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# A NOVEL SMART STETHOSCOPE FORHEALTH-CARE PROVIDERS

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**Abstract— A stethoscope is an instrument used in auscultation to transmit signals from patient body to the ear of the healthcare provider. Depending on where the stethoscope is placed on the body, healthcare providers can hear the sounds of the bowels, the lungs and even blood going through an artery. In this paper, a novel efficient device is proposed to train health-care providers. Using the proposed device will enable the healthcare providers to properly use the medical stethoscope. A questionnaire is created to ask healthcare providers about the efficiency of the proposed device. Results show that more than 90% of the healthcare providers find the proposed device an excellent training tool.**

**Keywords Biomedical engineering; Stethoscope; Medical training**

## I. INTRODUCTION

A stethoscope can be used to diagnose a wide range of health issues. It can be used to diagnose cold or flu, a problem in breathing due to any respiratory problem. Medical personnel can listen to breath sounds through a stethoscope by placing the stethoscope on lungs. In addition, with a stethoscope, doctors and nurses can hear abnormal heart sounds such as; a murmur, irregular rate and other sounds that might not be normal. A health-care provider can hear the heart beating in the veins. Faint beats cannot be heard without a stethoscope. Moreover, the stomach and bowels make popping and gurgling noises. A stethoscope is used to hear these noises accurately. The absence of sound could mean an obstruction in bowels and a large number of noises could signal an infection or illness. Finally, an obstetrician uses a stethoscope to listen to heartbeat of a baby in the uterus [1, 2].

An efficient and excellent training is required and needed for health-care providers such as physicians and nurses. They have to be able to know the right part and position in the human body where they should place the stethoscope. In addition, they have to know and recognize various sounds acquired from the human body. Each sound has a meaning. In an early stage of a patient's treatment, a good health-care provider should be able to diagnose the patient's symptoms based on the sound heard bythe stethoscope.

In 1997, researchers examined how well 453 physicians in training and 88 medical students interpreted the information obtained via stethoscope. According to their study, "both internal medicine and family practice trainees had a disturbingly low identification rate for 12 important and commonly encountered cardiac events." [3]. Researchers wrote in the Archives of Internal Medicine [4], that skill "may decline after years in practice, which has important implications for medical decision-making, patient safety, cost-effective care and continuing medical education."

Different research groups have proposed wide range of solutions to enhance the training methods for health-care providers and enable them to interpret the human body sounds accurately.

Employing a computer simulator system in health-care environment such as clinics and universities is used in different research groups such as the research done in [5]. The research group utilized pre-recorded sounds. Health-care providers listened to the sounds and try to identify the meaning of the sound. The method is not efficient since there is no stethoscope involved in the training process. A health- care provider just listens to the sound. He/she may not know where to place the stethoscope on human body.

## II. CONCEPTUAL DESIGN

In this paper, a smart stethoscope equipped with a microprocessor, sensors, and a wireless communication module is proposed. The proposed smart stethoscope is designed and developed to efficiently train health-care providers to master the utilization of the medical traditional stethoscope. The proposed smart stethoscope helps health- care providers to place the stethoscope in the right position/location on the human body and to accurately interpret different sounds from the patient human body.

The proposed smart stethoscope consists of a microprocessor, MP3 module, Gyroscope Accelerometer IMU, Bluetooth module, and of course a speaker as shown in Figure 1. A health-care provider holds the developed stethoscope and be asked to perform a certain task such as listen to the heart sound. He/she should know where to place the stethoscope on the human body as shown in Figure 2 [6].

The heath-care provider trainee will move the stethoscope on the human body. The Gyroscope Accelerometer IMU inside the developed stethoscope can

detect its location on the human body relative to the patient

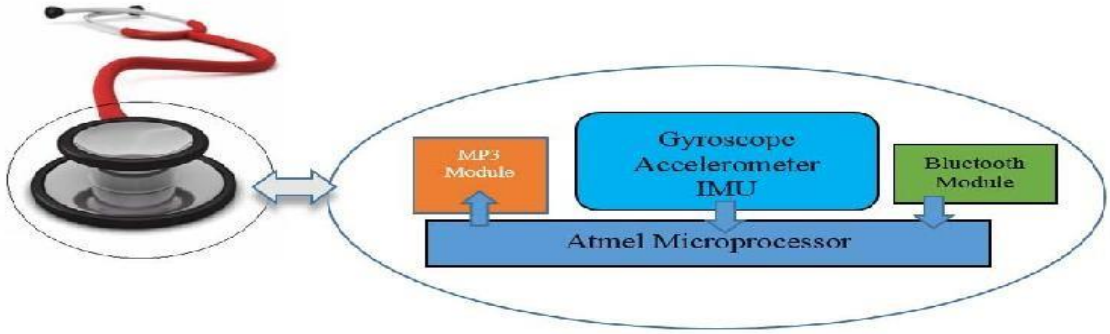


Figure 1. The Proposed Smart Stethoscope Structure

chin. In other words, the patient chin is considered the origin point (x,y,z = 0,0,0). If the trainee places the stethoscope in the wrong position on the patient body, no sound will be generated by the stethoscope. He/she must put the stethoscope on the correct position/place on the patient human body to be able to listen to the desired sound.

Once the stethoscope is placed on the right coordinates, a wide range of sounds can be played to the trainee based on a selection buttons in a developed cell phone app controlled by the instructor (expert physician). At each particular location on a patient body, different sounds can be played. Each sound has its own interpretation for a different physical meaning. For example, loud heart sound may mean hyperdynamic (fever, exercise), mitral stenosis, or atrial myxoma (rare). Soft first sound may be interpreted as low cardiac output (rest, heart failure), tachycardia, or severe mitral reflux (caused by destruction of valve). Variable Intensity of first sound means atrial fibrillation or complete heart block [7].

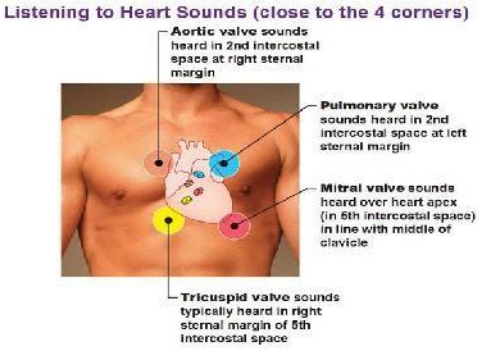


Figure 2. Different Stethoscope Positions in Patient's Body [6]

The cell phone app is developed to send group of commands to the smart stethoscope via Bluetooth. The instructor sends which sound will be played to the trainee if and only if he/she put the stethoscope on the right place on the patient human body. The instructor controls the type of sound the trainee listens to. The instructor may send a sound that indicates a good healthy condition or a sound that indicates a problem. The trainee should place the stethoscope on the right location on the patient body and listens to the generated sound and interpret it. The operation of the smart stethoscope is shown in Figure 3.

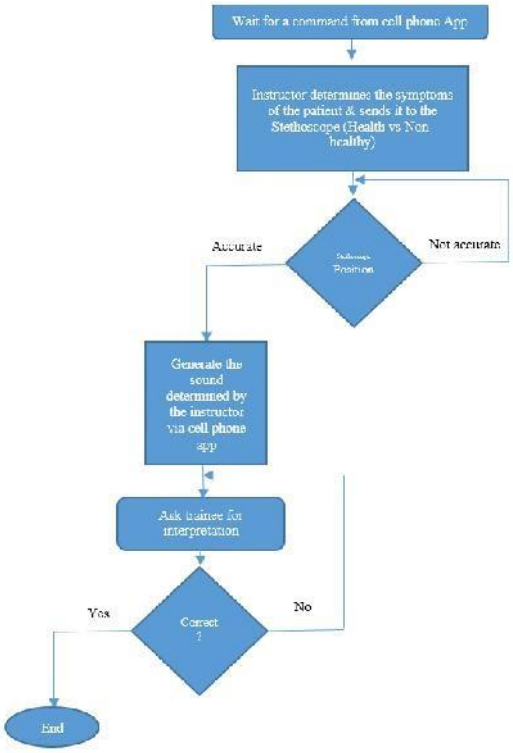


Figure 3. Smart Stethoscope Operation Flow Chart

## III. EVALUATION

The proposed stethoscope training system can be divided into three subsystems/modules in addition to the cell phone

app controlled by the instructor. The first module is the Gyroscope Accelerometer module. In Figure 4, the evaluation of the Gyroscope Accelerometer module is shown. If the module moves, the coordinates (x,y,z) are reported back via serial communication to the PC (only for testing purposes). So, these coordinates can be used to check the location of the stethoscope on the patient body.

The PC is not used in the real training process. The PC was just used to see and test the Gyroscope Accelerometer module and validate the coordinates once the module moves on different locations on the human body.

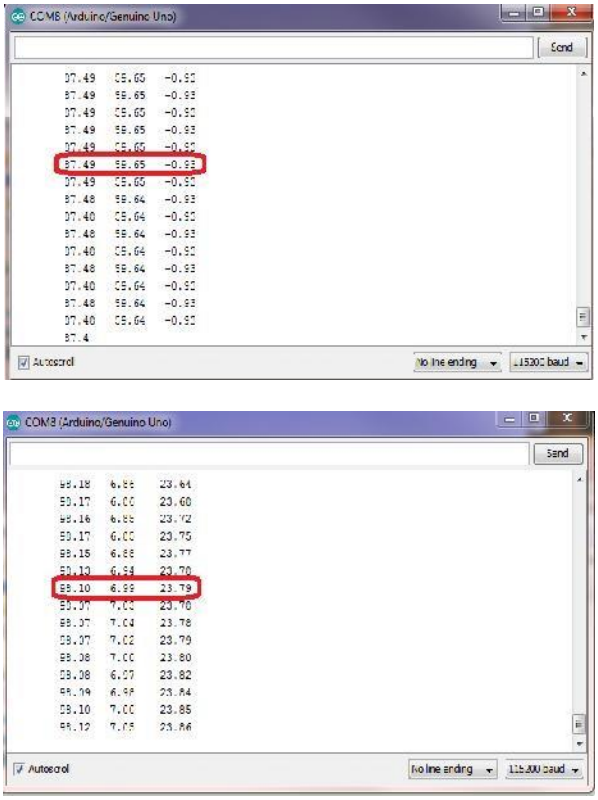


Figure 4. Coordinates reported to PC when Gyroscope Accelerometer Module integrated in the proposed Stethoscope moves

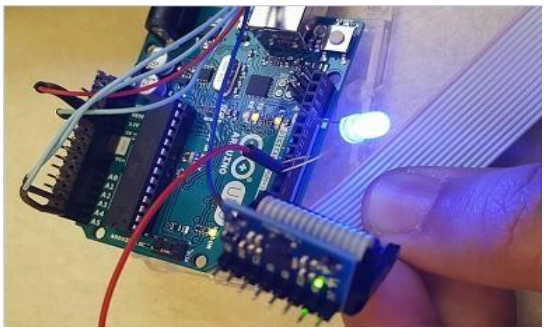

Figure 5. Successful functionality of the Gyroscope Accelerometer Module

Figure 5 illustrates the accurate functionality of the Gyroscope Accelerometer module. Figure 5 shows a working prototype of the module. If the Gyroscope Accelerometer module is placed on the right location with the expected x-y-z coordinates, simply, LED will be on.

The second module is the MP3 module. Figure 6 shows

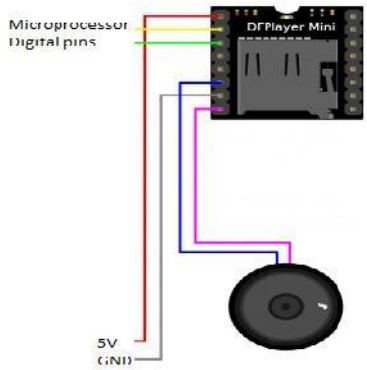


Figure 6. MP3 Module Connections to the Microprocessor

the circuit of the MP3 module and its connection to the microprocessor used in the proposed system. As shown, it is a very straight forward connection. The stethoscope's speaker is used to play any mp3 files stored in a micro SD card that should be inserted in the MP3 module. The instructor controls which file from the SD card should be played and heard by the trainee.

The Third module is the Bluetooth module. This module is used to transmit commands from the instructor's cell phone app to the smart proposed stethoscope. An instructor controls what sound will be heard by the health-care provider trainee (healthy vs non healthy sounds) only if the stethoscope automatically determines that the trainee places the stethoscope on the right place on the patient body.

In Figure 7, a Printed Circuit Board (PCB) of the proposed design is shown. It is designed by the author and built in China to cut the cost down.

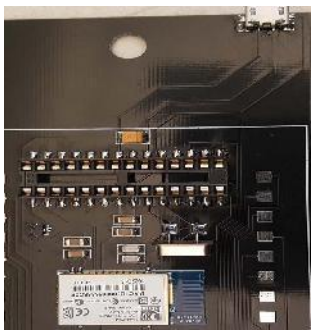

Figure 7. Developed PCB for the Smart Stethoscope Bluetooth Module and Microprocessor Slot

## IV. QUESTIONAIRE RESULTS AND DISCUSSION

A prototype of the proposed device was tested by ten nursing students. A questionnaire is developed and distributed to all participants. Nine out of the ten students reported back that they believe that the proposed device helped them to master the stethoscope usage. Only one student reported that it does not feel real.

## V. CONCLUSION

A stethoscope is a very important instrument in the health-care provider's life. It can be used to tell a lot of facts about patients especially in early stages of the physical exam and before any complicated tests. A good physician or nurse should be able to accurately use the stethoscope. They have to know where to place the stethoscope on the patient body. Moreover, they should know what sounds they may get based on each location on the patient body. Finally, they should be able to interpret these sounds correctly to avoid false diagnosis of the patient's condition. The proposed smart stethoscope can be used to provide enough and regular training to any health-care providers such as students, nurses, and physicians. The proposed stethoscope can detect its location on the patient body and only generates sounds ifthe stethoscope is on the right position. A wide range of sounds are stored in the proposed stethoscope to be played to the trainee. An instructor controls these sounds to test the trainee's ability to diagnose a wide range of possibilities that he/she can face in the real world.

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