Introduction

Problem :

The problem statement consists of creating a device similar to the now discontinued Myo Armband that can be used for a variety of applications. Specifically, our problem statement is to develop a solution that is affordable, reusable, compact, and comfortable for users who may be using it for long periods of time. We also need to create a user interface in which the user can discern as to what the various signals being collected from the device mean.

Solution :

The solution which has already been through both phase one and two of development as well as testing includes an arm band that obtains various signals that differentiates between hand gestures. The solution utilizes EMG sensors, which measure the electrical output when a muscle group is activated, IMU sensors, which measure angular and linear acceleration, GSR sensors, which measure the level of moisture on the skin, and a pulse sensor as well to measure heart rate.

The implementation of this idea can be seen in the visual aid section but it consists of six encasings of sensors. Through prior research, the team found that six sensors was the optimal amount in regards to price as well as accuracy of data measurement. These sensors will be put directly onto the skin and each sensor will be attached to a rubber band. The use of the rubber band is to ensure that if the band's circumference needs to be changed - someone with a smaller arm needs to use the band - the individual sensor's relative position will remain constant. Furthermore, rubber can easily be cleaned and retains its elasticity even after multiple uses. These two criteria are critical for our use cases as we want to make this product affordable - able to be used by various people - and durable.

Visual Aid :

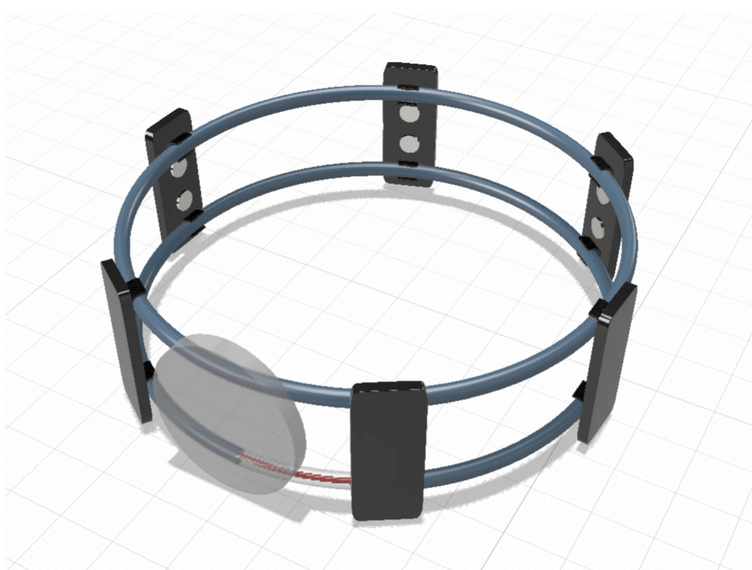


Figure 1: Proposed armband design which includes 6 sensor units as well as the encasing of the PCB

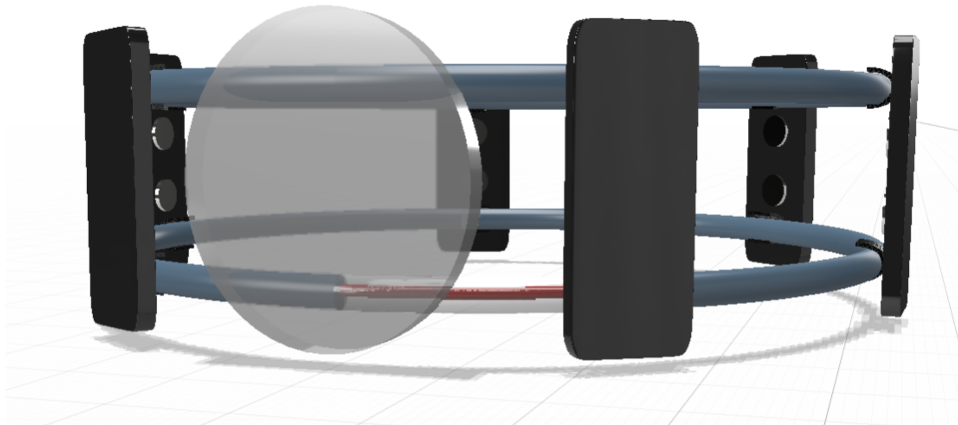


Figure 2: Front view of the proposed design

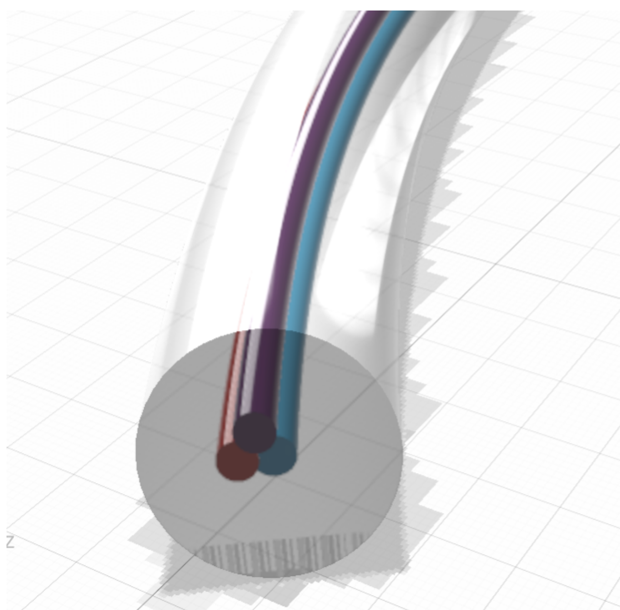


Figure 3 : Cabling which will include six (or more) different wires in order to connect the PCB to our sensors as well as provide power to each of them

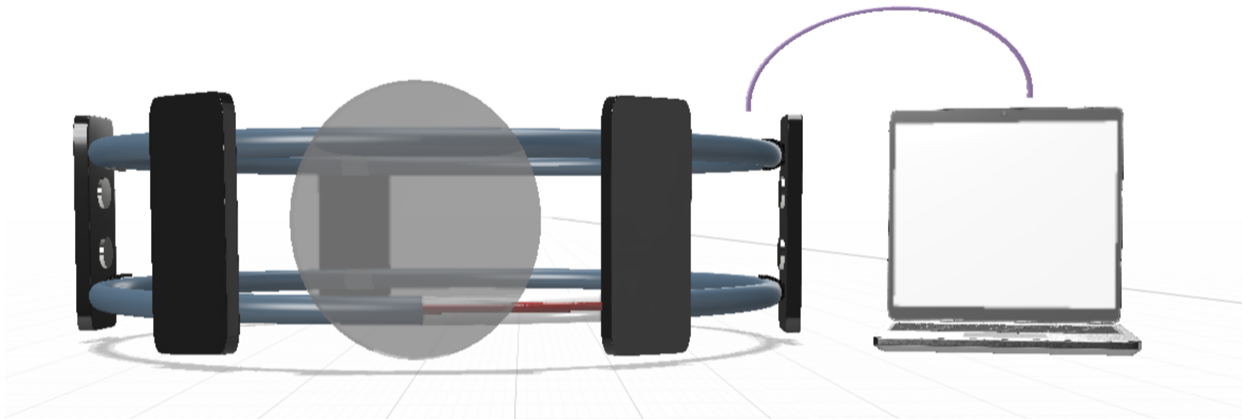


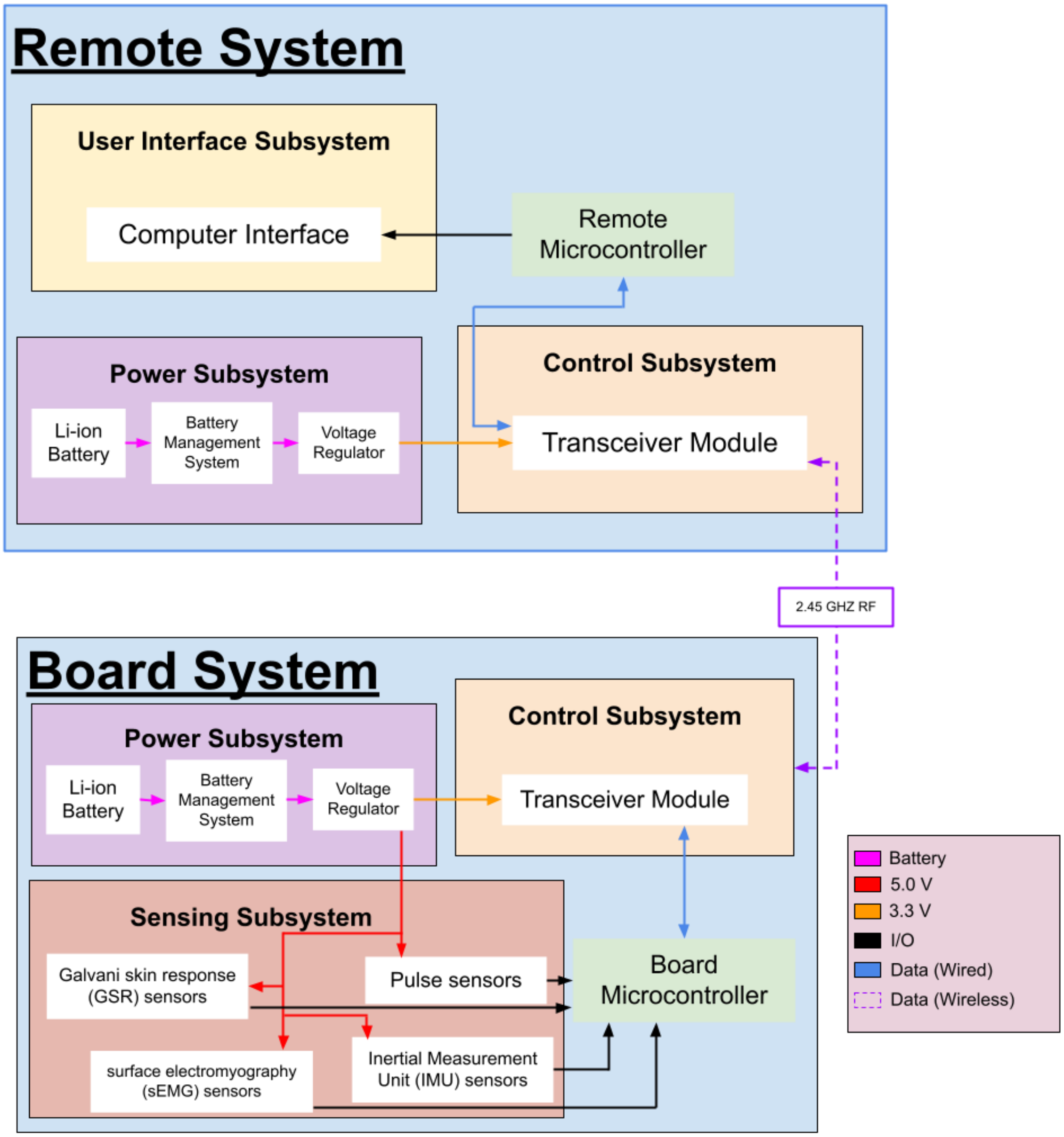
Figure 4 : The proposed solution has bluetooth in which there will be a UI built to interface the data

High - Level Requirements List :

1. The first quantitative characteristic this project must exhibit is the ability to change the circumference of the band - the size of the band - without hindering the accuracy and efficiency of data collection from the sensors. Essentially a user should be able to adjust the size of the band without the sensor's relative position to each other changing.
2. The second quantitative characteristic this project must exhibit is being able to be worn and collect data for extended periods of time with minimal to no discomfort put onto the user. This is essential because our main consumers are surgeons who will be using this device as a training tool and thus must be able to have it on for extended periods of time.
3. The third quantitative characteristic is that the proposed design should be smaller and more compact than the design that is currently available. This is essential for both use cases of stroke patients and doctors as they can not be wearing a bulky device that may further hinder their daily activities.

Design

Block Diagram :



Subsystem Overview :

Remote System: User Interface - Outputs user data from the remote microcontroller onto a computer screen. Power - Battery management system regulates the temperature and current of the battery to prevent overheating. Then the voltage regulator converts the voltage to 3.3V and 5.0V. Powers the control subsystem. Control - Powered with 3.3V. Uses Bluetooth to transmit and receive data to and from the remote microcontroller. Remote microcontroller - Sends and receives data to the control subsystem. Outputs data onto the computer interface.

Board System: Power - Similar to remote power subsystem. Battery management system regulates the temperature and current of the battery to prevent overheating. Then the voltage regulator converts the voltage to 3.3V and 5.0V. Powers the control subsystem and sensing subsystem. Control - Powered with 3.3V via the power subsystem. Uses Bluetooth to transmit and receive data to and from the board microcontroller. Sensing - Contains four sensors powered with 5.0V via the power subsystem. Outputs data to the board microcontroller.

Subsystem Requirements :

User Interface: This subsystem addresses the second quantitative characteristic that this project must be able to be worn and collect data for extended periods of time without being uncomfortable. It must be able to display and combine large amounts of data onto a computer to be visible to the user while they are wearing it. This data must be saved easily so that the user can look back and analyze the data to improve their performance. This subsystem will input this data from the remote microcontroller.

Power: The power subsystem will address the third quantitative characteristic that the proposed design should be smaller and more compact than the design that is currently available. The power subsystem is the most important for this characteristic because using smaller batteries will allow the design to be downsized while still maintaining the voltage and current ratings for the transceiver module. The power subsystem must be able to supply at least 3.3V +/- 0.1V with 30mA to the transceiver and 5.0V +/- 0.1V to all of the sensors within the sensing subsystem. It consists of a lithium-ion battery which is connected to a battery management system, which regulates the temperature and current of the battery to prevent overheating. The battery management system is connected to a voltage regulator that converts the voltage to 3.3V and 5.0V.

Control: The control subsystem will address both the second and third quantitative characteristics of the proposed design. In order for the armband to be used to train surgeons or help with rehabilitation, the data must be collected and presented in a user-friendly way. The data must be accurate and concise so that the user is able to read and analyze it to see where they can make improvements. Also, the design has to be small, wearable, and go around the arm. This will only be possible if the transceiver module within the control system is able to use Bluetooth and wirelessly transmit the data. It must receive 30mA at 3.3V +/- 0.1V from the power subsystem. It connects to the microcontroller. It receives data from said microcontroller as well as sends data back to the microcontroller to then be outputted onto the computer.

Remote and Board microcontroller: The microcontroller will address the second quantitative characteristic that the design must be worn and collect data for extended periods of time. The microcontroller is essential for this because it connects all of the other subsystems together. It receives raw data from the sensing subsystem, sends it to the control subsystem, and outputs it on the computer. It can also receive data from the control subsystem in order to process and filter the data. The small size of microcontrollers also allows the armband to be downsized and wearable.

Sensing: The sensing subsystem comprises four different types of sensors: GSR, Pulse, sEMG, and IMU. It addresses all three quantitative characteristics of the project. First, the size of the band must be able to be adjusted without changing the sensors' relative positions or decreasing their accuracy and efficiency. Second, the sensing subsystem must collect data efficiently while still being comfortable for the user. The electrodes of the sensors have to make direct contact with the skin of the user without being uncomfortable. Lastly, the sensing subsystem addresses the need of the design to be small and compact. The design will need to be small while still accurately reading data from the users via the sensors.

Tolerance Analysis :

The following are aspects that could hinder the successful completion of this project:

- **Housing development:** It is imperative to develop an apt enclosure that could house the sensors, power delivery subsystem, and other components of the iBand. This is because the goal is to create a portable system to monitor data collected from the sEMG, IMU, and other sensors. Furthermore, the housing should be designed in such a way that it accounts for different sized arms.
- **Placement of Sensors:** It is imperative that the sensors are placed correctly around the arm in order to collect accurate data. This is important because sensors, such as sEMG, need to be placed correctly to identify the electrical signals that are generated when muscles contract / expand.
- **User interface:** It is imperative that there exists an usable interface that can allow users to monitor and make sense of the data collected from the iBand.

Ethics and Safety

There are several potential ethical and safety problems that must be considered while developing the iBand. The following are the concerns that must be addressed:

- HIPAA (Health Insurance Portability and Accountability Act of 1996) prevents the disclosure of a patient's medical data without consent. As we collect data from sensors, we must make sure that all data is locally processed and is not used in any way that violates the HIPAA act.
- The housing needs to have adequate safety measures to prevent perspiration or other conductive material from seeping in. This is done to prevent short circuits and other electrical hazards.
- The power management module must be designed correctly to prevent overcharging and overheating the batteries.

- The communication protocol must be designed correctly with security measures taken into consideration. Security concerns, such as unencrypted data transmissions, and so on, are among the problems that need to be addressed.
- Additionally, the device must make sure that it is transmitting data to the correct Rx module if there are multiple Rx devices in the vicinity. This needs to be done to protect the user's privacy.