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Wireless Digital Stethoscope

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Abstract: *In view of the recent Covid-19 epidemic, which enforced tight social distance standards on people's safety. We came up with a concept of a wireless stethoscope that would not only help doctors but also patients to adhere to regulations on social distancing. It also provides patient's metrics from the patient's home so as the medical authorities can engage patients to recover remotely and safely. It can also be implemented in ICU wards, which would further lower the risk faced by medical workers. The data obtained from the patient's end is passed on to the doctors and can be saved for future reference.This project gives a reliable alternative that is more public centric, i.e. accessible to all sections of the population, by cutting the cost of the device and digitalizing the capabilities of an acoustic stethoscope. Because of the system's simplicity, a non-medical practitioner may operate this electronic stethoscope with ease.*

Key Word*: stethoscope, heart sounds, auscultation, telemedicine, remote, COVID-19, healthcare.*

I. Introduction

The acoustic stethoscope is the most often used stethoscope. They operate by the transmission of sound through a chest piece to the listener's ears through air-filled hollow tubes. Acoustic stethoscopes have the disadvantage of displaying peaks and troughs at precise frequency owing to tube resonance; their sound level is relatively low, which might be a major concern in a noisy environment. Acoustic stethoscopes have a drawback that digital stethoscopes strive to address. By substituting the hollow tube between the chest-piece and the hearing-piece with wireless communication, more flexibility in device usage can be introduced, as well as a reduction in pathogen transmission. Additionally, all existing stethoscopes are focused on single users, implying that details heard by one user during a particular duration of examination cannot be verified by other team members unless the data is directly accessed from a third party device or computer. We've lately seen an increase in the use of smart devices among both healthcare professionals and the general public. In this day and age of digitalization, the way sounds relevant to the heart are auscultated will change with the adoption of an electronic stethoscope that functions digitally. With recent advancements in acoustic sensor design, enhanced digital signal processing, and computer-based machine learning methodologies, acoustic-based automated diagnosis of heart disease using an electronic stethoscope has received a great deal of interest. We focus on the design reconfiguration and advancement of the electronic stethoscope in this study by incorporating wireless transmission of the captured heart sounds.
Our project's design is largely based on an acquisition circuit, data processing in Raspberry Pi, and telemedicine implementation. The first constituent of a wireless stethoscope is a real stethoscope head coupled with a microphone that records audible heart sounds that are acoustically amplified by the stethoscope. The analogue data will then be sampled, filtered, and further amplified by the raspberry pi before being wirelessly transmitted to facilitate telemedicine.

II. Literature Survey & Related Work

Telemedicine is defined by the World Health Organization (WHO) as the use of telecommunications and virtual technology to provide healthcare beyond the traditional healthcare facilities, extending the scope of high-quality care and in-depth expertise to the home, as well as to remote and isolated communities. By 2027, the global telemedicine industry is anticipated to reach $82.03 billion.

Some of the goals of telehealth, according to the Mayo Clinic, include making health care more accessible to people who live in rural areas, improving collaboration and coordination of care among members of a health care team and a patient, providing support for self-management of health care, and making services more readily available or accessible for people with limited mobility, time, or transportation.

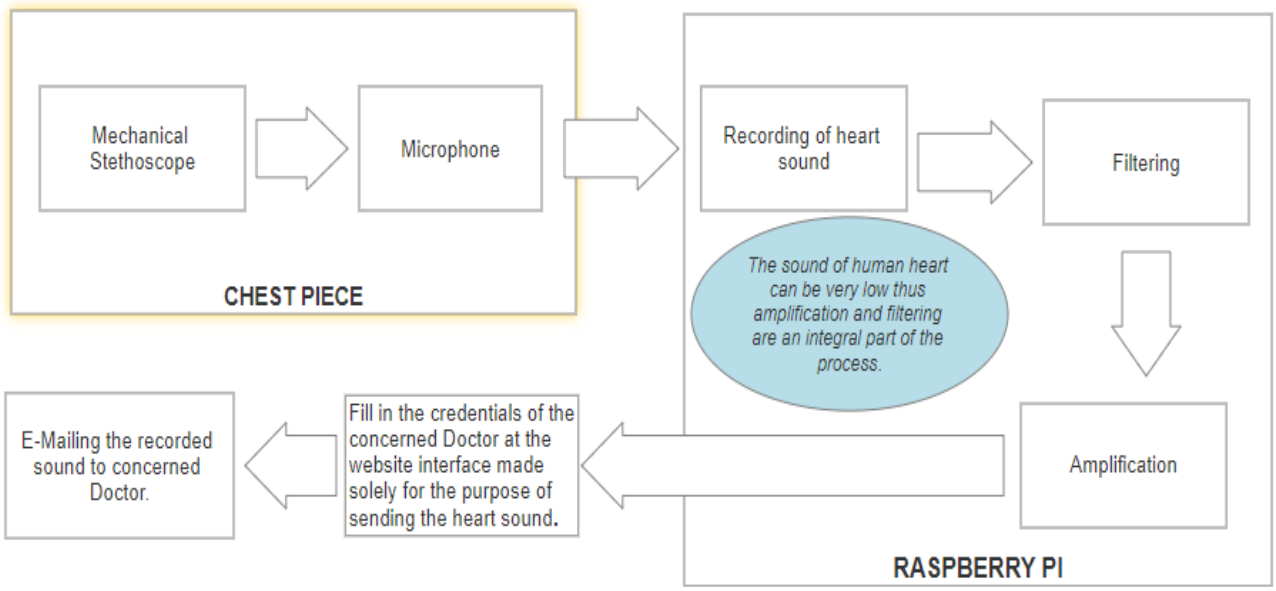
The development of the stethoscope may be dated back to the nineteenth century, when a French physician named Rene Laennec invented it in 1816.

Acoustic stethoscopes are more often used than electronic stethoscopes since they are less expensive but less effective than electronic stethoscopes. An electronic stethoscope[1] is a device that electronically enhances physiological sounds. Because the sound waves are conveyed electronically, it is possible for it to be wireless and provide noise reduction. [2,3] presents concepts for an electronic stethoscope based on an integrated CPU and Bluetooth communication to address auscultation deficiencies. It comprises a portable equipment that plays heart sounds after pre-processing and amplification. The basic function of electronic stethoscopes is to detect cardiac sounds, which may be studied using[7] . It comprises a heart sound detection system based on the novel XH-6 sensor that collects minor heart sounds and displays them in real time.[8], proposes a new home diagnosing system idea based on an electronic stethoscope and smart analysis software. As a result, the system creates a database of patients, including their normal S1 and S2; also, a series of heart disease murmurs are saved as patterns.

Other efforts are based on phonocardiography applications [4], which focus on both primary and irregular heart sounds and utilize Bluetooth for wireless communication. On the market, there are various commercially available electronic stethoscopes. One of them is the 3M Littmann Electronic Stethoscope Model 3000[5]. The greatest non-electronic stethoscopes offer up to 18 times the amplification. Another electronic stethoscope that is regularly used is CEI electronic stethoscope type CE-3D21 made by C.E.I Technologies. The amplification is up to 18 times that of a typical acoustic scope, and there are built-in, 8-level volume adjustments. The study[9] describes data transfer via LAN and proposes the development and implementation of a Web-Based remote digital stethoscope that blends existing software, hardware interface devices, PC, and Internet into remotely operated virtual instrumentation.

III. Block Diagram

Figure No 1: Proposed block diagram.



IV. Methodology

An inbuilt CPU i.e a Raspberry Pi, powers this electronic stethoscope. The data can be communicated wirelessly by transmitting data via a website and receiving the data via email.
A condenser microphone is used to capture the sound of a heartbeat detected by a stethoscope head.
The heart sound received by the sensor is filtered and amplified before being wirelessly sent via a website so that various medical specialists may do auscultation.
Doctors can also hear the heart sounds recorded by connecting a bluetooth device to their phone or straight via the phone's speaker.

FILTERING
A digital filter is a signal processing device that performs arithmetic computations on a sampled, discrete-time signal in order to diminish or enhance certain aspects of it. We used the Python libraries to sample, quantize, and store the audio in this stethoscope so that it could be transmitted.
To increase accuracy while keeping audio storage in mind during transmission, the above-mentioned steps are carried out utilising a 24-bit pulse coded modulation (24-bit PCM) technique.
As we know higher the per bit sample higher the bit-rate thus higher the accuracy.
The sample rate for the transmission component is calculated using the Nyquist Criteria.
"According to the Nyquist criteria, the sampling frequency must be at least twice the highest frequency of the signal, otherwise the signal's information would be lost."

Transmission frequency(fm)=sampling frequency*2;
Rb=n*fs; where:-Rb=Bit-rate,n=no. Of bits used in PCM,fs=sampling frequency
Fs=2*fm where:-fm=modulation frequency(Frequency of heart sound);

AMPLIFICATION
The operation of an amplifier, which is a natural or manmade device that boosts a signal, is referred to as amplification.We utilised the python script pydub to import and manipulate audio files, which enhances the audio input in our application.
This wireless digital stethoscope amplifies audio by 6db, which may be adjusted as needed.
In addition, the audio may be renamed based on our requirements. The Raspberry Pi does the rest of the audio conversion into a.wav file as we included all the necessary packages into the python script.
The depiction of cardiac sounds in the form of a wave, which is digitised by the 24 bit-PCM, is the most important benefit of this stethoscope. With the use of this graphical depiction, the plot of an unhealthy patient's heart sounds can be compared to that of a healthy one.

V. Result

The final result of the project includes a website, which controls all the operation such as send,store and view the recorded heart sounds to the doctor. The Data can be sent with ease using websites. It makes the communication between doctor and patient very convenient, safe and comfortable.
Our website consists of 4 pages:-

1) Home Page
2) Record & Send
3) fgg
4) About the project

The stethoscope head mated with a microphone is shown in the fig alongside. This apparatus is then connected to a Raspberry Pi, to implement wireless transmission of the data sensed by this piece.

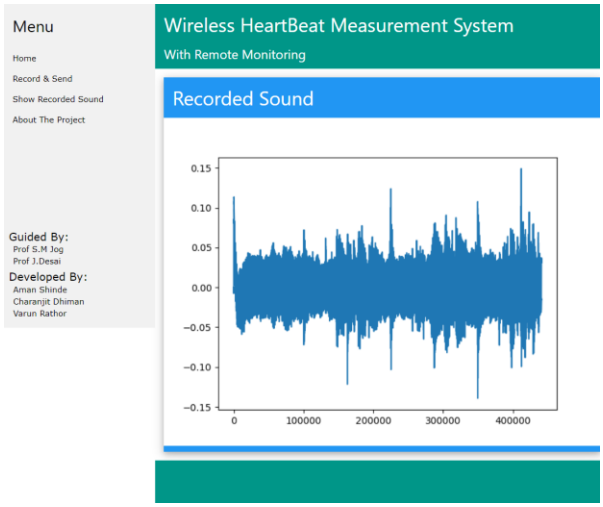
Figure No 2 : Result of system with software.

1) The front face of the website that introduces our product to the user which also depicts different pages of the website demonstrates such as record & send, View recording etc.

2) The GUI of the website for recording and sending the recorded .wav file which the patient will use for emailing and accessing his device.

3) A snap of email that will be received by the doctor, containing a filtered and amplified version of the recorded sound.

4) Website view on how the graphical representation of heart sounds will be demonstrated for the last recorded heart sound of the patient, that is being sent to the doctor.



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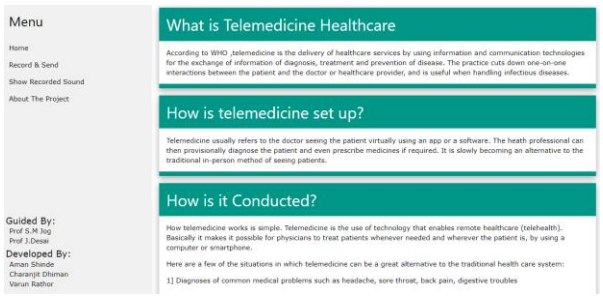
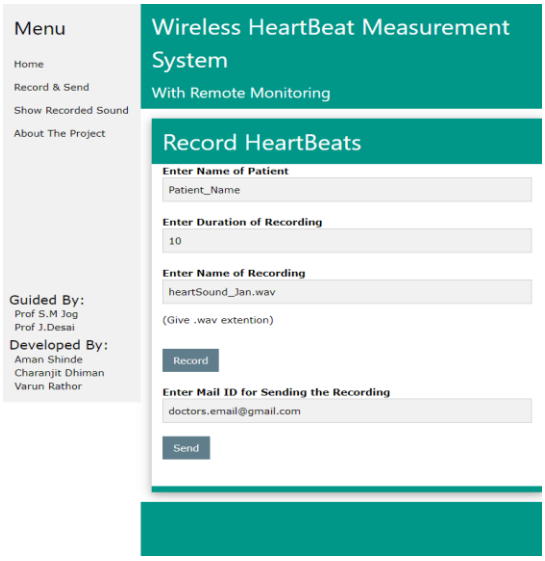
5) The final page of the website on what telemedicine is and how it's useful for everybody. Also to spread awareness and encourage the use of telemedicine .





VI. Conclusion & Future Scopes

A novel design approach for creating and simulating a wireless digital stethoscope using the Raspberry Pi has been presented. With the use of internet connectivity, the same heart sound may be sent to multiple Specialists via Email , which can be accessed from anywhere in the world at any time. With this approach, replay and analysis of Auscultation will be much easier since multiple opinions can be taken into consideration.
To assess and explore the operations of the Raspberry Pi, some sensors were used before actually recording the sound.Results showed us the way we can transmit the heart sounds globally and easily using Email. Replacing the hollow tube with a wireless system increased the device's operating distance, minimising the possible danger of virus and pathogen transfer, particularly COVID-19, and also aided not only doctors but also patients in adhering to social distancing conventions.

The project's future scope can be viewed as:

1. Adding a play button on the website itself to hear the recorded sounds, in order to avoid unforeseen complications with email access.
2. Multiple recipients can be added as potential receivers to whom the patient can send the heart sounds all at once.
3. Integration of a database to store and analyse each patient's data on the website, which doctors may access from their end.
4. The data gathered may be utilised to train an ML model that predicts disease/abnormalities for each patient, and the doctor may be notified.
5. The website could evolve into a comprehensive one-stop healthcare solution portal that can be used to schedule online appointments and consultations as well as perform a variety of tasks such as online video-conferencing, patient metric analysis, recent healthcare industry alerts & news and helpful informational blogs.

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