A Novel Design and Development of Condenser Microphone Based Stethoscope to Analyze Phonocardiogram Spectrum Using Audacity

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ABSTRACT
Phonocardiography is one of the major medical interpretations to determine heart valve problems. However, capturing it properly and processing the data often becomes troublesome. Our goal was to reduce the complexity. We designed and developed a condenser based microphone and captured the Phonocardio Gram (PCG) signal and analyzed it using Audacity. We inserted a condenser based microphone inside the stethoscope. We have used miniaturized microphone as much as possible in order to not jeopardize the vibration of diaphragm. After our own developed circuit we recorded the heart sound directly by the stethoscope and it is sent to Audacity 2.2.2 using stereo microphone input of computer and we got very prominent signal of PCG and its spectrogram was observed for determination of physiological disorder of heart specially heart valves. Which implies, in future these data of a normal subject can be compared with a patient with heart valve and other mechanical heart problem and from that a new and simpler system can be developed which can determine any heart valve problems specially murmur condition of the heart.

Key words: Phonocardiography; Condenser; Microphone; Audacity; Heart valves; Murmur.

INTRODUCTION
Heart is a muscular organ which helps in pumping as well as in circulation of blood. The four valves present inside human heart named mitral valve, tricuspid valve, aortic valve and pulmonary valve are responsible for the unidirectional blood flow. Heart sounds are produced as a result of closure of heart valves and resultant flow of blood. Two prominent heart sounds S1 and S2 are produced by the closing of atrioventricular valves and semilunar valves respectively; another low intensity heart sound S3 is produced due to the opening of mitral valve. The fourth heart sound or S4 is generally not audible but it can be audible in case of more rigid ventricles [10]. Phonocardiogram (PCG) is a graphical record of heart sounds produced with the help of phonocardiograph [3]. The frequency range of spectrogram [9] in PCG is 4-200Hz. The maximum limit is up to 500 Hz. In case of heart valve problem the frequency range becomes greater than 1000Hz especially for the murmur [1, 11] condition of the heart. Various heart valve problems [2] can be detected by analyzing the PCG waveform and its spectrogram.

PROCEDURE
We inserted a condenser based miniaturized microphone inside the tip of the pipe of a stethoscope. After pre amplification of the output signal of the microphone it is filtered and connected with a stereo male connector and fed in to audio input of a computer. Here we have used a special type of band pass filter of design by us having pass band region 4Hz-1.5 KHz. Though the frequency range of PCG lies between 4-200Hz, yet the high cut-off of the bandpass filter is kept very high to detect the murmur condition of heart in which the frequency range exceeds 1 kHz for the patients having different heart valve problem [7]. We have used transistor based pre amplifier for this purpose. The audio input signal has analyzed by the software Audacity version 2.2.2 which is easily available at internet. We have performed various spectrum analyses (Welch, Rectangular) on it and got accurate result. The entire procedure is depicted in Fig: 1.
Fig: 1. Block diagram presentation of PCG signal measurement and analysis

The structure of the developed electronic stethoscope is shown in Fig: 2.

Fig: 2. Diagram of developed electronic stethoscope
RESULT AND ANALYSIS

We got prominent wave pattern of first and second heart sound (S1 and S2) in the Audacity waveform which is depicted in Fig: 3.

![Waveform pattern of heart sound in Audacity Software](image)

Fig: 3. Wave form pattern of heart sound in Audacity Software

We have performed spectrum [8, 9] analysis on that rectangular window which is depicted in Fig: 4. From Fig: 4, it is clearly observed that for the normal patients all the frequency component [6] of high value amplitude in dB is within the 100Hz and the amplitude is gradually decreasing with increase in frequency which is theoretically deserved.

![Frequency spectrum of PCG signal in Rectangular window](image)

Fig: 4. Frequenciespectrum of PCG signal in Rectangular window

In case of any problem in heart valve which can affect the PCG wave, it can be determined by the spectrum analysis [4, 5, 9] of the PCG wave or by the waveform recorded at the Audacity 2.2.2 software. The standard autocorrelation of the recorded PCG wave in rectangular window is taken and shown in Fig: 5, which is also give the satisfactory output.
Fig: 5. Auto correlation of recorded PCG signal

CONCLUSION
The result we have got is excellent in comparison to the phonocardiograph which exists in the market. It is also low in cost not low cost it is cost less than the other existing phonocardiograph system in the market. The software we have used is easily available in the internet as normal software which is used in phonocardiograph machine interface is very expensive. The quality of wave form in the used software is quite good with respect to the normal PCG machine. The software we have used has many features useful for better result and analysis of heart valve diseases.

FUTURE SCOPE
This system can be used to determine various heart valve problems in future. That can be achieved by the comparison of spectrum analysis of PCG wave of normal and diseased heart. Heart valve diseases like valvular insufficiency (also called regurgitation), or leaky valve can lead to severe medical conditions. Our future goal is to design a system which can determine the heart valve problems like these effortlessly.

REFERENCES