Musical Instrument Tuner

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Abstract—There are numerous types of signal processing with audio signal processing being a major sub-set. As the name suggests, audio signal processing is the processing of audio signals which are sound waves in their electronic form. This has wide applications like analog-digital format conversion, removal of background disturbance(noise) for clearer audio, addition of required effects, and many others. According to a number of studies, there is an acute need of representing musical audio signals in the form of their fundamental frequencies for the purpose of tuning. This paper proposes a moderate accuracy level representation of an audio file on the basis of power spectral density plot in order to determine whether the given note is flat or sharp that is to determine and verify a chord via audio signal processing on the basis of power or frequency spectral density plot using MATLAB. Result analysis of the fundamental frequencies was completed and compared with the values of fundamental frequencies of various musical instrument notes from the database chart. In this paper, we have used the Welch Method and the Periodogram Method to compute the power spectral density.

Index terms-Audio signal processing, Welch power spectrum, Periodogram power spectrum, fundamental frequency, audio octave level, audio string.

I. Introduction

The human auditory system, with a hearing range of 20Hz-20kHz, is capable of processing complex mixture of sound and identify the sources and environmental abstractions. Such a process is called auditory scene analysis. But it is not sensible enough to always determine correctly with accuracy if for given audio octave level-string played is sharp or flat. This is where the problem arises for the musicians. People operating with musical instruments have a problem in determining whether the tune or note that they are playing is flat or sharp. For a given audio octave level, if the frequency of the note goes higher than its required fundamental frequency, it is called a sharp note. Similarly, if it goes lower than its required fundamental frequency, it is called a flat note. It makes a significant difference if flat note of a string is played instead of its sharp note and vice versa i.e. G flat instead of G sharp results in lower frequency note which sounds out of tune while playing a musical instrument. There are a number of power spectral density types to estimate the fundamental frequencies of a given audio file- Welch method, periodogram method, covariance method, Burg method among others.

II. Theory

A. Welch's Method

Welch's Method is used for estimating the power of a given signal at different frequencies.The spectrum is a result of converting a signal from time domain to frequency domain.The noise generated is reduced in the Welch's method of spectral density estimation. [1]

B. Fast Fourier Transform

A signal consists N number of complex points in the time frequency system , these points contains two values that is real and imaginary. The N point time domain signal is obtained by decomposing the N time domain signal each of them have single point. The next step is of finding the N frequency spectra of the obtained N time domain signal and the end step is synthesizing the the N spectra into a single frequency spectrum, this concept can be understood by a simple example of 16 point signal which is decomposed in 4 different stages, here we first make 16 point signal into two, 8 point signal then in next step these two 8 point signal is decomposed into 4 signals of 4 point. This process keeps going on till there are N signal having single point. The decomposition used for cutting the signal in two is called as interlaced decomposition.

III. Methodology

Audio signal processing [2]of the played note was carried out on MATLAB software.The input is an audio file which will be obtained by recording the voice note played by the string instrument.The audio signal can be in any any format such as .mp3, .wav, .wma, .ogg among others.The audio signal was converted into audio samples for further processing.The Welch Power Spectral Density Analysis helps in determining the fundamental frequency of the note.The spectrum was analysed and observed.The fundamental frequency obtained by the spectral analysis of the audio signal was then compared with the chord frequency chart shown in Fig. 1.If the obtained frequency of the voice note is greater than the fundamental frequency of the chord then the instrument is sharp, similarly if the obtained frequency is lesser than the fundamental frequency then it is flat.Thus, we computed whether the instrument is in tune or out of tune.The Fast Fourier Transform of the voice signal was also observed and analysed [3]. The code for determination of fundamental frequency was written on MATLAB software and the required waveforms were obtained.The waveforms that were analysed were Welch Power Spectral Density Analysis, Periodogram Spectral Analysis, Fast Fourier Transform Spectrum.The time taken for execution of Welch Spectrum and the Periodogram Spectrum were noted. [2] [3]. [1].

	OPEN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Guitar	E 330	F 349	F# 370	G 392	G# 415	A 440	A# 466	B 494	C 523	C# 554	D 587	D# 622	E 659	F 698	F# 740	G 784	G# 831	A 880	A# 932	B 988	C 1047
Guitar	B 247	C 262	C# 277	D 294	D# 311	E 330	F 349	F# 370	G 392	G# 415	A 440	A# 466	B 494	C 523	C# 554	D 587	D# 622	E 659	F 698	F# 740	G 784
Guitar	G 196	G# 208	A 220	A# 233	B 247	C 262	C# 277	D 294	D# 311	E 330	F 349	F# 370	G 392	G# 415	A 440	A# 466	B 494	C 523	C# 554	D 587	D# 622
Guitar	D 147	D# 156	E 165	F 175	F# 185	G 196	G# 208	A 220	A# 233	B 247	C 262	C# 277	D 294	D# 311	E 330	F 349	F# 370	G 392	G# 415	A 440	A# 466
Guitar	A 110	A# 117	B 123	C 131	C# 139	D 147	D# 156	E 165	F 175	F# 185	G 196	G# 208	A 220	A# 233	B 247	C 262	C# 277	D 294	D# 311	E 330	F 349
Guitar	E 82	F 87	F# 92	G 98	G# 104	A 110	A# 117	B 123	C 131	C# 139	D 147	D# 156	E 165	F 175	F# 185	G 196	G# 208	A 220	A# 233	B 247	C 262
Note and frequency in Hertz (approx.) for standard tuning.																					
Bass	G 98	G# 104	A 110	A# 117	B 123	C 131	C# 139	D 147	D# 156	E 165	F 175	F# 185	G 196	G# 208	A 220	A# 233	B 247	C 262	C# 277	D 294	D# 311
Bass	D 73	D# 78	E 82	F 87	F# 92	G 98	G# 104	A 110	A# 117	B 123	C 131	C# 139	D 147	D# 156	E 165	F 175	F# 185	G 196	G# 208	A 220	A# 233
Bass	A 55	A# 58	B 62	C 65	C# 69	D 73	D# 78	E 82	F 87	F# 92	G 98	G# 104	A 110	A# 117	B 123	C 131	C# 139	D 147	D# 156	E 165	F 175
Bass	E 41	F 44	F# 46	G 49	G# 52	A 55	A# 58	B 62	C 65	C# 69	D 73	D# 78	E 82	F 87	F# 92	G 98	G# 104	A 110	A# 117	B 123	C 131

Fig. 1. Fundamental Frequency Chart

IV. SYSTEM FLOWCHART

The system flowchart is as shown in Fig. 2 The input audio file will be loaded and read.The Power Frequency Spectrum of the audio signal is then observed and analysed on the MATLAB software.The Fast Fourier Transform is computed. In this flowchart

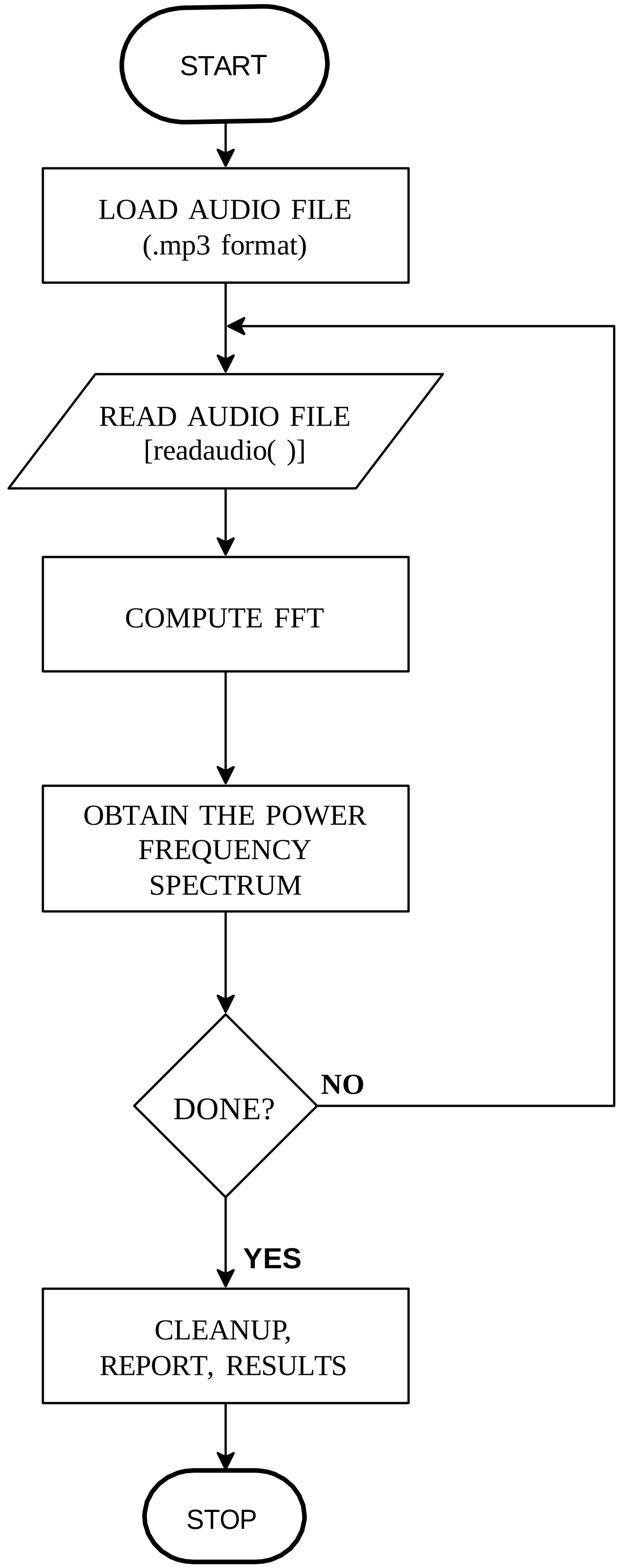

Fig. 2. Flowchart

V. RESULTS

The results of the strategy in this paper is focused towards analysis of the input audio signal. Determining the fundamental frequency of the audio signal using power spectral density analysis is essential in computing whether the instrument is in tune or not. Simplicity and digital implementations were essential during the analysis.The efficiency obtained by Welch Power Spectrum was found to be better than that of the Periodogram Spectrum [1]

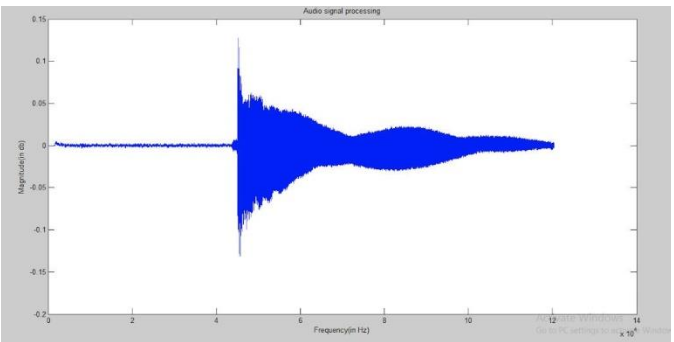

Fig. 3. Audio Signal Processing

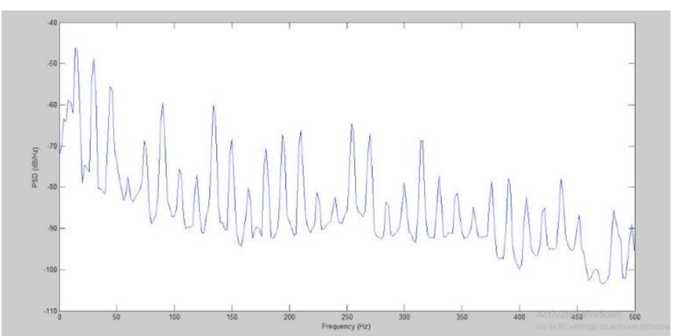

Fig. 4. Welch Power Spectrum

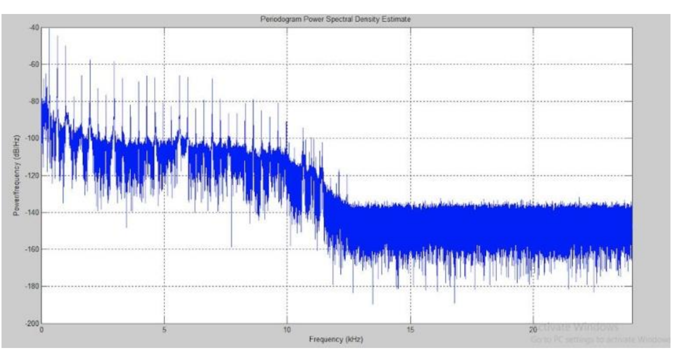

Fig. 5. Periodogram Power Spectrum

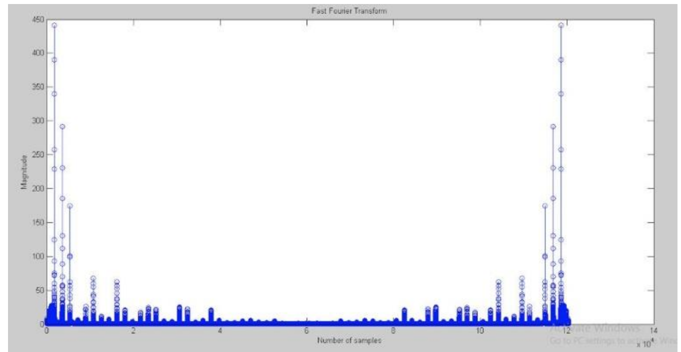

Fig. 6. Fast Fourier Transform

VI. CONCLUSION

Our study has been towards the analysis and determination of the fundamental frequency of the audio signal. The Power Density Spectrum analyses the signal and tells us the fundamental frequency of the played note. Thus, the problem of calculating the frequency of a voice note is solved. With this we computed whether the instrument is in tune or out of tune.

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