Lab4

1.1.1.2

By applying a discrete Fourier transform to the signal created using the existing function, the following image is obtained, and we can see that the frequency of the signal is concentrated at plus or minus 440Hz.

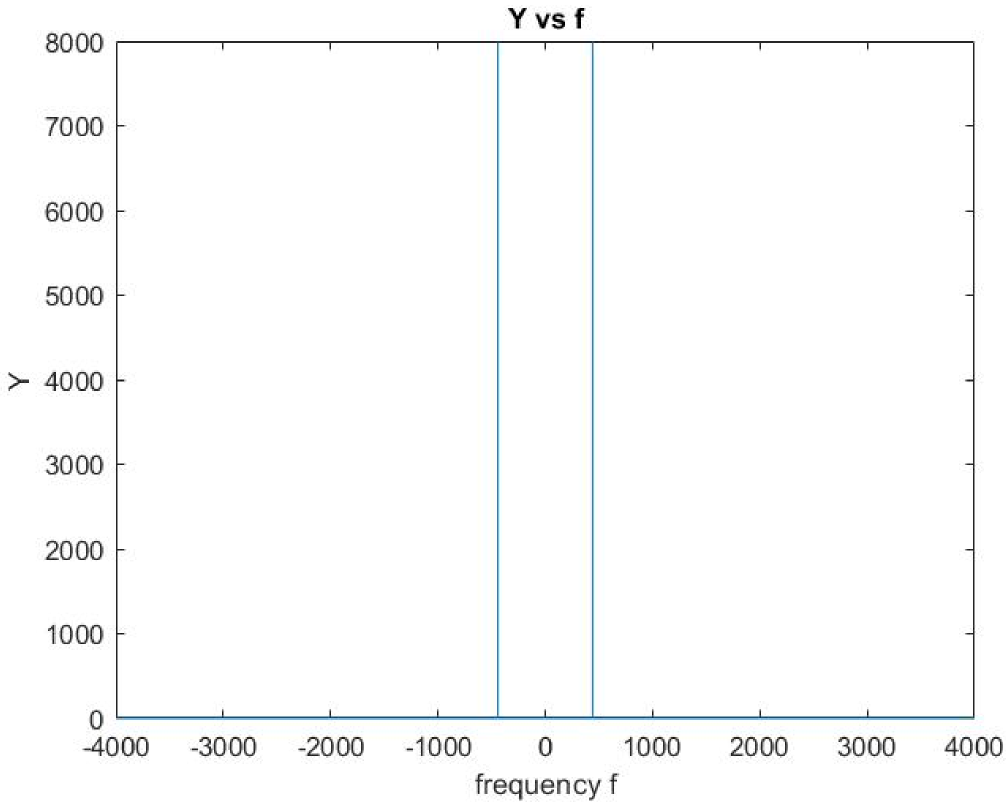

Figure 1. Y vs f

1.1.1.3

We can only correctly observe the notes which frequency is 0.5*N Hz like "Note 31, 33, 42, 43, 45, 54, 55, 57, 67, 69, 81, 93, 96, 105" which are in the table.

With the formula below, we can derive that the frequency of note 110 is 4698.64 which is not 0.5*N Hz, so we can not observe it correctly.

$$f_0^{note} = 440 \times 2^{\frac{(note-69)}{12}}$$

The reason why we can't do that is because of the function myFFT, the minimum step size of the frequency is 8000/16000 as 0.5.

```
f=(0:NFFT-1)'*Fs/NFFT;
```

1.1.2.2

The figure of the signal is as below.

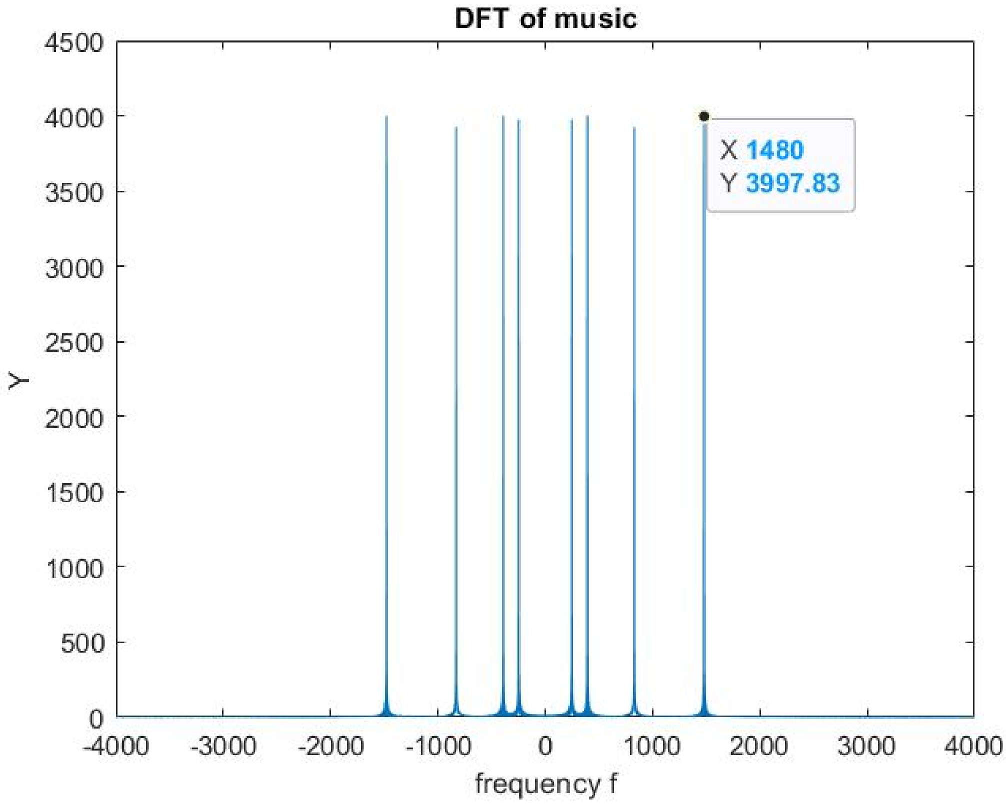

Figure 2. **DFT of the music**

1.2.1.1

We create a melody with note 25 and 107, the DFT figure of the signal is shown as below and the cutoff frequency I choose is 250 Hz.

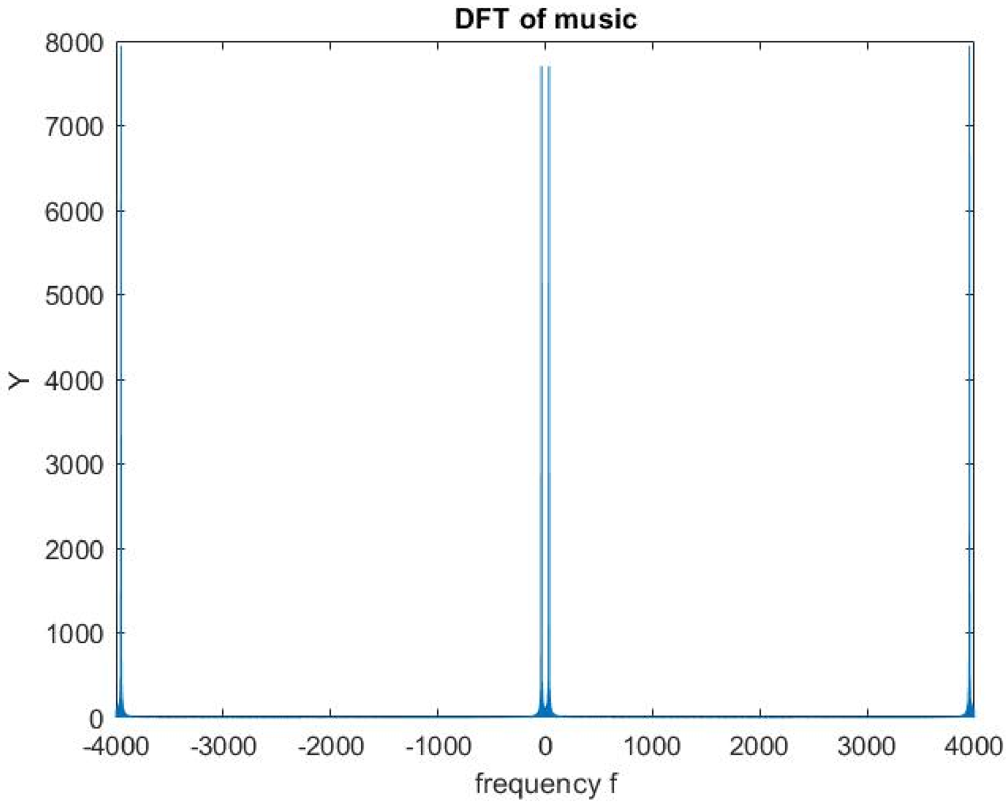

Figure 3. **DFT of the music**

1.2.1.3

The audio after the filter sounds deep. The DFT of the filtered audio is shown as below, we can see that we have removed the high frequency part.

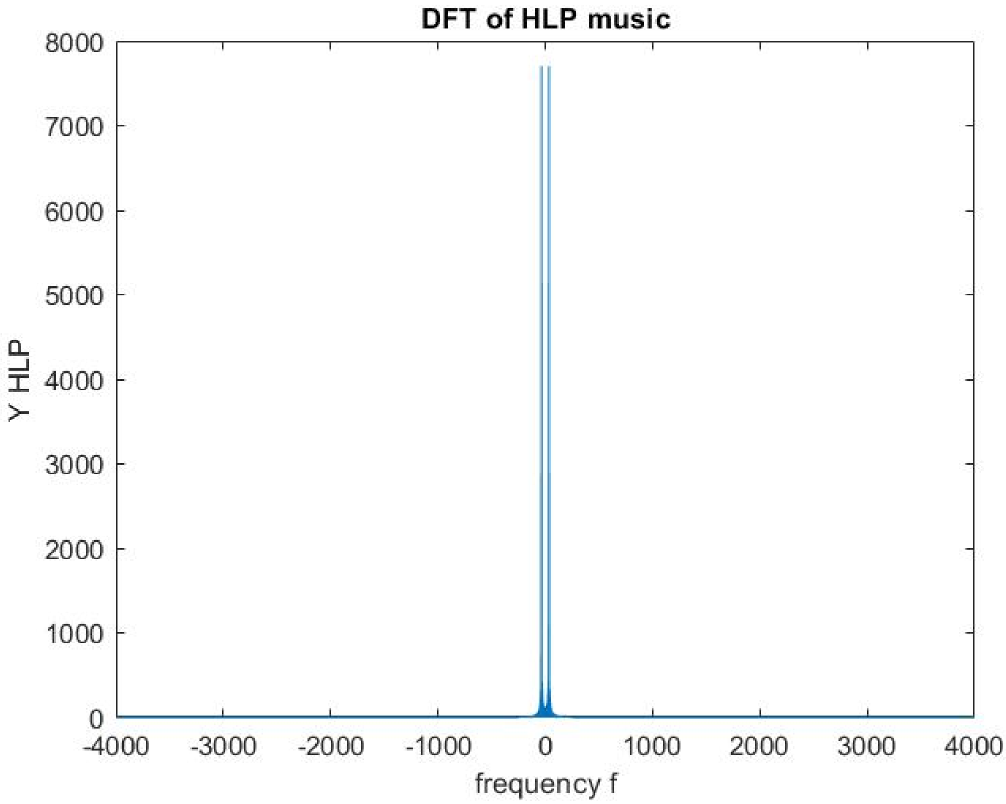

Figure 4. **DFT of HLP music**

1.2.1.4

The audio after the filter sounds sharp. The DFT of the filtered audio is shown as below, we can see that we have removed the low frequency part.

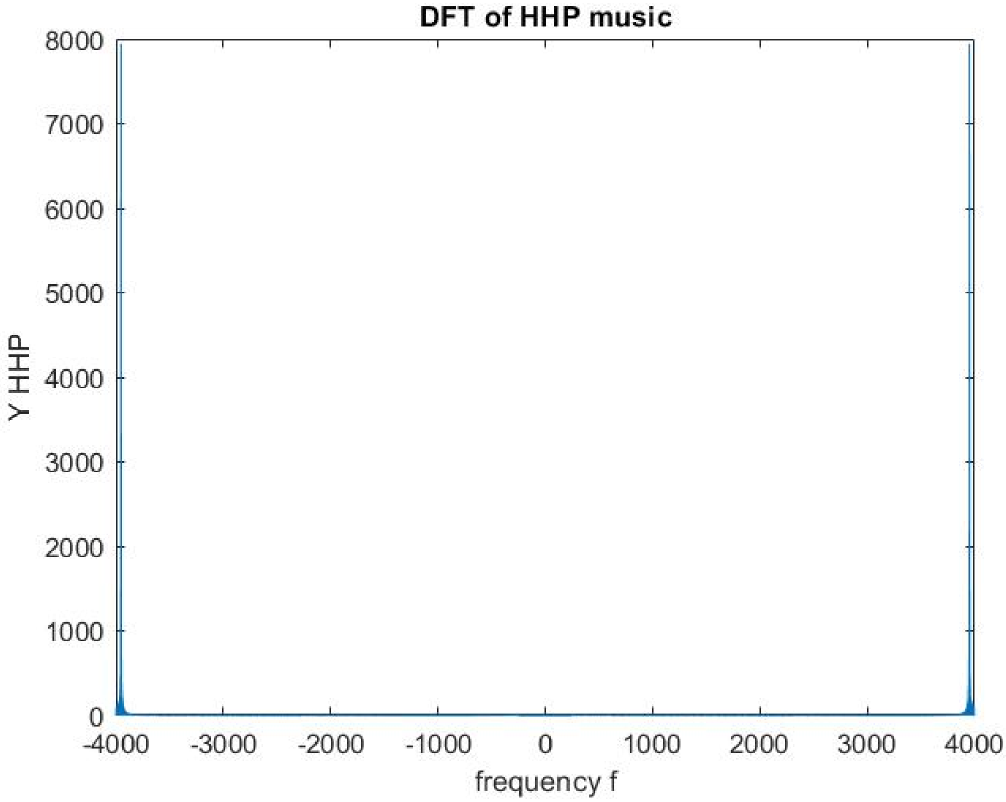

Figure 5. **DFT of HHP music**

1.2.2.1

I created a signal which contains the note from 51 to 60 and the duration of each note is 1 s. The DFT spectrum is as below.

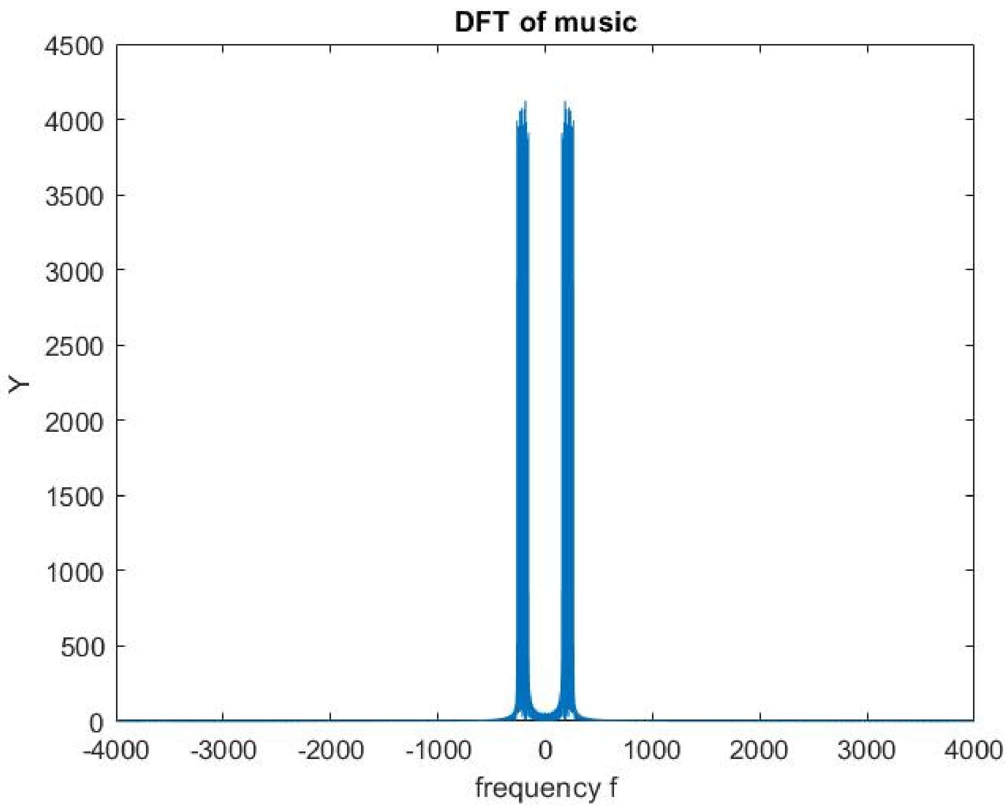

Figure 6. **DFT of x1**

1.2.2.2

I created a signal which contains the note from 72 to 81 and the duration of each note is 1 s. The DFT spectrum is as below.

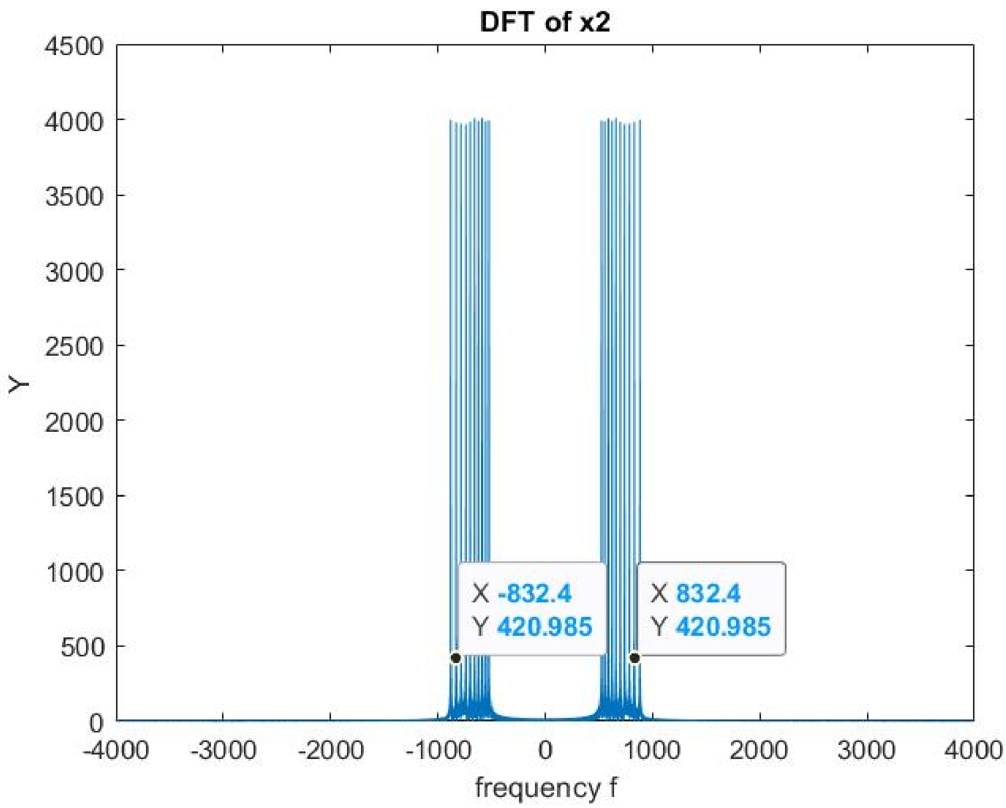

Figure 7. **DFT of x2**

1.2.2.5

The result signals are similar to the real sources. The Euclidean distance between x1 and y1, x2 and y2 are both 3.43.

1.2.2.6

The spectrum of the signals is shown as below.

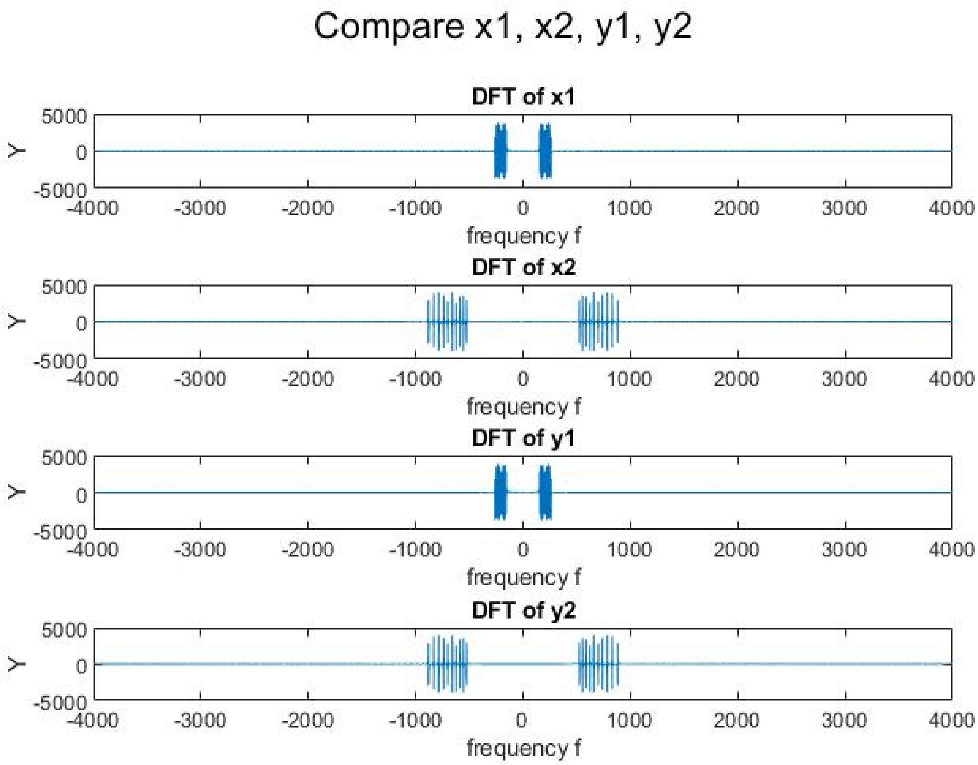

Figure 8. **DFT of x1, x2, y1, y2**

1.2.2.7

When we decrease the cutoff frequency to the threshold value , high frequency signal will be distorted by low frequency signal and the the low frequency signal will lose its information. When we increase the cutoff frequency to the threshold value , low frequency signal will be distorted by high frequency signal and the the high frequency signal will lose its information.

1.2.2.8

The spectrum of the original signal is shown as below. In order to obtain uniquely the melodic line, we could use a ideal low-pass filter with cutoff frequency is 70 Hz, and the result spectrum is also shown as below.

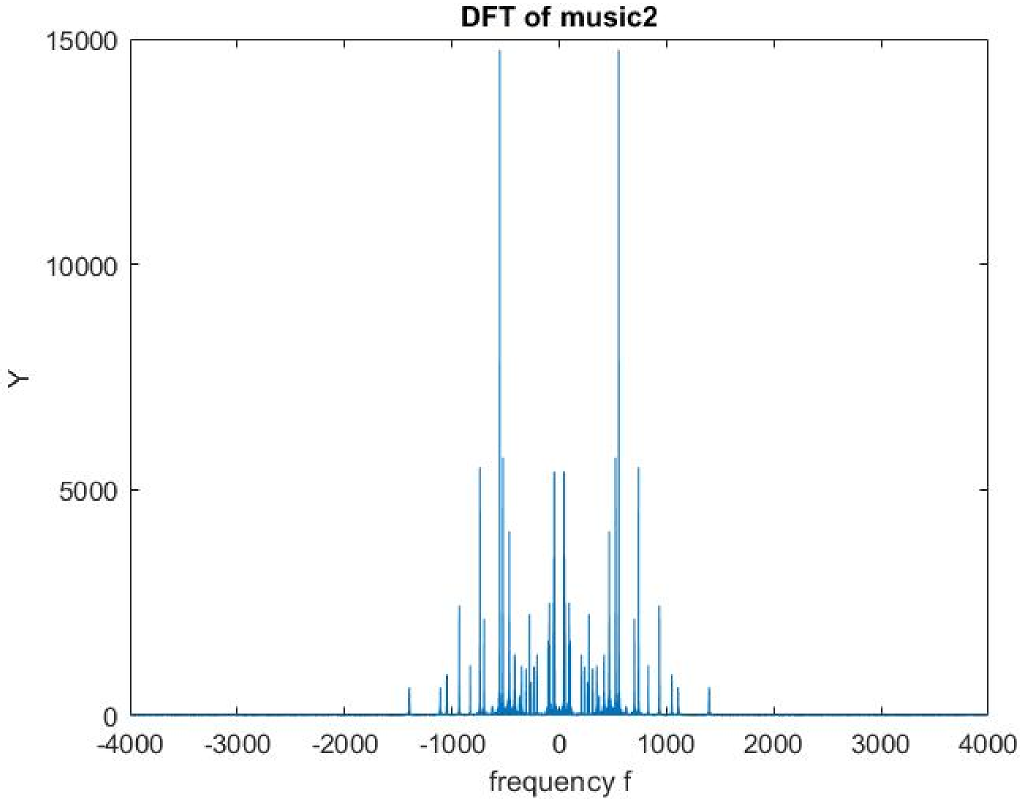

Figure 9. **DFT of original music**

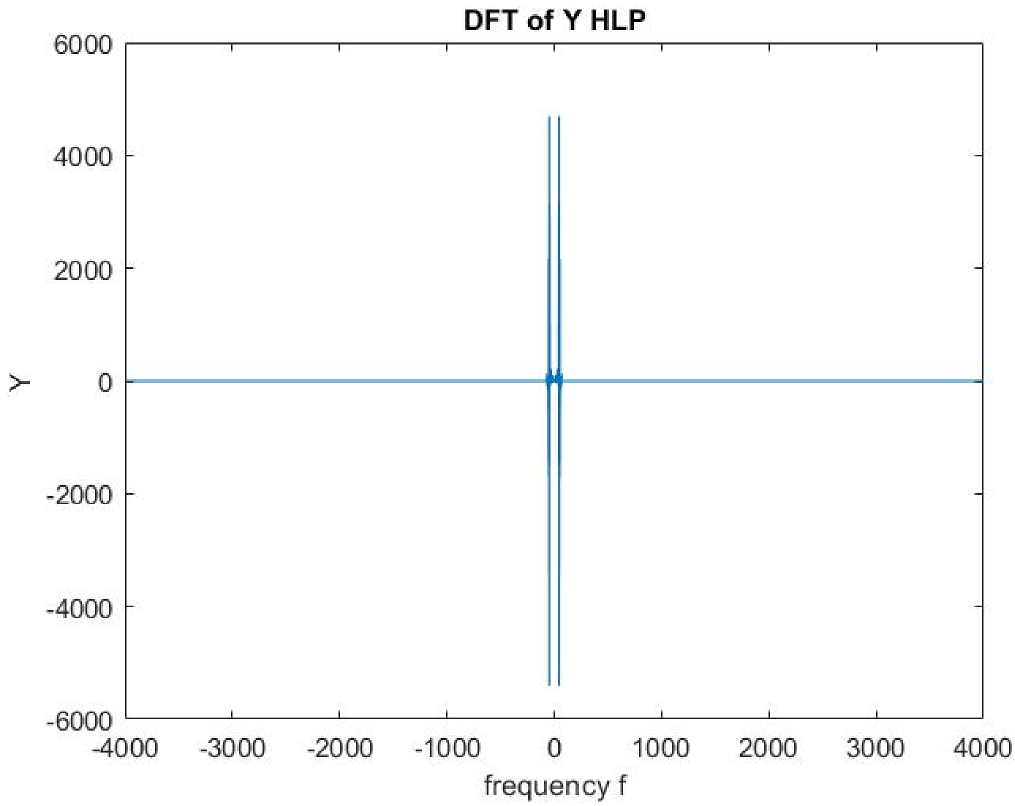

Figure 10. **DFT of uniquely the melodic line**

1.3.1.1 Full note

The Full note spectrum of each instrument are shown as below.

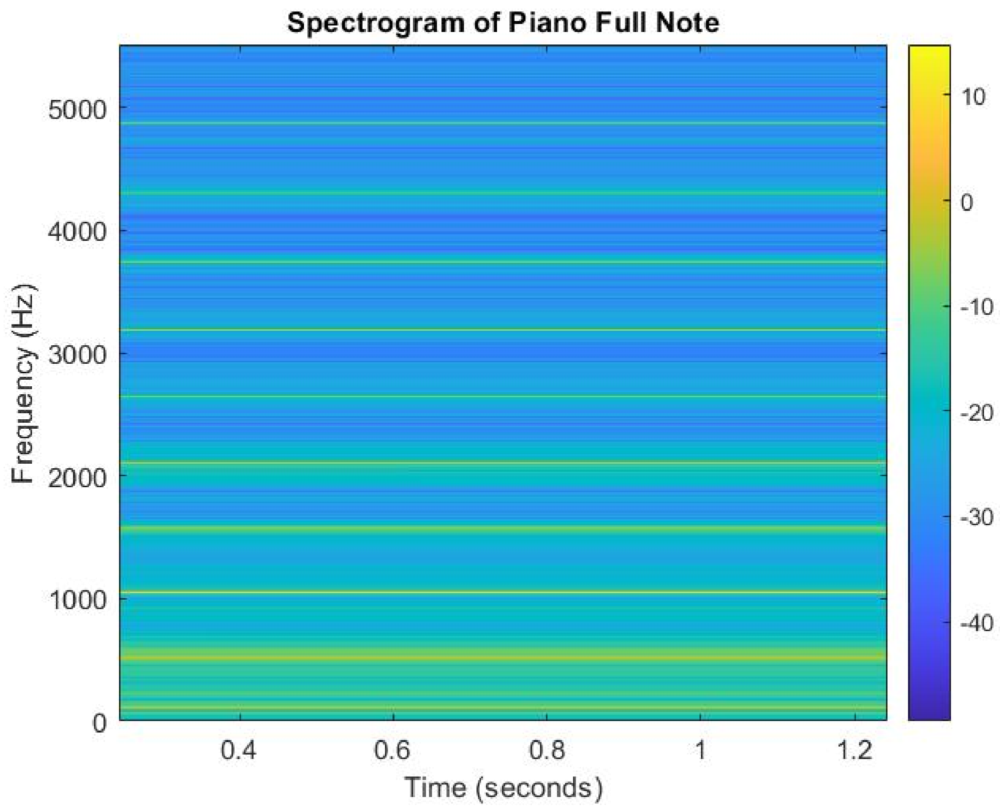

Figure 11. Spectrum of Piano Full Note

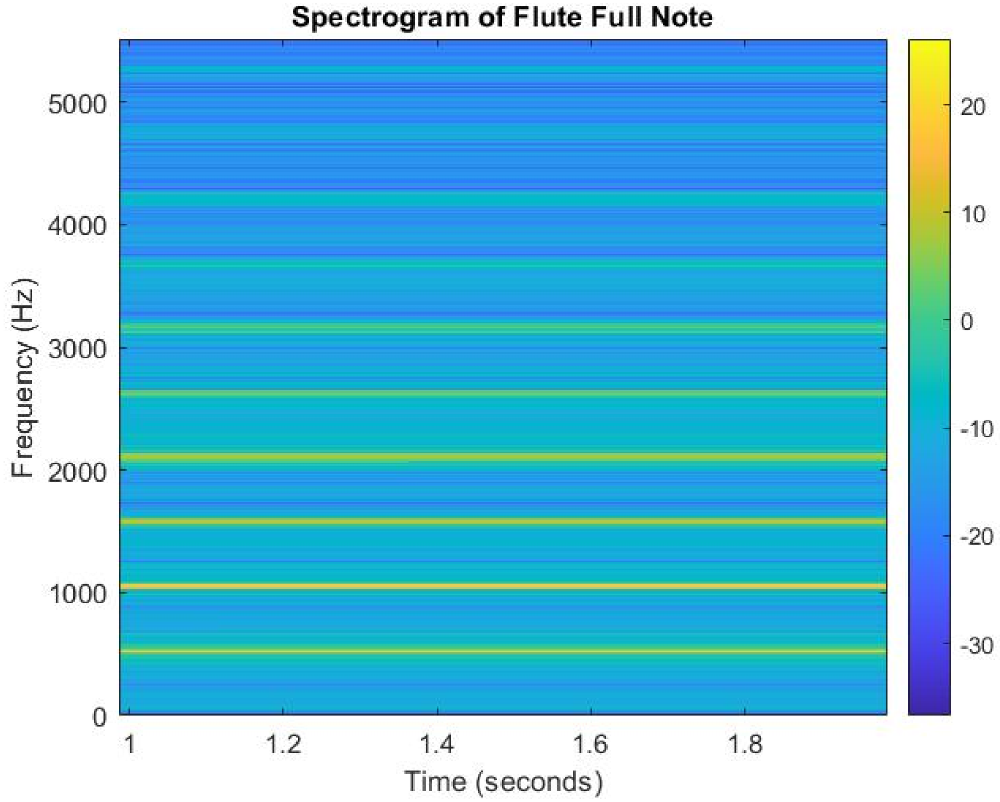

Figure 12. Spectrum of Flute Full Note

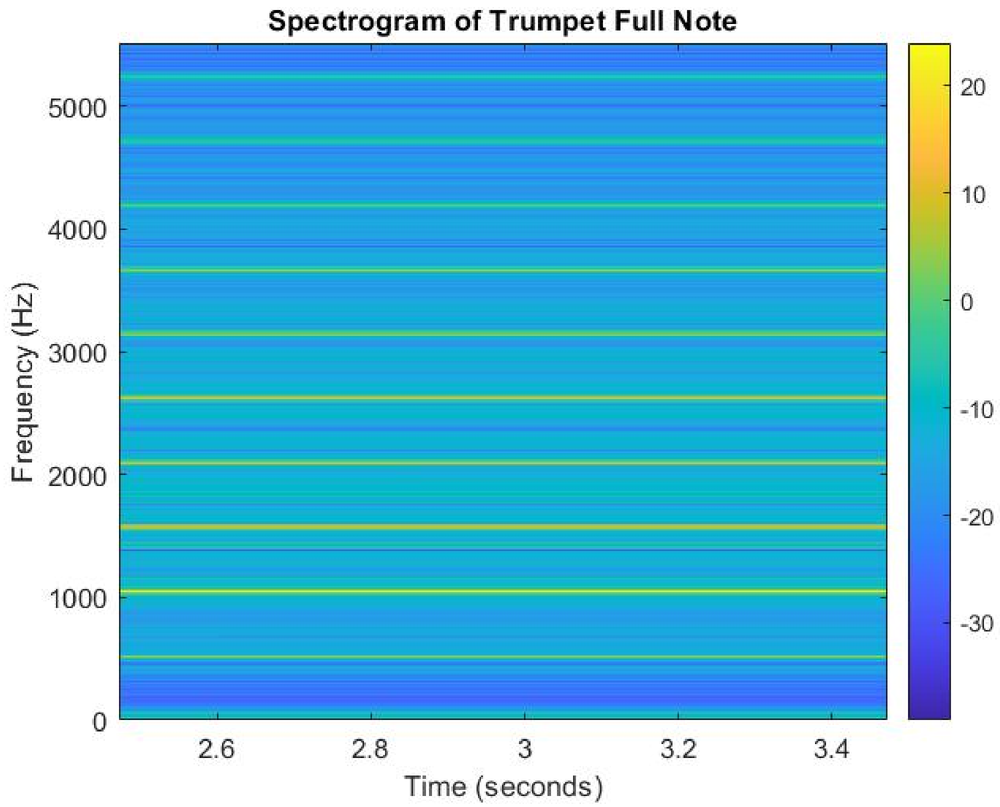

Figure 13. Spectrum of Trumpet Full Note

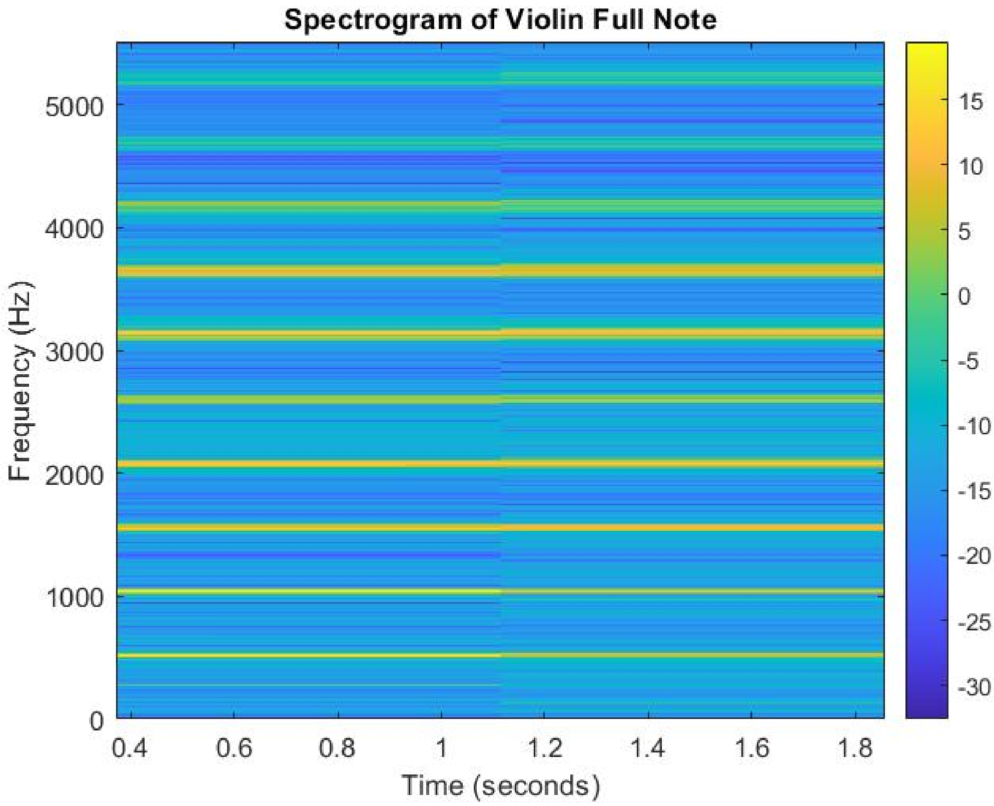

Figure 14. Spectrum of Violin full Note

1.3.1.2 Window length = 40ms

The spectrum of each instrument are shown as below.

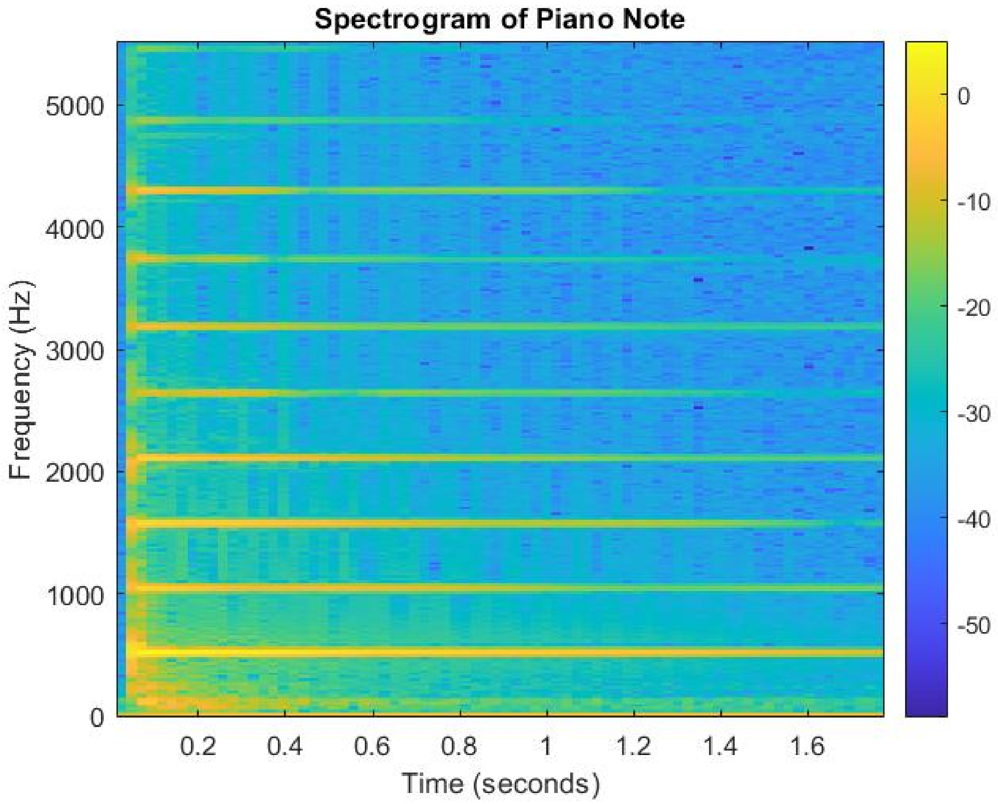

Figure 15. Spectrum of Piano Note

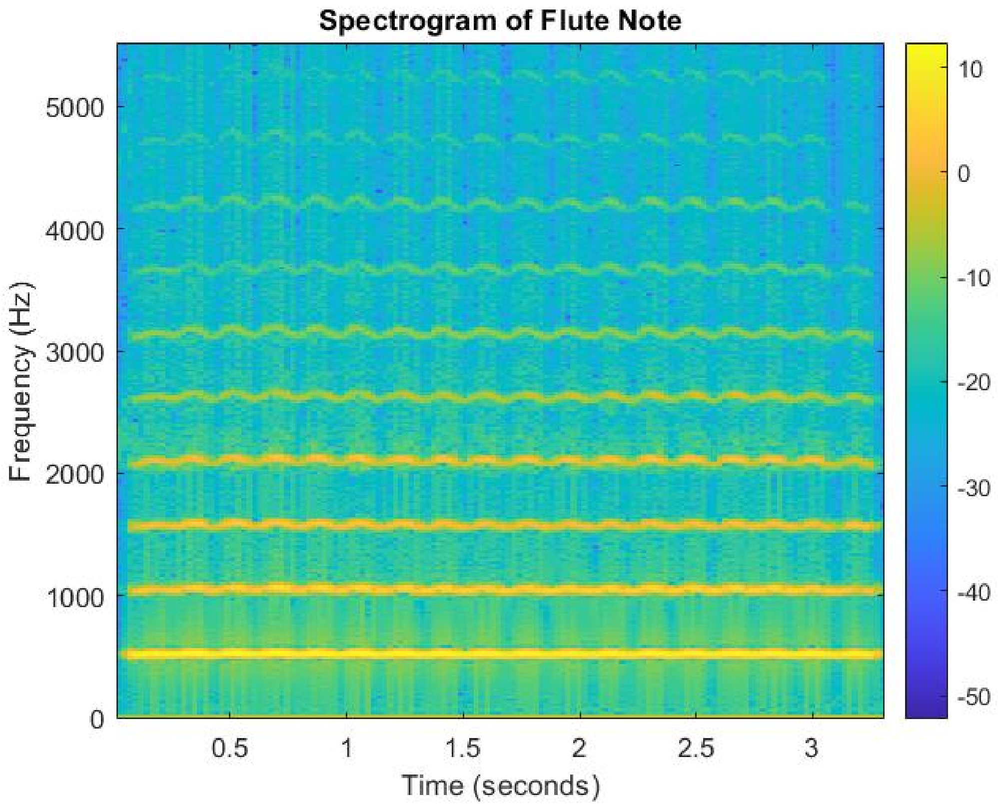

Figure 16. Spectrum of Flute Note

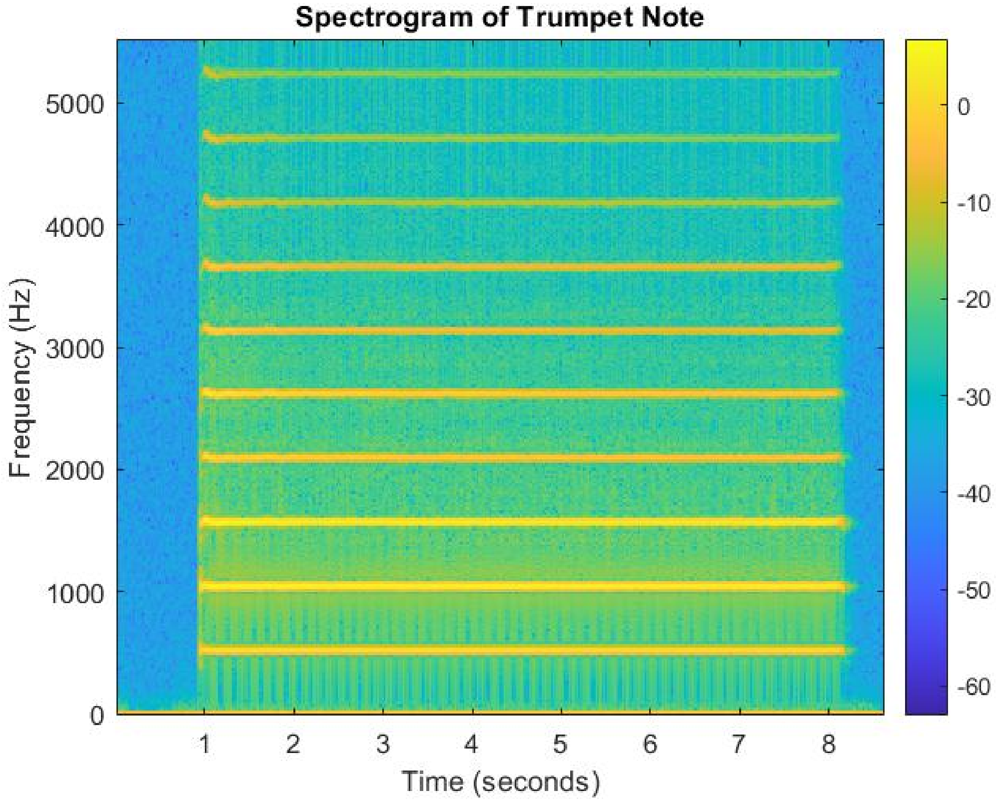

Figure 17. Spectrum of Trumpet Note

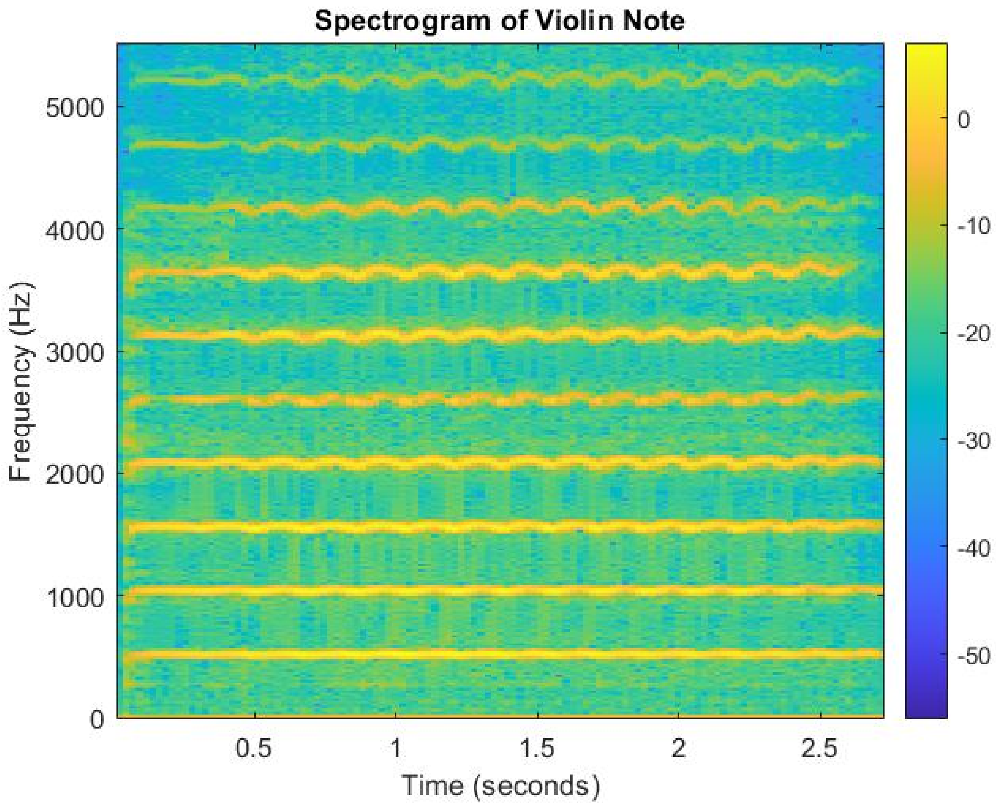

Figure 18. Spectrum of Violin Note

Through the spectrum, we can see that the spectrum diagram of different Musical Instruments has different performances at different frequencies, and the amplitude of the piano is more concentrated on its main frequency, and the attenuation is faster,as a result, it will perform more accurately. Violins, on the other hand, have a more uniform frequency distribution, decay more slowly, and behave more harmoniously.

Compare full note spectrum with STFT spectrum, we can see that in full note spectrum, there are no significant image differences between instruments. But we can distinguish instruments with STFT spectrum.

1.3.2.1

The spectrogram of the song(2'28 - 2'31) is shown as below.

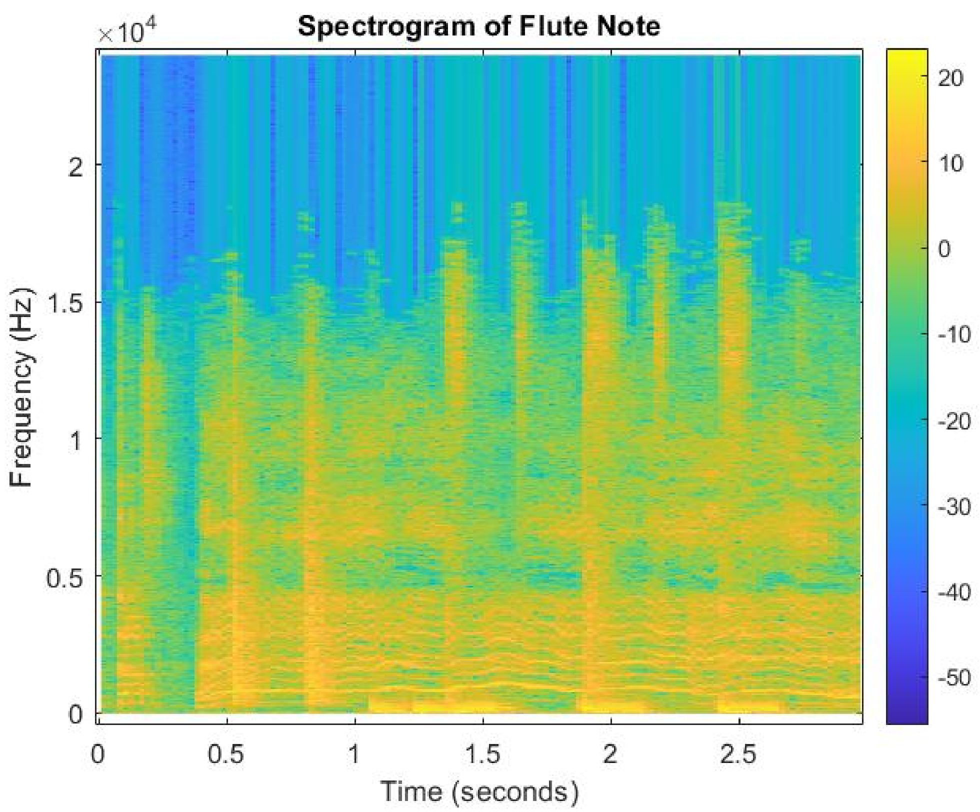

Figure 19. Spectrum of the music

1.3.2.2

The electro effect is the very low frequency part, the sing frequency is the continuous part vary from 0 - 0.5.And the drum is the sticks vary from 0 to 1.5.

1.3.2.3

The figure below clearly shows the spectrogram from 1s - 8s. With no human voice, it allows us to better distinguish between the three features

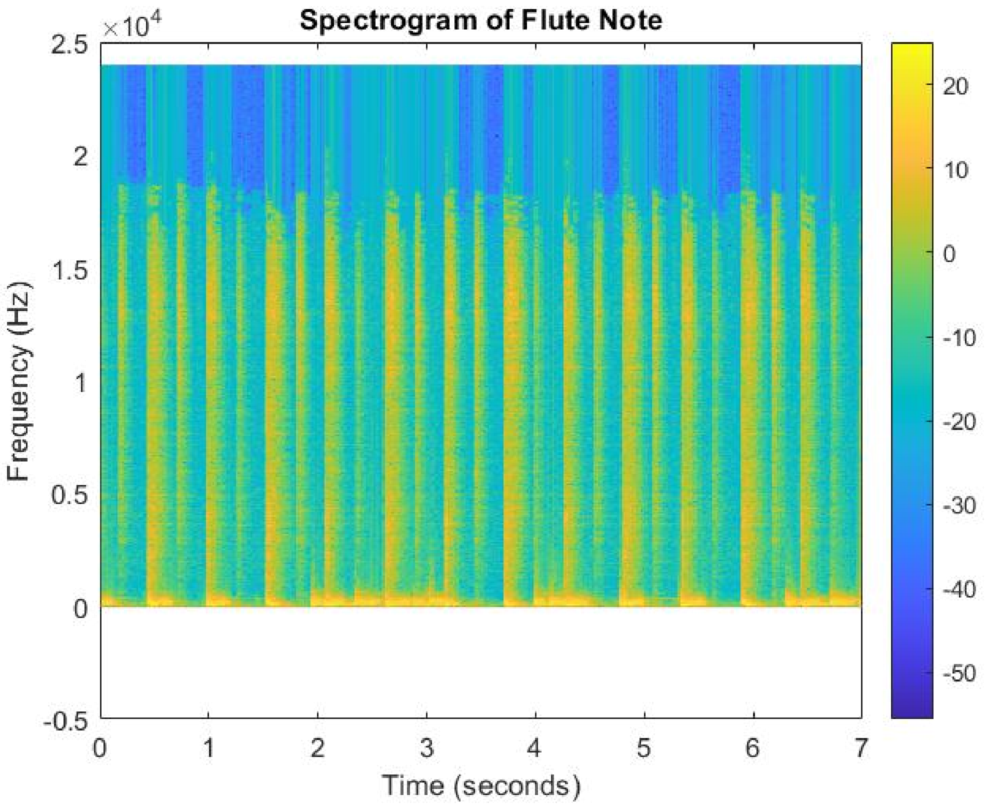

Figure 20. Spectrum of the music

1.3.3.1

The Spectrogram with different window size is shown as below.

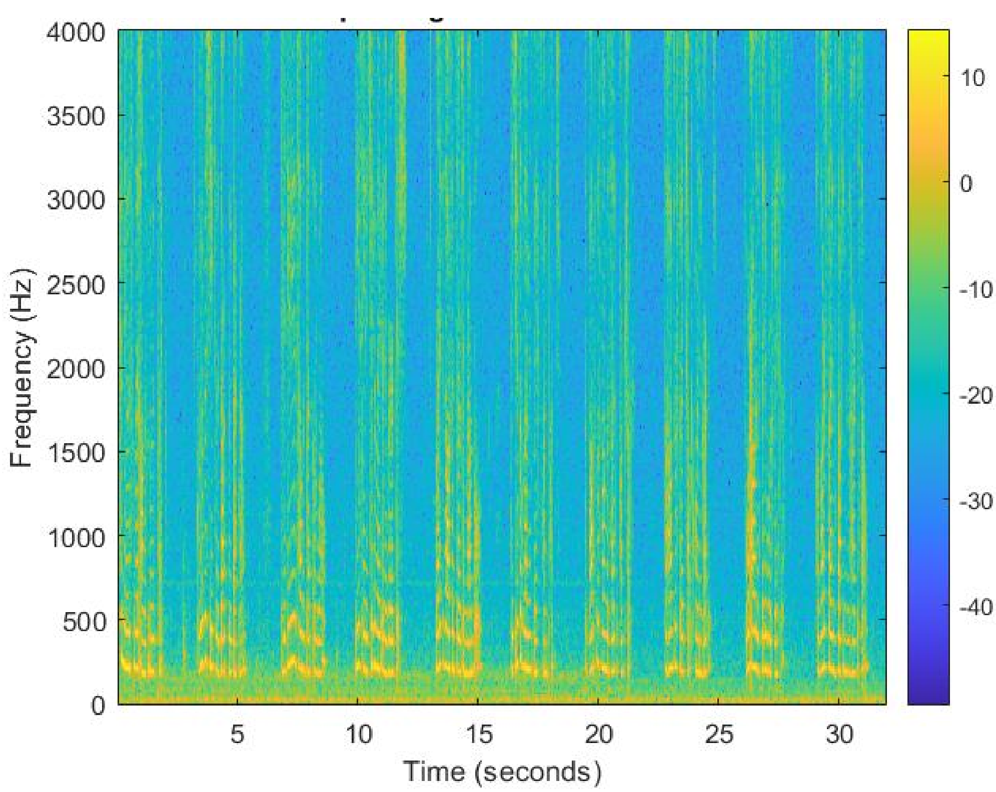

Figure 21. Spectrum with window size 40ms

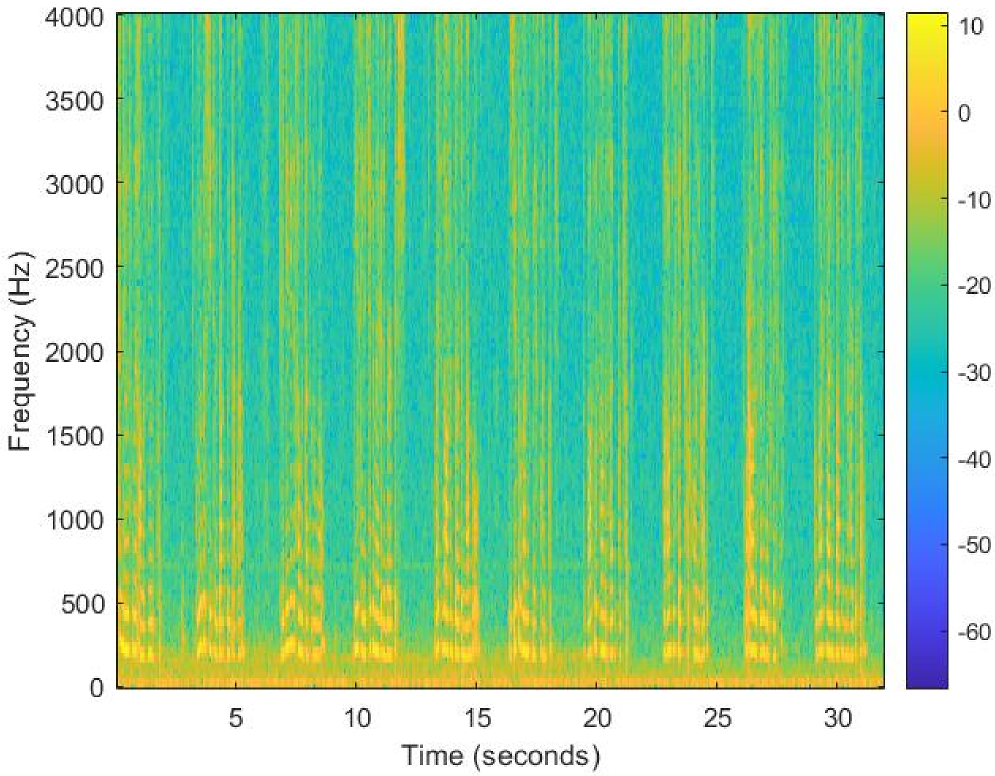

Figure 22. Spectrum with window size 20ms

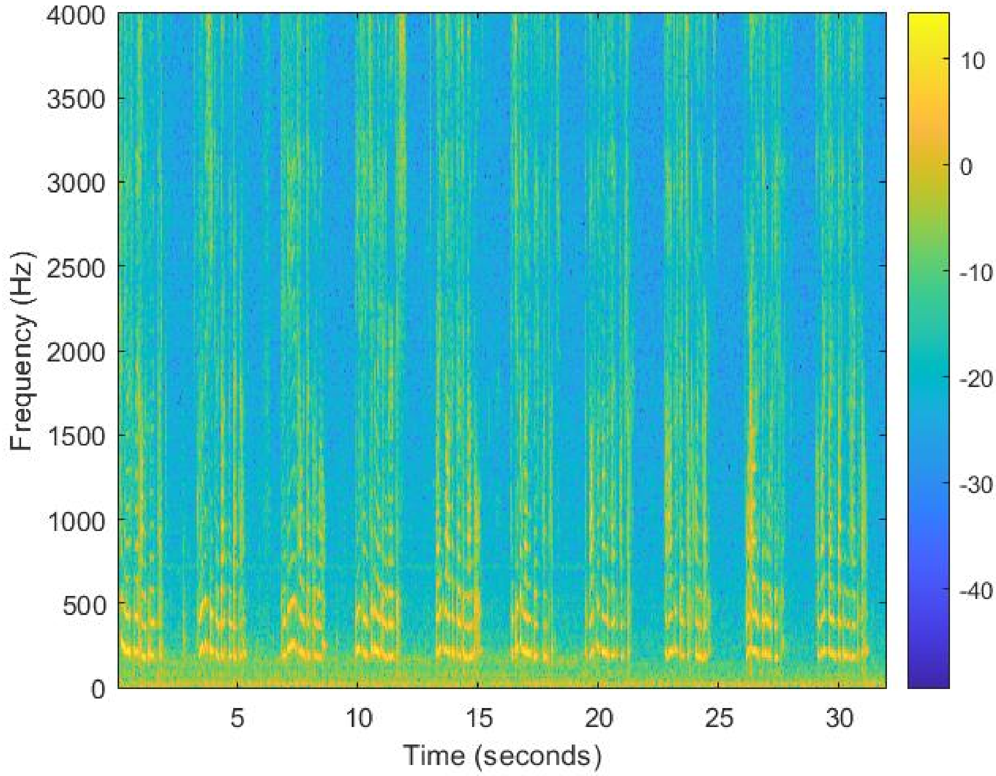

Figure 23. Spectrum with window size 60ms

1.3.3.2

The Spectrogram with a super-imposed tone is shwon as below. We can clearly distinguish the noise from the speech.

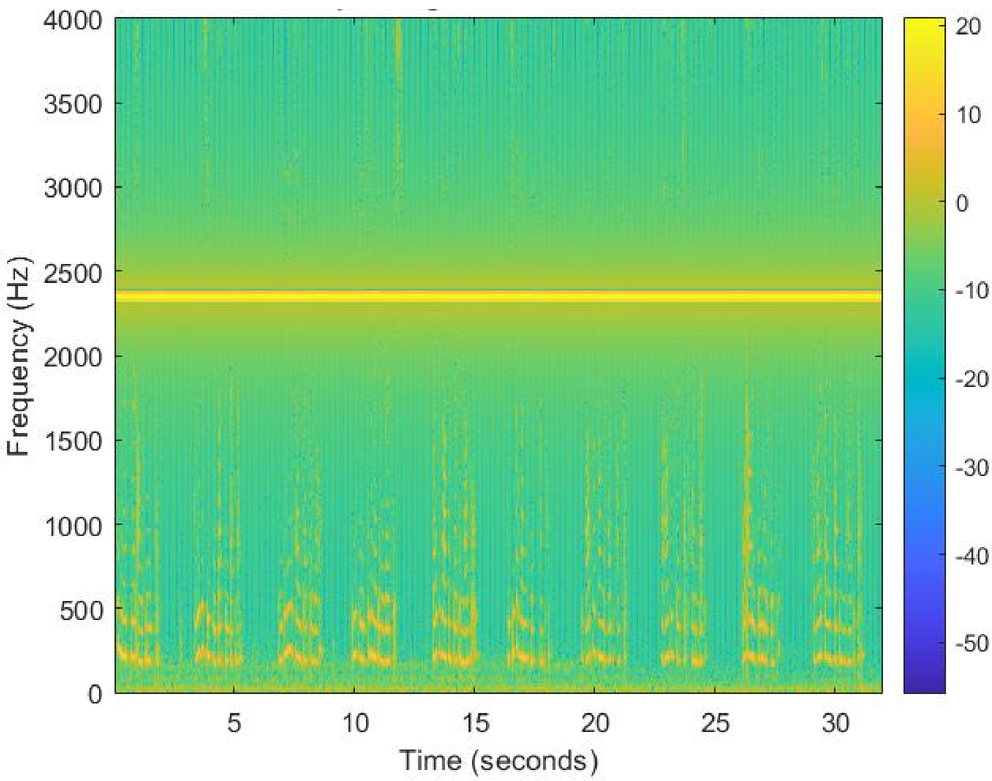

Figure 24. Speech with a noise note

1.3.4.1

The ECG of two types of patients is shown as below.

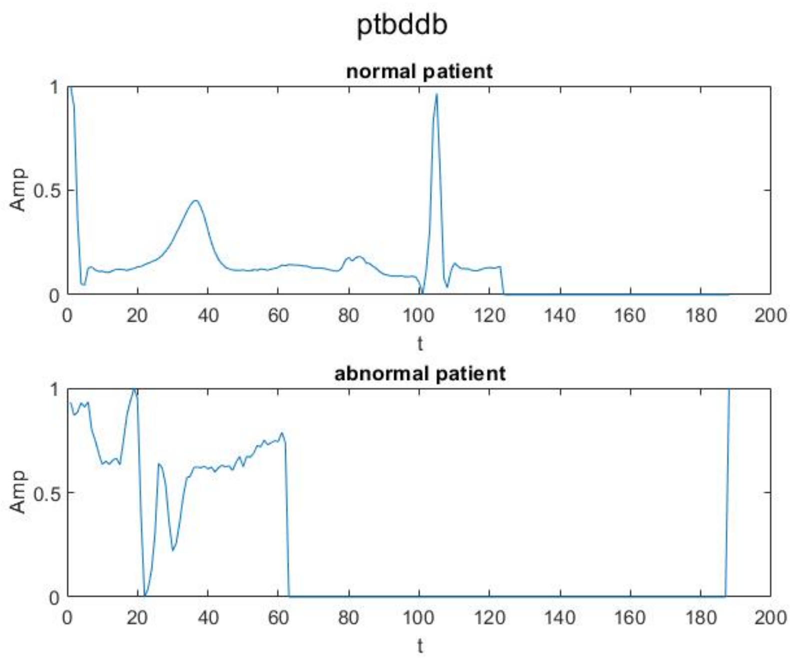

Figure 25. ECG of two types of patients

1.3.4.2

In time domain, we can see that there are distinct serrations in the waveform of the abnormal patient, and we can judge that the heart is in fibrillation. In frequency domain, we can see that the frequencies of anomalous images behave in a less periodic and more concentrated manner in time.

Through literature review and lab results, we know that each of the two methods has its advantages and disadvantages in electrocardiogram. The time domain map can identify the typical characteristics of P wave and F wave, but it cannot detect asymptomatic or paroxysmal fibrillation. STFT can show its dynamic change, improve the detection rate and prediction ability, but it is not convenient for rapid clinical diagnosis and typical feature recognition.

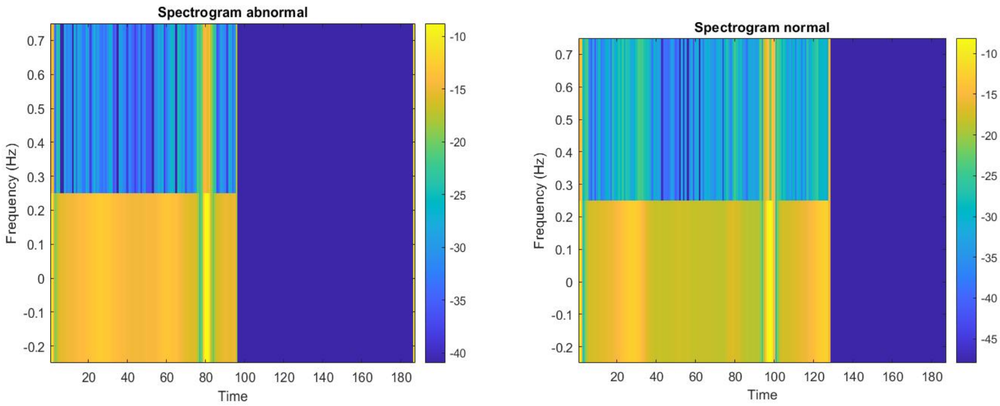

Figure 26. ECG of two types of patients