Wearable Simulator for Enhanced Realism

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Abstract

Simulations are an incredibly useful tool for training medical personnel on high-risk and infrequent scenarios [1]. Although there are many high fidelity simulations on the market, all of them are based around plastic mannequins that lack the ability to interact and move the way a real human would thus breaking a sense of realism for the medical personnel [2]. Therefore, the team proposes a wearable simulation vest that can be worn by an actor or instructor. This will enhance the authenticity of the experience between the medical personnel trainee and the patient by allowing the trainee to interact with someone that can talk, act, and move the way a real patient would. The vest will include speakers that emit heart and lung sounds that are hearable through a stethoscope. Ultimately, the goal is to have a functional simulation vest that has heart and lung sounds and can be used to assist doctors, residents, and nurses in training by providing the most realistic interpretation of any given scenario.

Background

- Medical Simulations
  - Education and training for various situations
  - CPR, surgery, emergency rescue, basic life support [3]
- No more than $500
- Must be a wearable simulator of reasonable weight and size to fit the average person
- Can be used about 12 hours per week
- Outputs can be modified during simulation to respond to interventions
- Simulates heart sounds
- Simulates lung sounds

Competition

There is currently no product like the wearable vest on the market, but SIM mannequins are currently being used for medical education.

Figure 1: The SimMan 3G [4]

- High fidelity mannequin
- Closely resembles human symptoms and anatomy
- Pre-programed scenarios
- Able to undergo certain procedures
- Palpable anatomical landmarks

Figure 2: Gaumard Heart and Lung Sound Adult Torso [5]

- Low fidelity
- Multiple heart or lungs sounds
- Compatible with stethoscope for listening
- Use for repeated practice

Motivation

- Current simulations are inanimate mannequins that make it difficult for students to interact in a realistic way
- More personal and human interactions
- Use across multiple medical disciplines
- Lower cost option compared to the 66,000 USD Laerdal SimMan 3G
- Global medical simulation market valued at 1.9 billion USD [6]
  - CAGR of ~14.6% [6]

Final Design

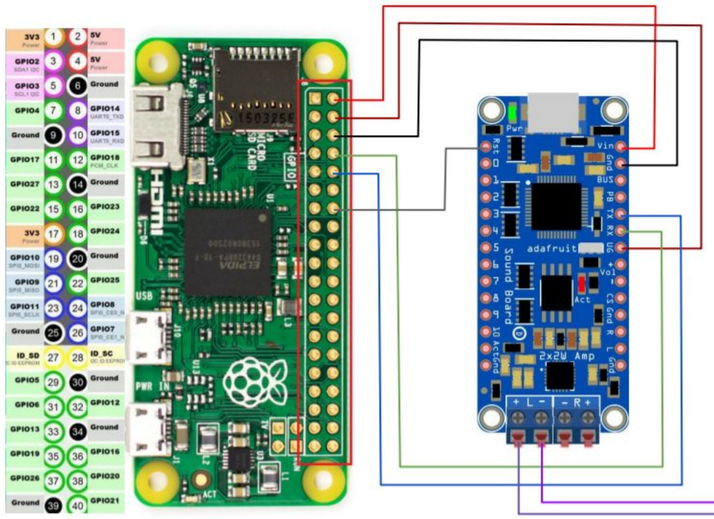

Figure 3: *Hardware circuitry diagram. The Raspberry Pi Zero W communicates with the Adafruit FX Soundboard to play heart and lung sounds through the speaker.*

Figure 4: *Hardware layout within vest. 1) The speakers are placed on the front and back to simulate heart and lung sounds. 2) Battery packs are used to power the 3) soundboards and 4) raspberry pi. Everything except the speakers is housed in plastic electronics boxes along the sides of the vests for protection.*

Testing

1. **Wearability Evaluation**
   - 1.1. Criteria: Is the vest comfortable?
   - 1.2. Method: Team members wore the vest
   - 1.3. Result: Vest is comfortable and can fit multiple body types
2. **Circuitry Testing**
   - 2.1. Criteria: Can an operator play various sounds on command?
   - 2.2. Method: Arduino control with two test sounds
   - 2.3. Result: Controller is able to switch between sounds at will
3. **Loudness Evaluation**
   - 3.1. Criteria: Can the sound be heard through the vest?
   - 3.2. Method: Placed ear on other side of vest and played a sound
   - 3.3. Result: Passed subjectively by all team members
4. **Duration Test**
   - 4.1. Criteria: Will the circuit survive extended periods of use?
   - 4.2. Method: Connected the system to power for 1.5 hours
   - 4.3. Result: Success, the system was able to play sounds after the testing period had ended. Temperature remained low.
5. **Durability Test**
   - 5.1. Criteria: Will the hardware box survive operational loading?
   - 5.2. Method: Stacked weightlifting plates on box (300 lb) and balanced a point load on the center of the box (45 lb)
   - 5.3. Result: The box did remained intact for both loads, , but yielded under the point load

Future Work

- Make the control system fully wireless so that the controller can change sounds to respond to interventions in real-time either through a handheld device or web interface.
- Incorporate electronics into the vest
- Conduct comprehensive scenario-based testing of an emergency situation.
- Add additional speakers to more accurately represent all of the different stethoscope listening points on a patient.

References

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