VOICEPRINT RECOGNITION

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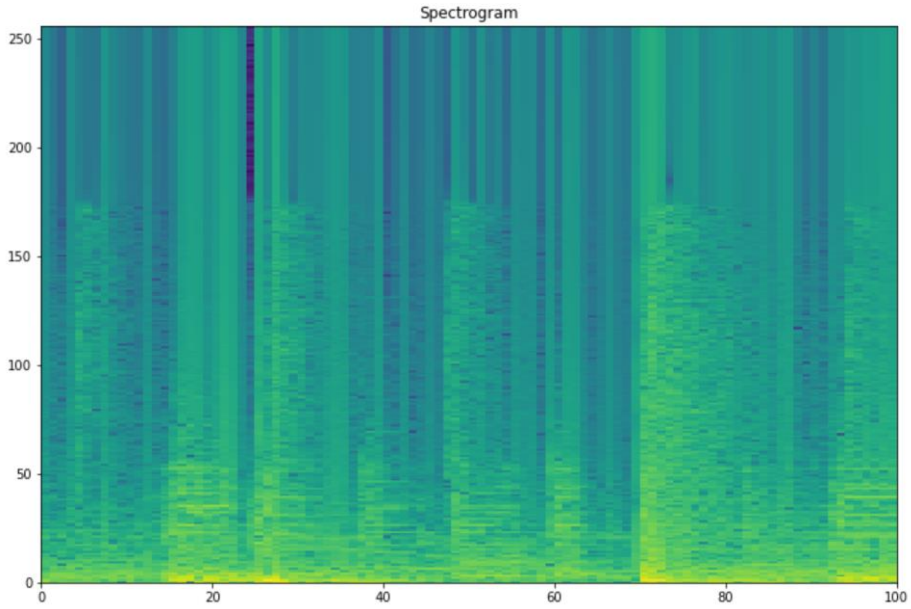
Introduction

This project is implemented through python and mainly working as a usable tool to implement voiceprint recognition. Reference the implementation of SHAZAM, which is a widely used platform in reality.

Music compression

A plot in pseudocolor of the magnitude spectrum of 100 audio frames (spectrogram). Horizontally the 100 frames, vertically the frequency (DFT index).

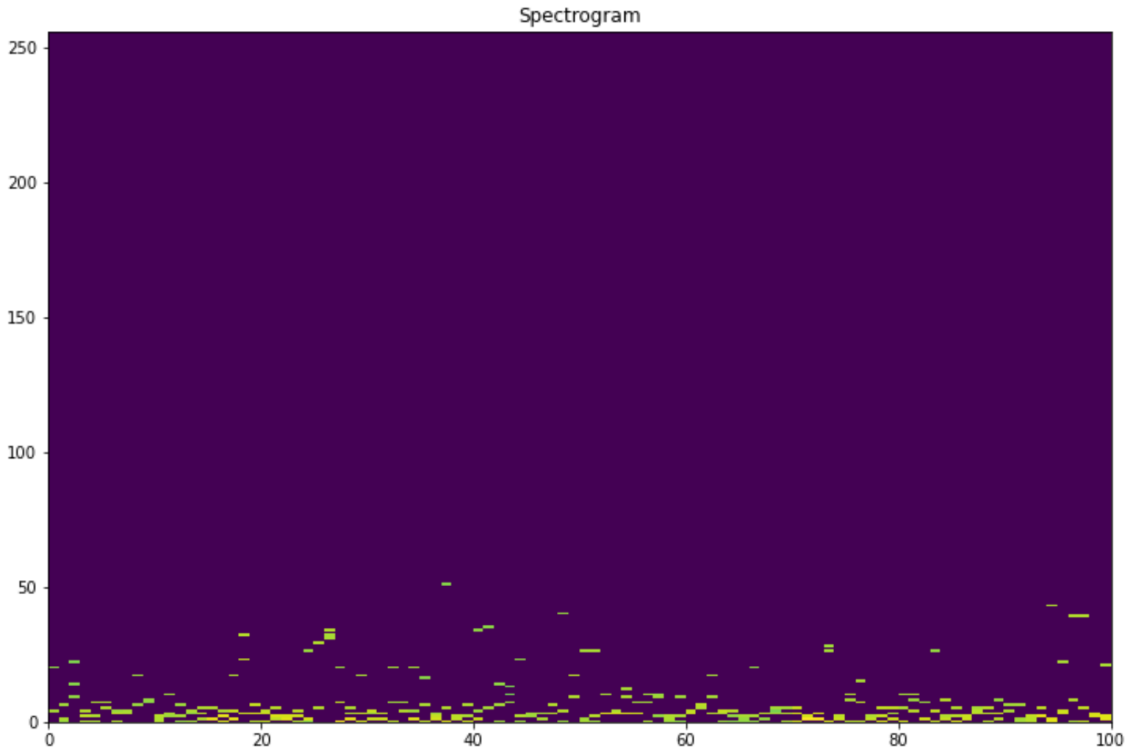


Since the sampling rate is 44100HZ, thus the length of frame in milliseconds is:

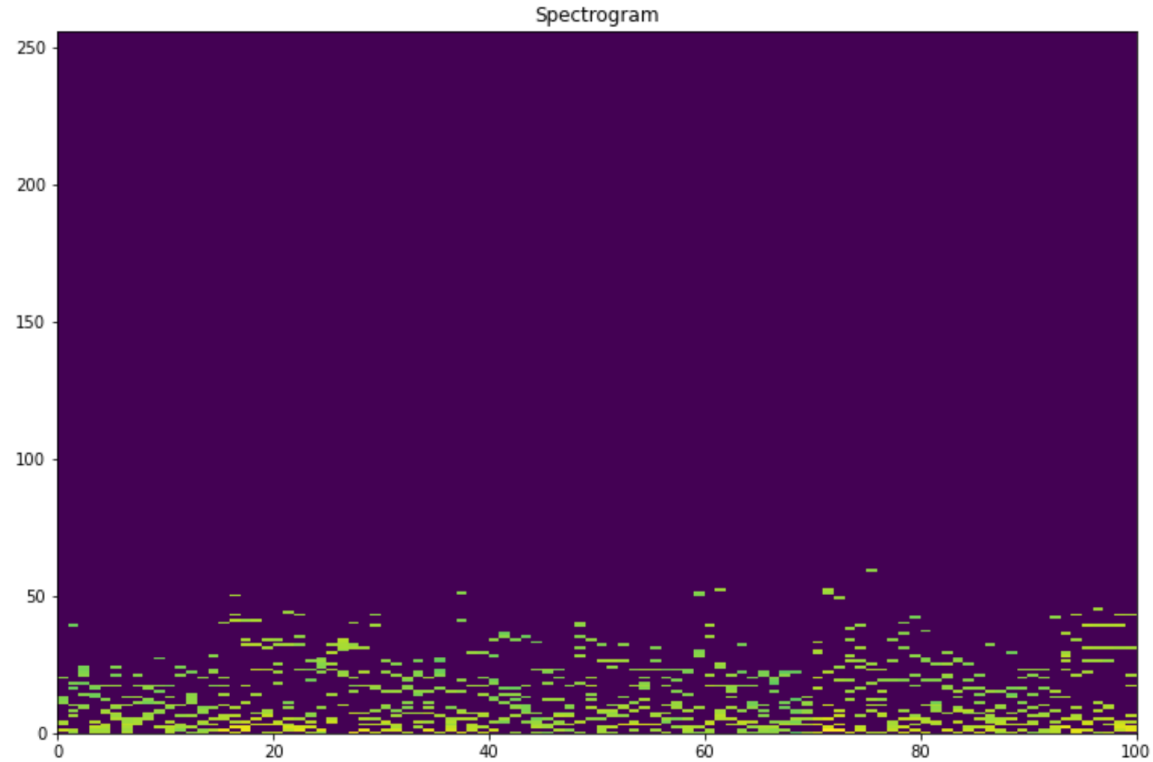
512/44100*1000=11.6ms

The total number of frames of the file using is 857.

Since there is lot of noise in the whole audio signal, only the coefficients that have the largest magnitude are those which has the highest effect in the sound recognition for human beings. Thus, we have to keep the important audio signal and shrink the effect of the noise.



A plot in pseudocolor of the magnitude spectrum of 100 audio frames when keeping only the 3 largest DFT coefficients in the range [0,N/2]. Horizontally the frames, vertically the frequency (DFT index).

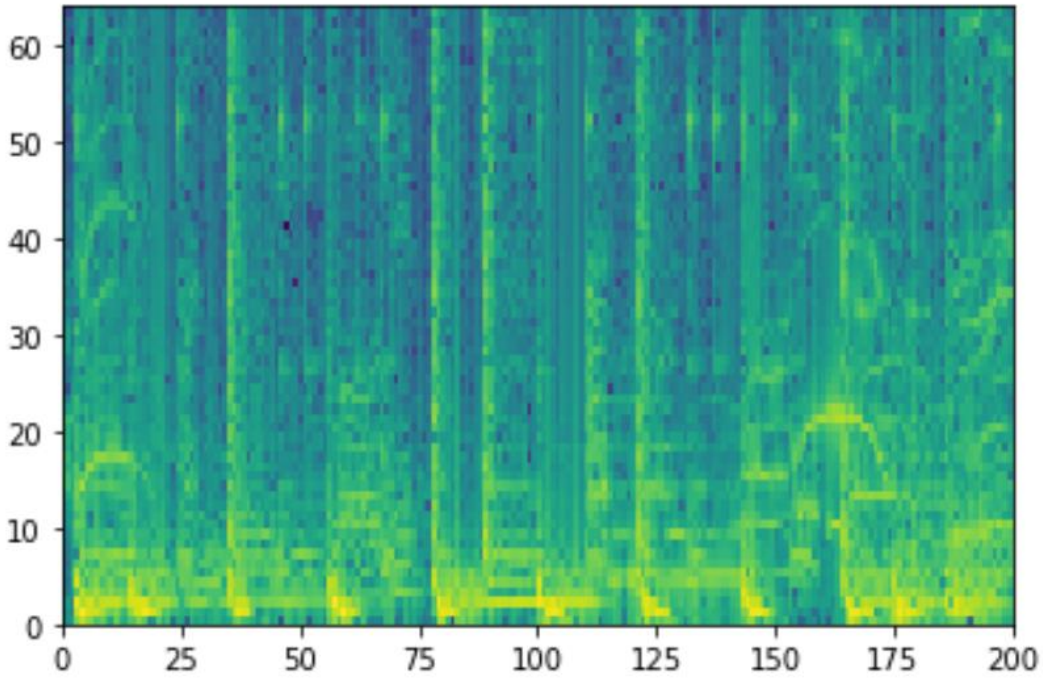


Show a plot in pseudocolor of the magnitude spectrum of 100 audio frames when keeping the 8 largest DFT coefficients in the range [0,N/2]. Horizontally the frames, vertically the frequency (DFT index).

From the plots about and by listening to the compressed signal, I choose 10 as the value of DFT coefficients to keep in the compressed signal. Since L = 10, 19 samples are kept in each frame, then the compression rate is 19/512 = 0.037.

For the whole file, it will be 857*19/438784*100%=3.7%

Voiceprint Recognition



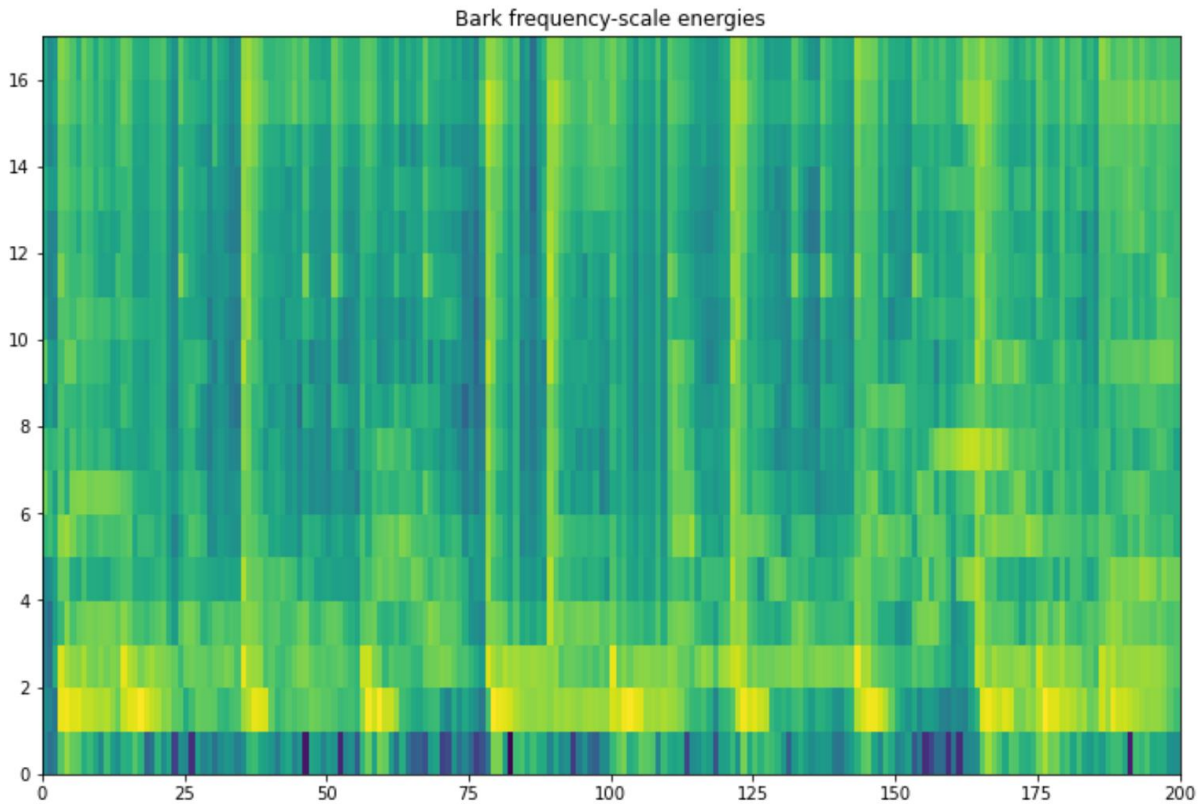
A plot in pseudocolor of the magnitude spectrum of 200 audio frames (spectrogram) of music file

'query_blurred_lines_1.wav'. Horizontally the 200 frames, vertically the frequency (DFT index).

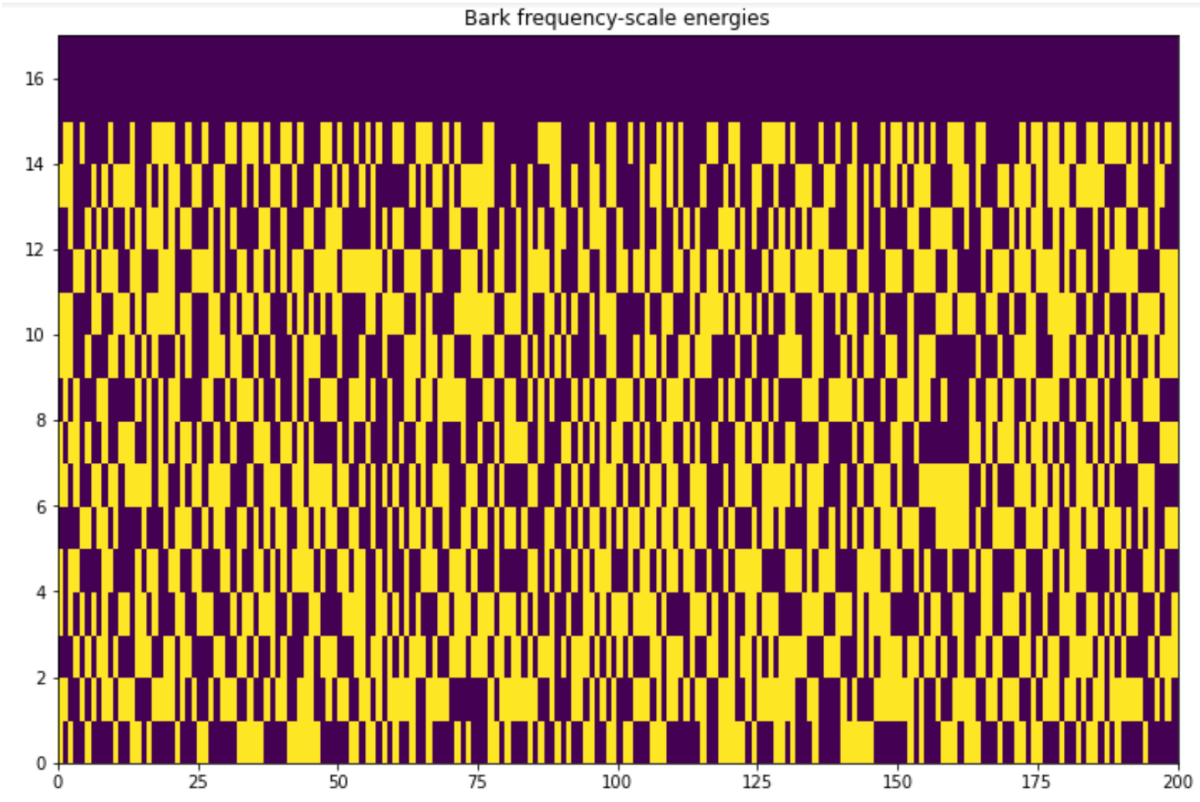
For the length of each frame in milliseconds, like what we have done before, since the sample rate is 22050HZ, the length is

512/22050*1000=23.2ms

The total number of frames in the file 'query_blurred_lines_1.wav' is 257.



A plot in pseudocolor of the bark scale energies of the music file ‘query_blurred_lines_1.wav’. Horizontally the 200 frames, vertically the bark scale frequency bands (0-16).



A plot in pseudocolor of the fingerprint (0-1 pattern) of the music file ‘query_blurred_lines_1.wav’. Horizontally the 200 frames, vertically the bits (0-15)

Finally, I choose to use bit error rate to compare the fingerprints of the files. Since the BER can show the difference of the provided files and the given fingerprint. The smaller the difference, the more similar the two fingerprints are. Thus, we can use the BER as a good method to compare the similarity of two fingerprints.

For a completely unrelated song, the BER should be around 0.5. And for a different version of the same song, it should be about 0.25.

CODE-Compression

```
fs, mmdata = wv.read("data/musicclip.wav")
display(Audio(mmdata, rate=fs))
nicesignalplot(np.arange(0,len(mmdata)/fs,1/fs),mmdata,'audio file
musicclip.wav')

N = 512
M = int(len(mmdata)/N)
mmdata.resize(N * M, refcheck = False)
MMFRAMES = mmdata.reshape([M,N])
MMFRAMES = np.fft.fft(MMFRAMES)
print(MMFRAMES.shape)
plt.figure(figsize=[12,8])
plt.pcolor(np.log(np.abs(MMFRAMES[0:100,:int(N/2)].T + 0.0001)))
plt.title('Spectrogram')
plt.show()

#2*L-1 = 15
L = 10
CMFRAMES = np.zeros(MMFRAMES.shape ,dtype = 'complex_')
for i in range(MMFRAMES.shape[0]):
    indices = np.argsort(MMFRAMES[i,:])
    largest = indices[indices.shape[0] - 2*L+1: ]
    for index in largest:
        CMFRAMES[i, index] = MMFRAMES[i, index]
plt.figure(figsize=[12,8])
plt.pcolor(np.log(np.abs(CMFRAMES[0:100,:int(N/2)].T + 0.0001)))
plt.title('Spectrogram')
plt.show()

plt.pcolor(np.log(np.abs(CMFRAMES[0:100,:int(N/8)].T)+0.0001))
CMFRAMES = np.fft.ifft(CMFRAMES)
signal = CMFRAMES.reshape(857*512)
display(Audio(signal, rate=fs))
```

CODE-Voiceprint Recognition

```
musicfiles =
['data/querysongs/query_call_me_1.wav','data/querysongs/query_call_me_2.wav',\
              'data/querysongs/query_call_me_3.wav','data/querysongs/query_cal
l_me_4.wav',\
              'data/querysongs/query_call_me_5.wav',\
              'data/querysongs/query_get_lucky_1.wav','data/querysongs/query_g
et_lucky_2.wav',\
              'data/querysongs/query_get_lucky_3.wav','data/querysongs/query_g
et_lucky_4.wav',\
              'data/querysongs/query_get_lucky_5.wav',\
              'data/querysongs/query_scream_shout_1.wav','data/querysongs/quer
y_scream_shout_2.wav',\
              'data/querysongs/query_scream_shout_3.wav','data/querysongs/quer
y_scream_shout_4.wav',\
              'data/querysongs/query_scream_shout_5.wav',\
              'data/querysongs/query_locked_out_1.wav','data/querysongs/query_
locked_out_2.wav',\
              'data/querysongs/query_locked_out_3.wav','data/querysongs/query_
locked_out_4.wav',\
              'data/querysongs/query_locked_out_5.wav',\
              'data/querysongs/query_blurred_lines_1.wav','data/querysongs/que
ry_blurred_lines_2.wav',\
              'data/querysongs/query_blurred_lines_3.wav','data/querysongs/que
ry_blurred_lines_4.wav',\
              'data/querysongs/query_blurred_lines_5.wav']


fs, xx = wv.read('data/querysongs/query_blurred_lines_1.wav')
display(Audio(xx, rate=fs))
nicesignalplot(np.arange(0,len(xx)/fs,1/fs),xx,'audio file
query_blurred_lines_1.wav')

Nframelen = 512
Mframes   = int(len(xx)/Nframelen)
print('Input speech is divided into',Mframes,'frames of length',Nframelen)
xx.resize(Mframes*Nframelen)
frames = xx.reshape([Mframes,Nframelen])
XX = np.fft.fft(frames)
print(XX.shape)

plt.pcolor(np.log(np.abs(XX[0:200,:int(Nframelen/8)].T)+0.001))
plt.show()

BarkScaleBandID = np.load("data/bark_scale_band_id.pkl", allow_pickle = True)
print(BarkScaleBandID)

BB   = np.zeros([Mframes,17])
for n in range(0,int(Nframelen/2)+1):
    BB[:,BarkScaleBandID[n]] += (np.abs(XX[:,n]))
```

```
plt.figure(figsize=[12,8])
plt.pcolor(np.log(BB[:200,:].T))
plt.title('Bark frequency-scale energies')
plt.show()

def e(BB, m, n):
    return (BB[m+1, n+1]-BB[m+1, n]) - (BB[m, n+1]-BB[m, n])

def b(m, n, BB):
    if (e(BB, m, n) >= 0): return 1
    else: return 0

bb = np.zeros((257,17))
for m in range(0, Mframes-1):
    for n in range(0, 15):
        bb[m, n] = b(m, n, BB)

plt.figure(figsize=[12,8])
plt.pcolor(bb[:200,:].T)
plt.title('Bark frequency-scale energies')
plt.show()

data = np.load('data/fingerprint.pkl',allow_pickle=True)

BER = []
for name in musicfiles:
    fs, xx = wv.read(name)
    Nframelen = 512
    Mframes   = int(len(xx)/Nframelen)
    xx.resize(Mframes*Nframelen)
    frames = xx.reshape([Mframes,Nframelen])
    XX = np.fft.fft(frames)

    BB   = np.zeros([Mframes,17])
    for n in range(0,int(Nframelen/2)+1):
        BB[:,BarkScaleBandID[n]] += (np.abs(XX[:,n]))

    bb = np.zeros((257,17))
    for m in range(0, Mframes-1):
        for n in range(0, 15):
            bb[m, n] = b(m, n, BB)

    D=0
    for m in np.arange(0, Mframes-1):
        for n in np.arange(0, 15):
            if(bb[m,n] != data[m,n]):
                D = D + 1
    D= D / (256 * 16)
```

```
    BER.append(D)

print(np.argmin(np.array(BER)))
print(BER)
```