Department of Electrical and Computer Engineering

McMaster University

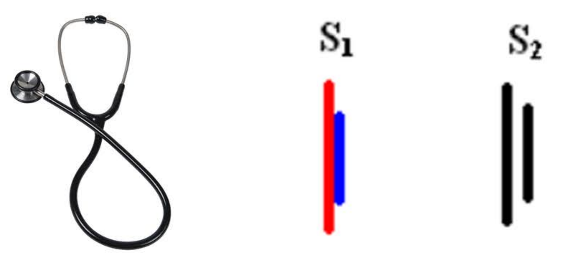
Lucia Iannantuono
Eric Kamada
Simon Ly
Stefano Vitucci

Oris

Digital Stethoscope for Intelligent Auscultations

Introduction

aus·cul·ta·tion
The action of listening to sounds from the heart, lungs, or other organs, typically with a stethoscope, as a part of medical diagnosis.



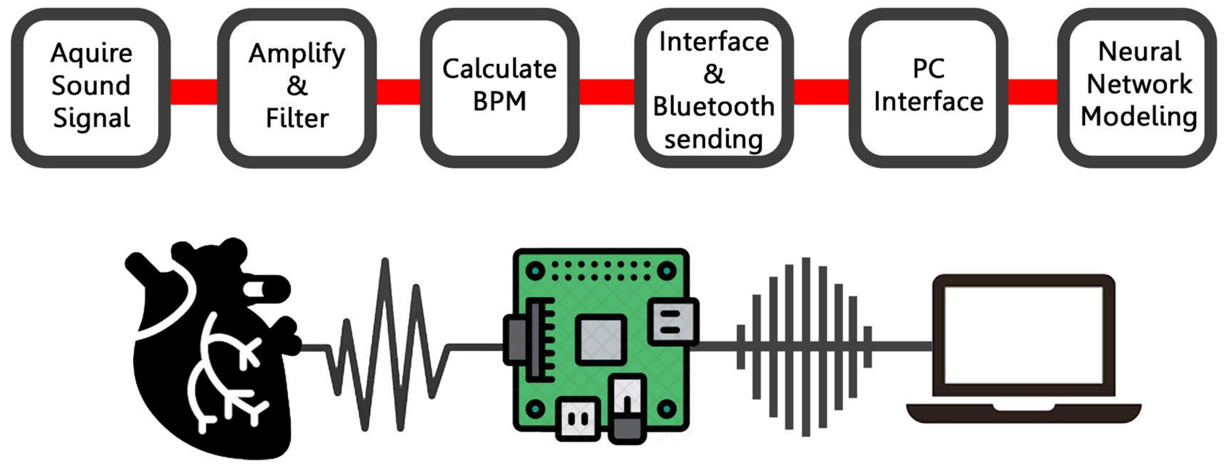
It can be very difficult to identify heart and lung conditions using traditional stethoscopes; it requires a trained specialist, with good hearing and a quiet environment to be able to discern abnormalities. Today, medicine is increasingly making use of technology to enhance collaboration, provide long-distance telemedicine, and provide easily accessible patient history with electronic medical records. An analog stethoscope cannot be easily integrated into a digital 21st century healthcare system. This was the motivation for our design: Oris, a digital auscultation device.

The objective of our project is to create an acoustic analysis tool that can be used by practitioners or even those with only some medical training. It will aid them with hearing and monitoring sounds, perform analysis for diagnosing cardiovascular conditions, and provide digital conversion for recording, replaying, and sharing the audio.

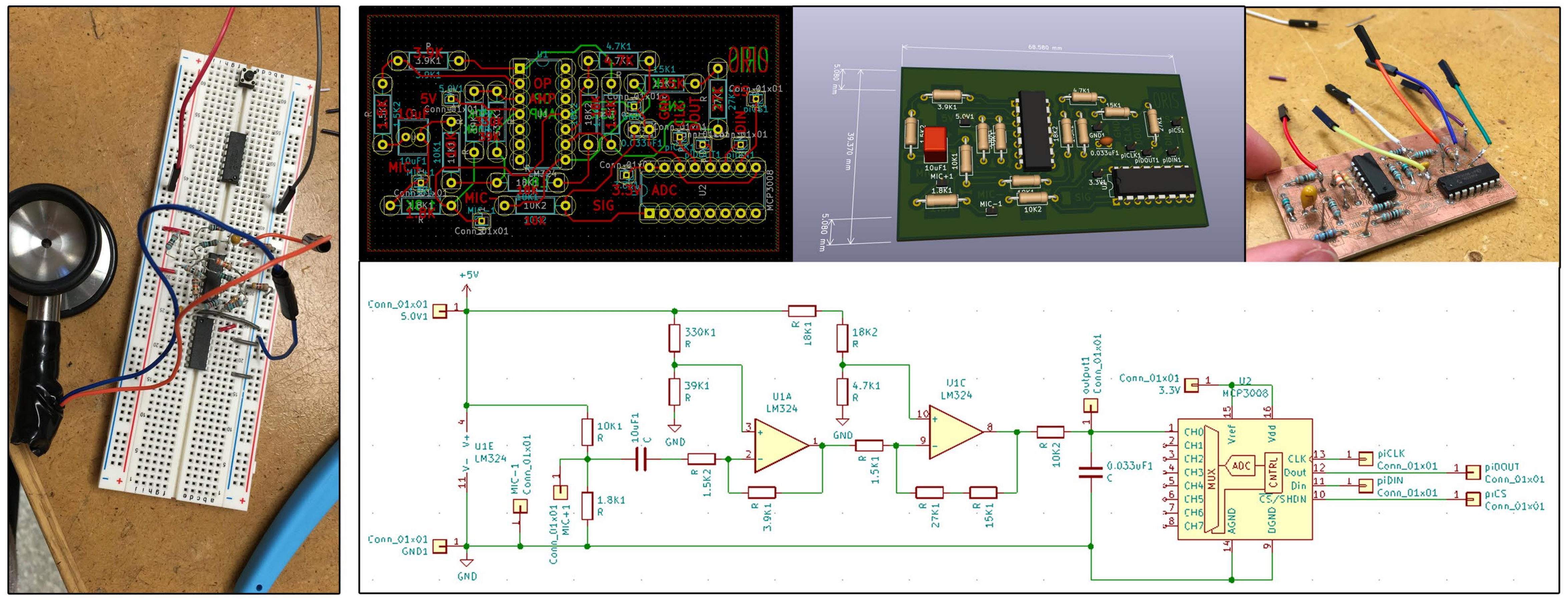
Methods

Our device consists of three components: hardware, embedded software, and a PC user interface.

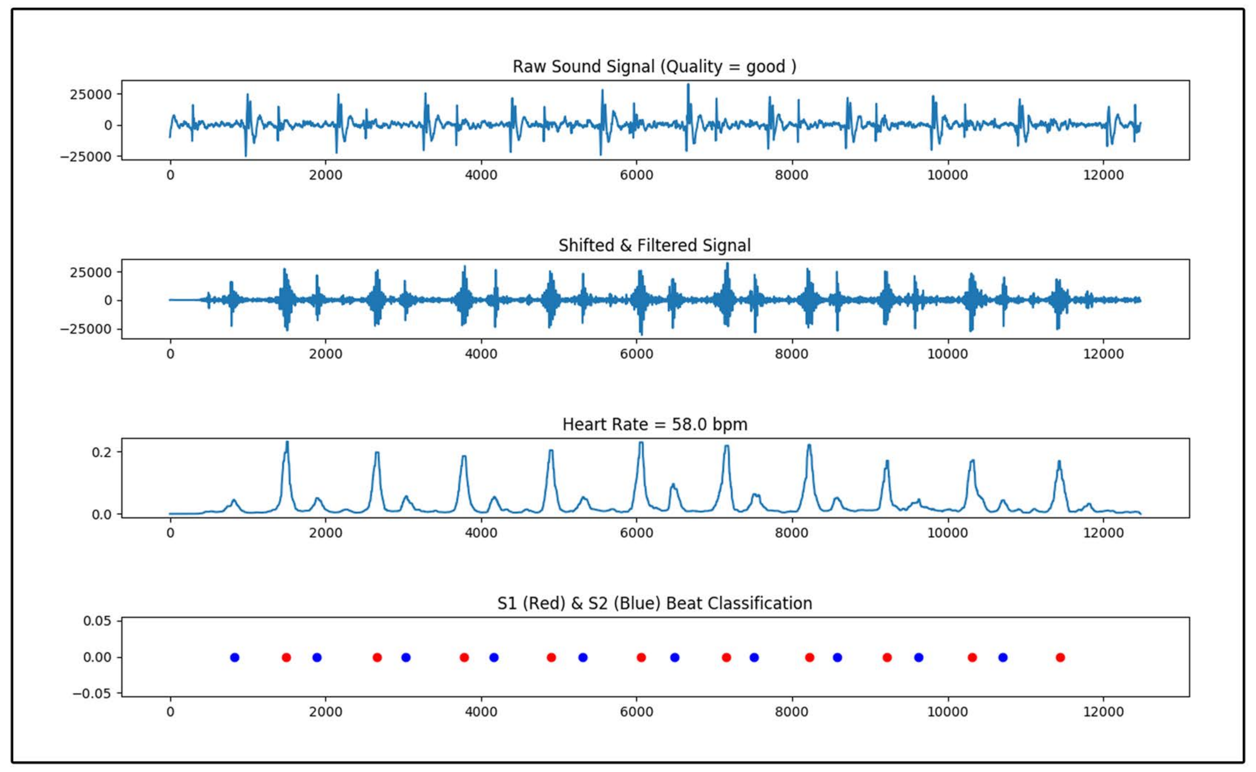
The preprocessing circuit amplifies, filters and converts sound obtained from a bell held to the patient's chest, which has a microphone embedded inside. The resulting digital signal is input to a microcontroller where it undergoes more precise digital filtering. At this stage our hand-held device displays basic diagnostic information to the user and offers Bluetooth functionality to transmit the recorded sound data to their PC. The PC user interface software allows practitioners to save sessions, playback sounds with optional frequency shifting, and run diagnostic analyses to see a normal/abnormal classification for the patient's heart recording.

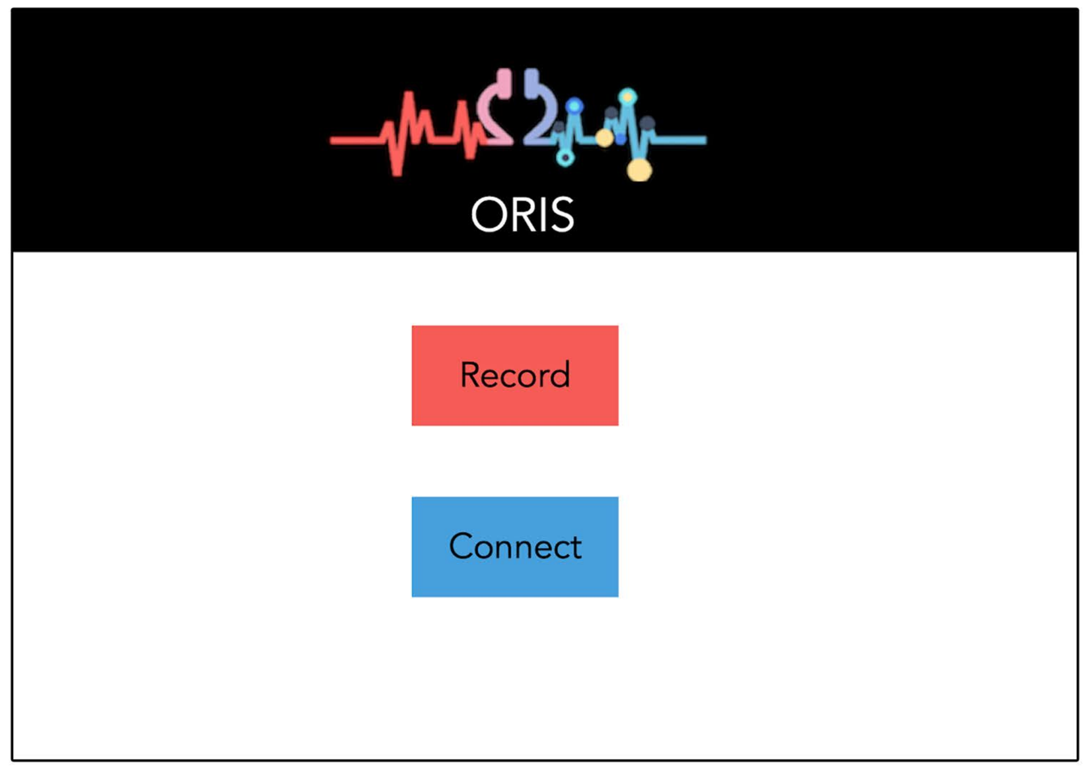


Signal Processing

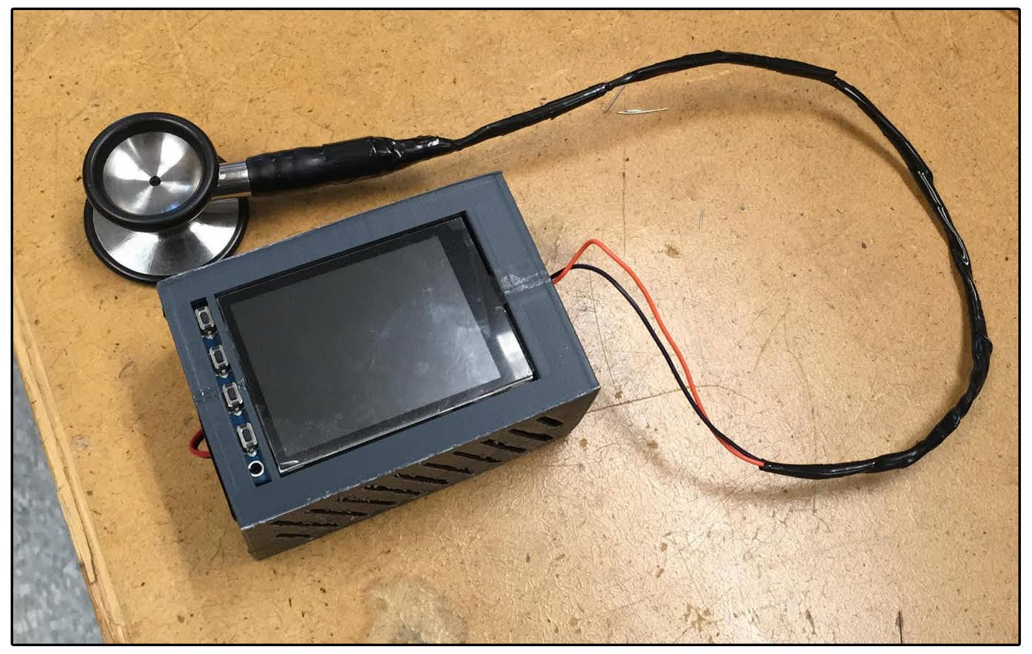


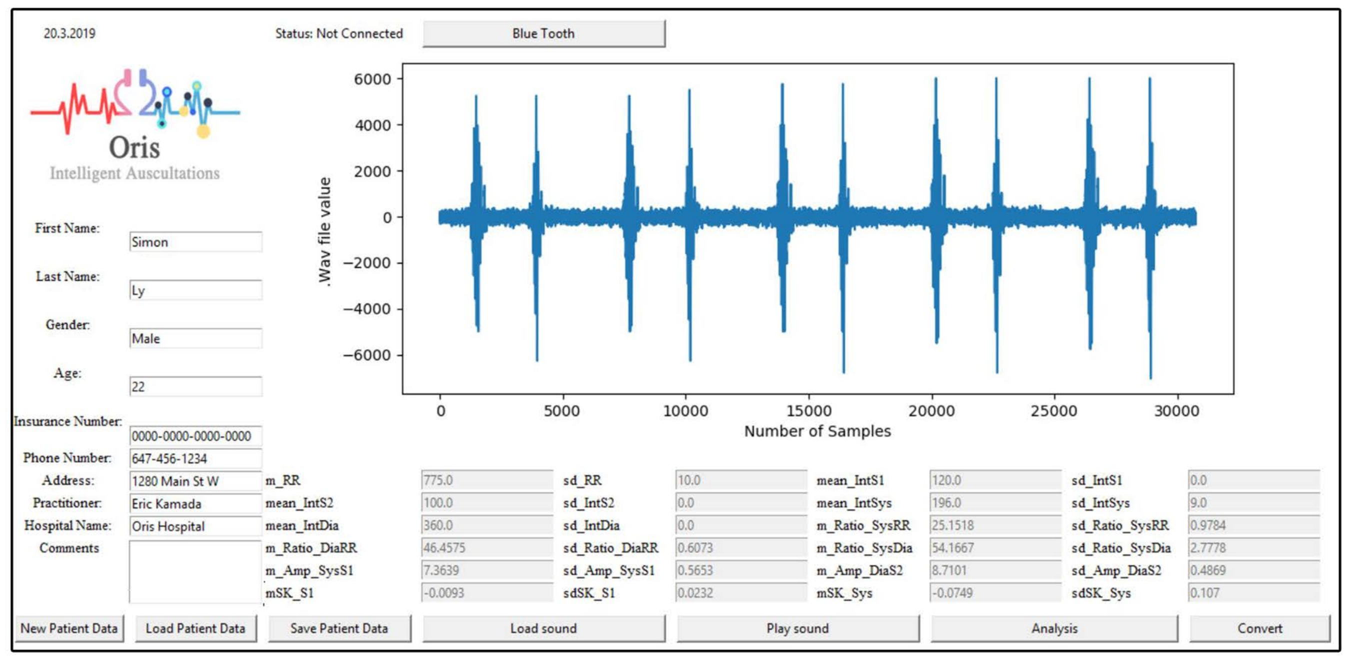
Embedded Software





User Interface





Results

Our system achieves end-to-end processing from acoustic bell to user PC through a convenient hand-held device. Sound can be recorded from a person's chest using a sensitive microphone embedded in the stethoscope head. Through amplification and filtering, a high fidelity digital sound signal is attained and basic information is displayed on the device. The sound recording can then be transmitted wirelessly to the user's PC, where the audio file can be played back, stored, sent, and undergo further analysis.

The heart beat and beat rhythm regularity appear on screen after the recording has finished (if it passes a signal quality check, to ensure accuracy). On the computer, the audio signal waveform and additional data are displayed. Then the audio is input to a more sophisticated neural net algorithm in MATLAB, which returns a designation of normal/abnormal, drawing on a large medical database of human heart recordings.

Algorithm Approach	Accuracy
Logistic Regression HSMM-based Heart Sound Segmentation	0.8602

Discussion

Our project is designed for heart monitoring, which is a large part of auscultation, but it can also be expanded to record and analyze sounds from the lungs.

Another future goal for our device would be to improve microphone sensitivity and digital filtering to allow for auscultation through the patient's clothing.

The current system goes through distinct stages of recording, displaying preliminary analysis, transmitting, and then further analysis. A future goal is real-time data streaming to the PC, and algorithms to classify data as it is streaming, which would allow all the steps to occur simultaneously.

The logistic regression algorithm used by the neural network in this project is limited to S1 and S2 heart sounds, with an accuracy of 0.8602. To further improve this we would need a database with more samples that contain issues such as arrhythmia, splits, murmurs, congestion and an additional database of lung sounds to cover the full field of auscultation.

References

Springer DB, Tarassenko L, Clifford GD. Logistic Regression-HSMM-based Heart Sound Segmentation. IEEE Transactions on Biomedical Engineering, 2016 Apr; 63(4):822-32. doi: 10.1109/TBME.2015.2475278. Epub 2015 Sep 1.

"PhysioNet/CinC 2016 Challenge Software Index", Physionet.org, 2019. [Online]. Available: https://physionet.org/challenge/2016/sources/. [Accessed: 27- Oct- 2018].