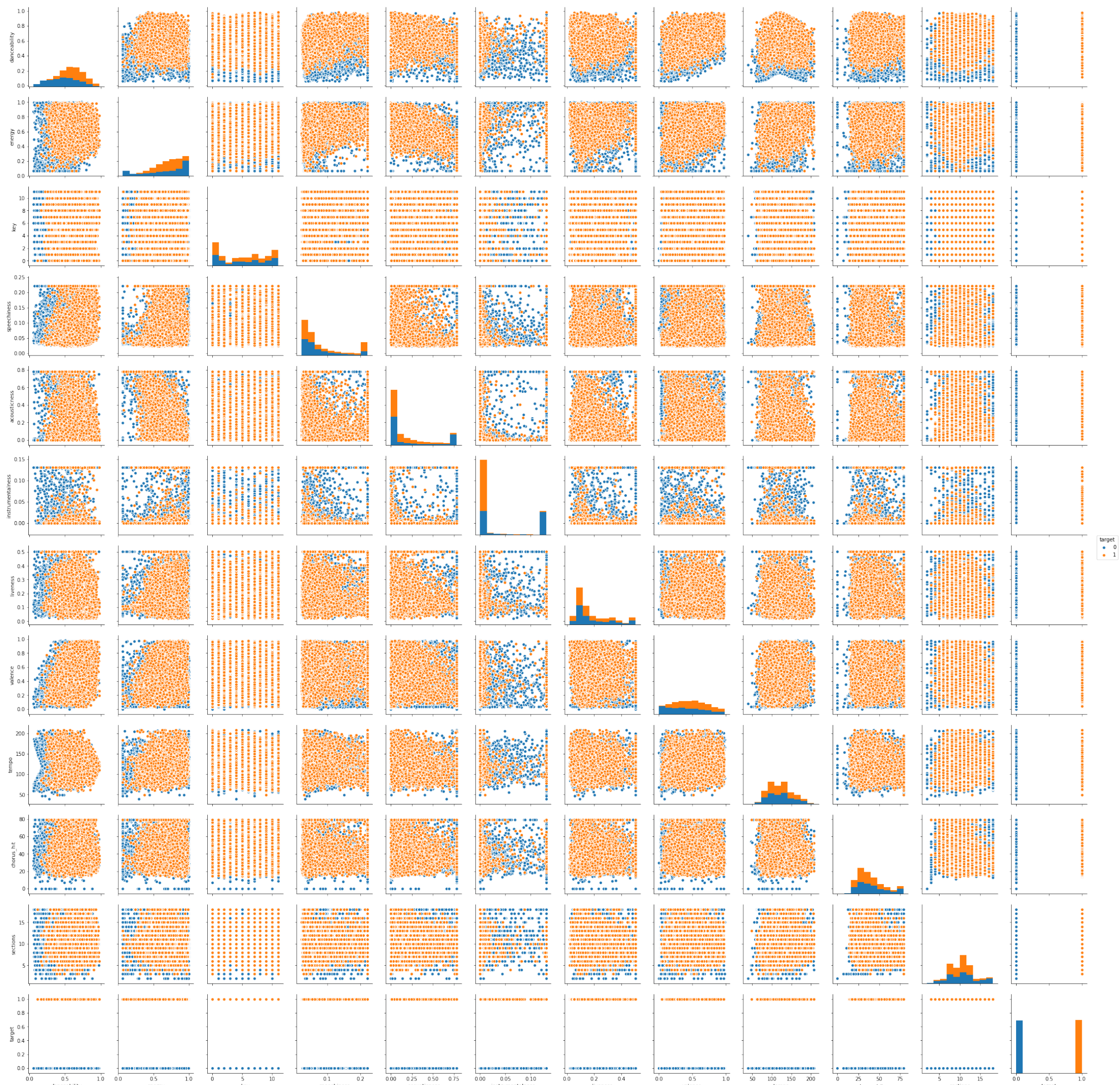
In [83]:
```
corrmat = X_train.corr()
plt.subplots(figsize=(18, 15))
ax = sns.heatmap(corrmat, vmax=1, annot=True, square=True, vmin=0,cmap="YlGnBu")
bottom, top = ax.get_ylim()
ax.set_ylim(bottom + 0.5, top - 0.5)
plt.title('Correlation Heatmap Between Each Feature')
plt.show()
```



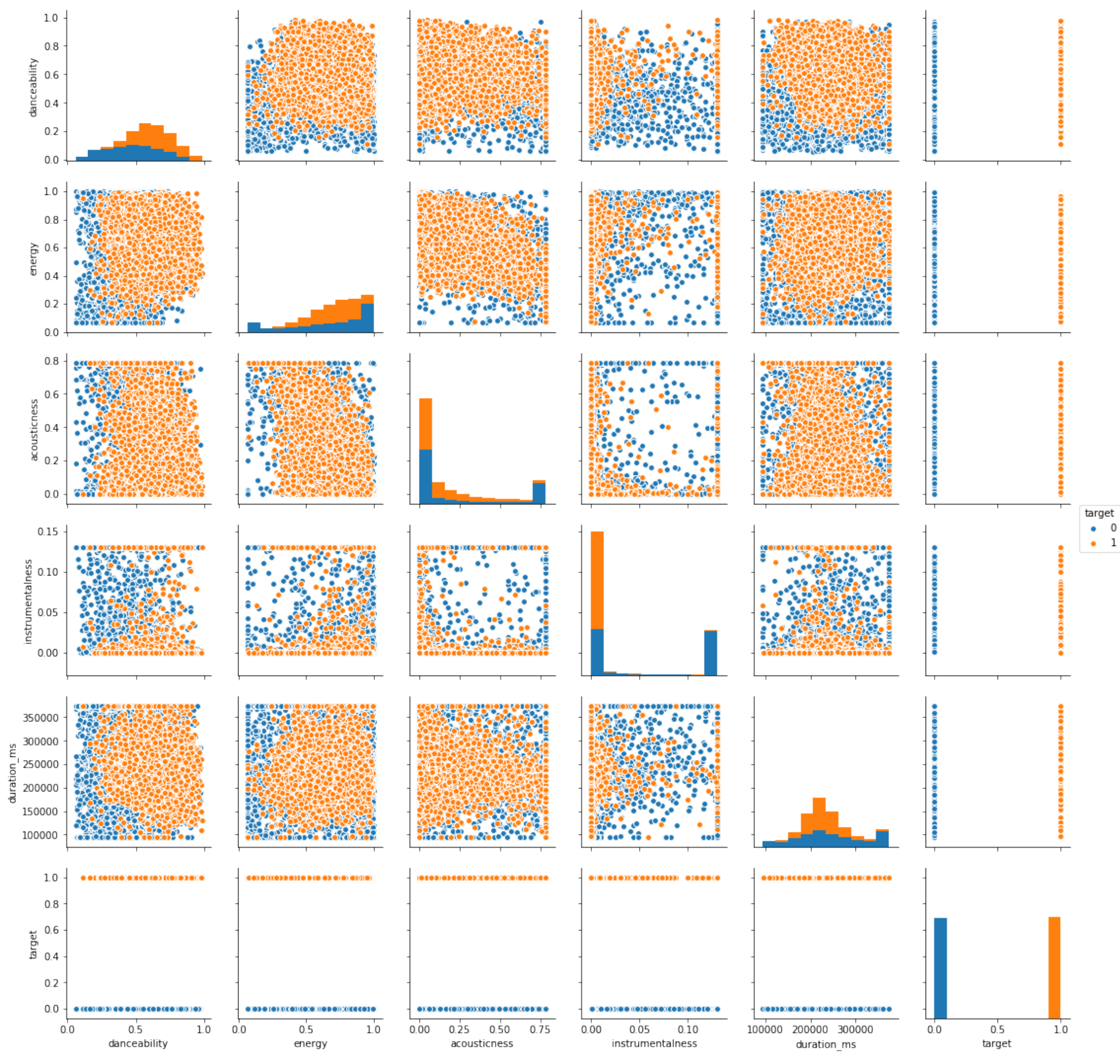

```
In [86]: corrmat = train_set.corr()
         plt.subplots(figsize=(18, 15))
         ax = sns.heatmap(corrmat, vmax=1, annot=True, square=True, vmin=0,cmap="YlGnBu")
         bottom, top = ax.get_ylim()
         ax.set_ylim(bottom + 0.5, top - 0.5)
         plt.title('Correlation Heatmap Between Each Feature')
         plt.show()
```




```
In [8]: sns.pairplot(train_set_numerical.drop(['loudness','mode','time_signature','duration_ms
        plt.show()
```

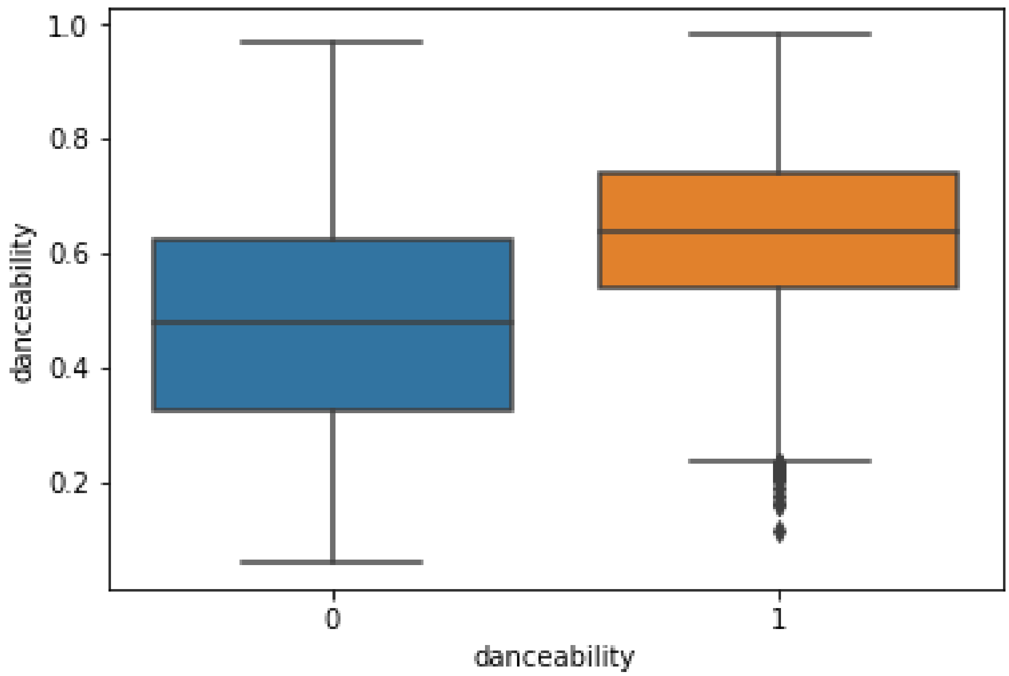


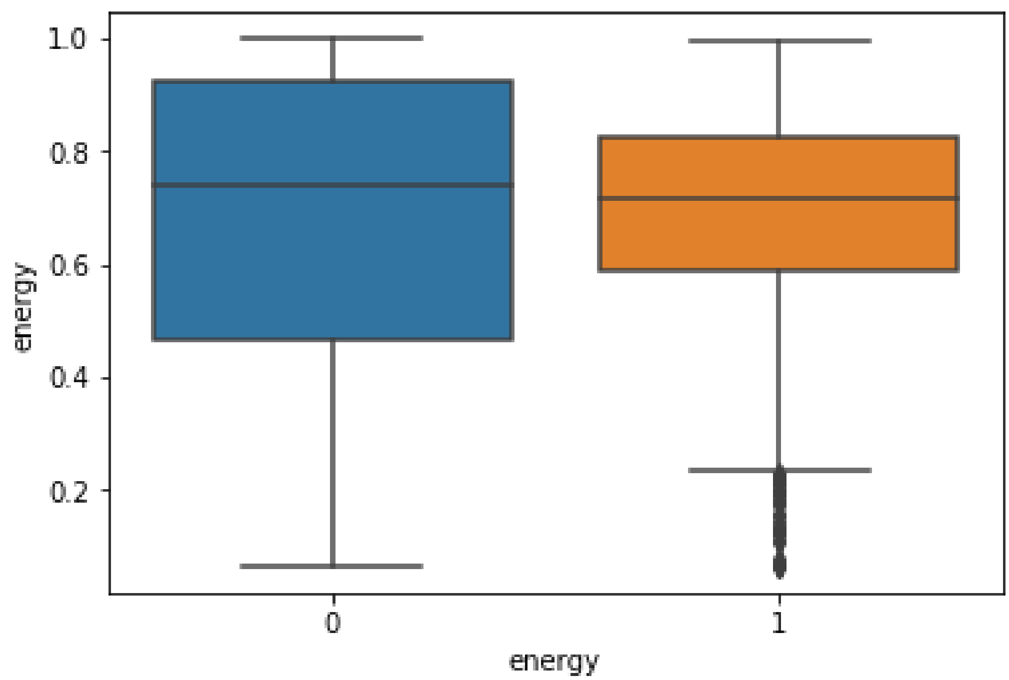

```
In [31]: sns.pairplot(train_set_numerical.drop(['loudness','mode','time_signature','speechines
                                                 'key','liveness','valence','tempo','chorus_hit'
         plt.show()
```

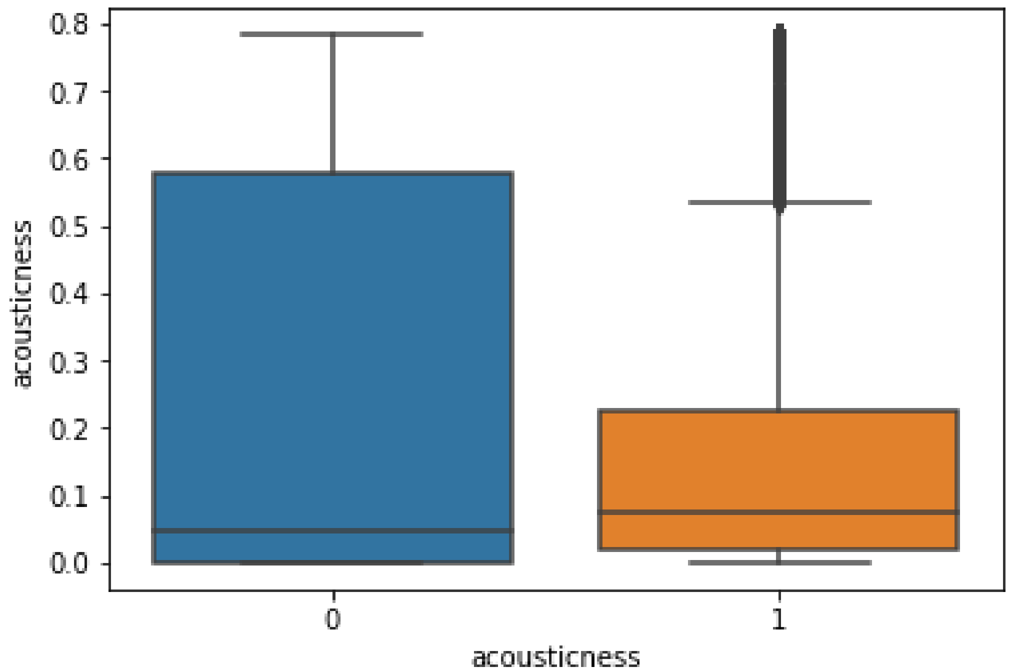


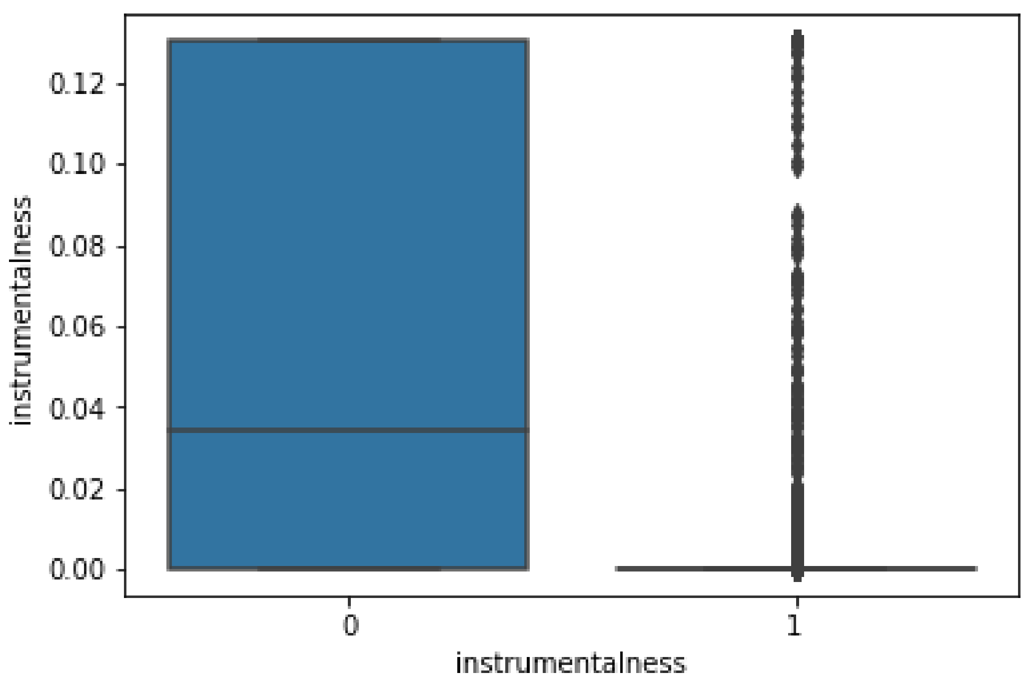

```
In [ ]: sns.boxplot(x='diagnosis', y='area_mean', data=df)

In [36]: sns.boxplot(x='target', y='danceability',data=train_set_numerical)
         plt.xlabel('danceability')
         plt.show()

         sns.boxplot(x='target', y='energy',data=train_set_numerical)
         plt.xlabel('energy')
         plt.show()
         #sns.boxplot(data=std_X_train['key'])
         #plt.xlabel('key')
         #plt.show()

         #sns.boxplot(data=std_X_train['loudness'])
         #plt.xlabel('loudness')
```

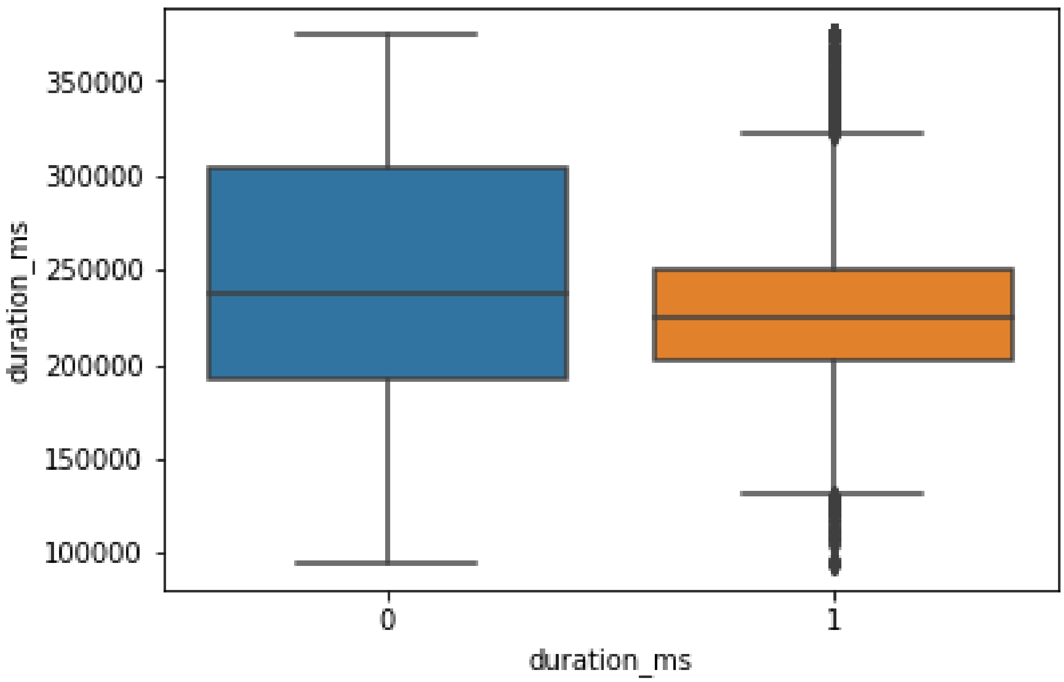
```
#plt.show()

#sns.boxplot(data=std_X_train['mode'])
#plt.xlabel('mode')
#plt.show()

#sns.boxplot(data=std_X_train['speechiness'])
#plt.xlabel('speechiness')
#plt.show()
sns.boxplot(x='target', y='acousticness',data=train_set_numerical)
plt.xlabel('acousticness')
plt.show()

sns.boxplot(x='target', y='instrumentalness',data=train_set_numerical)
plt.xlabel('instrumentalness')
plt.show()

#sns.boxplot(data=std_X_train['valence'])
#plt.xlabel('valence')
#plt.show()

#sns.boxplot(data=std_X_train['tempo'])
#plt.xlabel('tempo')
#plt.show()

sns.boxplot(x='target', y='duration_ms',data=train_set_numerical)
plt.xlabel('duration_ms')
plt.show()

#sns.boxplot(data=std_X_train['chorus_hit'])
#plt.xlabel('chorus_hit')
#plt.show()

#sns.boxplot(data=std_X_train['sections'])
#plt.xlabel('sections')
#plt.show()

#sns.boxplot(data=std_X_train['liveness'])
#plt.xlabel('liveness')
#plt.show()
```


1.0
0.8
0.6
0.4
0.2
danceability
0
1
danceability


1.0
0.8
0.6
0.4
0.2
energy
0
1
energy


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
acousticness
0
1
acousticness

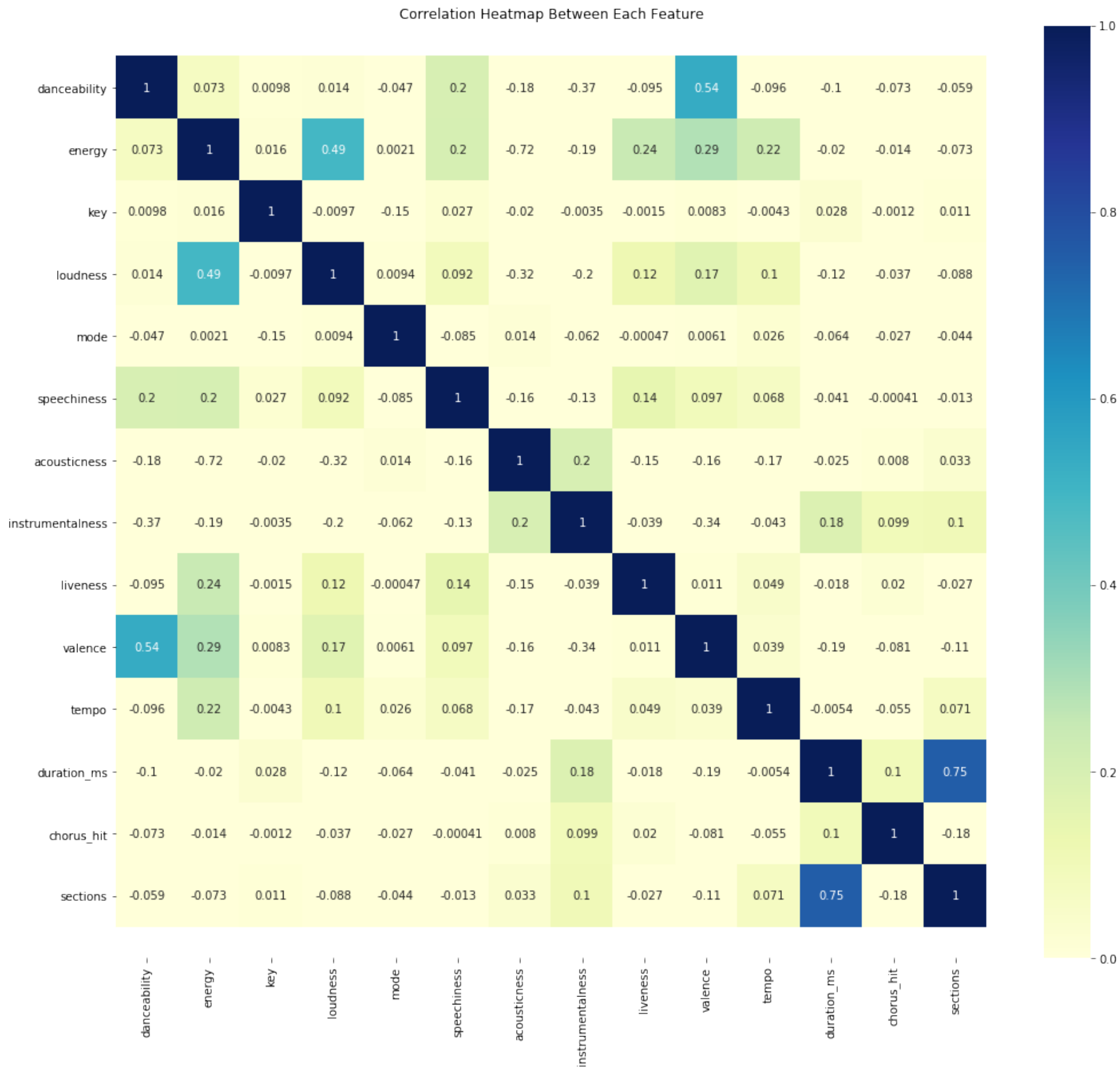

0.12
0.10
0.08
0.06
0.04
0.02
0.00
instrumentalness
0
1
instrumentalness




```
In [40]: #Use cross-validation
         from sklearn.model_selection import train_test_split
         x_train=std_X_train
         y_train=train_set_numerical['target']
         #y_train
         #x_train, x_val, y_train, y_val = train_test_split(x_train, y_train, test_size=0.2, t
         #logistic regression with l1
         x_test=std_x_test
         y_test=test_set_n['target']
```

```
In [42]: x_train_miss=std_X_train_miss
         y_train_miss=df_train['target']
         #y_train
         #x_train, x_val, y_train, y_val = train_test_split(x_train, y_train, test_size=0.2, t
         #logistic regression with l1
         x_test_miss=std_x_test_miss
         y_test_miss=df_test['target']
```

```
In [10]: corrmat = std_X_train.corr()
         plt.subplots(figsize=(18, 15))
         ax = sns.heatmap(corrmat, vmax=1, annot=True, square=True, vmin=0,cmap="YlGnBu")
         bottom, top = ax.get_ylim()
         ax.set_ylim(bottom + 0.5, top - 0.5)
         plt.title('Correlation Heatmap Between Each Feature')
         plt.show()
```



In [45]:
```python
#logistic regression
model_log=LogisticRegression(penalty="none")
model_log_n=model_log.fit(x_train, y_train)
model_log_miss=model_log.fit(x_train_miss, y_train_miss)
pred_train_log=model_log.predict(x_train)
pred_train_log_miss=model_log.predict(x_train_miss)

acc_train_logistic = accuracy_score(pred_train_log, y_train)
acc_train_logistic_miss = accuracy_score(pred_train_log_miss, y_train_miss)

print("the train accuracy =", acc_train_logistic)
print('REC of training set = ',recall_score(y_train,pred_train_log,average='micro'))
print('F1-Score of training set = ',f1_score(y_train,pred_train_log,average='micro'))
print("")
```

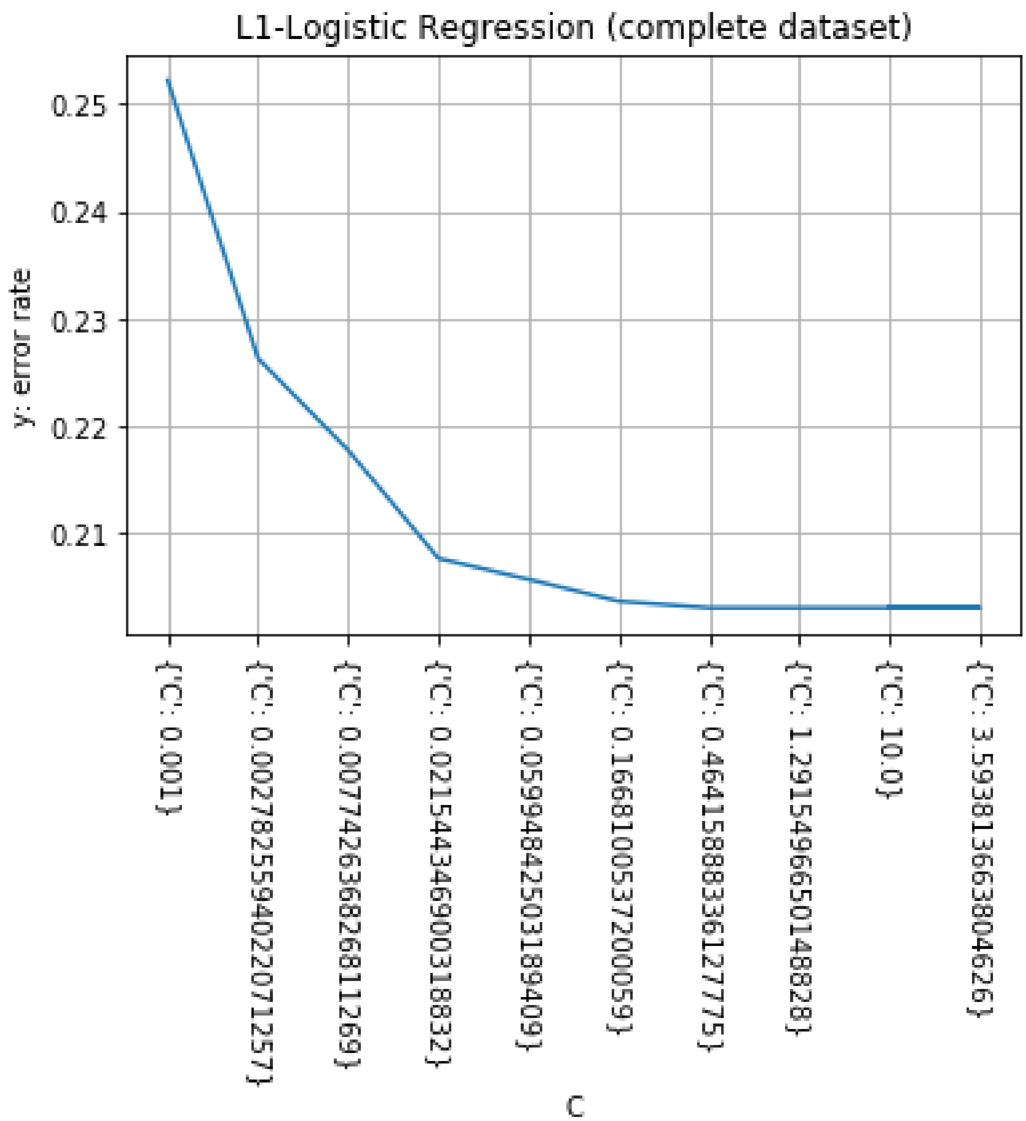
```
print("the train accuracy =", acc_train_logistic_miss)
print('REC of training set = ',recall_score(y_train_miss,pred_train_log_miss,average=
print('F1-Score of training set = ',f1_score(y_train_miss,pred_train_log_miss,average=
```

```
the train accuracy = 0.7933177141692982
REC of training set =  0.7933177141692982
F1-Score of training set =  0.7933177141692982

the train accuracy = 0.7831263471210099
REC of training set =  0.7831263471210099
F1-Score of training set =  0.7831263471210099
```

In [91]:
```
model_logistic_l1 = LogisticRegression(penalty="l1",solver="liblinear")

# search the best params-select model

grid_logistic_l1= {'C': np.logspace(-3,1,10)}

params_logistic = GridSearchCV(model_logistic_l1, grid_logistic_l1,cv=5)
params_logistic.fit(x_train, y_train)

pred_train_logistic = params_logistic.predict(x_train)

# get the accuracy score
acc_train_logistic = accuracy_score(pred_train_logistic, y_train)
#acc_test_logistic = accuracy_score(pred_test_logistic, y_test)

print("the best paramater = ",params_logistic.best_params_)
print("best accuracy in validation = ",params_logistic.best_score_)
print("")
print("the train accuracy =", acc_train_logistic)
print('REC of training set = ',recall_score(y_train,pred_train_logistic,average='micro
print('F1-Score of training set = ',f1_score(y_train,pred_train_logistic,average='mic
print("")
dict_l1=params_logistic.cv_results_
x_p=dict_l1['params']
y_p=1-dict_l1['mean_test_score']
plt.plot(x_p,y_p)
plt.xticks(rotation=270)
plt.xlabel('C')
plt.ylabel('y: error rate')
plt.title('L1-Logistic Regression (complete dataset)')
plt.grid()
plt.show()
```

```
the best paramater =  {'C': 3.593813663804626}
best accuracy in validation =  0.7968821880969006
```

```
the train accuracy = 0.7962717734542121
REC of training set =  0.7962717734542121
F1-Score of training set =  0.7962717734542121
```

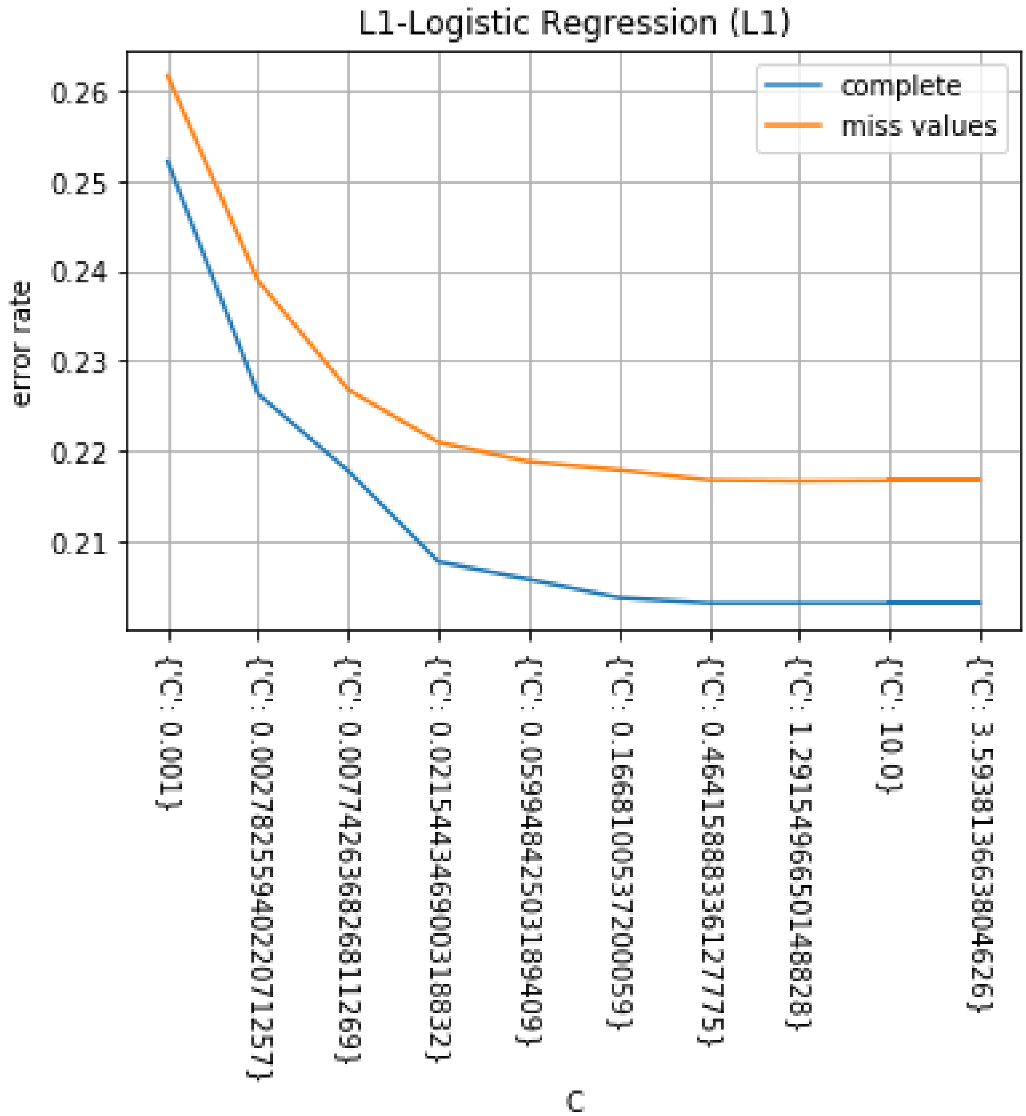


In [93]:
```
model_logistic_l1 = LogisticRegression(penalty="l1",solver="liblinear")

# search the best params-select model

grid_logistic_l1= {'C': np.logspace(-3,1,10)}
```

```
params_logistic_miss = GridSearchCV(model_logistic_l1, grid_logistic_l1,cv=5)
params_logistic_miss.fit(x_train_miss, y_train_miss)

pred_train_logistic_miss = params_logistic_miss.predict(x_train_miss)

# get the accuracy score
acc_train_logistic_miss = accuracy_score(pred_train_logistic_miss, y_train_miss)
#acc_test_logistic = accuracy_score(pred_test_logistic, y_test)

print("the best paramater = ",params_logistic_miss.best_params_)
print("best accuracy in validation = ",params_logistic_miss.best_score_)
print("")
print("the train accuracy =", acc_train_logistic_miss)
print('REC of training set = ',recall_score(y_train_miss,pred_train_logistic_miss,aver
print('F1-Score of training set = ',f1_score(y_train_miss,pred_train_logistic_miss,ave
print("")
```

```
the best paramater =  {'C': 1.2915496650148828}
best accuracy in validation =  0.783333315774003

the train accuracy = 0.7832289849122447
REC of training set =  0.7832289849122447
F1-Score of training set =  0.7832289849122447
```

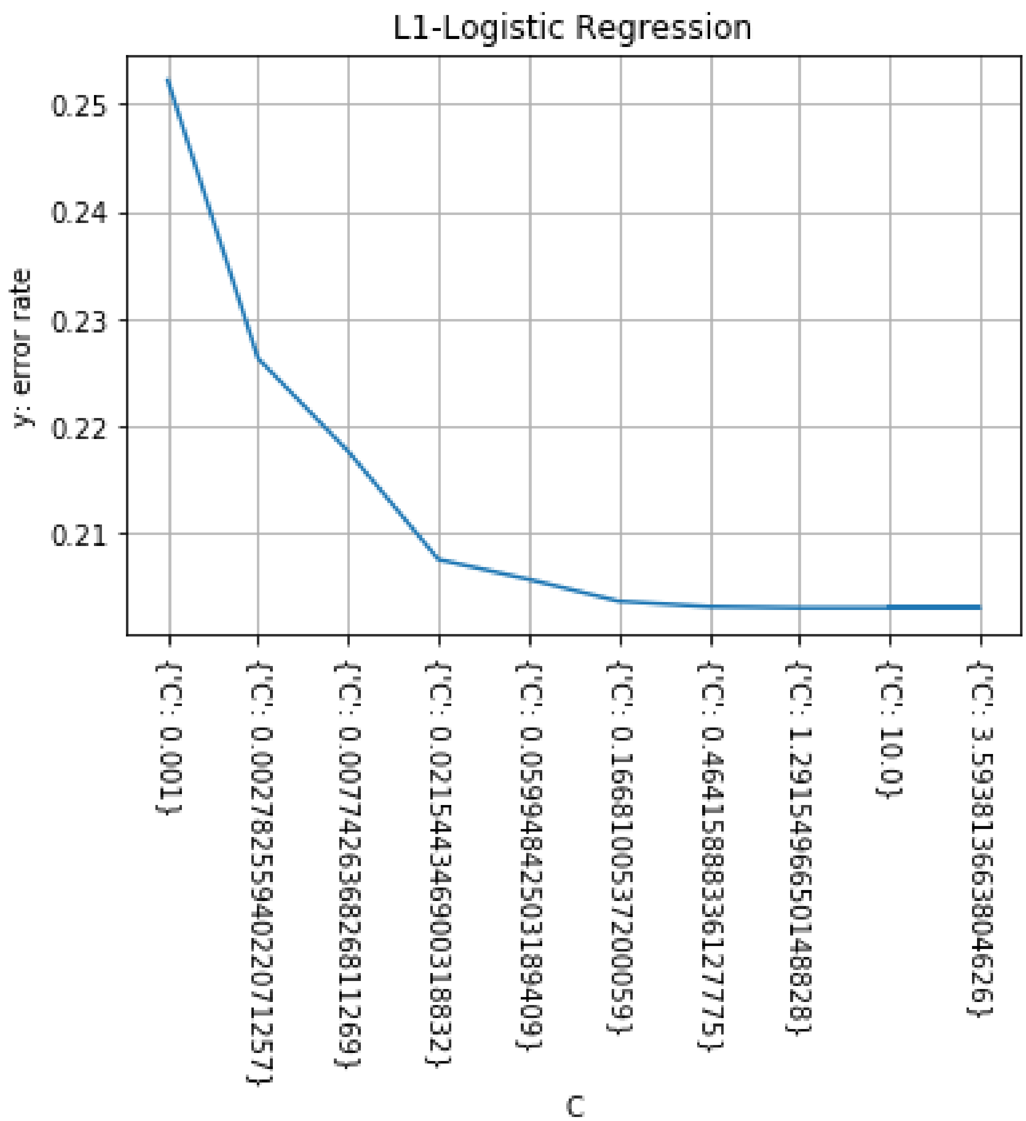
In [98]:
```
dict_l1=params_logistic.cv_results_
dict_l1_miss=params_logistic_miss.cv_results_
x_p=dict_l1['params']
y_p1=1-dict_l1['mean_test_score']
y_p2=1-dict_l1_miss['mean_test_score']
plt.plot(x,y_p1,"-",label="complete")
plt.plot(x,y_p2,"-",label="miss values")
plt.legend(loc='upper right')
plt.xticks(rotation=270)
plt.xlabel('C')
plt.ylabel('error rate')
plt.title('L1-Logistic Regression (L1)')
plt.grid()
plt.show()
```




```
In [53]: x_train.shape
         y_train.shape

Out[53]: (9817,)

In [68]: params_logistic.cv_results_

Out[68]: {'mean_fit_time': array([0.0123888 , 0.00997152, 0.01376228, 0.01795731, 0.01894703,
                0.01855254, 0.01894736, 0.01795325, 0.01835093, 0.01872344]),
          'mean_score_time': array([0.00319114, 0.00139952, 0.00119686, 0.00158978, 0.001794
                0.00099688, 0.00119858, 0.00179496, 0.0013947 , 0.00139427]),
          'mean_test_score': array([0.74778374, 0.77365711, 0.78231535, 0.79239977, 0.79423365
                0.79627088, 0.7967802 , 0.79688214, 0.79688219, 0.7967803 ]),
```

```
'param_C': masked_array(data=[0.001, 0.0027825594022071257, 0.007742636826811269,
                   0.021544346900318832, 0.05994842503189409,
                   0.1668100537200059, 0.46415888336127775,
                   1.2915496650148828, 3.593813663804626, 10.0],
             mask=[False, False, False, False, False, False, False, False,
                   False, False],
       fill_value='?',
            dtype=object),
 'params': [{'C': 0.001},
  {'C': 0.0027825594022071257},
  {'C': 0.007742636826811269},
  {'C': 0.021544346900318832},
  {'C': 0.05994842503189409},
  {'C': 0.1668100537200059},
  {'C': 0.46415888336127775},
  {'C': 1.2915496650148828},
  {'C': 3.593813663804626},
  {'C': 10.0}],
 'rank_test_score': array([10,  9,  8,  7,  6,  5,  4,  2,  1,  3]),
 'split0_test_score': array([0.74949084, 0.77596741, 0.78411405, 0.799389  , 0.8014256
       0.80295316, 0.80295316, 0.80244399, 0.80193483, 0.80193483]),
 'split1_test_score': array([0.75305499, 0.77953157, 0.7907332 , 0.79684318, 0.7953156
       0.79837067, 0.799389  , 0.799389  , 0.799389  , 0.799389  ]),
 'split2_test_score': array([0.74579725, 0.77534386, 0.78298523, 0.79113602, 0.7947019
       0.79572084, 0.79572084, 0.79623026, 0.79623026, 0.79623026]),
 'split3_test_score': array([0.74834437, 0.77126847, 0.77330616, 0.77789098, 0.780438
       0.78502292, 0.78604177, 0.7865512 , 0.78706062, 0.7865512 ]),
 'split4_test_score': array([0.74223128, 0.76617422, 0.7804381 , 0.79673968, 0.7992868
       0.79928681, 0.79979623, 0.79979623, 0.79979623, 0.79979623]),
 'std_fit_time': array([0.00098915, 0.00166839, 0.00193525, 0.00296044, 0.00218613,
       0.00325198, 0.00089405, 0.00244096, 0.00279246, 0.00180406]),
 'std_score_time': array([1.46648029e-03, 4.87381392e-04, 4.01153865e-04, 7.92908837e
       4.01118512e-04, 5.18723440e-06, 3.97784788e-04, 3.98958984e-04,
       4.89240534e-04, 4.88256756e-04]),
 'std_test_score': array([0.00362741, 0.00456927, 0.00564329, 0.0077399 , 0.00733439,
       0.00608238, 0.00583856, 0.00552926, 0.00523819, 0.00542969])}
```

In [70]:
```
dict_l1=params_logistic.cv_results_
x=dict_l1['params']
y=1-dict_l1['mean_test_score']
plt.plot(x,y)
plt.xticks(rotation=270)
plt.xlabel('C')
plt.ylabel('y: error rate')
plt.title('L1-Logistic Regression')
plt.grid()
plt.show()
```

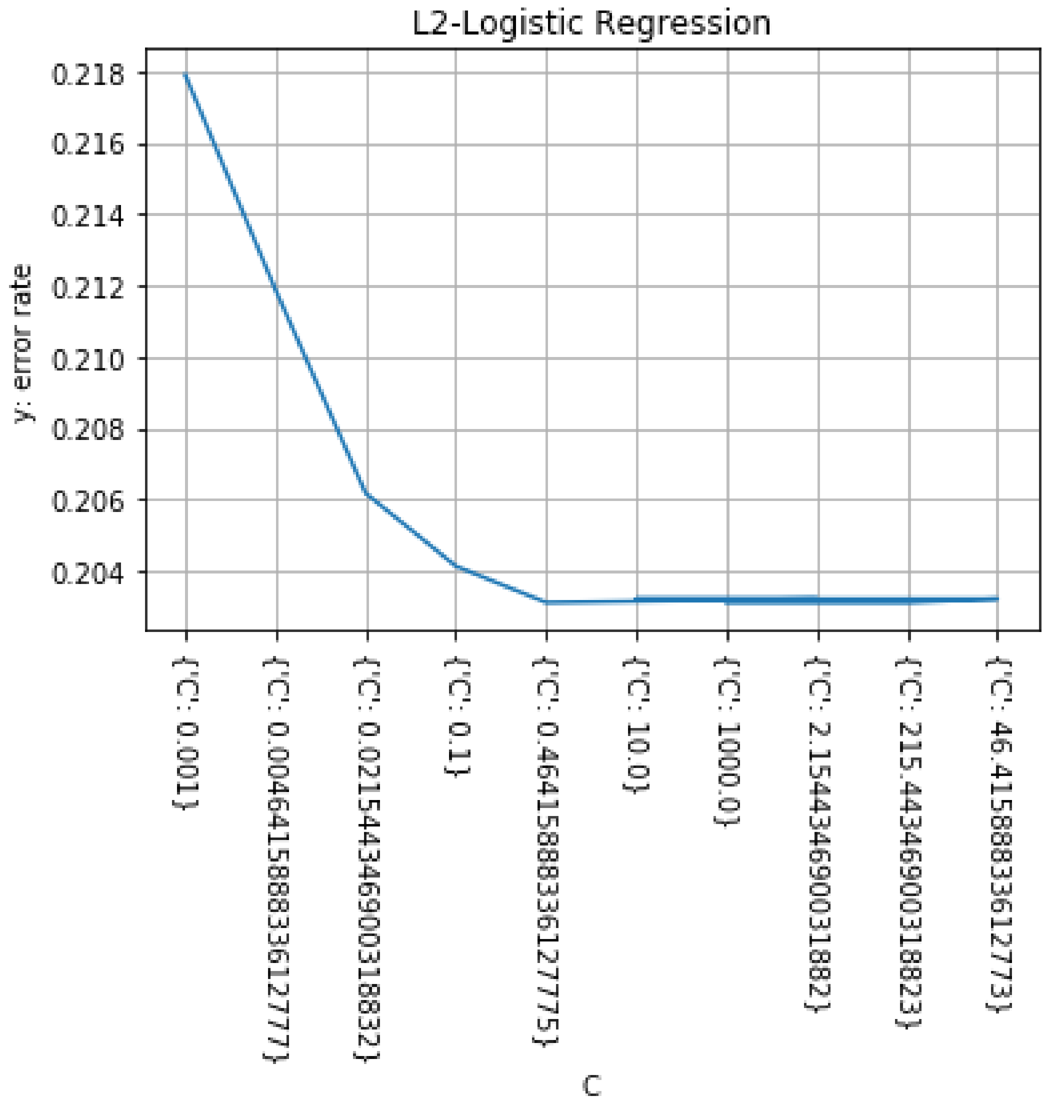


In [99]:
```
#logistic regression with l2

model_logistic_l2 = LogisticRegression(penalty="l2",solver="liblinear")

# search the best params-select model

grid_logistic_l2= {'C': np.logspace(-3,3,10)}

params_logistic_l2 = GridSearchCV(model_logistic_l2, grid_logistic_l2,cv=5)
params_logistic_l2.fit(x_train, y_train)

pred_train_logistic_l2= params_logistic_l2.predict(x_train)
```

```
#pred_test_logistic_l2=params_logistic_l2.predict(x_test)

# get the accuracy score
acc_train_logistic_l2 = accuracy_score(pred_train_logistic_l2, y_train)
#acc_test_logistic_l2 = accuracy_score(pred_test_logistic_l2, y_test)

print("the best paramater = ",params_logistic_l2.best_params_)
print("best accuracy in validation = ",params_logistic_l2.best_score_)
print("")
print("the train accuracy =", acc_train_logistic_l2)
print('REC of training set = ',recall_score(y_train,pred_train_logistic_l2,average='mi
print('F1-Score of training set = ',f1_score(y_train,pred_train_logistic_l2,average='r
print("")
#print("the test accuracy =", acc_test_logistic_l2)
#print('REC of test set = ',recall_score(y_test,pred_test_logistic_l2,average='micro',
#print('F1-Score of test set = ',f1_score(y_test,pred_test_logistic_l2,average='micro
```

```
the best paramater =  {'C': 0.46415888336127775}
best accuracy in validation =  0.7968821880969006

the train accuracy = 0.7959661811143934
REC of training set =  0.7959661811143934
F1-Score of training set =  0.7959661811143934
```

In [18]:
```
dict_l2=params_logistic_l2.cv_results_
x=dict_l2['params']
y=1-dict_l2['mean_test_score']
plt.plot(x,y)
plt.xticks(rotation=270)
plt.xlabel('C')
plt.ylabel('y: error rate')
plt.title('L2-Logistic Regression')
plt.grid()
plt.show()
```




```
In [101]: #decision tree
          from sklearn import tree
          from sklearn.model_selection import GridSearchCV
          from sklearn.metrics import accuracy_score

          model_tree = tree.DecisionTreeClassifier()

          # search the best params
          #'min_samples_split': [5, 10, 20, 50, 100,200, 500],
          grid_tree= {'max_depth': [10, 20, 30, 40, 50, 60, 70, 80, 90, 100, None], 'min_sampl

          params_tree = GridSearchCV(model_tree, grid_tree,cv=5)
          params_tree.fit(x_train, y_train)
```

```
pred_tree = params_tree.predict(x_test)

pred_train_tree= params_tree.predict(x_train)
#pred_test_tree= params_tree.predict(x_test)

# get the accuracy score
acc_train_tree = accuracy_score(pred_train_tree, y_train)
#acc_test_tree = accuracy_score(pred_test_tree, y_test)


# get the accuracy score
#acc_tree = accuracy_score(pred_tree, y_test)
#print("the validation error=", acc_tree)
#print(params_tree.best_params_)

print("the best paramater = ",params_tree.best_params_)
print("best accuracy in validation = ",params_tree.best_score_)
print("")
print("the train accuracy =", acc_train_tree)
print('REC of training set = ',recall_score(y_train,pred_train_tree,average='micro'))
print('F1-Score of training set = ',f1_score(y_train,pred_train_tree,average='micro')
```

```
the best paramater =  {'max_depth': 10, 'min_samples_leaf': 8}
best accuracy in validation =  0.8140981373329197

the train accuracy = 0.8696139350106957
REC of training set =  0.8696139350106957
F1-Score of training set =  0.8696139350106957
```

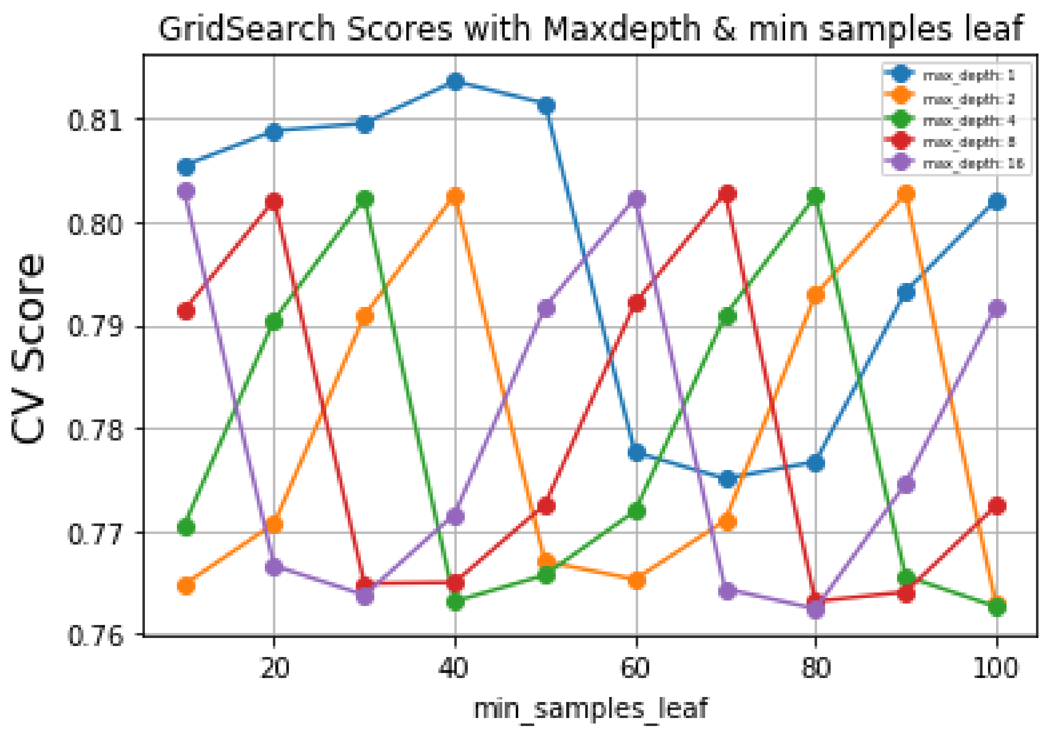
In [104]:
```
model_tree_miss = tree.DecisionTreeClassifier()

# search the best params
#'min_samples_split': [5, 10, 20, 50, 100,200, 500],
grid_tree= {'max_depth': [10, 20, 30, 40, 50, 60, 70, 80, 90, 100, None], 'min_sampl

params_tree_miss = GridSearchCV(model_tree_miss, grid_tree,cv=5)
params_tree_miss.fit(x_train_miss, y_train_miss)

pred_train_tree_miss= params_tree.predict(x_train_miss)

# get the accuracy score
acc_train_tree_miss = accuracy_score(pred_train_tree_miss, y_train_miss)

print("the best paramater = ",params_tree_miss.best_params_)
print("best accuracy in validation = ",params_tree_miss.best_score_)
print("")
```

```
    print("the train accuracy =", acc_train_tree_miss)
    print('REC of training set = ',recall_score(y_train_miss,pred_train_tree_miss,averag
    print('F1-Score of training set = ',f1_score(y_train_miss,pred_train_tree_miss,averag
```

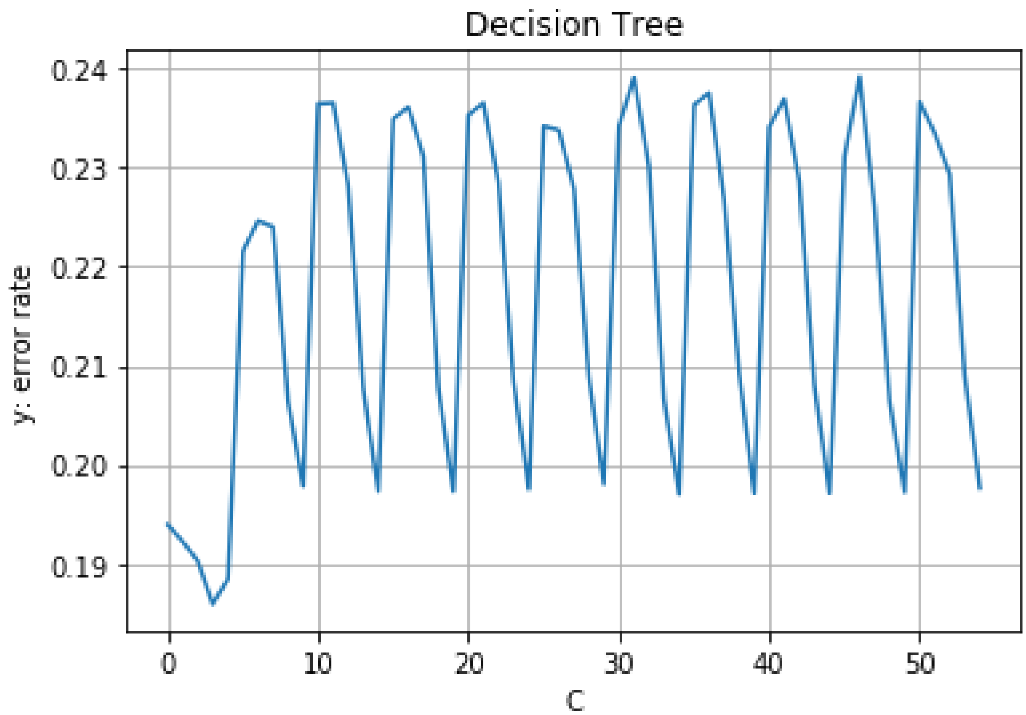
```
the best paramater =  {'max_depth': 10, 'min_samples_leaf': 16}
best accuracy in validation =  0.8055024268750468

the train accuracy = 0.8080673303910499
REC of training set =  0.8080673303910499
F1-Score of training set =  0.8080673303910499
```

In [51]:
```
#the code is modified from https://stackoverflow.com/questions/37161563/how-to-graph-
def Plotgridsearch(cv_results, grid_param_2, grid_param_1, name_param_1, name_param_2

    scores_mean = cv_results['mean_test_score']
    scores_mean = np.array(scores_mean).reshape(len(grid_param_2),len(grid_param_1))

    scores_sd = cv_results['std_test_score']
    scores_sd = np.array(scores_sd).reshape(len(grid_param_2),len(grid_param_1))

    # Plot Grid search scores
    _, ax = plt.subplots(1,1)

    # Param1 is the X-axis, Param 2 is represented as a different curve (color line)
    for idx, val in enumerate(grid_param_2):
        ax.plot(grid_param_1, scores_mean[idx,:], '-o', label= name_param_2 + ': ' + s

        ax.set_title("GridSearch Scores with Maxdepth & min samples leaf")
        ax.set_xlabel(name_param_1)
        ax.set_ylabel('CV Score', fontsize=16)
        ax.legend(loc="best", fontsize=5)
        ax.grid('on')
```

In [52]:
```
#min_samples_split=[5, 10, 20, 50, 100,200, 500]
max_depth=[10, 20, 30, 40, 50, 60, 70, 80, 90, 100, None]
min_samples_leaf=[1, 2, 4,8,16]
Plotgridsearch(params_tree.cv_results_, min_samples_leaf, max_depth, 'min_samples_lea
```




```
In [106]: dict_tree=params_tree.cv_results_
          array=np.array(dict_tree['params'])
          x_tree=[]
          for i in array:
              i=dict_tree['params'].index(i)
              x_tree.append(i)
          x_tree
          y=1-dict_tree['mean_test_score']
          #plt.figure(figsize=(12, 5))
          plt.plot(x_tree,y)
          #plt.xticks(rotation=270)
          plt.xlabel('C')
          plt.ylabel('y: error rate')
          plt.title('Decision Tree')
          plt.grid()
          plt.show()
```

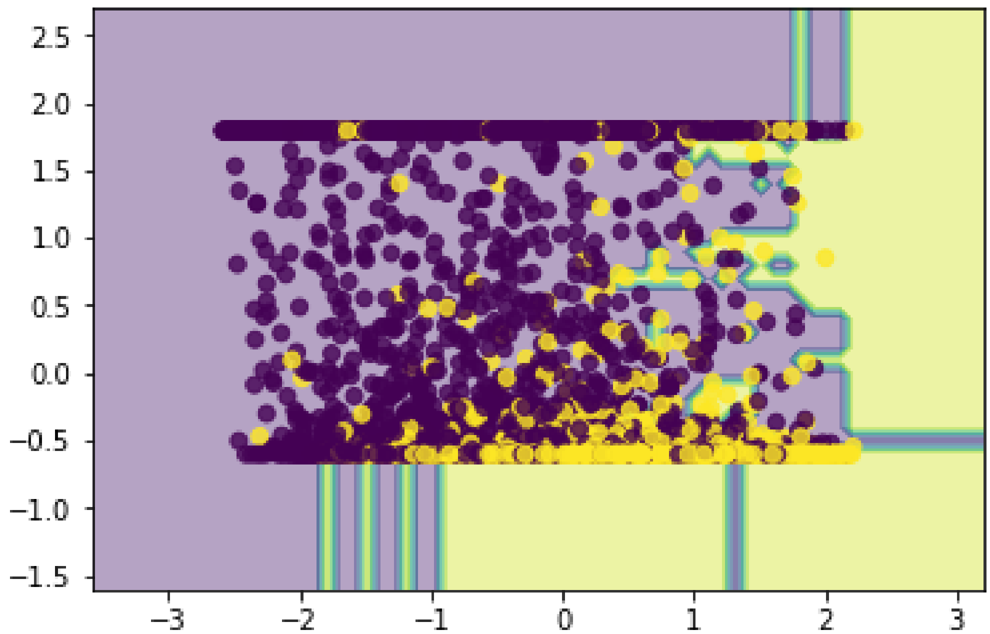



```
In [107]: from sklearn.ensemble import RandomForestClassifier
          from sklearn.model_selection import RandomizedSearchCV
          rf = RandomForestClassifier()

          # search the best params
          #grid_rf = {'n_estimators':[100,200,300,400,500], 'max_depth': [2, 5, 10]}
          grid_rf={'max_depth': [2,5,10, 20, None],
                    'min_samples_leaf': [1, 2, 4],
                    'min_samples_split': [2, 5, 10],
                    'n_estimators': [10,50,100,200, 300, 400, 500]}

          clf_rf = RandomizedSearchCV(rf, grid_rf, cv=5)
          clf_rf.fit(x_train, y_train)

          pred_train_rf= clf_rf.predict(x_train)
          #pred_test_rf= clf_rf.predict(x_test)

          # get the accuracy score
          acc_train_rf = accuracy_score(pred_train_rf, y_train)
          #acc_test_rf = accuracy_score(pred_test_rf, y_test)

          # get the accuracy score
          #acc_tree = accuracy_score(pred_tree, y_test)
          #print("the validation error=", acc_tree)
```

```
#print(params_tree.best_params_)

print("the best paramater = ",clf_rf.best_params_)
print("best accuracy in validation = ",clf_rf.best_score_)
print("")
print("the train accuracy =", acc_train_rf)
print('REC of training set = ',recall_score(y_train,pred_train_rf,average='micro'))
print('F1-Score of training set = ',f1_score(y_train,pred_train_rf,average='micro'))
print("")
```

```
the best paramater =  {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1, 'ma
best accuracy in validation =  0.8468981140923791

the train accuracy = 0.993276968523989
REC of training set =  0.993276968523989
F1-Score of training set =  0.993276968523989
```

In [157]:
```
x=x_train[['danceability','instrumentalness']]
y=y_train

rf_b = RandomForestClassifier(n_estimators=100, min_samples_split=5,
                              min_samples_leaf=1, max_depth=None)
rf_b.fit(x,y)

#h=.02
#x_min, x_max = x[:, 0].min() - 1, x[:, 0].max() + 1
#y_min, y_max = x[:, 1].min() - 1, x[:, 1].max() + 1
#xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))

    # Obtain labels for each point in mesh using the model.
#Z = clf_rf.predict(np.c_[xx.ravel(), yy.ravel()])

x_min, x_max = x.iloc[:, 0].min() - 1, x.iloc[:, 0].max() + 1
y_min, y_max = x.iloc[:, 1].min() - 1, x.iloc[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, 0.1),
                     np.arange(y_min, y_max, 0.1))

Z = rf_b.predict(np.c_[xx.ravel(), yy.ravel()]).reshape(xx.shape)

plt.contourf(xx, yy, Z, alpha=0.4)
plt.scatter(x.iloc[:, 0], x.iloc[:, 1], c=y, alpha=0.8)
plt.show()
```



In [117]:
```
rf_miss = RandomForestClassifier()

# search the best params
#grid_rf = {'n_estimators':[100,200,300,400,500], 'max_depth': [2, 5, 10]}
grid_rf_miss={'max_depth': [2,5,10, 20, None],
          'min_samples_leaf': [1, 2, 4],
          'min_samples_split': [2, 5, 10],
          'n_estimators': [10,50,100,200, 300, 400, 500]}

clf_rf_miss= RandomizedSearchCV(rf_miss, grid_rf_miss, cv=5)
clf_rf_miss.fit(x_train_miss, y_train_miss)

pred_train_rf_miss= clf_rf_miss.predict(x_train_miss)

acc_train_rf_miss = accuracy_score(pred_train_rf_miss, y_train_miss)


print("the best paramater = ",clf_rf_miss.best_params_)
print("best accuracy in validation = ",clf_rf_miss.best_score_)
print("")
print("the train accuracy =", acc_train_rf_miss)
print('REC of training set = ',recall_score(y_train_miss,pred_train_rf_miss,average=
print('F1-Score of training set = ',f1_score(y_train_miss,pred_train_rf_miss,average=
print("")
```

```
the best paramater =  {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4, 'ma
```

```
best accuracy in validation =  0.8393727420896095

the train accuracy = 0.9341065380273017
REC of training set =  0.9341065380273017
F1-Score of training set =  0.9341065380273017
```

```
In [108]: rf_ft = RandomForestClassifier(n_estimators=400, min_samples_split=5, min_samples_lea
          rf_ft.fit(x_train, y_train)
          arr_imp=rf_ft.feature_importances_
          df_imp=pd.DataFrame(arr_imp)
          df_imp.index=['danceability','energy','key','loudness','mode','speechiness','acousti
                        'instrumentalness','liveness','valence','tempo','duration_ms','ch
                         'sections']
          df_imp.columns = ['weight']
          df_imp
```

Out[108]:

	weight
danceability	0.119241
energy	0.089454
key	0.021190
loudness	0.024782
mode	0.005958
speechiness	0.045117
acousticness	0.112833
instrumentalness	0.283649
liveness	0.036160
valence	0.067785
tempo	0.038000
duration_ms	0.091831
chorus_hit	0.035635
sections	0.028364

```
In [109]: clf_rf.cv_results_
```

```
Out[109]: {'mean_fit_time': array([ 0.82580228, 13.46645923,  3.19709287,  7.31520963,  5.6301
                   0.08769679,  3.26112823, 11.53586755, 13.11668444,  0.77675943]),
           'mean_score_time': array([0.03649168, 0.36834331, 0.0920238 , 0.23152113, 0.2142612
                  0.00864916, 0.09166565, 0.32688484, 0.38946753, 0.03474975]),
           'mean_test_score': array([0.82153267, 0.84557351, 0.84435068, 0.83946119, 0.8228565
                  0.79647569, 0.84689811, 0.83813695, 0.84567503, 0.82265299]),
           'param_max_depth': masked_array(data=[5, 20, 20, 10, 5, 2, None, 10, 20, 5],
                        mask=[False, False, False, False, False, False, False, False,
                              False, False],
                  fill_value='?',
                       dtype=object),
           'param_min_samples_leaf': masked_array(data=[4, 1, 4, 2, 2, 4, 1, 4, 1, 2],
                        mask=[False, False, False, False, False, False, False, False,
```

```
                  False, False],
       fill_value='?',
            dtype=object),
'param_min_samples_split': masked_array(data=[10, 10, 5, 5, 10, 5, 5, 5, 2, 10],
             mask=[False, False, False, False, False, False, False, False,
                   False, False],
       fill_value='?',
            dtype=object),
'param_n_estimators': masked_array(data=[50, 400, 100, 300, 400, 10, 100, 500, 400,
             mask=[False, False, False, False, False, False, False, False,
                   False, False],
       fill_value='?',
            dtype=object),
'params': [{'max_depth': 5,
  'min_samples_leaf': 4,
  'min_samples_split': 10,
  'n_estimators': 50},
 {'max_depth': 20,
  'min_samples_leaf': 1,
  'min_samples_split': 10,
  'n_estimators': 400},
 {'max_depth': 20,
  'min_samples_leaf': 4,
  'min_samples_split': 5,
  'n_estimators': 100},
 {'max_depth': 10,
  'min_samples_leaf': 2,
  'min_samples_split': 5,
  'n_estimators': 300},
 {'max_depth': 5,
  'min_samples_leaf': 2,
  'min_samples_split': 10,
  'n_estimators': 400},
 {'max_depth': 2,
  'min_samples_leaf': 4,
  'min_samples_split': 5,
  'n_estimators': 10},
 {'max_depth': None,
  'min_samples_leaf': 1,
  'min_samples_split': 5,
  'n_estimators': 100},
 {'max_depth': 10,
  'min_samples_leaf': 4,
  'min_samples_split': 5,
  'n_estimators': 500},
 {'max_depth': 20,
  'min_samples_leaf': 1,
  'min_samples_split': 2,
```

```
  'n_estimators': 400},
 {'max_depth': 5,
  'min_samples_leaf': 2,
  'min_samples_split': 10,
  'n_estimators': 50}],
'rank_test_score': array([ 9,  3,  4,  5,  7, 10,  1,  6,  2,  8]),
'split0_test_score': array([0.83095723, 0.84674134, 0.84979633, 0.84674134, 0.83350
       0.77443992, 0.84826884, 0.84317719, 0.84928717, 0.83299389]),
'split1_test_score': array([0.82586558, 0.84928717, 0.84826884, 0.84164969, 0.82942
       0.81670061, 0.84674134, 0.84266802, 0.8503055 , 0.82790224]),
'split2_test_score': array([0.83087112, 0.84666327, 0.84156903, 0.84360672, 0.82832
       0.79266429, 0.85328579, 0.84004075, 0.84411615, 0.82577687]),
'split3_test_score': array([0.80183393, 0.83647478, 0.83596536, 0.82577687, 0.80438
       0.8013245 , 0.83647478, 0.8242486 , 0.83392766, 0.81049414]),
'split4_test_score': array([0.81813551, 0.84870097, 0.84615385, 0.83953133, 0.81864
       0.79724911, 0.84971982, 0.84055018, 0.85073867, 0.81609781]),
'std_fit_time': array([0.10773234, 0.22121   , 0.06287871, 0.12330948, 0.27646349,
       0.00217711, 0.1733441 , 0.30254303, 0.34598867, 0.05770969]),
'std_score_time': array([0.00489322, 0.00628014, 0.00202676, 0.00658703, 0.01719047
       0.00120778, 0.01186559, 0.02755266, 0.01838329, 0.00343182]),
'std_test_score': array([0.01090307, 0.00466713, 0.00502613, 0.00724211, 0.01044538
       0.01366205, 0.00564471, 0.00704655, 0.0063334 , 0.00818603])}
```

```
In [112]: dict_rf=clf_rf.cv_results_
          array=np.array(dict_rf['params'])
          array
```

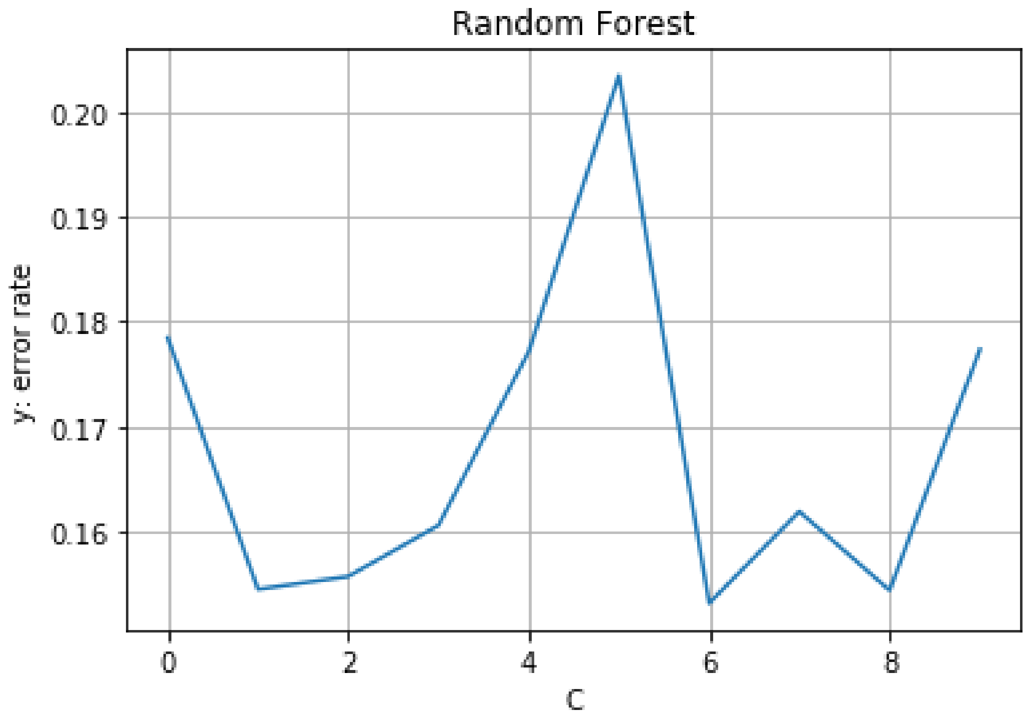
```
Out[112]: array([{'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_dep
                 {'n_estimators': 400, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_de
                 {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_dep
                 {'n_estimators': 300, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_dep
                 {'n_estimators': 400, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_de
                 {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_dept
                 {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_dep
                 {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_dep
                 {'n_estimators': 400, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_dep
                 {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_dep
                dtype=object)
```

```
In [113]: x=[]
          for i in array:
              i=dict_rf['params'].index(i)
              x.append(i)
          x
```

```
Out[113]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

```
In [139]: y=1-dict_rf['mean_test_score']
          #plt.figure(figsize=(12, 5))
```

```
plt.plot(x,y)
#plt.xticks(rotation=270)
plt.xlabel('C')
plt.ylabel('y: error rate')
plt.title('Random Forest')
plt.grid()
plt.show()
```




```
In [119]: from sklearn.ensemble import AdaBoostClassifier

          adaboost=AdaBoostClassifier()
          grid_ada={'n_estimators':[100,200,300,400,500],
                    'learning_rate':[0.025,0.05, 0.1, 0.15,0.20,0.25,0.30]}

          param_ada=GridSearchCV(adaboost, grid_ada, cv=5)
          param_ada.fit(x_train, y_train)

          pred_train_ada= param_ada.predict(x_train)
          #pred_test_ada= param_ada.predict(x_test)

          acc_train_ada = accuracy_score(pred_train_ada, y_train)
          #acc_test_ada = accuracy_score(pred_test_ada, y_test)

          # get the accuracy score
```

```
        #acc_tree = accuracy_score(pred_tree, y_test)
        #print("the validation error=", acc_tree)
        #print(params_tree.best_params_)

        print("the best paramater = ",param_ada.best_params_)
        print("best accuracy in validation = ",param_ada.best_score_)
        print("")
        print("the train accuracy =", acc_train_ada)
        print('REC of training set = ',recall_score(y_train,pred_train_ada,average='micro'))
        print('F1-Score of training set = ',f1_score(y_train,pred_train_ada,average='micro'))
```

```
the best paramater =  {'learning_rate': 0.1, 'n_estimators': 400}
best accuracy in validation =  0.8347755783418911

the train accuracy = 0.8421106244270143
REC of training set =  0.8421106244270143
F1-Score of training set =  0.8421106244270143
```

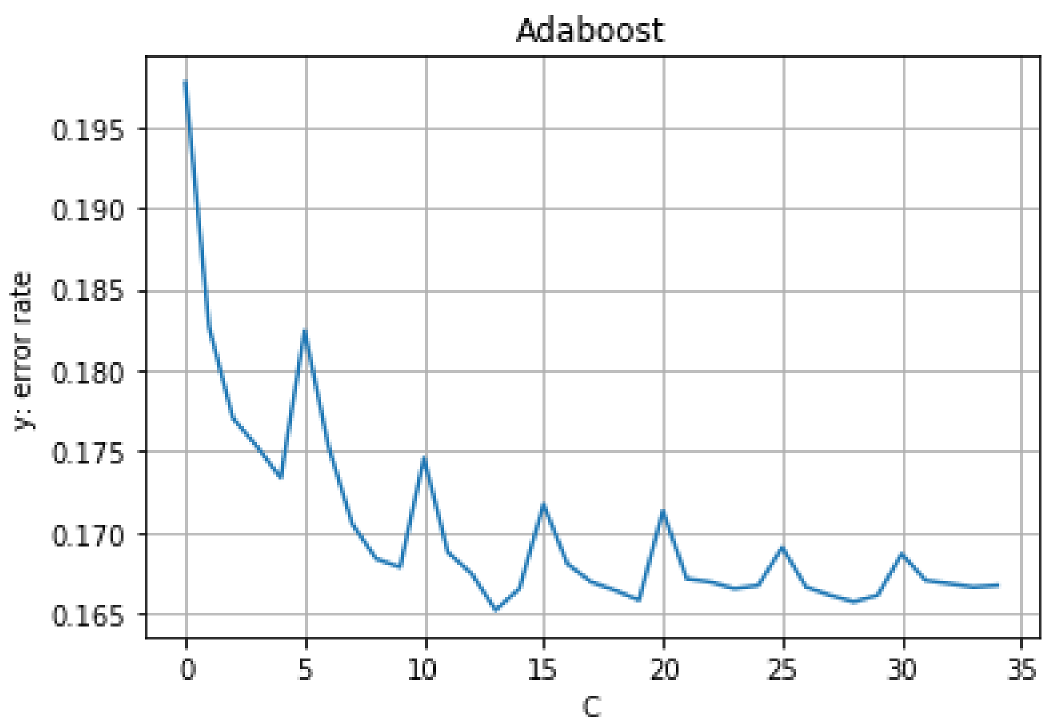
```
In [121]: dict_ada=param_ada.cv_results_
          array_ada=np.array(dict_ada['params'])
          array_ada
```

```
Out[121]: array([{'learning_rate': 0.025, 'n_estimators': 100},
                 {'learning_rate': 0.025, 'n_estimators': 200},
                 {'learning_rate': 0.025, 'n_estimators': 300},
                 {'learning_rate': 0.025, 'n_estimators': 400},
                 {'learning_rate': 0.025, 'n_estimators': 500},
                 {'learning_rate': 0.05, 'n_estimators': 100},
                 {'learning_rate': 0.05, 'n_estimators': 200},
                 {'learning_rate': 0.05, 'n_estimators': 300},
                 {'learning_rate': 0.05, 'n_estimators': 400},
                 {'learning_rate': 0.05, 'n_estimators': 500},
                 {'learning_rate': 0.1, 'n_estimators': 100},
                 {'learning_rate': 0.1, 'n_estimators': 200},
                 {'learning_rate': 0.1, 'n_estimators': 300},
                 {'learning_rate': 0.1, 'n_estimators': 400},
                 {'learning_rate': 0.1, 'n_estimators': 500},
                 {'learning_rate': 0.15, 'n_estimators': 100},
                 {'learning_rate': 0.15, 'n_estimators': 200},
                 {'learning_rate': 0.15, 'n_estimators': 300},
                 {'learning_rate': 0.15, 'n_estimators': 400},
                 {'learning_rate': 0.15, 'n_estimators': 500},
                 {'learning_rate': 0.2, 'n_estimators': 100},
                 {'learning_rate': 0.2, 'n_estimators': 200},
                 {'learning_rate': 0.2, 'n_estimators': 300},
                 {'learning_rate': 0.2, 'n_estimators': 400},
                 {'learning_rate': 0.2, 'n_estimators': 500},
```

```
{'learning_rate': 0.25, 'n_estimators': 100},
{'learning_rate': 0.25, 'n_estimators': 200},
{'learning_rate': 0.25, 'n_estimators': 300},
{'learning_rate': 0.25, 'n_estimators': 400},
{'learning_rate': 0.25, 'n_estimators': 500},
{'learning_rate': 0.3, 'n_estimators': 100},
{'learning_rate': 0.3, 'n_estimators': 200},
{'learning_rate': 0.3, 'n_estimators': 300},
{'learning_rate': 0.3, 'n_estimators': 400},
{'learning_rate': 0.3, 'n_estimators': 500}], dtype=object)
```

```
In [130]: x_ada=[]
          for i in array_ada:
              i=dict_ada['params'].index(i)
              x_ada.append(i)
          #x_ada
```

```
In [138]: y_ada=1-dict_ada['mean_test_score']
          #plt.figure(figsize=(12, 5))
          plt.plot(x_ada,y_ada)
          #plt.xticks(rotation=270)
          plt.xlabel('C')
          plt.ylabel('y: error rate')
          plt.title('Adaboost')
          plt.grid()
          plt.show()
```



```
In [129]: adaboost_miss=AdaBoostClassifier()
          grid_miss={'n_estimators':[100,200,300,400,500],
                     'learning_rate':[0.025,0.05, 0.1, 0.15,0.20,0.25,0.30]}

          param_ada_miss=GridSearchCV(adaboost_miss, grid_miss, cv=5)
          param_ada_miss.fit(x_train_miss, y_train_miss)
          pred_train_ada_miss= param_ada_miss.predict(x_train_miss)
          #pred_test_ada= param_ada.predict(x_test)

          acc_train_ada_miss = accuracy_score(pred_train_ada_miss, y_train_miss)
          #acc_test_ada = accuracy_score(pred_test_ada, y_test)

          # get the accuracy score
          #acc_tree = accuracy_score(pred_tree, y_test)
          #print("the validation error=", acc_tree)
          #print(params_tree.best_params_)

          print("the best paramater = ",param_ada_miss.best_params_)
          print("best accuracy in validation = ",param_ada_miss.best_score_)
          print("")
          print("the train accuracy =", acc_train_ada_miss)
          print('REC of training set = ',recall_score(y_train_miss,pred_train_ada_miss,average=
          print('F1-Score of training set = ',f1_score(y_train_miss,pred_train_ada_miss,average
```

```
the best paramater =  {'learning_rate': 0.15, 'n_estimators': 400}
best accuracy in validation =  0.8260307239114884

the train accuracy = 0.8336241404084984
REC of training set =  0.8336241404084984
F1-Score of training set =  0.8336241404084984
```

```
In [140]: df1_semi=pd.read_csv('C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/datas
          df2_semi=pd.read_csv('C:/Users/hp/Desktop/EE660/Final_Project/Myproject/dataset/datas
          DATA_semi=pd.concat([df1_semi,df2_semi])
          DATA_numerical_semi=DATA_semi.drop(['track','artist','uri','time_signature'], axis=1)
          DATA_numerical_semi
```

Out[140]:

	danceability	energy	key	loudness	mode	speechiness	acousticness	\
0	0.5780	0.4710	4	-7.270	1	0.0289	0.368000	
1	0.7040	0.8540	10	-5.477	0	0.1830	0.018500	
2	0.1620	0.8360	9	-3.009	1	0.0473	0.000111	
3	0.1880	0.9940	4	-3.745	1	0.1660	0.000007	
4	0.6300	0.7640	2	-4.353	1	0.0275	0.363000	
5	0.7260	0.8370	11	-7.223	0	0.0965	0.373000	
6	0.3650	0.9220	1	-2.644	1	0.0710	0.002850	

7	0.7260	0.6310	11	-8.136	0	0.0334	0.220000
8	0.4810	0.7860	10	-5.654	1	0.0288	0.053800
9	0.6470	0.3240	7	-9.679	1	0.0377	0.354000
10	0.7870	0.6320	8	-3.487	1	0.1370	0.103000
11	0.4910	0.7760	2	-3.887	1	0.0393	0.314000
12	0.4550	0.7370	1	-6.206	1	0.0272	0.001140
13	0.7250	0.7330	0	-6.660	1	0.0242	0.508000
14	0.4970	0.4210	2	-14.059	0	0.1870	0.985000
15	0.5090	0.9420	11	-6.899	1	0.0628	0.000639
16	0.7080	0.7280	7	-7.039	1	0.0298	0.011000
17	0.5180	0.9160	3	-3.858	1	0.0454	0.000148
18	0.3950	0.2480	1	-10.025	1	0.0519	0.979000
19	0.3780	0.9530	9	-3.632	1	0.1380	0.000719
20	0.9000	0.5930	10	-6.629	0	0.3330	0.055400
21	0.3290	0.8120	2	-11.480	1	0.0872	0.014100
22	0.3890	0.5980	4	-8.473	1	0.0363	0.782000
23	0.7440	0.6970	11	-5.063	0	0.1970	0.010600
24	0.7230	0.7850	5	-5.722	1	0.0302	0.024700
25	0.5600	0.8080	10	-6.725	1	0.0306	0.200000
26	0.6430	0.3910	10	-10.090	1	0.0296	0.622000
27	0.7350	0.7320	10	-8.915	1	0.0699	0.572000
28	0.5360	0.0810	8	-20.968	1	0.0877	0.958000
29	0.5870	0.8800	4	-5.725	1	0.0324	0.078400
...	...	...	...	...	...	...	...
6368	0.8550	0.9680	1	-3.278	1	0.1570	0.014300
6369	0.3890	0.1270	7	-16.157	0	0.0392	0.990000
6370	0.2060	0.9950	8	-5.096	1	0.1940	0.013100
6371	0.5260	0.8720	7	-5.079	1	0.0428	0.245000
6372	0.7570	0.6180	11	-7.964	0	0.0282	0.262000
6373	0.5180	0.1360	2	-17.510	0	0.0718	0.994000
6374	0.4000	0.0831	10	-21.565	1	0.0740	0.986000
6375	0.5080	0.9200	1	-4.387	1	0.0489	0.000007
6376	0.3000	0.9830	5	-5.809	0	0.0816	0.000244
6377	0.6280	0.6380	11	-8.033	1	0.0302	0.293000
6378	0.2710	0.9820	7	-4.295	1	0.1210	0.000258
6379	0.4390	0.9930	11	-2.923	1	0.1000	0.000937
6380	0.7000	0.7420	5	-6.777	0	0.0716	0.072200
6381	0.7860	0.8540	2	-4.247	1	0.0523	0.072900
6382	0.0934	0.1880	10	-16.340	0	0.0399	0.940000
6383	0.2970	0.4100	4	-16.100	0	0.0368	0.273000
6384	0.3950	0.9270	4	-4.418	1	0.1650	0.116000
6385	0.8020	0.8200	10	-5.969	0	0.1460	0.057900
6386	0.3960	0.0440	9	-25.088	0	0.0370	0.984000
6387	0.5650	0.8050	0	-4.457	1	0.0489	0.080800
6388	0.8740	0.4970	6	-5.484	1	0.0562	0.220000
6389	0.4020	0.6960	8	-4.799	0	0.0448	0.047600
6390	0.6550	0.6320	2	-4.802	1	0.0489	0.018900
6391	0.6120	0.8070	10	-2.810	1	0.0336	0.049500

6392	0.7800	0.7840	1	-5.039	1	0.1860	0.044700
6393	0.1720	0.3580	9	-14.430	1	0.0342	0.886000
6394	0.9100	0.3660	1	-9.954	1	0.0941	0.099600
6395	0.7190	0.8040	10	-4.581	1	0.0355	0.013200
6396	0.6000	0.1770	7	-16.070	1	0.0561	0.989000
6397	0.1210	0.1230	4	-23.025	0	0.0443	0.964000

	instrumentalness	liveness	valence	tempo	duration_ms	chorus_hit \
0	0.000000	0.1590	0.5320	133.061	196707	30.88059
1	0.000000	0.1480	0.6880	92.988	242587	41.51106
2	0.004570	0.1740	0.3000	86.964	338893	65.32887
3	0.078400	0.1920	0.3330	148.440	255667	58.59528
4	0.000000	0.1250	0.6310	112.098	193760	22.62384
5	0.268000	0.1360	0.9690	135.347	192720	28.29051
6	0.000000	0.3210	0.2900	77.250	89427	45.77202
7	0.000000	0.1930	0.7460	124.711	239240	35.59732
8	0.000000	0.0759	0.3890	153.105	253640	19.65701
9	0.000000	0.1150	0.3440	124.213	314286	32.66343
10	0.000007	0.3880	0.6120	141.026	198173	18.09100
11	0.000000	0.1460	0.4280	154.988	202547	37.86861
12	0.000487	0.1950	0.2060	94.028	224053	62.77759
13	0.000000	0.1730	0.8430	100.311	219827	27.06630
14	0.839000	0.1480	0.8040	92.190	232719	33.36130
15	0.882000	0.0788	0.1630	169.960	460080	34.78597
16	0.000023	0.0556	0.7040	119.881	258640	33.81641
17	0.000000	0.2910	0.6460	109.864	238880	19.81215
18	0.000000	0.1770	0.3240	85.174	207888	34.50252
19	0.000029	0.0936	0.5120	167.808	200347	20.58661
20	0.000000	0.0304	0.6330	92.946	172933	21.78144
21	0.078600	0.0603	0.4000	165.013	272880	97.84874
22	0.948000	0.0825	0.0396	140.002	226147	22.35533
23	0.000000	0.0842	0.7670	149.280	247413	42.63475
24	0.003470	0.2600	0.8160	128.030	209987	64.24515
25	0.308000	0.4160	0.6910	128.051	205827	30.93391
26	0.000014	0.1100	0.4180	143.786	219933	28.43124
27	0.000026	0.0997	0.6560	117.580	116507	45.59357
28	0.922000	0.1130	0.4770	138.498	186973	27.01863
29	0.000000	0.1820	0.7780	129.222	246240	20.93198
...	...	...	...	...	...	...
6368	0.002500	0.0988	0.7980	103.005	226107	35.92450
6369	0.958000	0.1110	0.0807	74.023	101387	36.44766
6370	0.799000	0.5290	0.1720	188.961	177040	72.06152
6371	0.000000	0.2430	0.5830	153.929	188147	17.64029
6372	0.000000	0.2210	0.8610	106.856	267160	18.19036
6373	0.690000	0.6260	0.4260	117.833	233182	37.61916
6374	0.901000	0.0891	0.4740	156.400	364720	27.71705
6375	0.864000	0.0853	0.6990	90.027	188493	50.45824
6376	0.771000	0.2580	0.3470	109.517	247960	15.58687

6377	0.000030	0.1890	0.7300	123.355	213720	44.49267
6378	0.004530	0.5860	0.1170	154.692	232867	82.72886
6379	0.000063	0.2850	0.1570	124.609	245947	81.97844
6380	0.019900	0.1100	0.1970	91.959	302000	20.40806
6381	0.000002	0.1790	0.6870	105.078	157165	83.47828
6382	0.903000	0.1160	0.0703	85.711	142339	28.01194
6383	0.942000	0.0947	0.1760	91.811	307040	19.16562
6384	0.000000	0.4410	0.9410	188.384	191905	68.27089
6385	0.000000	0.1490	0.6130	164.005	172196	17.21141
6386	0.947000	0.0802	0.0898	71.200	224636	15.34214
6387	0.000000	0.1730	0.8690	76.040	181933	38.94659
6388	0.000000	0.0761	0.5420	106.023	204502	30.10821
6389	0.000000	0.6280	0.2270	180.158	243093	31.53643
6390	0.000000	0.0722	0.4470	120.113	188493	51.52804
6391	0.017700	0.1010	0.3980	124.053	240400	91.20552
6392	0.000000	0.1220	0.4300	85.023	180706	46.62277
6393	0.966000	0.3140	0.0361	72.272	150857	24.30824
6394	0.000000	0.2610	0.7400	119.985	152000	32.53856
6395	0.000003	0.1390	0.6050	119.999	227760	20.73371
6396	0.868000	0.1490	0.5600	120.030	213387	21.65301
6397	0.696000	0.1030	0.0297	95.182	341396	71.05343

	sections	target
0	13	1
1	10	1
2	13	0
3	9	0
4	10	1
5	10	0
6	4	0
7	10	1
8	11	1
9	16	0
10	9	1
11	9	1
12	9	0
13	8	1
14	15	0
15	12	0
16	15	1
17	10	1
18	10	0
19	12	0
20	9	1
21	9	0
22	10	0
23	9	1
24	9	0

```
25           11       0
26           12       1
27            5       0
28            8       0
29           10       1
...         ...     ...
6368         10       1
6369          4       0
6370          7       0
6371          9       1
6372         13       1
6373         12       0
6374         16       0
6375          8       0
6376          9       0
6377         10       0
6378          9       0
6379          9       0
6380         12       1
6381          6       1
6382          8       0
6383         12       0
6384          8       0
6385          8       1
6386         12       0
6387          7       1
6388         10       1
6389         11       1
6390          8       1
6391          7       1
6392          8       1
6393          7       0
6394          8       1
6395          7       1
6396         14       0
6397         15       0

[12270 rows x 15 columns]
```

In [141]:
```python
#the code is modified from https://www.jianshu.com/p/2aad8205738c
import numpy as np
from sklearn.semi_supervised import LabelPropagation
from sklearn.metrics import accuracy_score,recall_score,f1_score
x_semi = DATA_numerical_semi
labels = x_semi.target
x_train_semi=DATA_numerical_semi.drop(['target'])
reg=np.random.RandomState(42)
random_unlabeled_points = reg.rand(len(x_semi.target))<0.3
```

```
#random_unlabeled_points = random_unlabeled_points
y=labels[random_unlabeled_points] #the label before delete the labels
labels[random_unlabeled_points]=-1 # make these labels become unlabeled data
print('Unlabeled Number:',list(labels).count(-1))

semi_model = LabelPropagation()
semi_model.fit(x_train_semi,labels)
y_pred = semi_model.predict(x_train_semi)
y_pred = y_pred[random_unlabeled_points] # predict the unlabeled data
print('accuracy',accuracy_score(y,y_pred))
print('Recall',recall_score(y,y_pred,average='micro'))
print('F1-Score',f1_score(y,y_pred,average='micro'))
```

```
Unlabeled Number: 3720
accuracy 0.5069892473118279
Recall 0.5069892473118279
F1-Score 0.5069892473118279
```

In [159]:
```
rf_final = RandomForestClassifier(n_estimators=100, min_samples_split=5,
                                  min_samples_leaf=1, max_depth=None)

rf_final.fit(x_train, y_train)

pred_train_rf= rf_final.predict(x_train)
pred_test_rf= rf_final.predict(x_test)

# get the accuracy score
acc_train_rf = accuracy_score(pred_train_rf, y_train)
acc_test_rf = accuracy_score(pred_test_rf, y_test)

#print("the train accuracy =", acc_train_rf)
#print('REC of training set = ',recall_score(y_train,pred_train_rf,average='micro'))
#print('F1-Score of training set = ',f1_score(y_train,pred_train_rf,average='micro')

print("the train accuracy =", acc_test_rf)
print('REC of training set = ',recall_score(y_test,pred_test_rf,average='micro'))
print('F1-Score of training set = ',f1_score(y_test,pred_test_rf,average='micro'))
print("")
```

```
the train accuracy = 0.8320423970648186
REC of training set =  0.8320423970648186
F1-Score of training set =  0.8320423970648186
```

In [163]:
```
import pickle
with open('model.pickle', 'wb') as file:
    pickle.dump(rf_final, file)
```

In [162]:
```
#baseline
from sklearn.dummy import DummyClassifier
dummy_clf = DummyClassifier(strategy="most_frequent")
dummy_clf.fit(x_train, y_train)
DummyClassifier(strategy='most_frequent')
dummy_clf.predict(x_train)
#array([1, 1, 1, 1])
dummy_clf.predict(x_test)
dummy_clf.score(x_train, y_train)
dummy_clf.score(x_test, y_test)
```

Out[162]: 0.4912352221769262