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A NOVEL DIGITAL STETHOSCOPE IN HEALTHCARE APPLICATIONS FOR TRIBAL AND ILLITERATE COMMUNITY

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ABSTRACT

The motive of this paper is to digitalize the stethoscope to improve its utilization and provides accurate measurement of heart beat and frequency rate. This work also contributes to predict the abnormality of a patient heart beat with the aid of a Light Emitting diode (LED) which flashes the corresponding heart-beat, frequency rate and the status of the patient denoting normal/abnormal. The present condition of the patient can also be shared with the physician through a smartphone. The status of the patient is thereby recorded and can send to the physician to enhance the treatment of the patient who is in an abnormal condition. The sound energy sensed by the stethoscope is converted to its corresponding electrical energy, which in turn flashes in the LED alphanumeric display unit. The normal and abnormal of the heart beat discrimination is performed by using an Embedded C coding fired in the display unit. Hence, whenever the heart beat is within the preset value, it denotes normal and contrarily when it crosses the preset value the LED display flashes as an abnormality. This user-friendly modified stethoscope will find applications for patients residing in remote hill stations and for physically challenged patients.

KEYWORDS: Embedded C, Stethoscope, Alphanumeric LED, Divider circuit.

1. INTRODUCTION

The Cardiac auscultation is significant investigative tool adopted by a physician to detect alterations in cardiovascular anatomy and physiology. Typically, heart sounds and murmurs are of relatively low intensity and are band limited to about 10–125 Hz. Meanwhile, speech signal is perceptible to the human hearing. Therefore, auscultation with an acoustic stethoscope is quite difficult. Only a small proportion of cardiovascular sound energy is audible by the human ear. The problem with acoustic stethoscopes is that the sound level is low, making diagnosis more difficult. The objective is to develop an AVR microcontroller based Digital Stethoscope to capture heart sounds and diagnose them with the help of display and analytic tools.[1] The proposed design of the system includes a LED and Divider. The objective is to develop a technique which makes a clear distinction between normal heart sounds and heart murmurs. Stethoscopes are used for auscultation of heart, lung and murmurs for over two centuries.[2] Recent developments in mobile healthcare or telemedicine for remote and rural areas revived the use of the stethoscope.[3] Numerical investigations are targeted to improve the acoustic performance of digital stethoscopes by studying the contribution of the components and materials on performance. Conventional acoustic stethoscopes sound levels are extremely low and there are some shortcomings for use in telemedicine and telecardiology. Improvements in performance are targeted to increase the performance of the stethoscope and the diagnostic capability in telemedicine environment.[3,4] The stethoscope is an acoustic medical device for auscultation, or listening to the internal sounds of an animal or human body. It typically has a small disc-shaped resonator that is placed against the chest, and two tubes connected to earpieces.[11] It is often used to listen the lung and heart sounds. It is also used to listen to intestines and blood flow in arteries and veins. In combination with a sphygmomanometer, it is commonly used for measurements of blood pressure. Less commonly, "mechanic's stethoscopes", equipped with rod shaped chest pieces, are used to listen the internal sounds made by machines, such as diagnosing a malfunctioning automobile engine by listening to the sounds of its internal parts. Stethoscopes can also be used to check scientific vacuum chambers for leaks, and for various other small-scale acoustic monitoring tasks.[12] A stethoscope that intensifies auscultatory sounds is called phonendoscope.

Stethoscopes is traditional symbol of healthcare professionals, as various healthcare providers are often seen or depicted with stethoscopes hanging around their necks. Researchers claim that the stethoscope, when compared to other medical equipment, had the highest positive impact on the perceived trust worthiness of the practitioner seen with it.[5] The advent of practical, widespread portable Ultrasonography some physicians to ask how soon it would be before stethoscopes would become obsolete.[6] Stethoscopes retain their value for listening to lungs and bowels for clues of disease, experts agree.[7] Thus, it is obvious that cardiology in the secondary and tertiary care settings may abandon the stethoscope many years before primary care, pediatrics, and physical therapy do.

2. MATERIAL AND METHODS

The digital stethoscope includes three stages viz. data acquisition, pre-processing, signal processing and also using different types of parameters. These are listed based on some functions such as piezoelectric sensor converts sound signal into electrical signal. The output of piezoelectric sensor signal contains some noise signal because heart beat signal is a low-frequency signal, so we are using bandpass filter by eliminating noise signal and also the buffering, amplification process are present in the first stage. But we need only for a digital signal (zero's, ones), therefore using an analog to digital converter, the preprocessing and signal processing which in turn shows the digital signal display.

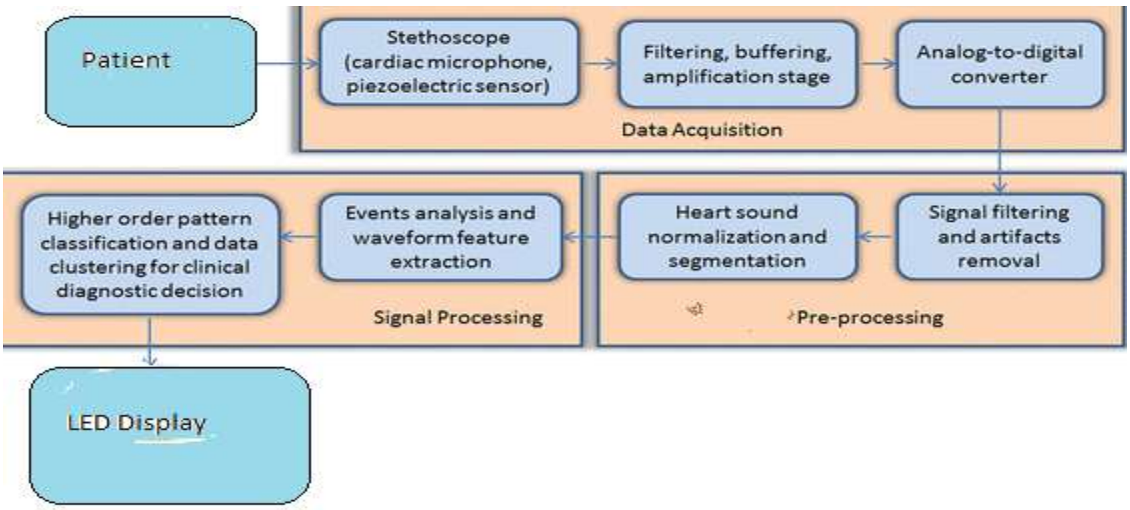

Figure 1: Typical block diagram for heart sound signal acquisition, processing and analysis.

2.1 Heart sound data acquisition module

The heart sound acquisition stage creates the digital heart sound data for further processing. A digital stethoscope sensor senses the heart sound signals and is directly collected from the patients by using a digital stethoscope. Some commonly used transducers in the stethoscope are, microphone, piezoelectric sensors, etc. The sound signals from the heart are converted to analog electrical signals.[13] Amplifier and filter amplification and filtering are the two major aspects in any signal acquisition system. Usually, a pre-amplifier with a small gain is used to suppress the 50 or 59 Hz interference from power lines. An anti-aliasing filter is then employed to prevent aliasing effect. In some system designs, the filter section is built with a bandpass filter circuit having the frequency range of the most heart sound signals. The use of bandpass filter with proper passband selection not only prevents aliasing but also removes some of the noises outside the passband. In post-amplification, the filtered signal is amplified to the level range required by the analog-to-digital converter. The amplified and filtered analog signal is converted to digital signal by the analog-to-digital converter. The sampling frequency and bit resolution can be set by the system designer. Usually, a higher sampling rate and bit resolution will provide higher accuracy, at the cost of more bandwidth required and power consumption.

2.2 Heart sound pre-processing module

In this stage, the digital heart sound signal will undergo noise reduction, normalization and segmentation. Signal denoising unit is a digital filter which is sometimes used to extract the signal within the frequency band of interest from the noisy data. To equip the system with even better denoising capability, some advanced artifacts removal techniques are generally utilized such that the output signal-to-noise ratio (SNR) can be further be improved.[14] Normalization and segmentation in data acquisition, different sampling and acquisition locations usually result in a signal variation. Thus, the heart sound signals are normalized to an absolute scale, so that the expected amplitude of the signal is not affected by the data acquisition locations and different samples.[15] After getting the normalized signals, the heart sound signals are segmented into cycles which are ready for heart sound components detection and features extraction.

2.3 Heart sound signal processing module

The feature extraction and classification are conducted in this stage. Feature extraction signal processing is carried out to convert the raw data to some parametric representation. This parametric representation is then used for further analysis and processing. Classification trained with the extracted features is used to categorize the data and assist the medical specialist in clinical diagnostic decision making. Therefore, the processing blocks are shown in figure form the core units of a computer-aided heart sound measurement and analysis. Based on an extensive study, it is found that the study for the automated detection of various heart pathological conditions and diseases from heart sound signal mainly focuses on three stages: (1) Heart sound acquisition system and sensor design (2) Denoising and segmentation of heart sound signals and (3) Appropriate feature extraction and automatic interpretation of heart sound.

The objective of 'market and stethoscope apps review' is to validate the needs, problems and gaps from the medical and market point of view as well as from a technology push perspective. The prior art search for market and smartphone stethoscope apps was performed by using the web search engines with the keyword "digital stethoscope" and "stethoscope apps," respectively. A total of eight products and five apps were selected for analysis and comparison. The results based on a comprehensive review of (1) Literature Articles, (2) Market (state-of-the-art) Products and (3) Smartphone Stethoscope Apps reviews. Finally, the signal retrieved from signal processing after displaying the heartbeat rating in LED and also calculating heart beat conditions status under normal /abnormal conditions using Embedded C program.

2.4 Novel Digital Stethoscope

A novel digital design based Stethoscope replaces the conventional stethoscope. This device consists of a digital display with a disc-shaped resonator connected to earpieces as shown in figure 2, which shows the rate of heart beat per minute within 6 seconds the device will count the sound deflection and calculate the heart beat per minute by an output of disc-shaped resonator. Also, we can hear the heartbeat sound by headphones. The power will retrieve from the battery, located in the device. A divider interface card is connected as shown in figure 4 for a smartphone app and to record the frequency rate from the headphone connectivity. This device is a user-friendly, where even tribes or illiterate community can handle this without much complexity.

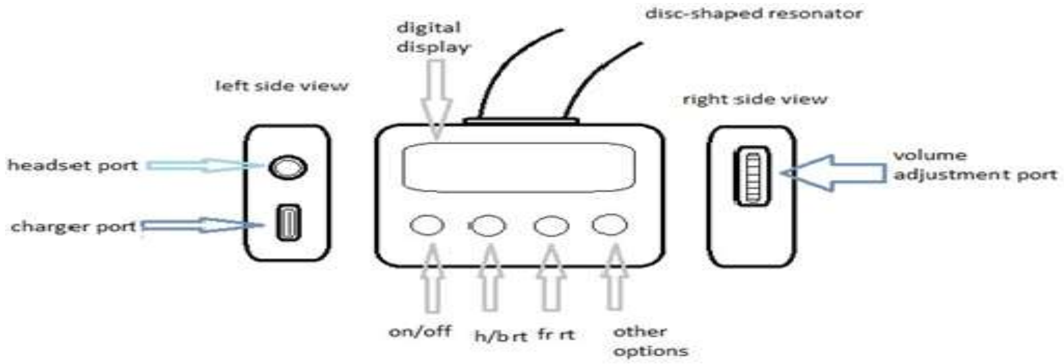

Figure 2: Proposed Digital Stethoscope.

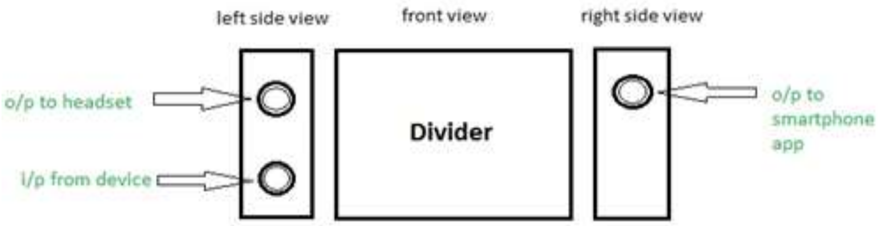

Figure 3: Interfacing Card of the Stethoscope and Smart phone.

2.5 Heart Sounds

Acoustic heart sounds are produced when the heart muscles open valves to let blood flow from chamber to chamber. A healthy heart will produce two heart sounds, S1 and S2 as shown in figure4.S1symbolizes the start of systole. The sound is created when the mitral and tricuspid valves close after blood has returned from the body and lungs. S1 is primarily composed of energy in the 30Hz - 45 Hz range. S2 symbolizes the end of systole and the beginning of diastole. The sound is created when theaortic and pulmonic valves close as blood exits the heart to the body and lungs which lie with maximum energy in the 50 Hz - 70 Hz range with a higher pitch. Typically, heart sounds and murmurs are of relatively low intensity and are band limited to about 100–1000 Hz. Meanwhile, the Speech signal is perceptible to the human hearing. Therefore, auscultation with an acoustic stethoscope is quite cumbersome.

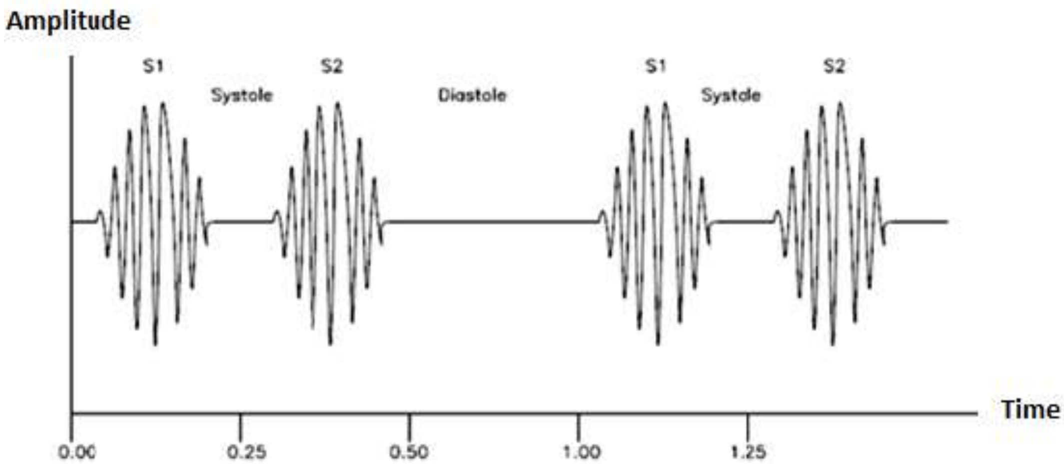

Figure 4: Heart Sounds.

3. RESULTS AND DISCUSSION

The results which are obtained from the work done are discussed below. The analog output which is obtained from stethoscope is divided into two parts: Pre-amplifier and Filtering stage. The corresponding outputs of the pre-amplifier stage and post filtering unwanted low-frequency noise output waveforms are shown in figures 5 and 6 respectively.

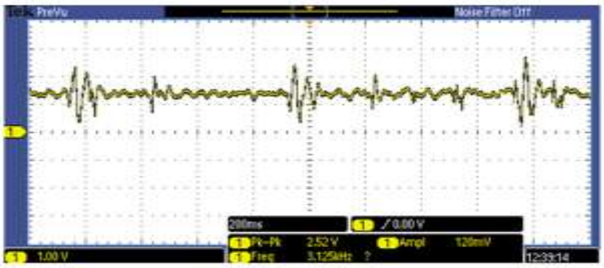

Figure 5: Output of preamplifier stage obtained at the CRO.

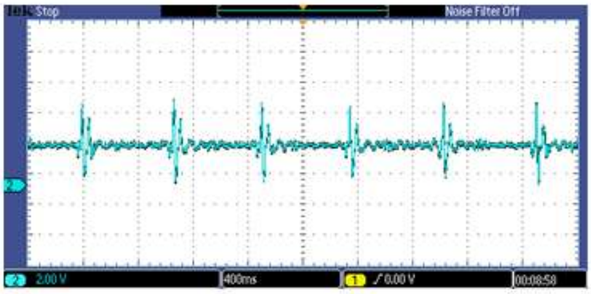

Figure 6: Output obtain after filtering the noise.

The novel prototype model Stethoscope is shown in figure 7, which shows the interfacing divider circuit and alphanumerical LED display. One of the primary objectives is to reduce the noise from the analog input. For this various filtering methodology are being adopted which shows the output obtained after filtering the noise from the pre-amplifier stage and the results are traced using a dual trace Cathode Ray Oscilloscope.

Figure 7: Novel Prototype model Stethoscope.

4. CONCLUSION

This paper presents a digital stethoscope, which is based on Embedded C programming, to meet the requirement of current major clinical application of the heart sound auscultation. It is folded with the following attractions such as the heart sound signal can be amplified and played in a speaker in real-time, avoids manual heartbeat counting and can be communicated to the smartphone. The gain of the amplification can be modified to satisfy the user's requirement. Also, the prevailing condition of the patient heartbeat can be sent to the physician and later as per the advice of the doctor it paves a way to undertake preliminary treatment. The LED screen on the portable device displays the heartbeat status as normal/abnormal level, which aids the tribes or illiterate community to safeguard the valuable human life.

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