Digital Stethoscope for Diagnosis with AR/VR Organ Guidance

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Introduction

The stethoscope is an instrument used by medical professionals to listen to the internal organs of a patient. This assessment is medically known as auscultation. Based on the sounds, a medical professional can assess and determine the well being of the patient and status of the lungs, heart, and intestinal tract.

Outside of the medical field, audio analyzing technology has improved so much that smartphones can not only understand words and phrases, but they can now distinguish between the voice of its owner and other voices. This project is the next step in audio analyzing technology, deep neural networks, and the internal organ auscultation process.

Recording sounds using a digital stethoscope, identifying the location of the sound, and classifying the type of sound using Deep Neural Networks can contribute to determining the diagnosis of a particular disease without medical training.

Motivation

Real-world applications of this device would allow underserved or low-resource communities the ability to monitor health conditions and receive a diagnosis without tests, expensive medical devices, and medical professionals.

Our product will include AR guidance and feedback to the user as they go through the auscultation process. The audio is then automatically analyzed by our software. Ultimately, this product will increase healthcare access because high costs, access to medical supplies, and access to trained medical professions will not act as a barrier for underserved communities.

Method

The AR/VR Guidance System, Audio Analyzation and Diagnostics, and The Digital Stethoscope Device

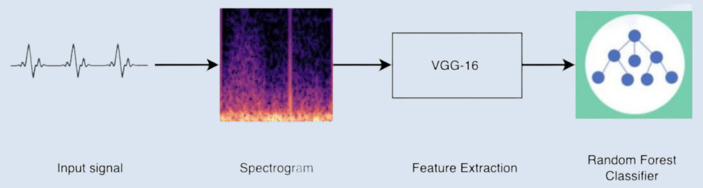
The AR/VR Guidance System uses the image of the user via a device's camera and uses anatomical biometric data to overlay auscultation points on top of the user's body on the screen. The software then tracts the hands of the user to ensure the stethoscope is in the correct position.

The Audio Analyzation portion of this project receives the sounds collected from the stethoscope and translates them into a spectrogram. A spectrogram is a visual representation of sound displayed in a time vs. frequency graph.

Using the spectrometry, we would superimpose the graph of the sound wave collected by the stethoscope onto other graphs from our database of normal and abnormal sounds. The classification process of this project utilizes Deep Neural Networks.

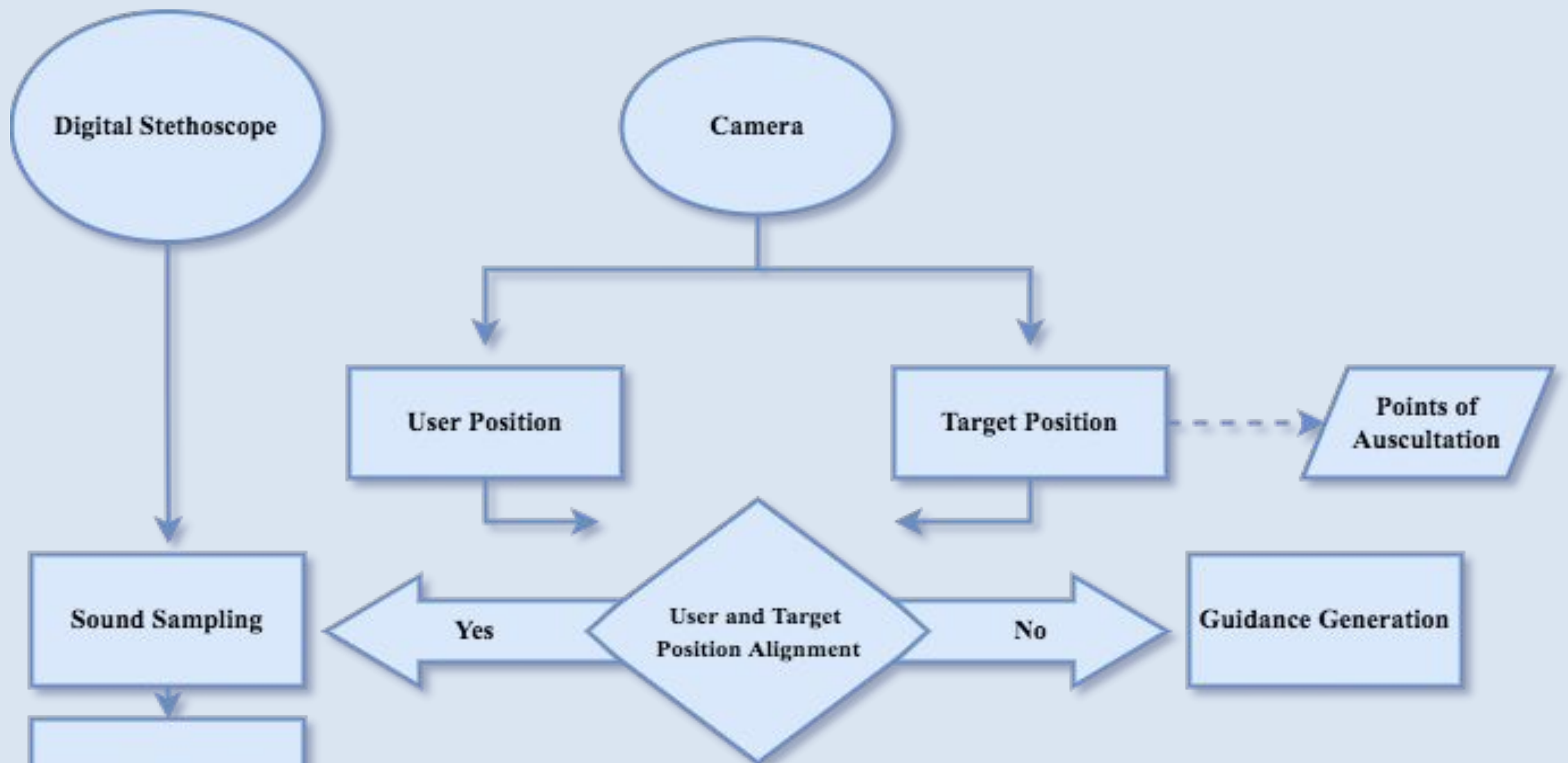
Deep Learning is a subfield of Artificial Intelligence that is used to sort through unstructured data types such as audio. Deep Neural Networks are multiple layers of algorithms that are meant to recognize underlying relationships and patterns in a given data set using sophisticated math modeling.

First we use the sounds collected as our input, and using a data set of previously identified sounds we will label periods within the total sound accordingly based on the present features. Next the features identified in the spectrogram are extracted using VGG-16 (a neural network) and a random forest classifier is applied to assign the sound to a disease.



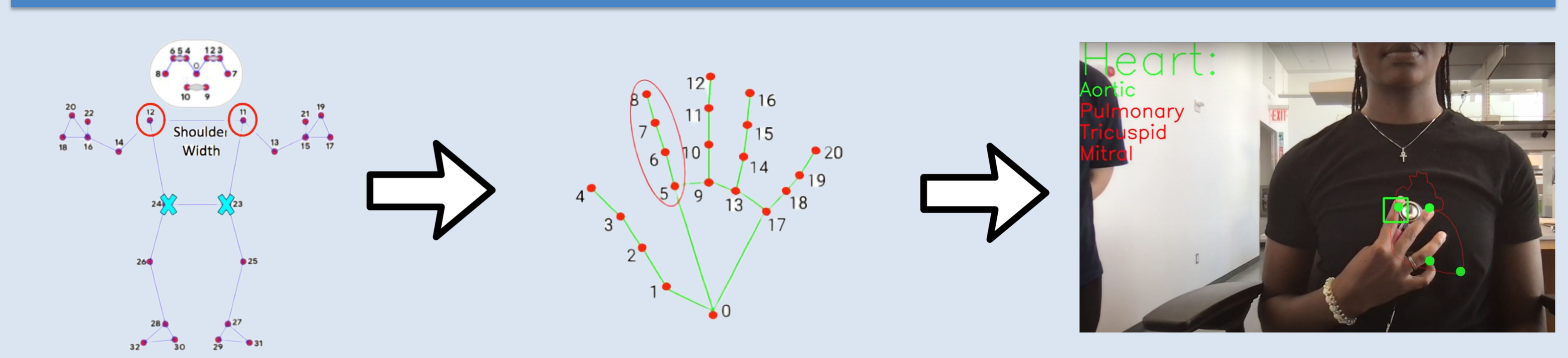
The Digital Stethoscope aspect of our project uses the chest-piece of a non-digital scope attached at the tubing to a microphone with a 3.5 mm headphone jack, which can be connected to a computer or recorder to collect a digital copy of sounds.

System Architecture



Digital Stethoscope Design

AR/VR Guidance Design



Types of Abnormal Sounds

Heart

Murmurs: whooshing or swishing caused by blood flow
Gallops: a third heart sound or triple heart beat
Arrhythmia: irregularity of the pace or rhythm of a heartbeat
Bruits: whooshing indicative of non-laminar blood flow

Lungs

Wheezing: high-pitched shrill whistle
Rhonchi: continuous gurgling and bubbling (inhalation and exhalation)
Rales: high-pitched clicking, bubbling, or rattling
Stridor: wheeze indicating blockage

Intestinal

Ileus: lack of intestinal muscle contractions
Hypoactive Sounds: slowed activity in intestinal tract
Hyperactive Sounds: increased intestinal activity

Disease Detection

Disease Detection Possible Based on The Location and Type of Sound

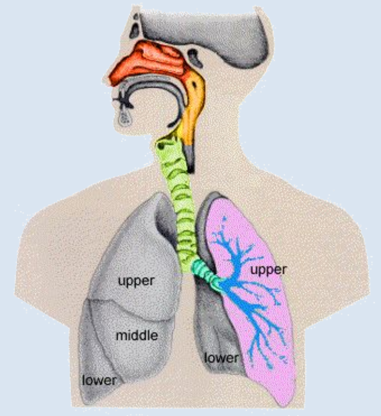


Figure 1. "Anatomy & Physiology of the Respiratory System." *The Virtual Autopsy*, Anatomy & Physiology of the Respiratory System. Accessed 29 July 2022.

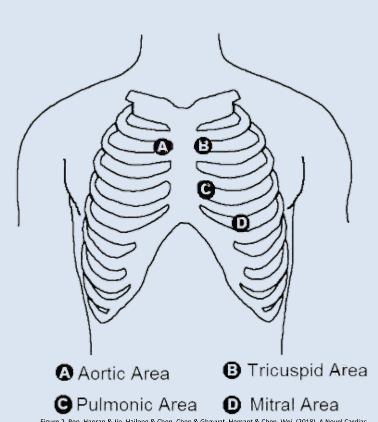


Figure 2. Ren, Haoran & Jin, Hailong & Chen, Chen & Ghayvat, Hemant & Chen, Wei. (2018). A Novel Cardiac Auscultation Monitoring System Based on Wireless Sensing for Healthcare. IEEE Journal of Translational Engineering in Health and Medicine. PP. 1-1. 10.1109/JTEHM.2018.2847329.

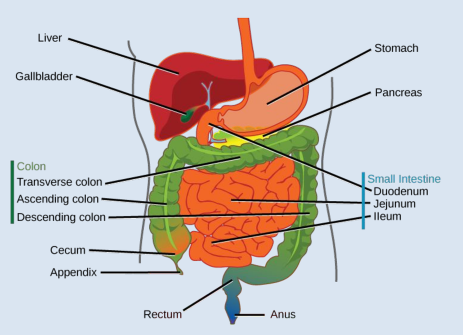


Figure 3. Anatomy of Abdomen

Lung Auscultation

- Chronic Obstructive Pulmonary Disease
- Acute Bronchitis
- Pneumonia

Heart Auscultation

- Congestive Heart Failure
- Carotid Artery Disease
- Arrhythmia
- Murmurs

Abdominal Auscultation

- Crohn's Disease
- Peritonitis

Preemptive Disease Detection

Idiopathic Pulmonary Fibrosis

Disease that causes scarring of lung tissue, making breathing difficult and worsens over time. The treatment is capable of slowing down disease progression but is unable to reverse damage. Typically found after lung biopsy and imaging is done

- Early diagnosis is challenging due to the non-specific physical symptoms that the patient experienced.
- Survival rate is typically 2-5 years after diagnosis found.
- → Early diagnosis is possible using audio analyzing software to detect "velcro-like" crackles which are attributed to this disease.
- → Digital Stethoscope Diagnosis allows for early treatment.

Acute Chest Syndrome

This is a syndrome that causes severe chest pain along with cough, hypoxia, and fever. Detection by imaging is difficult, not reliable, and often found too late.

- Leading cause of death among people with sickle cell anemia
- Currently only found after imaging and presence of pulmonary infiltrates is detected on imaging
- Due to varying symptoms such as fever and respiratory issues imaging is done late
- → Presence of pulmonary infiltrates is detectible using percussive devices and thus able to be detected using a digital stethoscope.
- → Digital Stethoscope Diagnosis allows for early treatment.

Future Work

- Continue to build the internal organ sound database to increase diagnostic accuracy
- Develop AR/VR Guidance App for smartphones
- Improve diagnostic process and user experience by allowing the user to provide a description of their symptoms

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