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Electronic Method for Detection of Heart Valve Defects

Aparajita Naik, Jivan Parab, Rajendra Gad

Abstract*: *This article describes a sophisticated method for detection of Heart valve defects at early stage i.e Grade 1 murmur without the expertise of a doctor. The diagnosis based on heard heart sounds through, either a conventional acoustic or an electronic stethoscope is itself a very specialized skill that will take years to acquire. Sometimes the doctors cannot detect these defects till the murmurs reach grade 3 and above which generally is too late for prognosis. Here, we have taken the recorded heart sounds from 350 subjects and performed the Fast Fourier Transform(FFT) on it, but it didn't give satisfying result. We have also recoded heart sounds using phonograph for 20 subjects in noise free environment. In this technique Frequency component with the maximum magnitude (in Hertz) was observed to be of varying values across some heart sounds (for e.g., heart sound from subject 41=13.0588Hz and heart sound from subject 58=324.5293Hz). Hence normal heart sounds could not be categorized in a generic way. To overcome this problem, we have used Shannon energy method on same data file, which will classify the condition of heart by finding S1(lub) and S2(dub) frequency component, if they lie between 30-100Hz, the heart is normal and if it is above 100Hz then the heart function is abnormal..

Keywords* : *DSP, ECG, FFT, Heart Valve, Shannon energy.

Keywords* : *About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

The disease which is seriously threatening human health is CARDIOVASCULAR. The most important information about these diseases will be provided by analyzing the Heart sounds, which is necessary for diagnosing various kinds of cardiovascular defects. For every doctor and medical student it is mandatory and basic requirement that analysis of Heart sound. The fundamental component for cardiac diagnosis is Heart auscultation . However, which is a difficult skill to acquire. The technology used earlier i.e analogue phonocardiograph doesn't have quantitative analysis hence Heart sound auscultation which is a subjective and qualitative approach. Wavelet Transform , Short-time Fourier Analysis (SFZ), Auto Regression Model which are stationary analysis and time-frequency analysis adopted by Digital phonocardiograph [1]. These methods resulted in some inferences after analyzing the first and second heart sound .Due to echocardiography methods, it is now possible to detect heart defects which were difficult earlier for diagnosis using ECG [2]. Due to the specialized skills necessary to monitor and interpret the echocardiography data results and also the higher price of such equipment, auscultation Method remains the main tool for screening and diagnosis. [3]. However, Drawing an diagnosis upon hearing the sounds acquired through either a acoustic method which is conventional or an electronic stethoscope will take many years to acquire, as this skill are difficult to teach in a oriented way.Thre are no such instruction for the diagnosis based on heart sound is offered in internal medicine and cardiology programs [4]. It would have been very handful if the benefits of technique based on auscultation could be obtained with a reduced learning curve, using low-cost, robust, and easy to use equipments. one third of the total death are due to cardiovascular disease based on science daily research [5] . The normal heart gives two sounds which are "lub" "dub". The first heart sound "lub" , named as S1, and it appears due closure of mitral and tricuspid valves at the beginning of systole which causes turbulence . The 2nd sound, "dub" or S2, is due to the closure of aortic and pulmonic valves, which signifies the end of systole. The time duration between the S1 and S2 defines systole (ventricular ejection) and the time between the S2 and the next S1 sound defines diastole (ventricular filling)[6]. S1 and S2 has components in 10-140Hz bands and 10-400Hz bands respectively.

Recent technology advances in recording data and signal processing in digital domain have made it possible to record heart sound and analyze the recorded signals [7]-[11]. However to analyze the recorded signals from the heart, it is necessary that various components of heart cycle are timed and separated. In this paper We have developed a method for detecting heart sounds and identifying the systole and diastole in auscultation signals. Based on the frequency of the signal, its intensity and location of the peak intensity point in the spectrum helps to analyze the murmurs of systolic and diastolic.

II. METHODS

There are several methods available to find the heart valve defects as discussed in introductory section.

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Here we have tested a FFT technique and Shannon energy technique to find the heart valve defects at early stage so as to take precaution and necessary treatment.

A.**Analysis of Heart sound**

FFT of complete heart sound

A database of recorded heart sounds of 350 normal subjects were obtained from a local hospital. A sample of a recorded sound with FFT signal is shown in Fig.1. The FFT of the complete heart sound of normal subjects was computed and the frequency component(Hz) of maximum amplitude was tabulated and graph of the same is plotted as shown in Fig. 2.

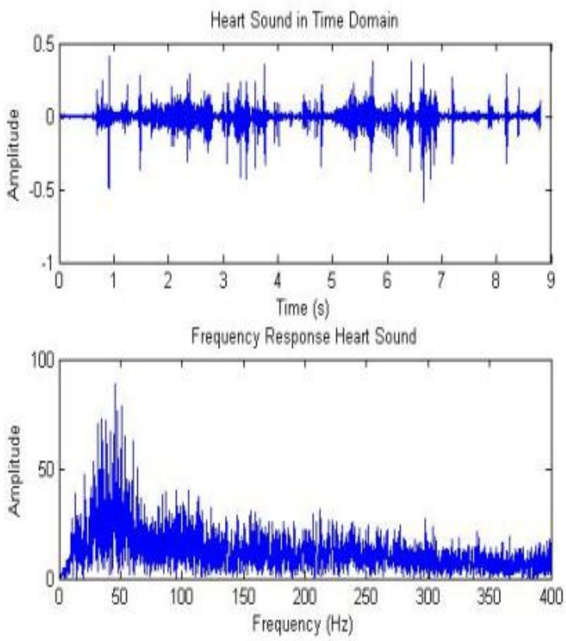

Fig.1 Normal heart sound and its peak amplitude at 45.3036 Hz

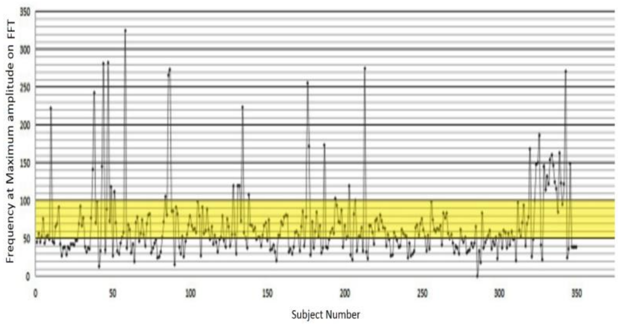

Fig. 2 Graph of all the heart sounds plotted

B. *Shannon Average Energy*

A normal heart has a clear "lub dub" sound pattern, with the time between S1 & S2 shorter than the time from S2 to the sunsequent S1 (when the heart rate is less than 140 beats per minute). Most of the time normal heart rates at resting state are between 60 and 100 beats per minute it will go to 140 in excited state.

The steps are correctly depicted in flowchart given in fig. 3. In the abnormal heart sound category, the heart murmurs sound also there is whooshing, roaring, rumbling, or turbulent fluid noise in one of two temporal locations: (1) from S1 to S2 or (2) between S2 and next S1. They can be the symptoms of most of the heart disorders, some of them may be of serious in nature. One of the things considered for diagnosis is the occurrence of the murmurs i.e. between S1 and S2 or between S2 and subsequent S1.

It is very important to suppress the noise in order to extract the meaningful diagnostic features from heart sound. The recorded signals were pre-processed before performing segmentation. Then the pre-processed signals were down sampled and Digitally filtered. The next step is to devise a method for determining the location of S1 and S2 sounds within the audio data, by segmenting the Normal heart sound data and Abnormal heart sound data and the segmentation was performed. Then, the Shannon envelope of the normalized signal was calculated along with the Shannon average Energy in continuous windows of 0.02 seconds throughout the signal with overlapping of 0.01 second. This method helps to reduce the effect of low noise and makes it possible for low intensity sounds easier to be detected. The every peaks of recorded portion, whose levels crosses the threshold value, are first selected and for time being assumed as the first or the second heart sound. Although there are more than one peak above the threshold value but here, only one peak for each overshoot is selected. The criteria for selecting the peak of every overshoot is based on : (1)at least one peak is selected; (2) two ar more peaks implies the presence of split first or second heart sound, hence the first peak is selected to get the onset of each and every sound [13]. In order to eliminate the additional peaks, the time intervals between every neighboring peak are calculated. In order to delete the extra peaks as shown in fig. 4a and fig 4b,the low-level threshold time limit is fixed at 30ms and high-level at 250ms. .

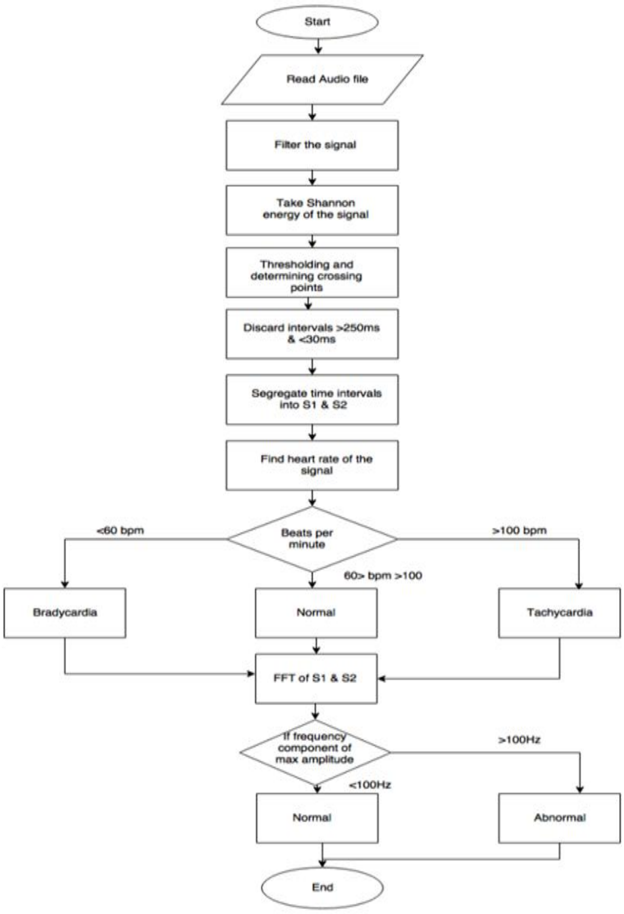

Fig. 3: Flow chart of technique

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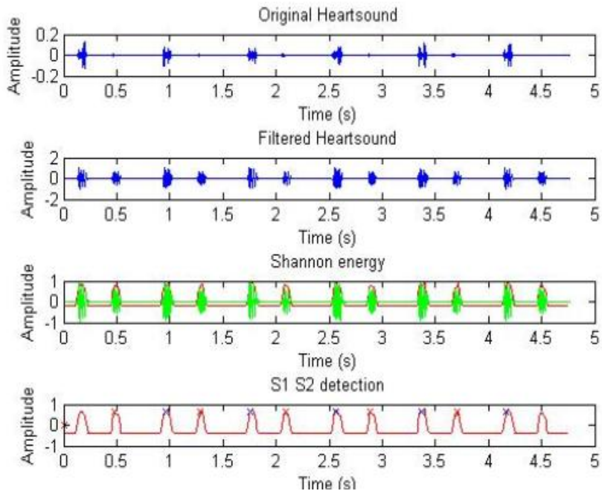

Fig 4a) Normal Heart sound

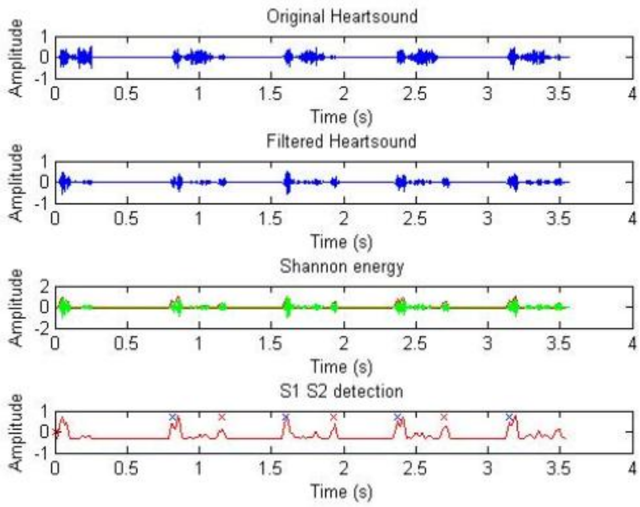

Fig. 4 b) Abnormal Heart sound

III. RESULT ANALYSIS

In the beginning we have performed Fast Fourier Transform(FFT) on the recorded heart sounds from 350 subjects, but it didn't give clear distinction about the status of heart condition. We have also recoded heart sounds using phonograph for subjects in noise free environment. In this technique Frequency component with the maximum magnitude (in Hertz) was observed to be of varying values across some heart sounds (for e.g., heart sound from subject 41=13.0588Hz and heart sound from subject 58=324.5293Hz). Hence normal heart sounds could not be categorized in a generic way. To overcome this problem, we have used Shannon energy method on same data file, which had clearly classified the condition of heart by finding S1(lub) and S2(dub) frequency component, if they lie between 30-100Hz, the heart is normal and if it is above 100Hz then the heart function is abnormal as shown in fig. 4.

IV. CONCLUSION

Recorded Heart sound reflects the heart valve functioning. By using Shannon energy algorithm the S1 and S2 are detected very accurately. This presented automatic detection and identifying algorithm will eliminate the noise interferences i.e. heart murmurs and background noises, and effectively detects the primary heart sound (i.e. First heart sound and Second heart sound). By using pre-processing technique low level murmurs and background noises is removed. The result obtained shows that it's nearly 95.6% successful detection . In spite of this method giving excellent performance for detecting S1 and S2 in heart sound, still it fails to detect the high amplitude level of heart murmurs which are the kind of early symptom of prosthetic valve dysfunction and heart malfunction.

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AUTHORS PROFILE

Aparajita Naik has completed her Master of Engineering, Bioengineering from University of California, Berkeley, USA in May 2018. She worked for her master's dissertation in the area of Non-Invasive Piezoelectric Sensor for Health Diagnostics and monitoring at UC Berkeley Fung Institute for Engineering. Prior to her master's degree, she studied at Agnel Institute of Technology and Design for her bachelor's degree in Electronics and communication engineering under Goa University, India. She worked in the area of Non-Invasive Blood Pressure Measurement by Fusion of Oscillometric and Auscultatory Principle for her bachelor's dissertation. Her research area includes brain computer interface, Biomedical device development and digital signal processing. She has attended and participated many national conferences and workshops.

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