Remote Triage System for the DARPA Drone Challenge

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Motivation and Problem

- The specific motivation for DARPA to issue this challenge was the immediate need for new triage tools to support medical decision-making in diverse military and civilian settings [1]
- Currently, before triage can even begin, first responders must manually search through these areas to find all victims. This takes too much time.
- In other words, the problem in which we are setting out to solve is the lack of a quick enough automated triage system in a mass casualty setting

Proposed Solution

Our solution is to design a sensing system that can measure a person's heartbeat and respiratory rate, non-contact, using radar as well as cognitive abilities using a voice detection system. All the data acquired from these sensors will then be sent to a computing system, wirelessly, where it will process this information and sort the person into an injury classification system which will follow the START method.

START

- **S**imple
- **T**riage
- **A**nd
- **R**apid
- **T**reatment

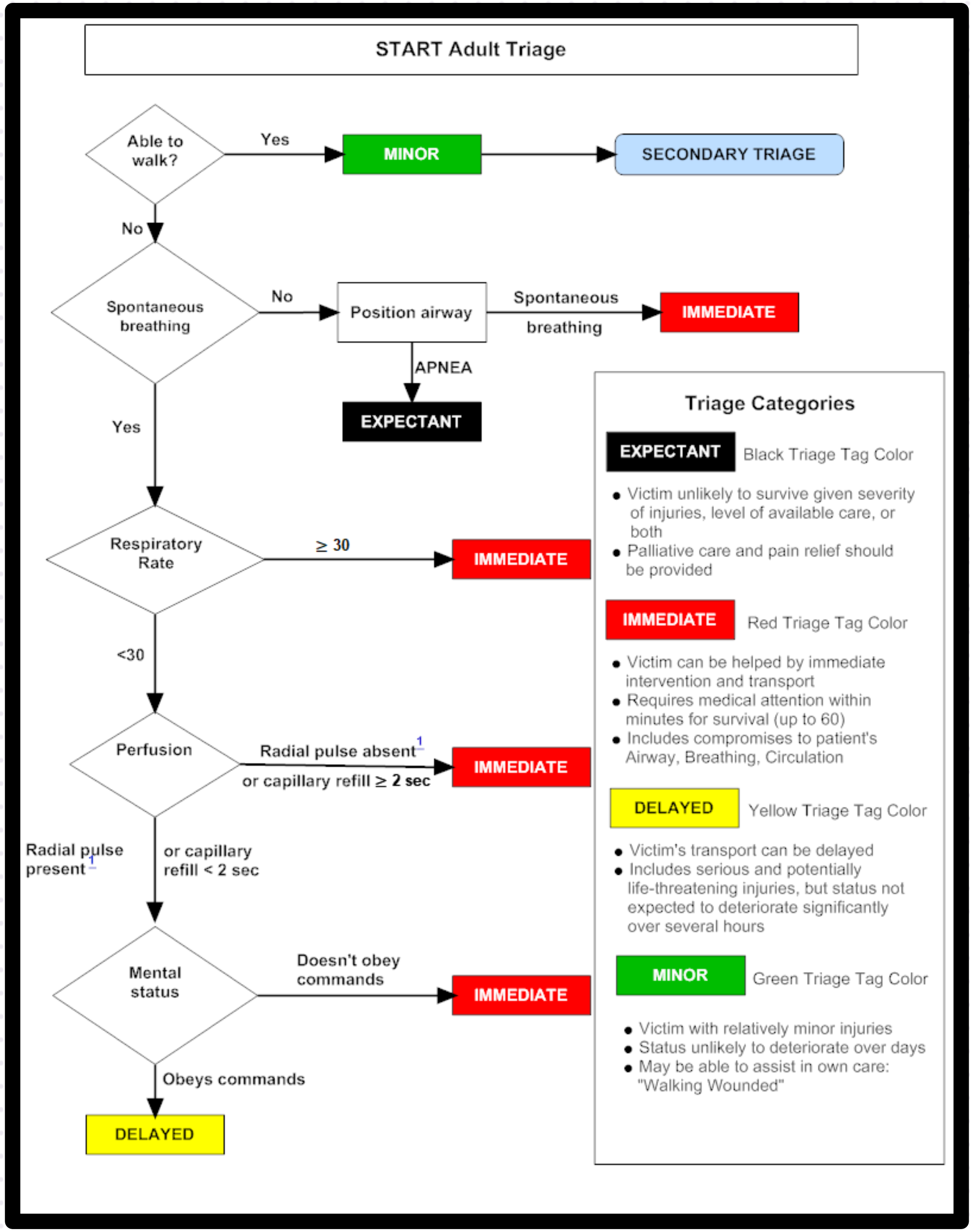


Fig. 1. The above chart displays all categories of the START Method [2]

Constraints and Solutions

Constraint	Solution
Obtain the presence of a heartbeat	Used a 24 GHz radar module
Obtain the presence of respiratory rate	Used a 24 GHz radar module
Detect if human voice is present	Used a microphone module
Sense vitals from at least 1 meter way	Constructed a test stand 1 meter tall
System must weigh less than 6 pounds	Carefully picked lighter components
Operate at full functionality for 15-60 minutes	Constructed a power system using a battery
Display triage results and vitals wirelessly	Used a LoRa Transceiver module to send to UI
Display results in close to real time	Used a raspberry pi as computing system

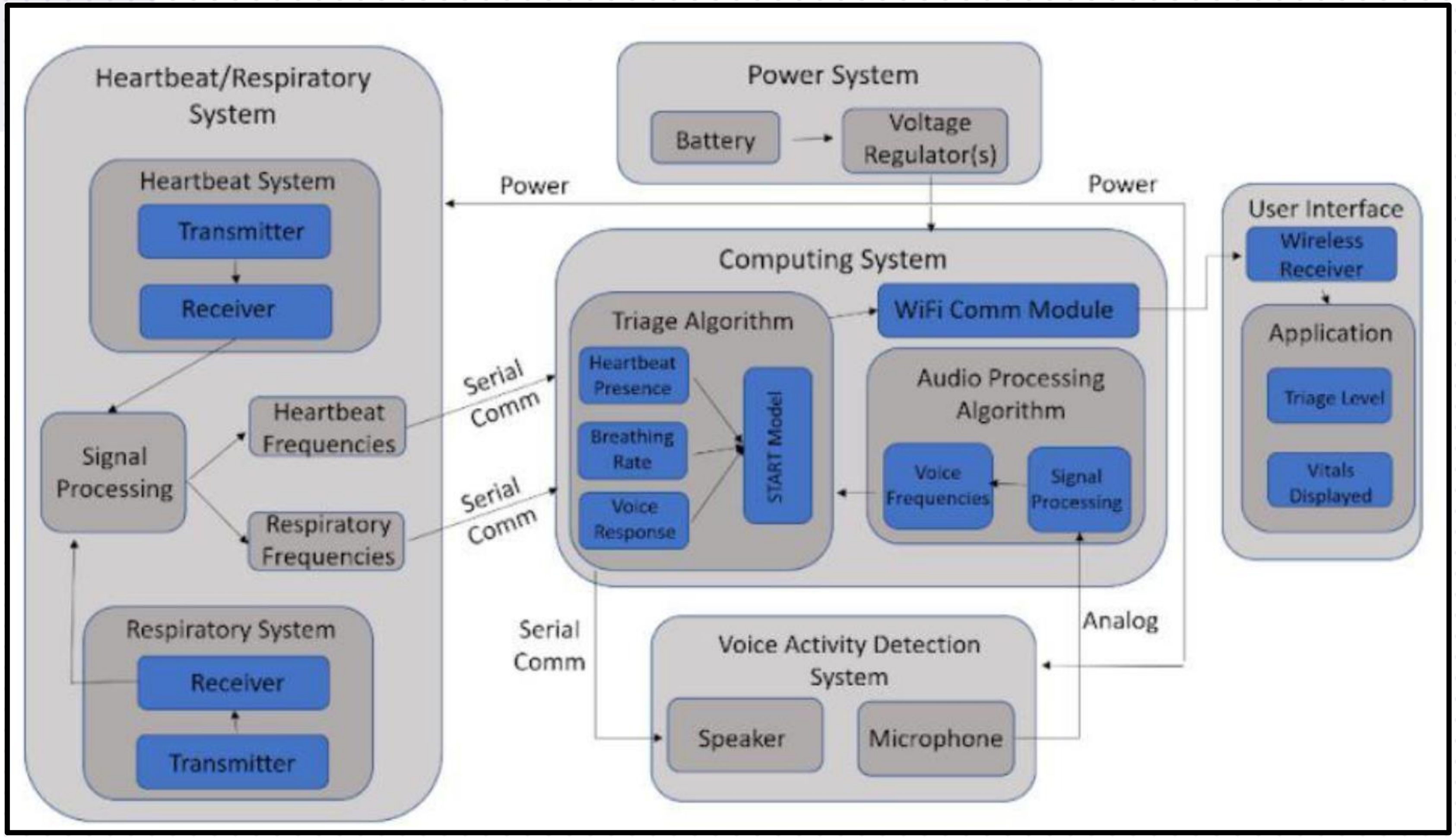
Standards Considered

- IEEE 1662-2016: Power System Standards
- IEEE C95.1-2019: Radio frequency effects on human skin
- FAA 14 CFR Part 107: Drone lighting
- One-party/ two-party consent laws: Audio and visual recording
- FCC Part 15 Subpart C
- FCC Part 15 Subpart D

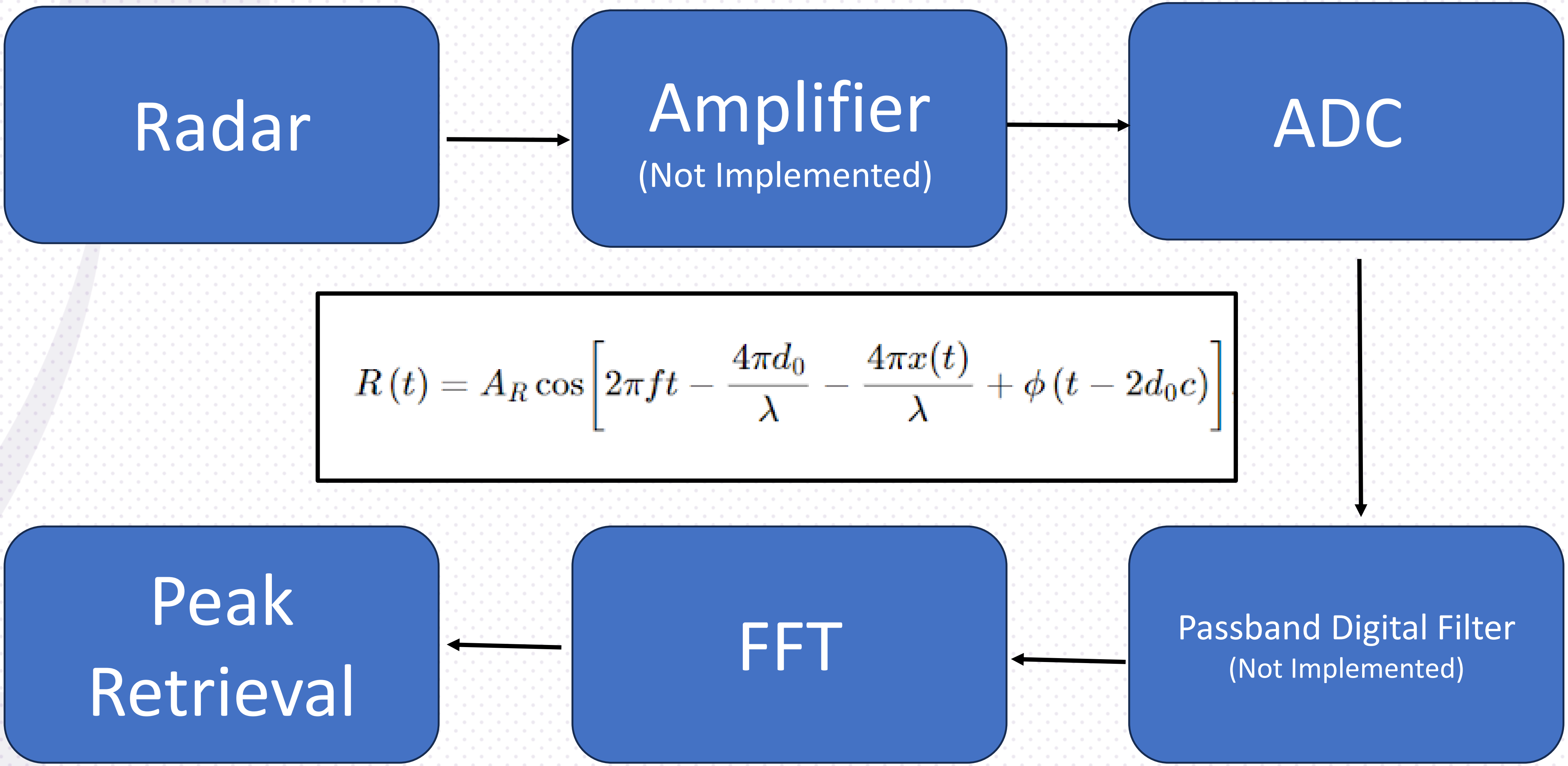
Ethical Considerations

- Government usage
- Poorly constructed power system could harm environment
- Sensing system may have the capabilities to save many lives that have been affected by a disaster.

Conceptual Block Diagram

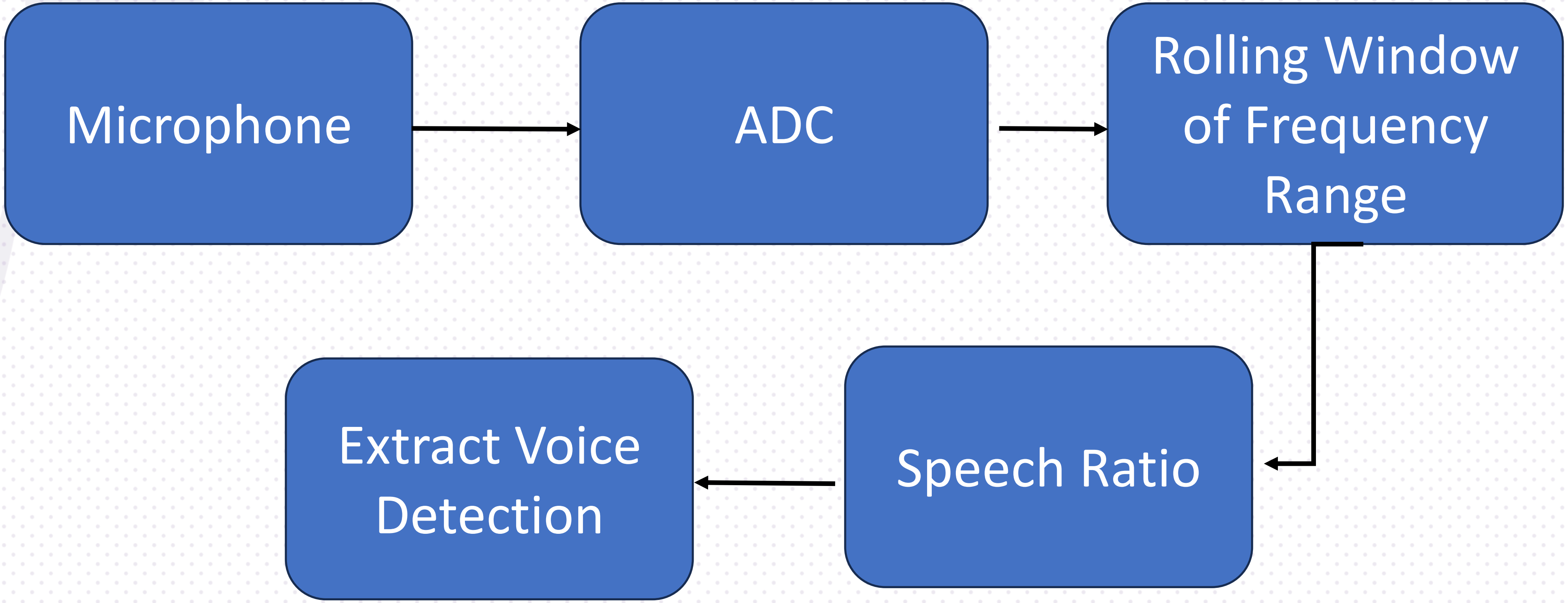


Heartbeat and Respiratory Subsystem

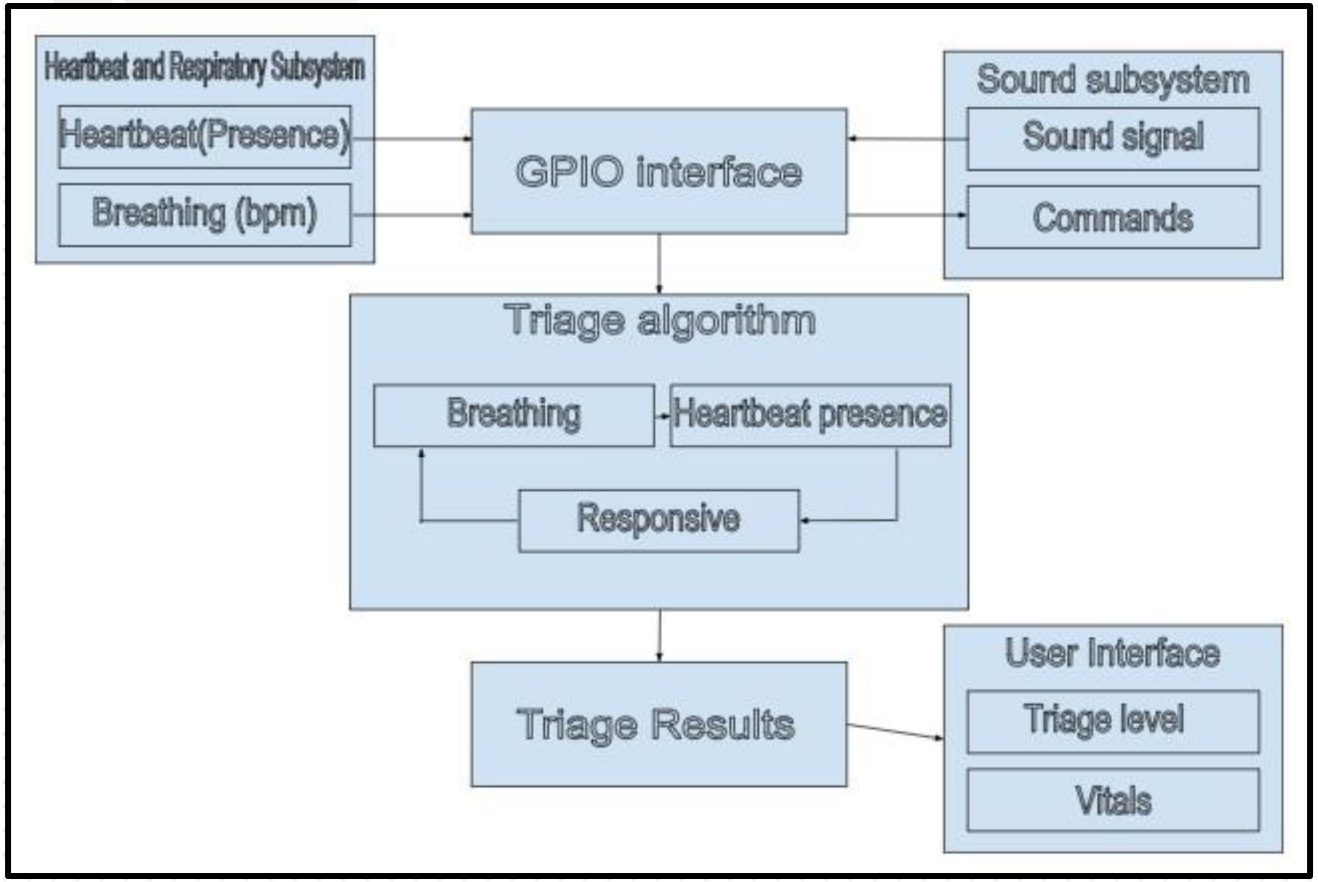


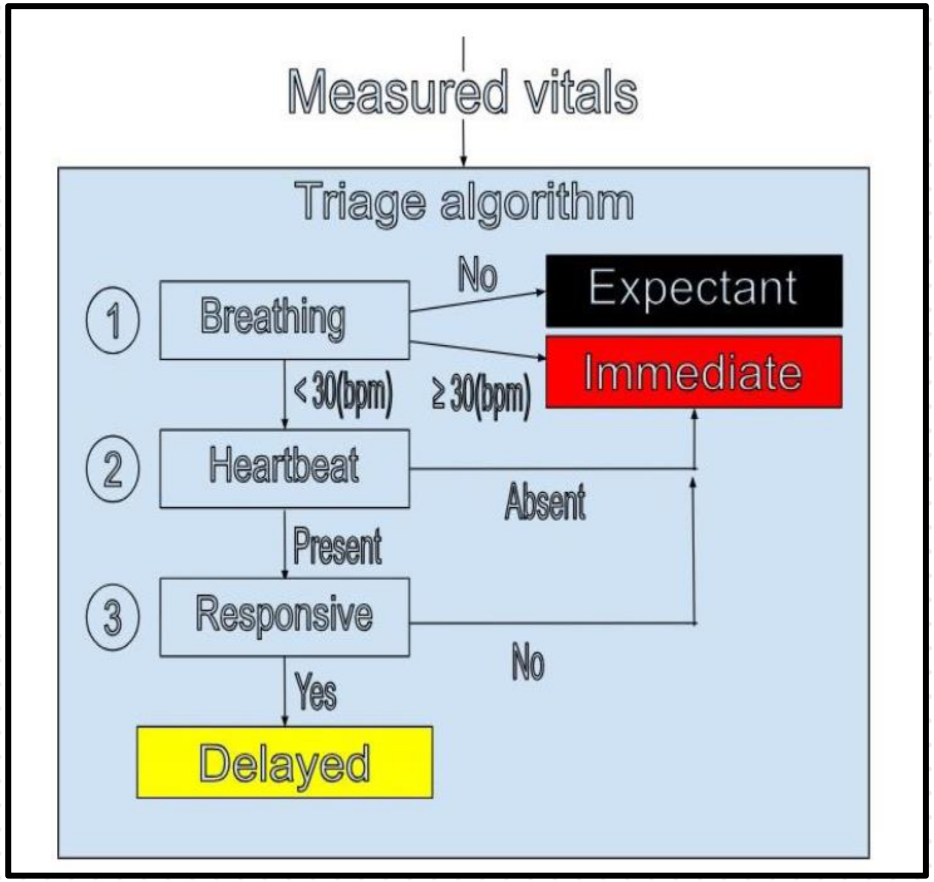
$$R\left(t\right) = A_R \cos\left[2\pi f t - \frac{4\pi d_0}{\lambda} - \frac{4\pi x(t)}{\lambda} + \phi\left(t - 2d_0 c\right)\right]$$

Voice Activity Detection



Computing Subsystem

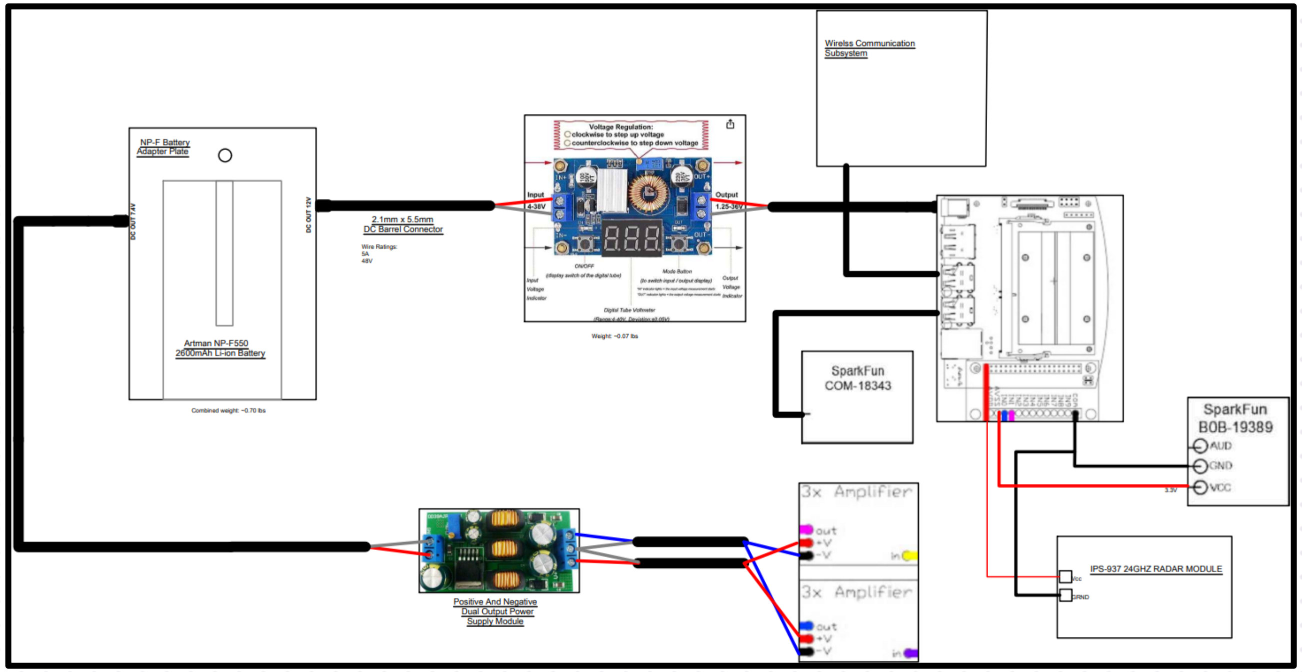




Power Subsystem

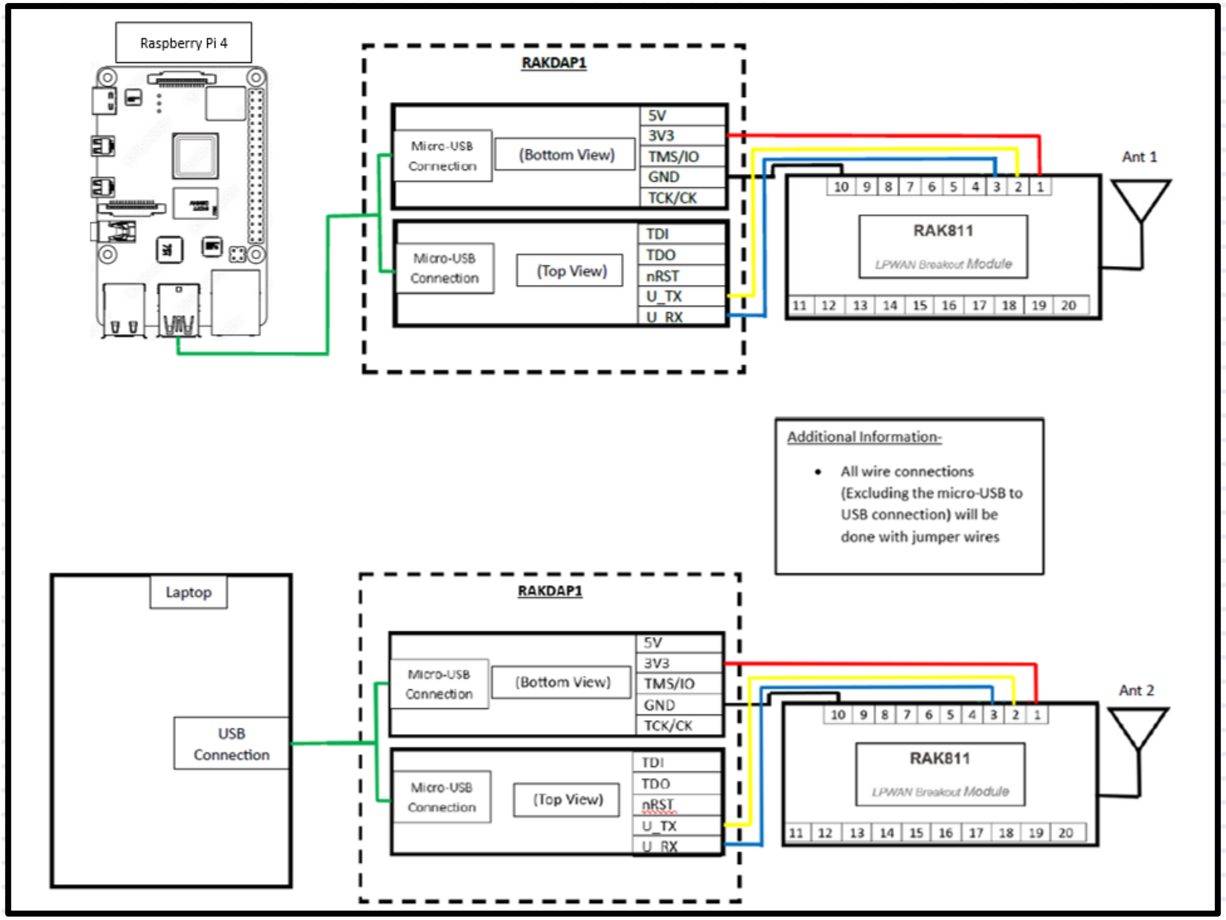
- Max 220 mV peak to peak input voltage ripple
  Measured: 30 mV peak to peak

- Input voltage of 5 V with worst case current 1.1250 A resulting in a total power consumption of 5.625 W



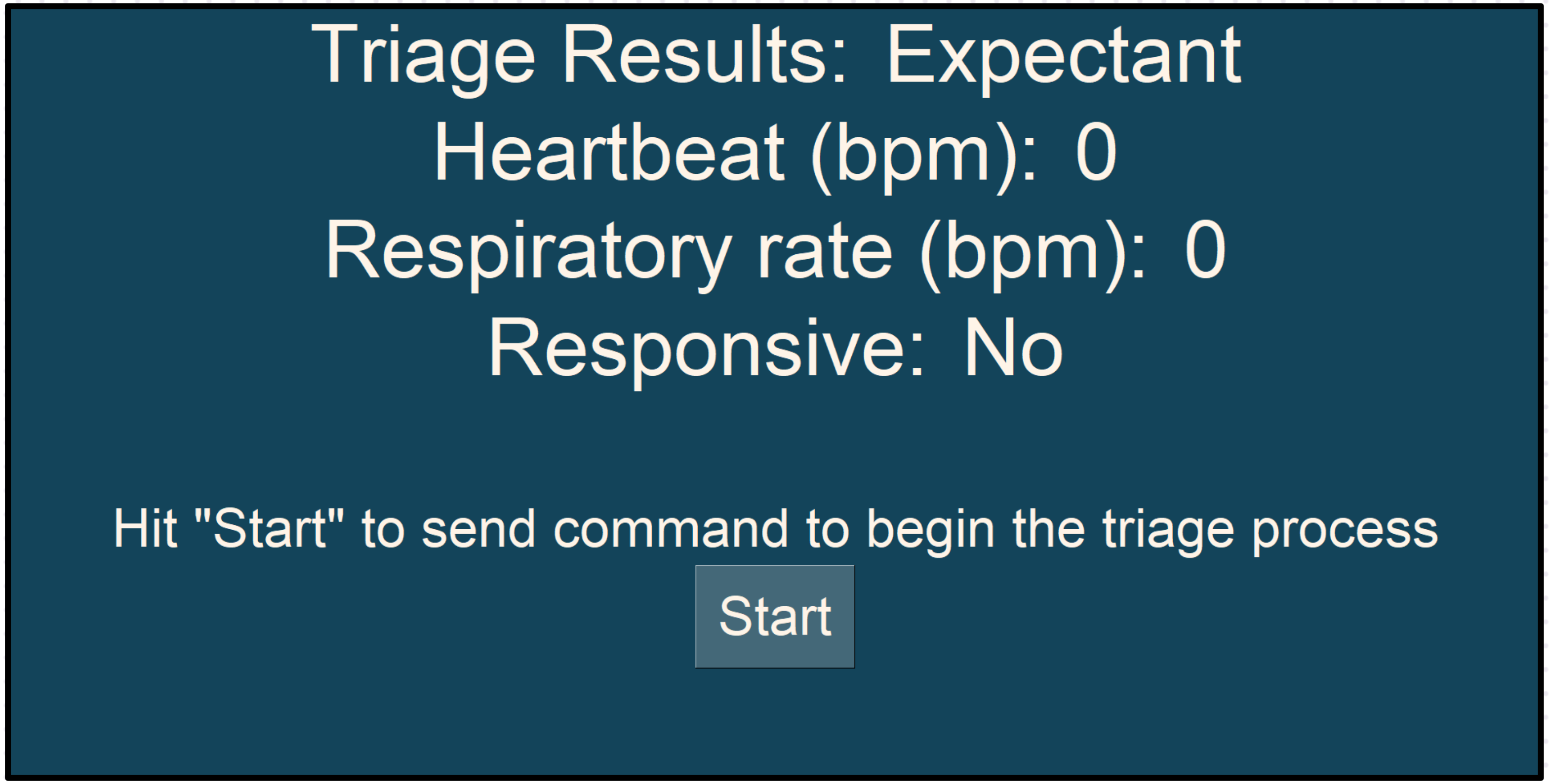
Wireless Communication Subsystem

- RAK811 LPWAN Breakout Module (LoRa Module)
- RAKDAP1 debug and flash tool



User Interface Subsystem

- For user interface, software was developed to display all information described under Constraints.
- Any Windows laptop can access and display the software.

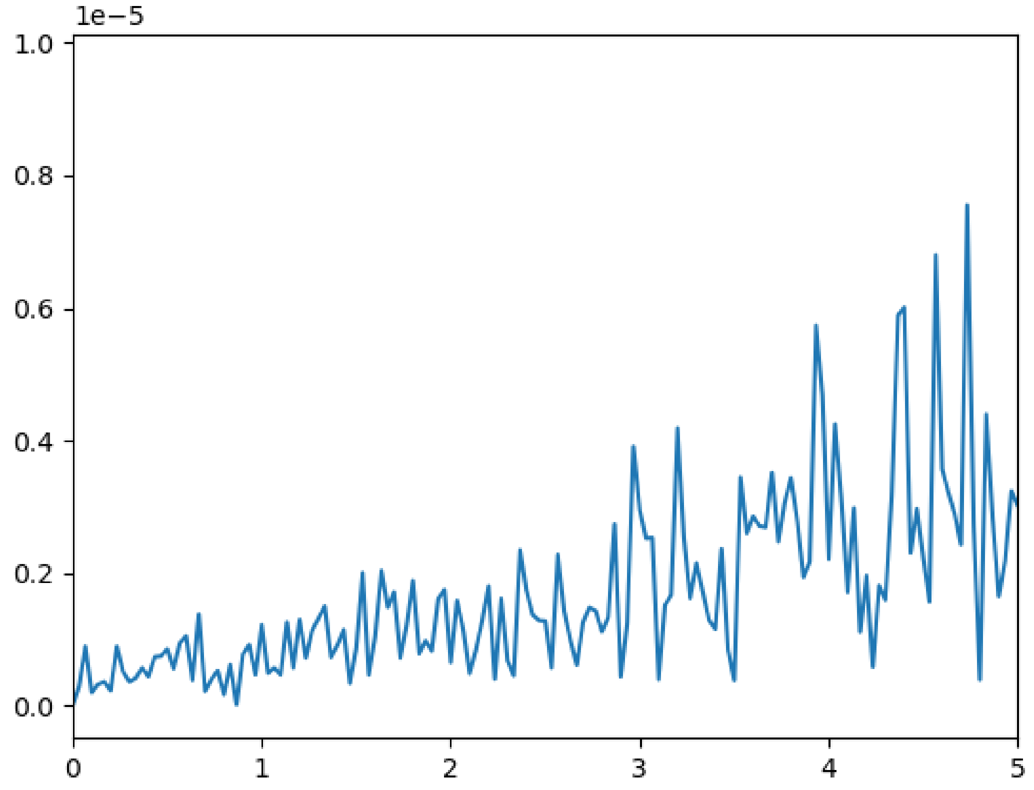


Budget

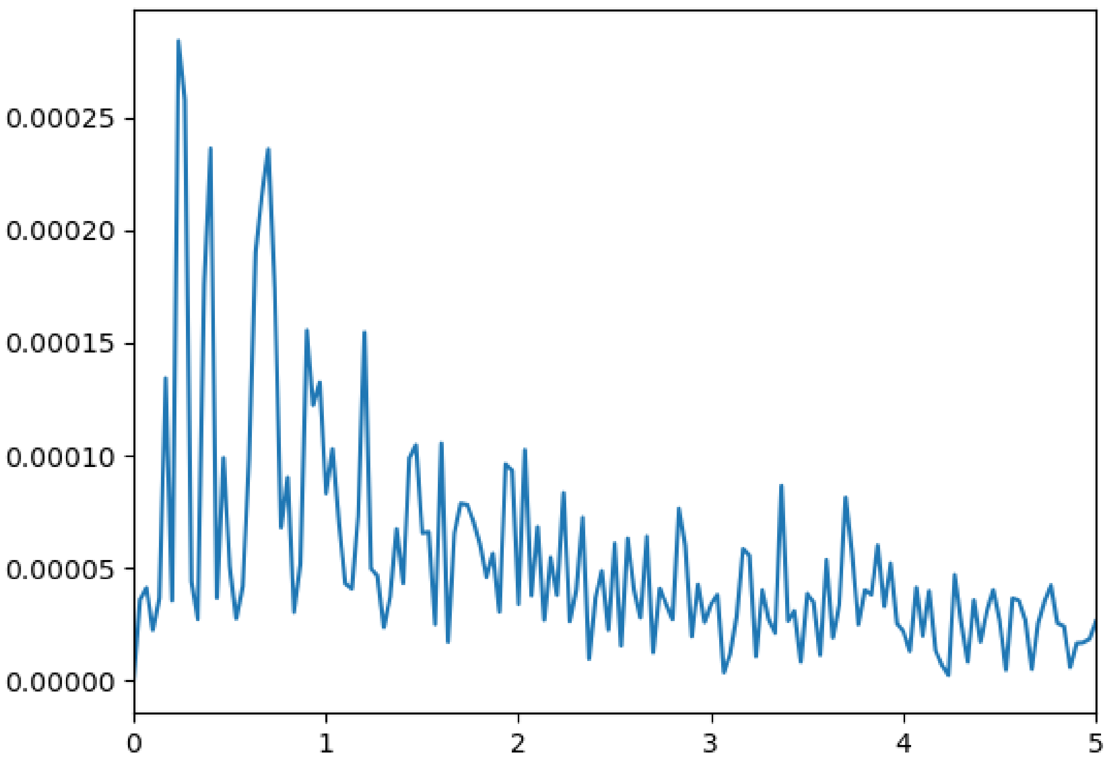
Subsystem	Price (Design)	Price (Actual)
Heartbeat/Respiratory Subsystem	$203.39	$97.28
Computing Subsystem	$279.00	$68.77
Power Subsystem	$74.06	$67.17
User Interface Subsystem	$0.00	$0.00
Wireless Communication Subsystem	$94.86	$94.86
Voice Activity Detection Subsystem	$17.90	$17.90
Total:	$669.21	$345.98

Experimental Results

Heartbeat and Respiratory Subsystem Results

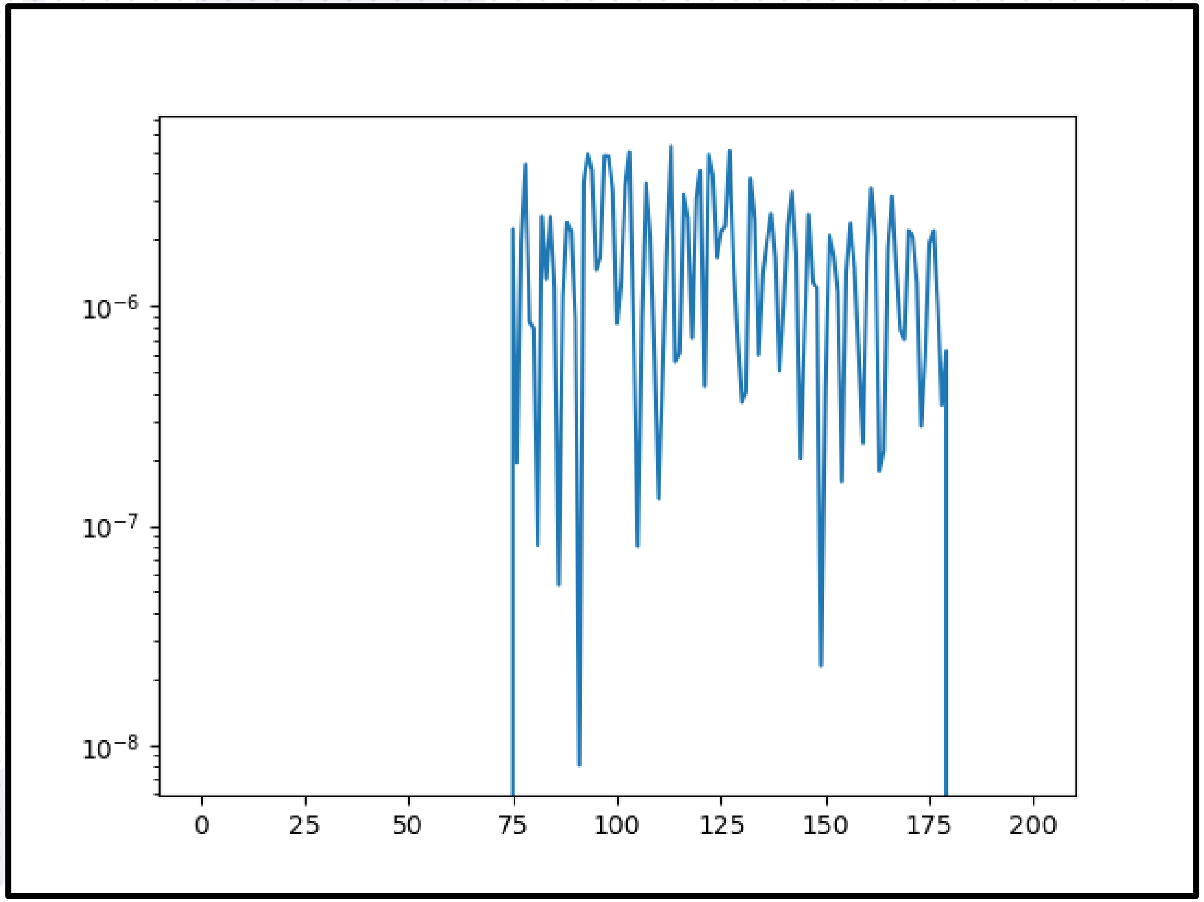


Individual Not Present

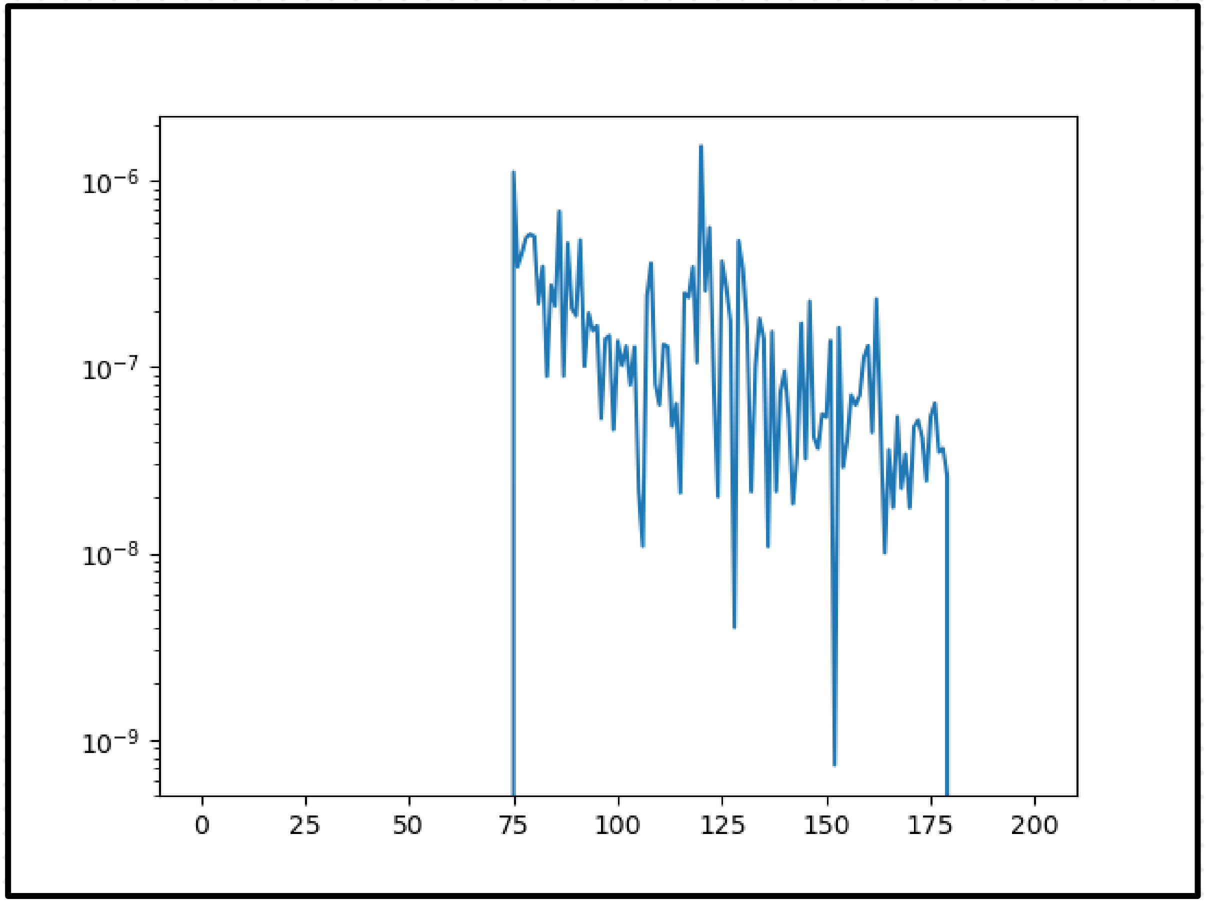


Individual Present

VAD Subsystem Results

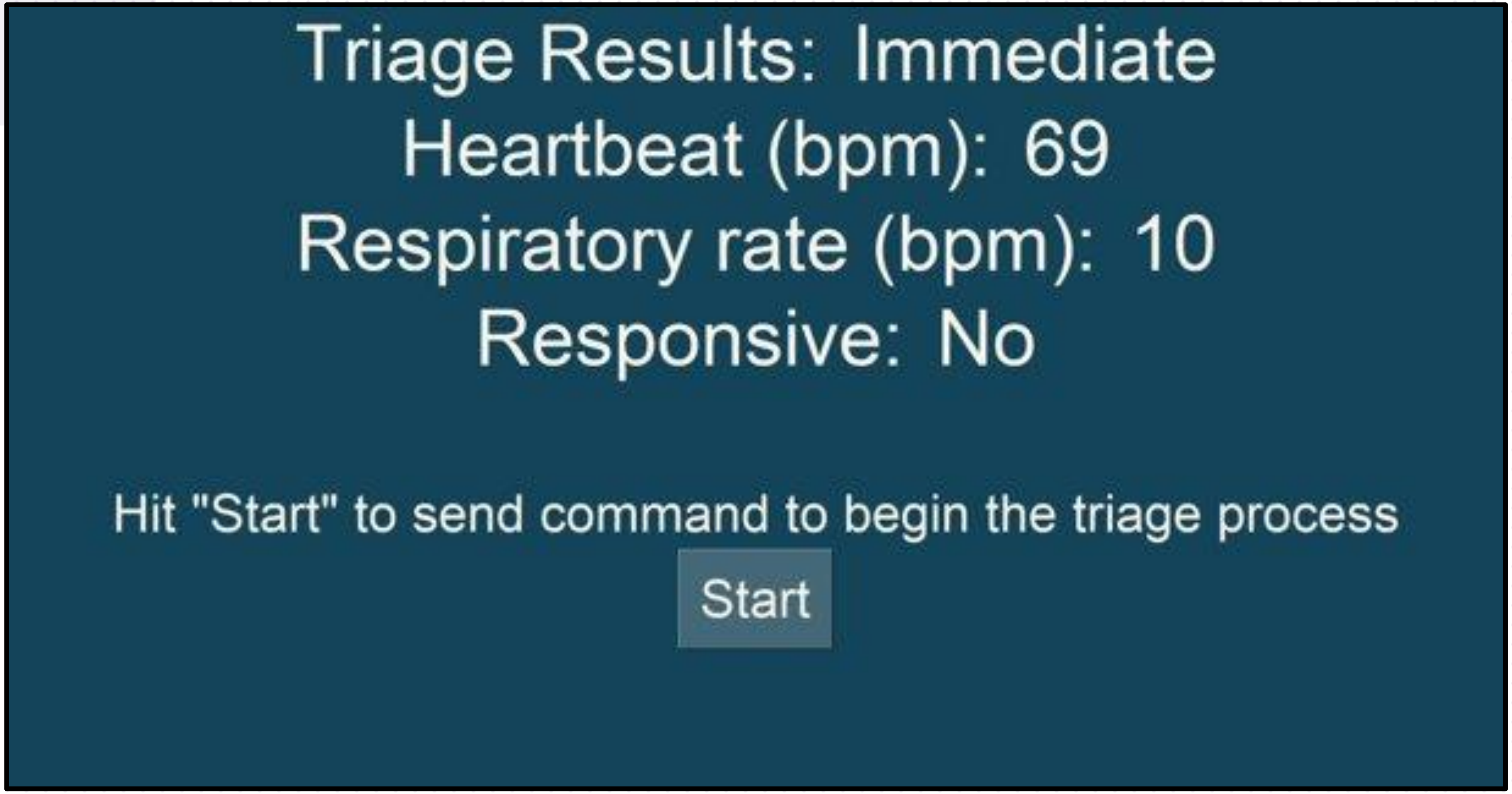


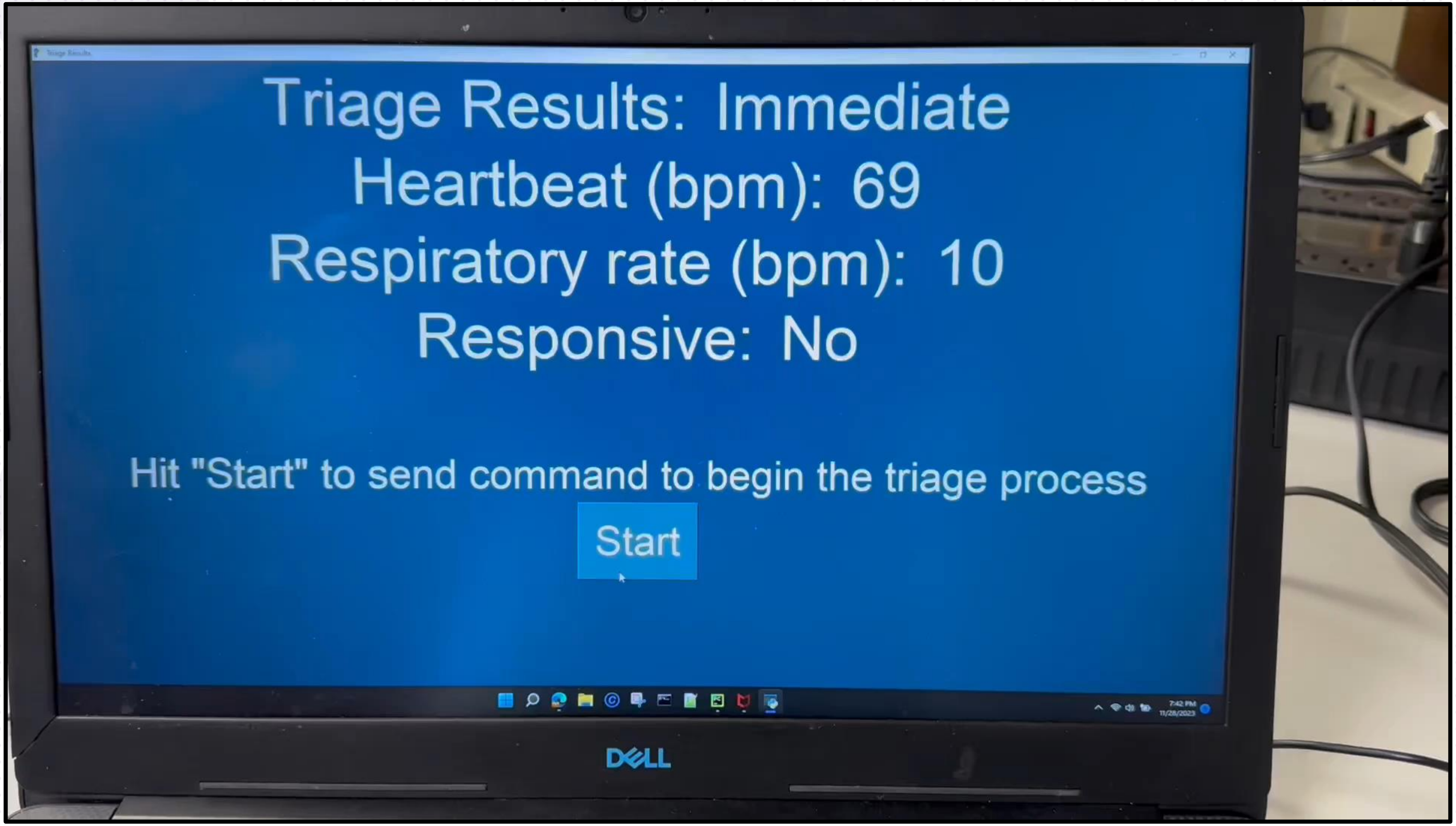
Voice Detected



Voice not Detected

Experimental Results (UI)




Triage Results: Immediate
Heartbeat (bpm): 69
Respiratory rate (bpm): 10
Responsive: No
Hit "Start" to send command to begin the triage process
Start

Project Success and Usefulness

- Able to detect the presence of a respiratory rate and acquire an actual quantity for the rate from a 1-meter distance with an error of 10.12%

- Able to detect the presence of a heart rate and extract a potential quantity for the rate from a 1-meter distance with an error of 6.95%

- Able to detect high volume voice activity within human voice frequency ranges

Project Success and Usefulness

- Able to successfully categorize an individual based on the quantities extracted from the radar and VAD systems

- Able to wirelessly transmit sensor data from computing system to UI system

- Able to maintain maximum functionality for 1 hour while powered off battery

Future Goals

- Further improvements to DSP algorithm for the radar to more accurately determine heart and respiratory rate
- Further improvements on the voice activity detection algorithm to raise accuracy and speed of human voice detection and implement speaker to play an audio command
- Visual sensor to be added to allow victims to be detected easier
- Sensing system to be attached to a drone to fulfill DARPA’s challenge
- Increased testing of system in austere environments
- Further improvements on system casing to be resistant to austere environments

Sources

- [1] "DARPA Triage Challenge," *Sam.gov*. [Online]. Available: https://sam.gov/opp/9f3fdae8285e44aabdeb0a9c3dfd6c17/view. [Accessed: 28-Feb-2023].
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- [5] Carlo Massaroni , Andrea Nicolò, Massimo Sacchetti, and Emiliano Schena, "Contactless Methods For Measuring Respiratory Rate: A Review," in *IEEE Sensors Journal*, June 2021. [Online]. Available: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9194745&casa_token=jq0bsmaLzLEAAAAA:IraDjnCiMISmKulsYJ3AG0ibf8fIskdaysX6aIF7K3PYK_0drMpECk-2QLCY2R51uEC4ZYirbg&tag=1
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