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Wireless Stethoscope and Pulse Oximeter for Recording and Remote Monitoring of Heart

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***Abstract*—Stethoscope is acoustic device used to listen heart sounds and monitor pulmonary disease. By using conventional stethoscope it is difficult to capture heart sounds accurately and cannot be recorded for documentation. Wireless stethoscope can be used for remote monitoring of patient heart health by analyzing acoustic properties of the heart. This paper illustrates a wireless wearable stethoscope with pulse oximeter. Wireless stethoscope consists of condenser microphone, pulse rate sensor, stethoscope diaphragm, operational amplifier, RF transceiver module and an App. Initially heart signals were acquired using microphone and pulse rate sensor, obtained signals were filtered and transmitted wireless using RF transceiver for processing. Heart rate was measured and displayed. Using firebase cloud messaging (FCM) technique sends notification to doctor through an app for fast diagnosis.**

***Index Terms*— digital stesthoscope, pulse oximeter, monitoring system, heart sounds and digital signal.**

I. Introduction

The digital stethoscope was designed and developed to help the doctors to hear heart rate for diagnosis. The system consist of both hardware and software, the hardware part was used to collect the heart sounds and software part used for processing the data for analysis. Electronic stethoscope was developed to listen the heart sound [1]. The drawback of traditional stethoscope was which gets effected soon by external noise interference and it has low sensitivity sound. Electronic stethoscope strengthens the heart signals, minimizes the error also covers the shortage of less sensitive signals [2]. The output will be visualized in the form of spectrum and sounds were played using audio player. Digital stethoscope designed based on Bluetooth technology to find cardiac sound. Initially heart sounds are acquired using microphone, amplified and transmitted wireless [3, 13]. This device can be used as a patient monitoring system for cardiac diseases also device supports real time signal monitoring for long distance. Some electronic stethoscopes were built by considering two piece Bluetooth system by removing connecting cables in stethoscope. Electronic stethoscope consist of Bluetooth based integrated chest piece and microcontroller (MSP430). The design was tested using signal source of 10Hz to 5 kHz frequency. The results were in the form of operational frequency bands which were consistent with expected behavior of the stethoscope [4, 5]. Pulse oximeter are used to monitor patient's oxygen saturation in blood and pulse. The device was designed using simple microcontroller to measure parameters in real time by using arterial pressure wave with peak valley detection method. Pulse and oxygen saturation in blood were obtained using an

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oscilloscope [6]. Using near infrared spectroscopy method with the design of conventional oximeter a wireless pulse oximeter was designed based on Bluetooth technology using smart cell app[7]. Pulse oximeter uses near infrared transmission spectroscopy detection technique to process the data. The smart phone operates pulse wave signal to value of oxygen saturation and pulse rate [11]. Along with the calculation of heart rate phonocardiogram was displayed in real time. Phonocardiogram is the representation of heart sounds in graphical form. Using fast Fourier transform (FFT) frequencies of heart sounds were transformed from time domain to frequency domain [8]. The phonocardiogram system was designed with electronic stethoscope consist of chest piece, mic preamp, mic condenser and battery. Heart signals were recorded, processed and the signals were analyzed using FFT [9]. The frequency response of the output signal was consistent, hence the system was reliable and repeatable [10]. Using micro electro mechanical system (MEMS) an electronic stethoscope was developed consist of diaphragm, electronic circuit and an app. App can record, replay, visualize the heart beat and also transfer the information to hospital center [12, 14].

II. Wireless Stethoscope for Recording Heart Rate

Wireless stethoscope proposed for monitoring heart sounds consists of condenser microphone, pulse rate sensor, stethoscope diaphragm, operational amplifier, trimpot, 2.4 GHz RF transceiver module and Arduino (atmega328) with 16MHz crystal oscillator. Fig 1 shows proposed design flow diagram of digital stethoscope.

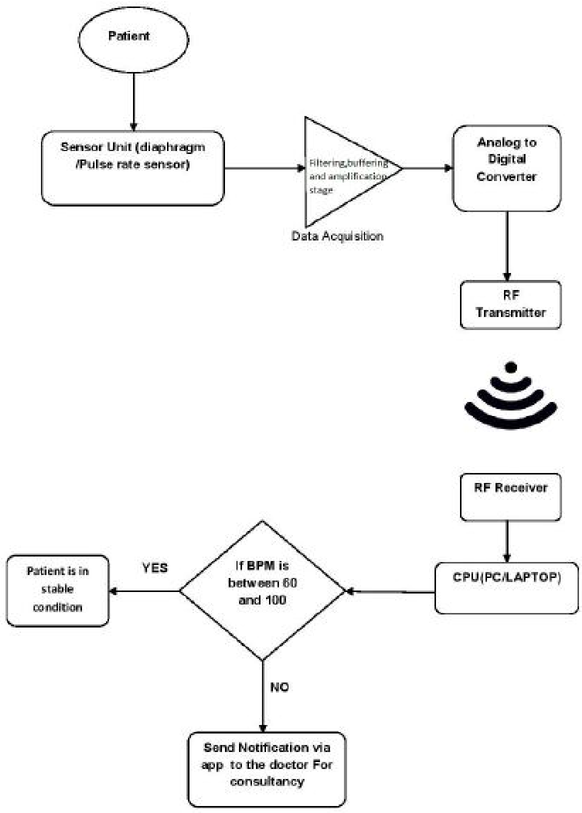


Fig 1: Flow diagram of digital stethoscope

A. Data acquisition

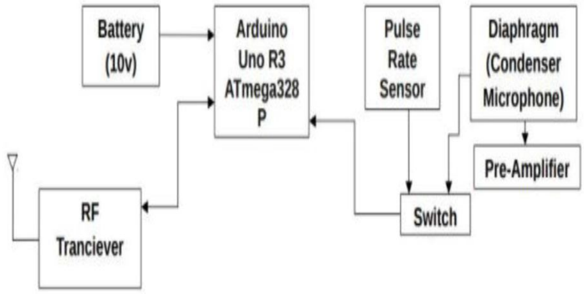
The stethoscope diaphragm was placed on the chest region, condenser microphone connected to stem of diaphragm records the heart sound in analog form. In addition pulse sensor is also used to read the heart rate. Microphone was designed with biasing voltage of 2V for operation.

B. Pre-processing

In preprocessing signal amplification, filtering and removal of artifacts was done. Acoustic signal from the microphone has very low voltage in the range of millivolts. For further processing the signal needs to be strengthened. OP-AMP LM358 was used to increase the signal gain. Since stethoscope and pulse oximeter were used to acquire the signal there is a possibility of addition of noise and both signals are different to overcome these trimpot is used for tuning and calibration of circuits.

C. Wireless Transmission (CC2500 RF transceiver)

Preprocessed signal was sent to Arduino, preprocessed signal in analog form are converted into digital signal then the Signal is passed to the RF transmitter module for transmitting the sound data, and transmission is achieved by using FM modulation techniques. Fig 2 shows the block diagram and experimental set up of transmission part of stethoscope.



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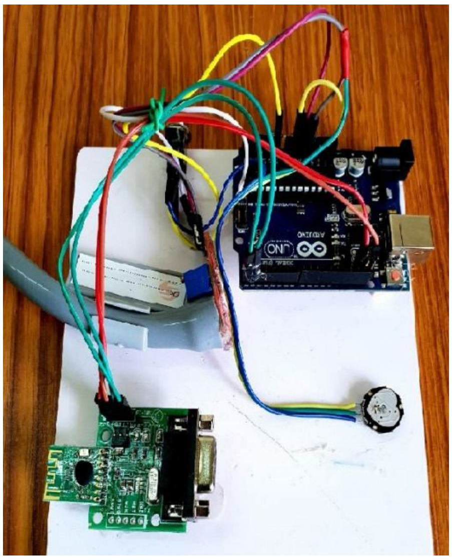


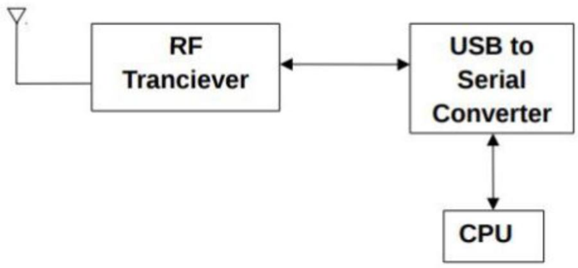
(b)

Fig 2: (a) Block diagram of transmitter part (b) Experimental set up of transmission part of wearable digital stethoscope prototype

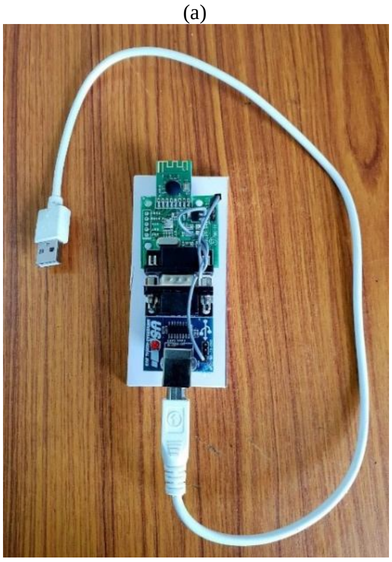
The receiving part consists of RF receiver module which is interfaced to the PC through MAX232 which is used in RS232 communication system for the conversion of voltage levels on transistor-transistor logic (TTL) devices that are interfaced with the PC serial port and the Microcontroller. Fig 3 shows the block diagram and experimental set up of receiver part of stethoscope.

D. Signal processing

The digital signal that is retrieved from the sensors by Arduino is sent to the computer wirelessly through the RF transmitter. The tool which was used for processing is integrated development environment (IDE) where the software part and the back end side of the prototype lies. The receiver unit is connected to the PC through the USB hub, the digital signal which is sent to the computer performs calculations and plots the cardiac activity graph and also gives us the BPM rate through the processing IDE platform. The waveform and the BPM rate obtained is compared with the standard forms. Any irregularities found in the test, a notification is sent to the consulting doctor for immediate attention towards the patient. The recordings are stored in the cloud so that the



(a)



(b)

Fig 3: (a) Block diagram of receiver part b) Experimental set up of receiver part of digital stethoscope prototype

related ones can access the information about the patient at any given instant. Firebase cloud messaging (FCM) tool is used to send the notification. Fig 4 shows the block diagram of FCM.

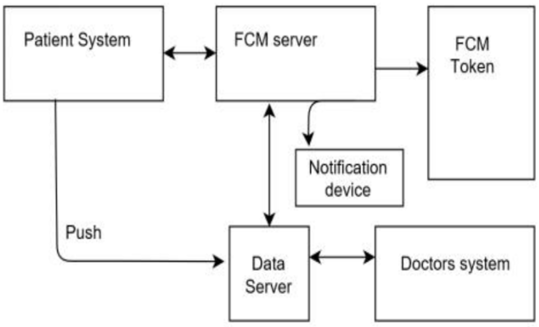


Fig 4: Block diagram of Firebase cloud messaging

The FCM token has to be initially pushed into the doctor's phone. The doctors have to send a request to firebase asking for registration. The Firebase responds to this by sending a unique string token character. The tokens sent to the doctors is stored in a unique database (cloud) from which it is accessed later on. The doctors initially login with the patient's name before taking the readings. In the patient system, a request is sent to the FCM server whenever abnormality's found in the heart rate. When this happens, the data being monitored is pushed into data server. A notification is sent directly to the device to which the FCM token was initially registered. Patient name as well as a unique ID will be provided for the patients. Using this ID, a doctor can access the patient's data which is in the data servers (cloud). The doctor can take necessary steps to deal with the patient by looking at the patient's data.

III. EXPERIMENT RESULTS

Fig 5 represents the graph of human heart beat which is plotted via the variation taken by the condenser microphone. The intensity in the acoustic variation is converted into visual form through processing interface. On the bottom part the pulse window scale (PWS) was present, which can be varied to make the graph look more accurate and easier to analyze. The Inter-beat interval also varies according to the PWS. In Fig 5, it shows a standard value of 422ms, which is the time interval between which the measurement is taken. The heartbeat of the person measured can be seen as 79 beats per minute.

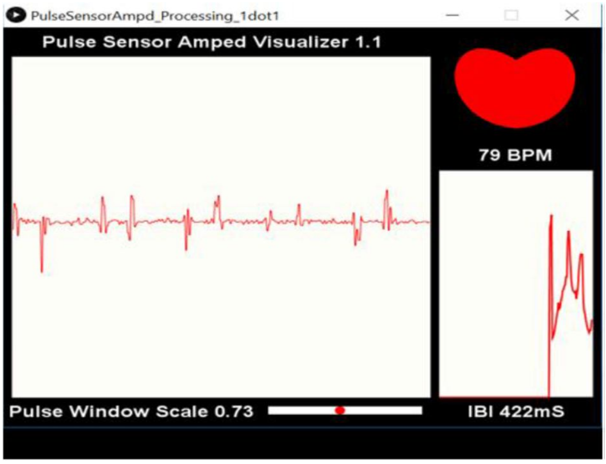


Fig 5: Output of the condenser microphone on PC in terms of time (ms) verses amplitude (Db)

Fig 6 represents the graph of human beat which is measured through pulse sensor. The sensor measures small variation in capillaries and plots this variations with respective time interval. The pulse rate of the person measured is 81 beats per minute with Inter beat interval of 796ms.

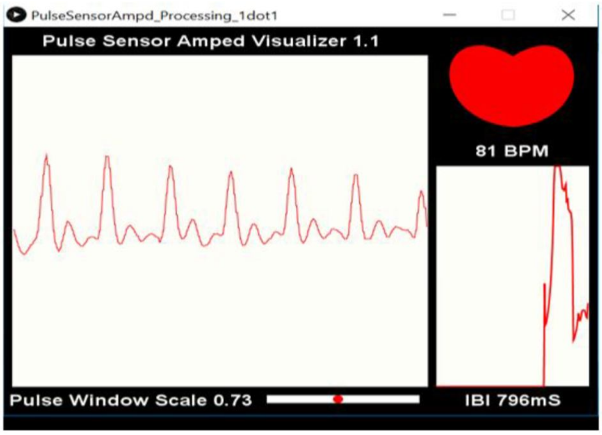


Fig 6: Output of the oximeter on PC

Fig 7 shows the picture of registration window of patient ID. Doctors initially login with the patient's name or ID number. In the patient system, a request is sent to the FCM server whenever abnormality’s founds in the heart rate. In this case a person with ID 117 is fed into the server. The unique ID was obtained by FCM notification to the doctor's mobile phone.
Fig 8 show that a patient with name shreyas rao with ID 117 was notified to the doctor. The doctor can get his data by filling the ID in the processing application.

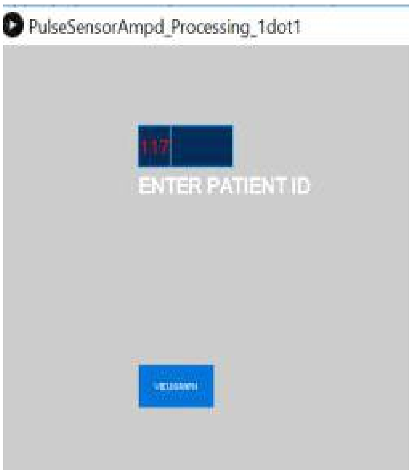


Fig 7: Smart phone display with patient ID number

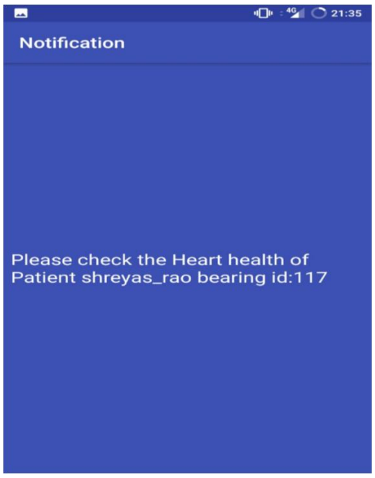


Fig 8: Smart phone display of notification sent to doctor device

To verify the system feasibility, 4 students pulse rate were tested and compared with conventional method, the results were shown in table 1 and the system shows very small error.

TABLE I. PULSE RATE TEST DATA COMPARISON

Numbers	Conventional stethoscope (BPM)	Digital stethoscope (BPM)	Pulse oximeter (BPM)
1	78	79	78
2	69	69	68
3	80	80	81
4	71	72	70

IV. CONCLUSION

A digital stethoscope with pulse oximeter was designed and implemented which helps the doctors for better diagnosis. Heart sounds were recorded, transmitted wirelessly, analyzed digitally and verified the feasibility of the system with conventional method. The digital stethoscope and pulse oximeter measures heart rate accurately and data transmission to remote areas with App were reliable. The developed device supports real time visualization, data storage, and signal monitoring for long distance and also cost effective. Cloud storage has been used where pulses or heart rate are stored, later a notification is sent to doctor through app. To improve a system further body temperature, blood pressure or glucometer can be added to system.

REFERENCES

[1] Ade Surya Iskandar, Ary Setijadi Prihatmanto and Syahban Rangkuti, “Design of Electronic Stethoscope to Prevent Error Analysis of Heart Patients Circumstances”, IEEE 4th International Conference on System Engineering and Technology (ICSET) 978-1-4799-7189-3, 2014 IEEE

[2] W.Y. Shi, Jeffrey Mays, and J.-C. Chiao, “Wireless Stethoscope for Recording Heart and Lung Sound”, 978-1-5090-1694-5, 2016, IEEE.

[3] Frank, P.-W Lo and Max Q.-H Meng “A Low Cost Bluetooth Powered Wearable Digital Stethoscope for Cardiac Murmur”, Proceedings of the IEEE International Conference on Information and Automation 978-1-5090-4102-2 pp.1179-1182 2016 IEEE

[4] Godfrey A. Mills, Thomas A. Nketia And Isaac A. Oppong,“ Wireless Digital Stethoscope Using Bluetooth Technolgy”, International Journal of Science and Research, vol.4, pp.3961-3969, 2012.

[5] W.Y. Shi, Jeffrey Mays, and J.-C. Chiao, “ A Wireless Stethoscope”, pp.197-198 978-1-4799-8543-2, 2015, IEEE
[6] Michael Tamayo, Andrew Westover and Ying Sun, “Microcontroller Based Pulse Oximeter for Undergraduate Capstone Design”, 978-1-4244-6924-6 2010 IEEE.
[7] Yanchen Dai, Jian Luo, “Design of Noninvasive Pulse Oximeter Based on Bluetooth 4.0 BLE”, Seventh International Symposium on Computational Intelligence and Design, pp. 101-103, IEEE.
[8] B. Malik, N. Eya, H. Migdadi1, M.J. Ngala, R.A. Abd-Alhameed and JM Noras, “Design and Development of an Electronic Stethoscope”, 978-1-5090-4815-1, IEEE, pp. 324 -328, 2017.
[9] Sumarna, Juli Astono, Agus Purwanto, Dyah Kurniawati Agustika, “The Improvement of Phonocardiograph Signal (PCG) Representation Through the Electronic Stethoscope”, Proc. EECSI 2017 978-1-5386-0549-3 IEEE
[10] Demiao Ou, Liping OuYang, Zhijun Tan, Hongqiang Mo, Xiang Tian, and Xiangmin Xu, “An Electronic Stethoscope for Heart Diseases Based on Micro-Electro-Mechanical-System Microphone”, 978-1-5090-2870-2 IEEE pp.882-885,2016.
[11] C Joshitha; P Kanakaraja; S Rooban; Bandaru Satya Durga Ram Prasad “Design and Implementation of Wi-Fi Enabled Contactless Electronic Stethoscope” IEEEApril2022
[12] Shreyas S. Joshi, Manoj R. Patil, Nikhil P. Kanawade, “Bluetooth-based Wireless Digital Stethoscope” 978-1-7281-8519-4/21 IEEE Xplore June 2021
[13] Janhvi Malwade, Suaad Sayyed, Jamima Nasir, “Wireless Stethoscope with Bluetooth Technology” IEEExploreJuly2020 978-1-7281-6644 5/20/
[14] Samiun Tune, Asmd Ashraful Islam et al, “End-user acceptability of a prototype digital stethoscope to diagnose childhood pneumoni“ BMC Digital Health 10.1186/s44247-023-00027July2023.