ECE/RS-493 SENIOR ADVANCED DESIGN PROJECT

This form must be completed and returned to the Course Coordinator by 5:00 p.m. on Friday of the second week of the semester. (See "Schedule and Due Dates".) The faculty member supervising this project must sign this form before it is turned in.

Email will be used to contact you during this course. You must check it regularly. If you do not respond to an email request related to ECE/RS-493, the entire project team will be "adversely rewarded" when the final grade is determined.

TYPE carefully and clearly (particularly email addresses), all information requested below. Use only GMU email addresses.

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TITLE OF PROJECT: *E-Band*

Faculty Supervisor Name: Nathalia Peixoto

Faculty Signature: _______________________________________ Date: _____________

Project Description

When a seizure takes place, one or more of these areas are most affected: decreased heart rate, increased and rapid muscle contraction, and sporadic movement [3]. Seizures may occur in hazardous environments which poses an additional risk to the patients. These individuals need to have proper safety protocols in place for these events.

The epileptic community was specifically targeted because of the substantial amount of patients. Roughly, 1.2% of the United States' population has epilepsy which means there are about 3 million adults and 500 thousand children who suffer from seizures [2]. Furthermore, 70% of children experience silent seizures, often with no convulsions, preventing caretakers and observers from using standard seizure detection methods [1].

In essence, epileptics lack a solid device that can accurately track their physiological symptoms, detect seizures, and notify proper caretakers. At the moment, no notable engineering company offers these services within an affordable, compact product catered towards these individuals, even though one is desperately needed.

The *E-Band* provides those safety protocols through extensive physiological monitoring such as heart rate and muscle contraction. The device monitors rapid change in movement like falling. The *E-Band* is suited with a force-sensitive resistor (FSR), photoplethysmography (PPG) sensor, and an accelerometer which will measure muscle contraction, heart rate, and rapid movement, respectively. When the *E-Band* has two or more sets of data exceeding their thresholds, an alert is sent to the user requesting the individual to respond if they are having a seizure or not. Thresholds are a set magnitude or value that must be exceeded by the sensors in order for an action to occur by the *E-Band*. If the user fails to respond within a certain time or confirms a medical emergency, an alert is sent to the user's emergency contact(s) with their location and a message indicating that they may be having a seizure. This device has the potential to save lives and provide real-time monitoring of physiological traits with an easy-to-use user interface.

This project provides an opportunity to design products that assist those within the epileptic community. Many engineering products that do physiological monitoring are catered towards athletes in an attempt to improve their physical abilities. None of these devices are engineered and catered to specifically monitor those with epilepsy or the disabled community in both an accurate and discrete manner.

References

[1] "About us," *PulseGuard*. https://pulseguard.org/about-us/ (accessed Oct. 01, 2020).

Test Plan

We will be testing the accuracy and ongoing stability of each individual sensor when operating on the same computing board. The requirements will have to have greater than or equal to 90% accuracy in relevance to each sensor's specific measurement. The behaviors that we will be checking is if each sensor outputs consistent and accurate data to the raspberry pi 0, and that the code will continuously monitor if any sensor output rises above the set thresholds. Once this happens, we expect the device's main function to activate. The device should output a warning to the user and ask if emergency services should be contacted. If this warning is ignored or the user replies yes, then a text will be sent to emergency contacts within a given timeframe. If the user replies no to the warning, then the device will begin monitoring again as normal.

There are two phases for our testing plan. In the first phase, all members of our team will wear the device for 8 hours. While wearing the device, the team members will adhere to the test plan below. The ones and zero in the table below indicate if that sensor will be or will not be tested, respectively. The duration for each test will be 5 minutes maximum, and the space in between each individual test thereafter will be 30 minutes. When having to set off multiple sensors each test needs to be done consecutively and within 2 minutes within each other. Phase two of the testing plan is to test the device with two individuals who experience seizures 1-2 times a year and 1-2 times a month. Phase two will use the same testing plan as phase one.

Hourly	Muscle	HR	Fall
Test 1	0	0	0
Test 2	0	0	1
Test 3	0	1	0
Test 4	0	1	1
Test 5	1	0	0
Test 6	1	0	1
Test 7	1	1	0
Test 8	1	1	1

A TENS, transcutaneous electrical nerve stimulator, unit is used to mimic muscle contractions similar to muscle contractions from seizures. To trigger the accelerator's threshold, the individual should collapse to the ground in a safe and fast-moving fall. To increase heart rate, the user should perform strenuous physical activities. The exact activity and duration will depend on the person's endurance and health. The chosen exercise should not cause the untested sensor to trigger. For example in test 7, running and jumping jacks should be avoided to not trigger the fall sensor. A possible exercise for test 7 is biking as it increases heart rate but does not allow quick acceleration of the arm to trigger the fall sensor. Recommended exercises will be given to the test subject to engage the required sensors as needed for each individual test.

The data to be collected all pertain to primary physiological traits that are most affected during seizures, including heart rate, muscle contraction, and sporadic movements via falling. Heart rate will be measured in beats per minute (BPM). For muscle contraction, it will be measured by a change in voltage across the FSR when pressure is applied to it. This data is displayed as a digital value interpreted by the ADC. Finally, in the case of sporadic movement, an accelerometer will act as a fall sensor, detecting an acceleration, or quickening in motion, in the downward direction. Locational data will also be collected to show where the user is in the case of the device needing to send an emergency signal via a GPS component.

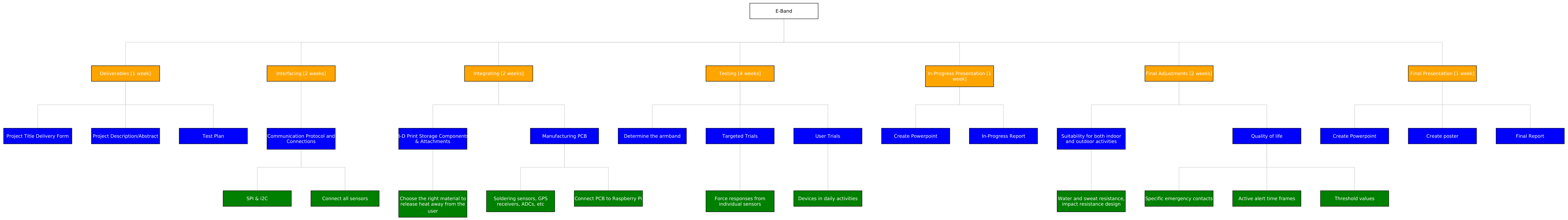
Since there are multiple sensors, the method used to process the raw data depends on the sensors. For the heart rate sensor, the analog signal is converted into a digital value by an ADC. This digital value is the heart rate of the user For the fall sensor, the accelerometer determines if the user's acceleration exceeds a value within a timeframe. For the muscle contraction sensor, the analog voltage is converted into a digital value by an ADC. The digital value is the muscle contraction parameter. The heart rate, muscle contraction parameter, and fall status are compared by the *E-Band*. If two of the three sensors are flagged, the device sends a notification.

The results will be stored in AWS. The acceleration data will be presented in a binary output, whether the user fell or not. The heart rate measurements will be displayed as a digital value interpreted by the ADC. The muscle contraction measured data will also be displayed as a digital value interpreted by the ADC. Graphs will not be displayed, however, each sensor data will be analyzed for greater than or equal to 90% accuracy.

The questions to monitor the project's success will be the following:

- Is the sensors' output accuracy greater than or equal to 90%?
- Is the device's main functionality working as intended?
- What is the rate of false positives?
- Are the device instructions and setup user friendly?
- Does the device send emergency messages only when thresholds are met?
- Did any of the sensors lose functionality?
- Is the device durable enough for everyday use?
- Is the device energy-efficient enough to last the entire 8 hours?

E-Band


E-Band
Deliverables [1 week]
Interfacing [2 weeks]
Integrating [2 weeks]
Testing [4 weeks]
In-Progress Presentation [1 week]
Final Adjustments [2 weeks]
Final Presentation [1 week]
Project Title Delivery Form
Project Description/Abstract
Test Plan
Communication Protocol and Connections
3-D Print Storage Components & Attachments
Manufacturing PCB
Determine the armband
Targeted Trials
User Trials
Create Powerpoint
In-Progress Report
Suitability for both indoor and outdoor activities
Quality of life
Create Powerpoint
Create poster
Final Report
SPI & i2C
Connect all sensors
Choose the right material to release heat away from the user
Soldering sensors, GPS receivers, ADCs, etc
Connect PCB to Raspberry Pi
Force responses from individual sensors
Devices in daily activities
Water and sweat resistance, impact resistance design
Specific emergency contacts
Active alert time frames
Threshold values