Abstract

In this paper, a heart sound analyzer is presented for interpretation of heart sound signals and automated diagnosis of valvular heart disease. The heart sound analyzer includes data acquisition from multiple positions, signal analysis to extract auscultatory features and information, and an acknowledge-based program to provide a likely diagnosis. Experiments using clinical data from real patients show good performance for the automatic analysis. Due to its simplicity and fast implementation, the method has potential for clinical deployment and eventually to be used in distributed diagnosis settings.

Index Terms—Valvular Heart diseases, Auscultory.

1. Introduction

THE heart is divided into four chambers. The upper chambers are called atria while the lower chambers are called ventricles. Blood is squeezed by heart muscle from chamber to chamber. During the squeezing process, valves keep blood flowing as smoothly as possible into the heart and out to the body by automatically opening to let blood in from chamber to chamber and closing to prevent blood backflow.

Heart sounds, the composite sound produced by myocardial systolic and diastolic, hoist valve, blood flow and cardiovascular vibration impact, contain a great deal of physiological and pathological information regarding human heart and vascular. By combining the advantage of heart sounds analysis and traditional cardiac auscultation; phonocardiogram analyzer can treat diagnosis of early stage cardiovascular disease in the following steps: space location of heart sounds can be distinguished by using a headset, the heart sounds can be shown by real-time waveform which includes the normal sound and murmur. Cardiac auscultation can be visualized; Data of heart sounds can be stored in the long run, be quantified and analyzed through modern signal processing methods [1]. Electrical and mechanical activities are the basic activities of heart. In each cardiac cycle, electrical activities are conducted prior to the mechanical activities [1]. ECG reflects electrical activity of the heart. While PCG records the mechanical heart activity (acoustic phenomena). Normal heart sounds are composed of S1, S2, S3 and S4. The pumping action of a normal heart is audible by the 1st heart sound (S1) and 2nd heart sound (S2). The 4th heart sound (S4) appears with a lower energy prior to the S1 and 3rd heart sound (S3) normally appears after S2. On the other hand, murmurs are created by damage valves and fusion of the valve leaflets. So The objective of this project is to develop a low cost automatic heart sound analysis in computer systems. A heart sound analyzer is presented for interpretation of heart sound signals and automated diagnosis of valvular heart disease.

2. System Description and Theory

As shown in Fig. 1 heart sounds data is collected in data acquisition stage by using a stethoscope. They are filtered and amplified by a signal conditioning circuit. By this way, the heart sound waveform can be shown on the screen, at the same time, the heart sounds are played. Because the large volume near patients easily affects the acquisition quality of heart sounds, heart sounds can play not by speakers but headphone [3]. The headphone for auscultation must be selected carefully, it is required to wear comfortably and exclude external noise. In this paper monitor headphone is used and recommended. Data acquired using stethoscope was used as reference for detection and comparing of heart sounds of patients. Created database for typical valvular heart diseases. Pre-processing - In the step of preprocessing s3 and s4 sounds were removed. Post-processing - In this stage using a specific algorithm (explained in latter chapters) diagnosis for the heart diseases done. Diagnosed Disease
3. Signal Processing And Real Time Playback Software

The major components of heart sound wave are below 500 Hz, and the murmur is below 1500 Hz, so the signal is passed through the Bandpass filter then it is applied to amplifier. The output of amplifier is given to the computer for processing. Now, the processing is done in Matlab. The input signal is having a very high number of samples. So the number of samples is reduced to a adequate level by using a windowing method. Then segmentation of waveform is done. After this, envelope of the original signal is calculated by using Homomorphic Envelogram method. An envelope is, as the name suggests, a smooth curve covering the whole signal [1]. Although envelopes have less information than the signal itself, they facilitate the detection of sound lobes and the respective boundaries. This section describes how to obtain the envelope of a signal using Homomorphic Filtering.

A. Homomorphic Envelopogram Method

Theoretically, a signal can be seen as a product of its frequency (FM) and amplitude (AM) components [2]. Theoretically, a signal can be seen as a product of its frequency (FM) and amplitude (AM) components.

\[ s(t) = f(t) \cdot a(t) \]

As the first step, we consider the logarithm of the modulus of the signal,

\[ s'(t) = \ln|f(t) \cdot a(t)| \]

Since the logarithm is being applied, zeros in the signal must be first eliminated, so, a small, arbitrary value is added to the modulus, before applying the logarithm.

Considering the properties of logarithm and knowing the AM component is always positive we have:

\[ s'(t) = \ln|f(t)| + \ln a(t) \]

The FM component has higher frequencies, thus, by applying an appropriate low-pass, linear filter L that component can be eliminated while the AM one is preserved:

\[ sf'(t) = L[\ln|f(t)| + \ln a(t)] \]

\[ = L[\ln a(t)] \]

Finally, the envelope, called Homomorphic Envelogram, is calculated by exponentiation of the last term. After obtaining an envelopogram using the above algorithm the last step includes the correlation of sounds recorded with the patients one. Here a question may arise why not use correlation at the first step itself? Without performing following steps but after going through research papers it proved that to obtain an efficient and reliable diagnosis one has to perform the steps so that sound is processed in an more efficient way. Thus, we can say that before coorealting different heart sounds, a particular set of steps has to be followed called as preprocessing techniques so as to make sure for reliable diagnosis.

4. Simulation Experimental Results

During laying out plan for the project it was encouraged to design a digital stethoscope. Working through the stethoscope it was found that the efficiency of a digital stethoscope was very low. As the analysis is completely mathematical noise and other disturbances was a major source of inefficency and incorrect analysis. As a solution to this, for checking the efficiency of the system a more software was tested in a more practical way. Heart sound was given to analyzing software through a microphone. Microphone was selected so as to give input heart sound along with other disturbances (Surrounding noises of fan, speech etc.) Testing the system through this way showed satisfactory results. Fig. 2 shows graphical representation of heart sound recorded. Multiple cycles are shown in this window so as to give a clear picture to the medical students about the interval murmurs. Fig. 3 shows a single cycle of the browsed sound wave. Number of samples can be reduced. inorder to decrease the processing time one has to trade-off between number of samples and processing time. Even though samples are reduced my certain number, it hardly affects analysis. Fig.4 shows an envelopogram. No negative values in graph is clearly noticeable. Fig.5 displays a window showing diagnosis and name of the valvular heart disease.

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5. Conclusions

The correct identification of S1 and S2 lays ground for the detection of pathologies, since by having S1 and S2 segmented, both the diastolic and systolic period can be analyzed for the presence of murmurs and extra heart sounds, indicating possible pathologies. Heart sounds are one of most important human acoustic signals. Developing heart sounds analyzer which combines the traditional clinical auscultation advantage, quantify and analyze the heart sounds signal is of vital social and economic value.

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References

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