e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:07/July-2022 Impact Factor- 6.752 www.irjmets.com

HEART MURMUR CLASSIFICATION BASED ON HEART SOUNDS FROM ELECTRONIC STETHOSCOPE USING DEEP LEARNING

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ABSTRACT

In this project, a chest-piece of an analog stethoscope was taken and a condenser microphone was attached to the rubber tube to convert the physical vibrations of the chest piece to analog form. The audio signals obtained were pre-amplified with BC547 Transistor. This pre-amplified signal was then power-amplified using TDA1517 IC. Using an AUX module, live sounds can be heard using a high-quality headphone. A passive RC lowpass filter is included to the output of the signal to be recorded. The filtered signal obtained is recorded using an Android Application. The live classification of the audio can be displayed inside an application.

Keywords - Chest-piece, Pre-Amplifier, Power-Amplifier, Deep Learning, Android Application.

I. INTRODUCTION

Auscultation is the process of listening to art sounds using a stethoscope. Generally, auscultation is used to analyze the coronary heart sounds and breath sounds along with gastrointestinal sounds [1]. Fundamentally, it is the preliminary biopsy of the body to deliver a definite proof of any particular pathological condition which has been apparent within the subject.

The stethoscope consists of a bell and a diaphragm. In an elementary function, the bell transmits sounds of decreased frequency while the diaphragm transmits sounds of better frequency. The bell is designed such that it heeds to the low-pitched sounds and the diaphragm is designed to survey the high-pitched sounds. They are related through rubber tubing to the ear pieces. Usually, analog heart sounds are difficult to hear when the heart sounds are subaudible and in low frequency. Due to this problem, more than often, doctors can miss heart murmurs and that can result in increased fatality in the long run. Hence, digital stethoscopes can be used to monitor the patients without curbing any mobility thereby decreasing the perspective of missing heart sounds.

There are 3 categories as to how the systolic murmurs can be categorized. The being: The Early Systolic murmurs (ESM), The Mid-systolic murmurs (MSM) and Late Systolic Murmurs (LSM). Holo-systolic murmurs can be divided into Mitral Regurgitation (MR), Tricuspid Regurgitation (TR), Pulmonic Stenosis (PS), Aortic Stenosis (AS), Atrial Septal Defects (ASD), Mitral Valve prolapse (MVP) and Ventricular Septal Defects (VSD).

In this project, we shall focus towards ESM which begins with S1, becomes a faint voice and collapses well before S2. There are 2 conditions as to which ESM can be caused, Ventricular Septal Defects (VSD) and Mitral Regurgitation (MR). We have used a Small Diaphragm Condenser microphone due to its size and excellent transient response. An amplifier is an electronic device that enhances the voltage, current or power of a signal. Generally, amplifiers are used in wireless communications and broadcasting and in all kinds of audio equipment. These can be categorized as weak signal amplifiers or power amplifiers. The weak signal amplifiers are used in wireless receivers along with being employed in acoustic pickups, audiotape players and compact disc players. The specification which denotes the effectiveness of a weak-signal amplifier is sensitivity. BC547 is a NPN transistor which has 3 pins: emitter, base and collector. The supply voltage is given between 6V and 9V. The maximum current output at the collector is 100mA.

In this project, BC547 is used in common emitter configuration and in active regions for pre-amplification which is the forward biasing of the collector and emitter terminal. Along with this, the capacitors are connected for AC analysis.

TDA1517 has been integrated, which is a Philips dual stereo 6W Power Amplifier. It is an integrated class-B dual audio amplifier. High output power, good ripple rejection and having thermal protection with a heat sink attached to it are some of the vital features of the amplifiers. The amplifiers are reverse polarity safe along with having electrostatic discharge protection. This IC consists of 2 identical amplifiers with a fixed gain of 20dB each. An android application has been developed with the help of Kotlin as the basic language in Android studio. The murmur classification model has been developed based on the pre-trained YAMNET model.

II. METHODOLOGY

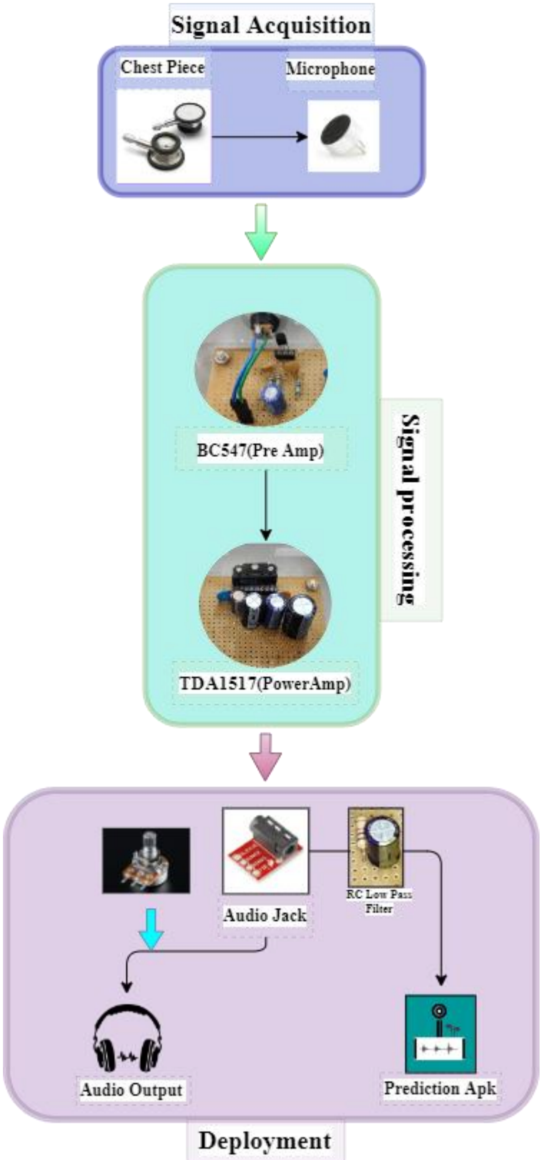

Figure 1 – Block Diagram

2.1 Signal Acquisition

As depicted in Figure 2, the chest piece of the stethoscope is connected to the condenser microphone. The microphone works as a transducer which converts the physical vibrations of the heart from the chest piece to an electrical signal. The vibrations picked up by the condenser microphone from the diaphragm of the chest piece is sent to the BC547 for pre-amplification.

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Figure 2 – Stethoscope head with microphone

2.2 Signal Processing

As depicted in Figure 1 The vibrations of the diaphragm is picked up by condenser microphone. The vibrations will be converted into electrical signals by the microphone and the signal is sent to the input of the pre-Amplifier. The pre-amplifier used here is built on the BC547 NPN transistor. The heart sounds range from 30Hz – 80Hz(S1) and 100Hz – 250 Hz(S2). The signal from the output of the pre-amplifier is given to input of the power-amplifier. The power amplifier used here is TDA1517 Philips power-amplifier. As depicted in Figure 6, the output of the power-amplifer.is given to an AUX 3.5 mm TRSS module where the audio can be heard live using a high-quality headphones or earphones. The output of the power-amplifier is given to a passive RC low-pass filter [2]. The audio is filtered with any high frequency noises and background noises picked up by the diaphragm. The filtered output is given to an AUX 3.5 mm TRSS module. Signal output is given to the mic port of the module so that the audio is recognized by the mobile phone and computer.

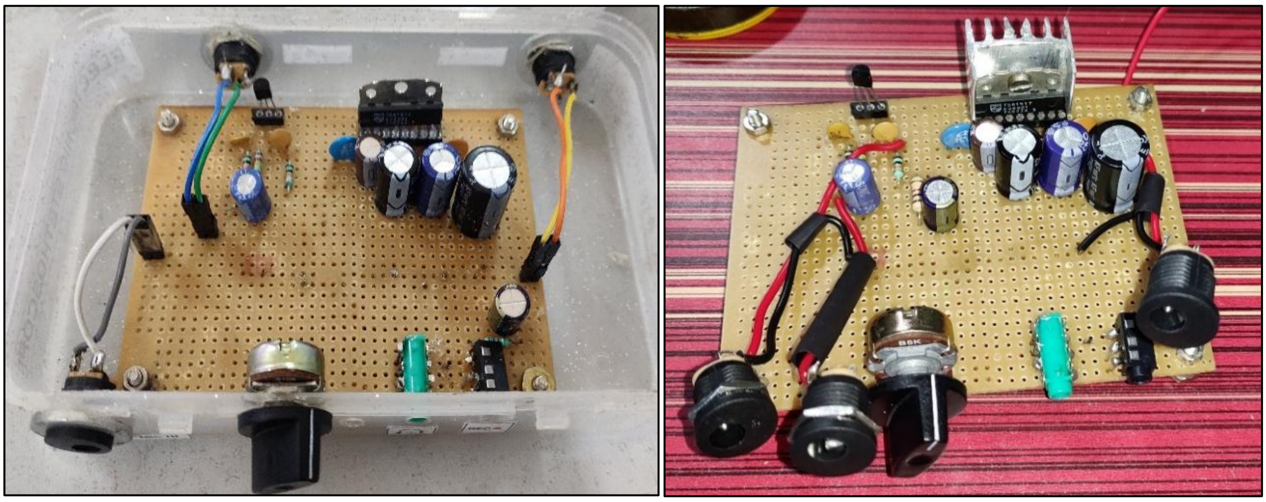

Figure 3 – Circuit board

2.3 Deployment

The amplified heart sound can be heard live using high quality headphones or earphones from the AUX module [7]. The volume of the output audio can be controlled using a potentiometer. An android application has been specifically developed for this project. The features include:

- S1 and S2 heart sound peaks can be visualized as a waveform.
- The recording option is provided for storage and further analysis.
- The recorded heart sounds can be viewed and played back in comfort.

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- The real time classification output for the heart sounds obtained from filter is shown in a website hosted inside the application.

The deep learning model for the heart sound classification is obtained by pre-training the YAMNET model with the dataset that is collected from the project board. There are three different classes with the samples of around 700 each. The pre-processing steps include resampling the audio signal and computing an array of MEL spectrograms.

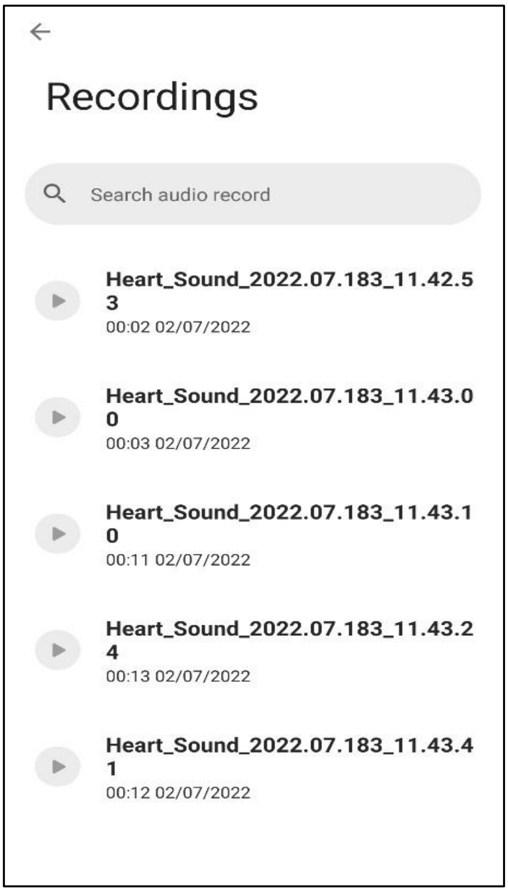

Figure 4 – Android application recording UI Figure 5 – Display of recorded heart sounds in the application

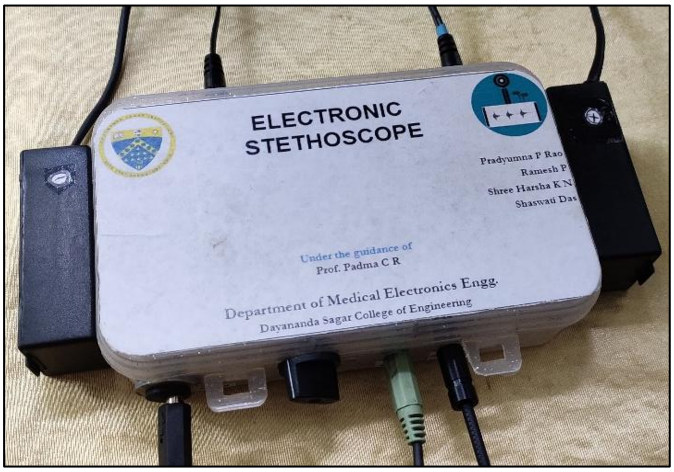

Figure 6 – Final prototype

IRJMETS
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III. RESULTS

- The S1 and S2 heart peaks is visualized live as depicted in Figure 7 using the Application built.
- The recorded heart sounds is displayed and played back in comfort.
- The live classification of the Heart sounds is displayed in the website hosted inside the application.

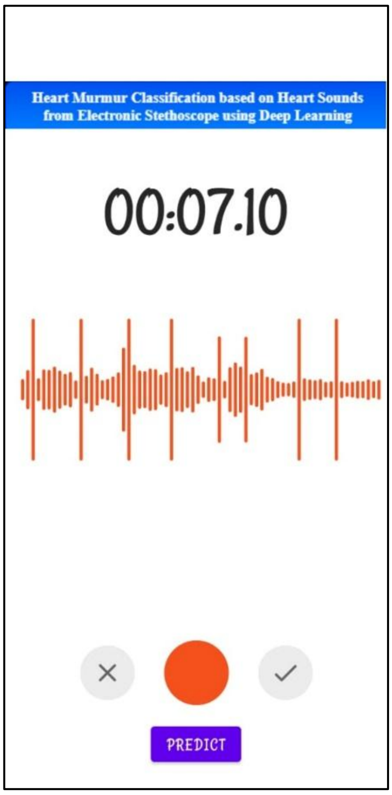

Figure 7 – Live waveform display

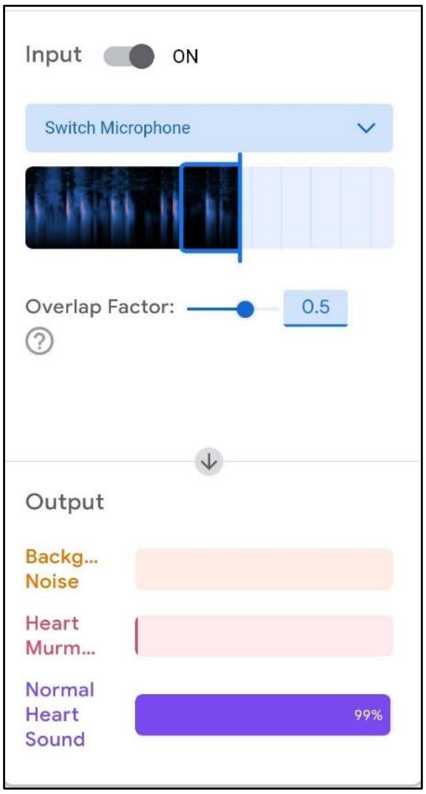

Figure 8 – Live classification from the application

IV. CONCLUSION

- The Electronic stethoscope designed and developed provides doctors with the correct tools to hear subaudible sounds and murmurs, hence improving their diagnosis.
- The heart sound signal can be amplified, processed heard by headphones in real-time. There is no need of using the conventional earpiece.
- The signal can be transmitted to Mobile Application by AUX cable and can be stored for further analysis.
- Using Deep Learning (DL) model we can classify input into normal and abnormal heart sounds (heart murmurs) in real time.

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