ECE 445 Project Proposal

Glove For Programmable Prosthetic Hand

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1 Introduction

1.1 Problem: Modern robotic prosthetics may achieve fine motor control through predefined hand motions encoded into the prosthetic. Modern prosthetics may have the ability to save preset positions but don't have the ability to adjust and tweak positions on the fly. We plan to implement a hardware/software solution that is able to measure the positions of a functional organic hand and translate this motion into a prosthetic hand in order for this prosthetic to mimic this motor control on the move. With features such as mirroring we are able to have 2 hands, 1 organic and simulated prosthetic, we are able to introduce a level of dynamic programmability. Also introducing multiple preset positions through organic hand gestures, the user can recall most used positions for convenience. By adding sensors to individual fingers, we can combine combinations of gestures in order to control the prosthetic beyond mirror mode and be able to change the preset positions using these gesture controls.

1.2 Solution: We propose to create a glove with flex sensors and hall effects that can measure the motion of the fingers and detect gestures that the user gives. From this the user can then control a robotic hand with their organic hand making it easier to adjust position as well as record motions for the robotic hand to execute.

1.3 Functions: The product is supposed to record an organic hand and either save positions from the organic hand or mimic the movement of the organic hand.

1.4 Benefits: It provides the user with the ability to make quick and easy changes to their robotic hand while on the go. It also allows the user to mimic the users organic hand's movement.

1.5 Features: The parts of this project that make it marketable is the quick and easy reprogrammability on the fly and the ability to mimic the users hand movement.

1.6 Visual Aid:

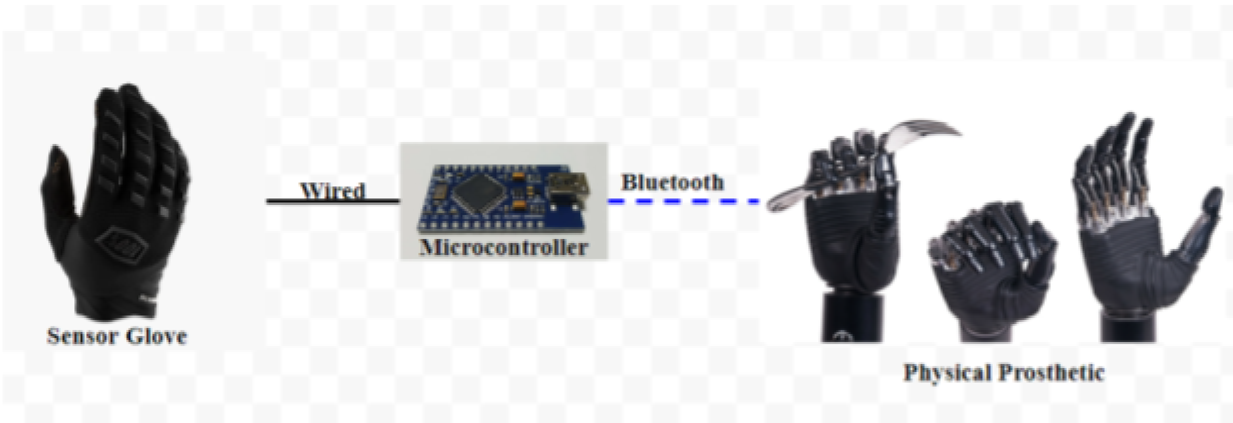


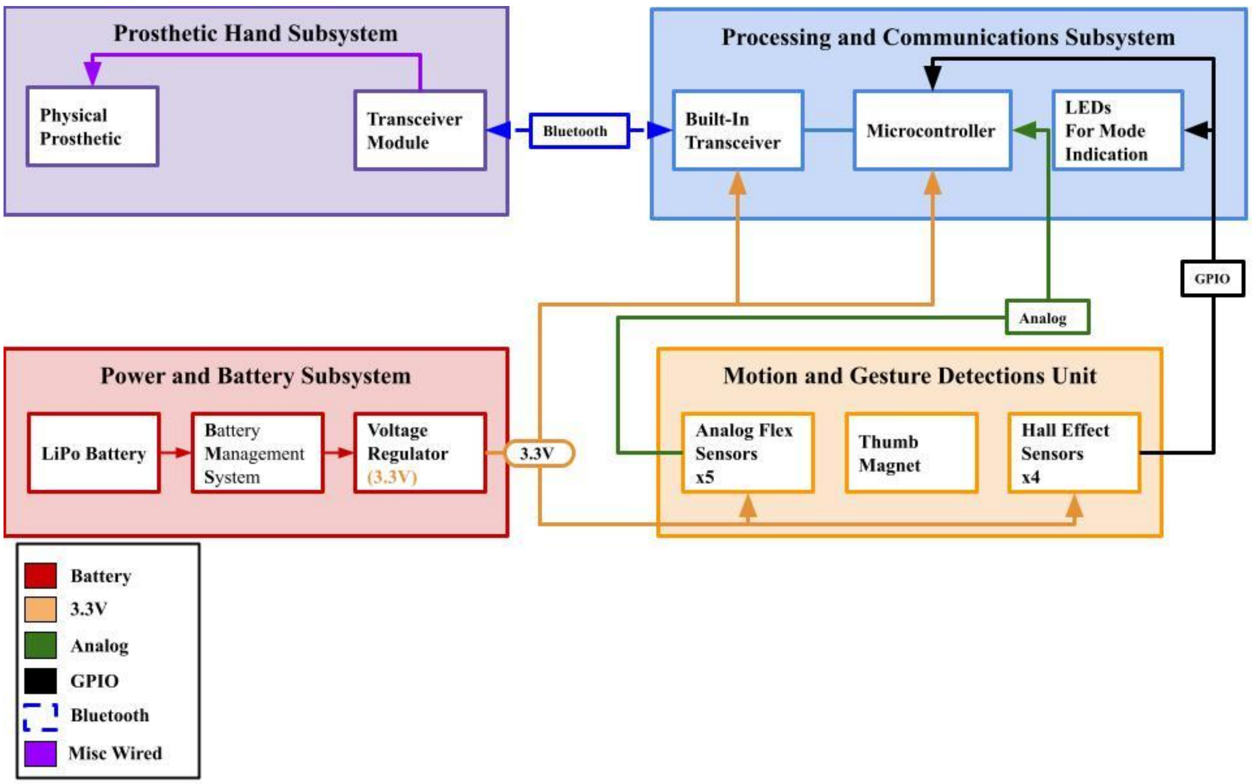
Figure 1: Visual Aid for Glove for Programmable Prosthetic Hand

1.7 High-level requirements list:.

1. Have the ability to detect each of the 5 fingers movement and also move the digital/physical robotic hand appropriately
2. Must detect 4 gestures at minimum
3. Must have the ability to move to 3 pre-set positions and mirroring mode

2 Design:

2.1 Block Diagram:



3 Subsystem Requirements:

3.1 Subsystem 1: Processing/Communication Unit Microcontroller -

The Microcontroller is responsible for processing Motion/Gesture Unit inputs, processing the data and sending the results via Bluetooth to the Hand. This unit will also feature small LEDS that give the user feedback on what mode they are in/the preset options they are selecting.

Microcontroller must contain on-chip support for bluetooth LE and be able to run off 3.3V. The microcontroller must have on-chip Flash in order to support saving user configurations or an off chip-flash will interface via SPI to achieve the same function. Ideally the micro will have a power saving/sleep mode that will increase battery life of the system. The microcontroller must have at least 5 analog in pins and 4 digital in pins at the minimum and be able to run off the voltage regulator ripple specs. The User Feedback LEDs must be able to operate off of 3.3V.

3.2 Subsystem 2: Motion/Gesture Detections Unit.

The Motion/Gesture Unit is used to collect data about the user's finger positions as well as to control the unlocking/programmability it sends data to the Processing Unit.

The Detection Unit must consist of 5 Analog Flex Sensors and 4 Hall Effect Sensors that will all interface with the microcontroller for sensor feedback and draw power at 3.3V from the Power/Battery System. The noise must be filtered and magnetics tuned so that each hall effect sensor input is distinguishable from one another and can be repeatedly triggered. The flex sensors will interface with a resistor of the same nominal Resistance to form a voltage divider to read flex/finger positions may need to consider input impedance of ADC pins as some flex sensors have high impedance.

3.3 Subsystem 3: Power/Battery System.

The Power/Batter System will take a LiPo rechargeable battery and regulate the voltage/current to 3.3V so that our system functions. This is responsible for powering the Motion/Gesture Unit and the Processing Unit.

The power/battery system must be able to provide a 3.3V +- 0.1 to power the microcontroller and various sensors. The system's main power supply should be a rechargeable LiPo battery. The supply IC/battery should be able to supply at least 40 mA peak to allow for the system to operate(see power analysis). The battery should be able to power the glove system for a minimum of 8 hours.

3.4 Subsystem 4 Robotic Hand:

This robotic hand will be used to demonstrate the effectiveness of our project and will interface with the Communication/Processing Unit via Bluetooth. The physical hand used to demonstrate capabilities of the project will communicate with the glove and microcontroller via bluetooth. 5 digits must be modeled and the angle of the finger will be adjustable. This hand will also have to respond to the 4 gesture commands such as prerecorded positions and mode switching. We plan to model our hand using an open source robotic hand from InMoove.[6.2] Since our project is focused on modeling the organic hand and mimicking the movement into the robotic hand, we opted to use an open source hand as a way to devote more time into the sensing of the hand rather than the design of the robotic prosthetic.

4 Tolerance Analysis:

An aspect to our project that could lead to a large road block is trying to hit our goal of 8 hours of continuous usage. To tackle this problem we decided to base our tolerance analysis around calculating the estimated energy that our system requires in order to operate see Fig 3 and Fig 4.

First sensor power consumption was determined based on possible component's worst case operating voltages/current draws. For the CPU, an average current draw was found from the manufacturer's website. The bluetooth power was estimated based on the microcontroller manufacturer's transmission specs for -6dB operation.

Next to find energy we separated calculations by burst power draw(BLE) and continuous average power draw(everything else). To find BLE energy consumption we found the time for one transmission and multiplied it by the total number of transmissions per day to get total transmission time. The total transmissions per day was found by multiplying 8Hrs by 30Hz(the transmission rate of our system). Next, we added all the continuous power draw quantities and multiplied by 8 Hrs to find the energy consumption of non-BLE components. Finally, we accounted for inefficiency in the power regulation IC by multiplying the total energy consumption by 1.2(80% efficiency).

In the end, we found out that our system requires 3.2kJ to operate. Our LiPo will provide around 11kJ, meaning that we can meet the 8Hr operation specification easily with some room for error.

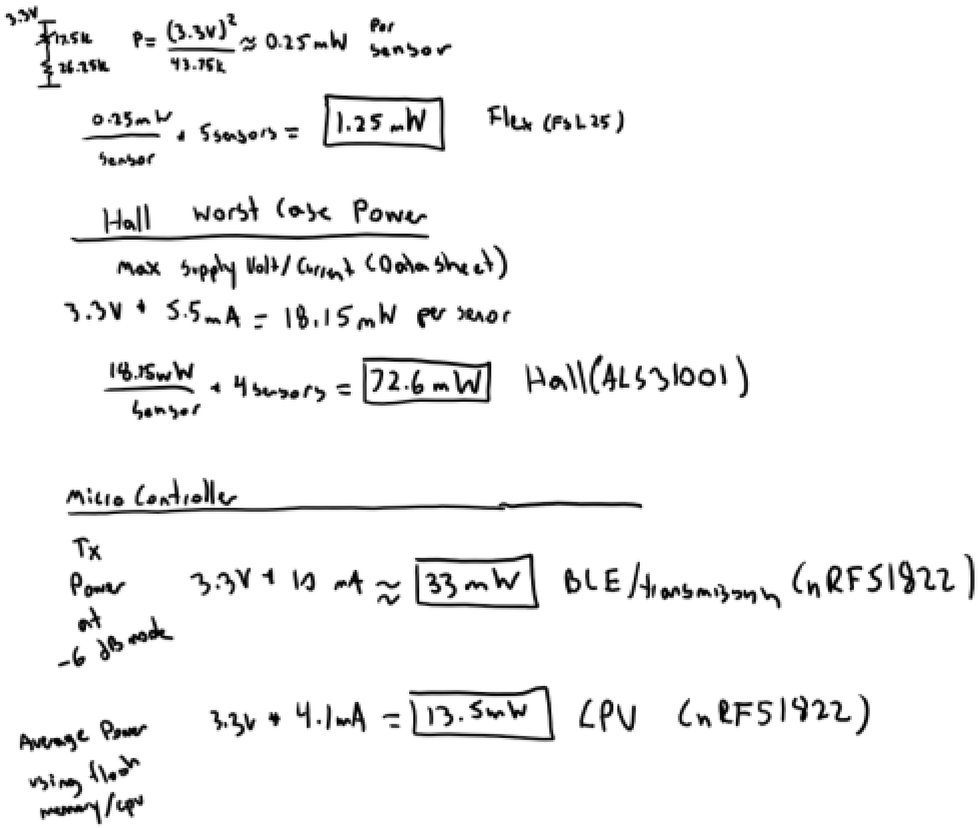


Figure 3: Power calculations

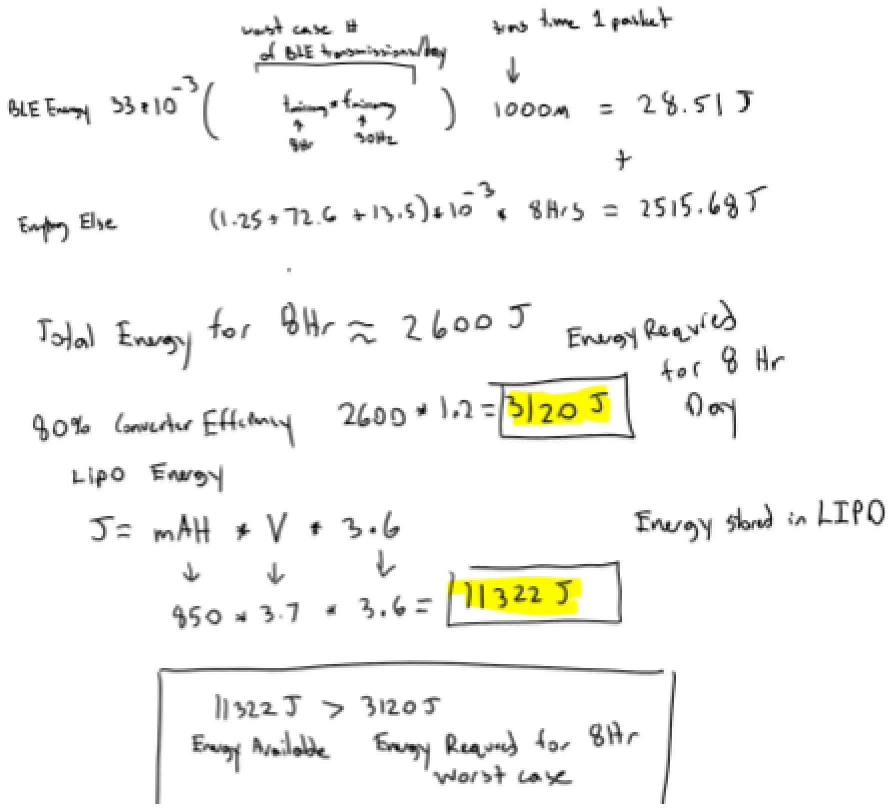


Figure 4: power calculations

5 Ethics and Safety

Our team made sure to comply with both the IEEE ethics and safety guidelines as well as the ACM code of ethics while detailing out our project. The safety of our users is our number one priority and we want to make sure that we are not abusing or using anyone in the creation and distribution of our product. This includes our users who will most likely be disabled people. Some issues we can see with the usage of our project is that it is a wearable so we want to make sure that the usage of our project doesn't cause harm to anyone. [6.1]

Furthermore to comply with section 1.5 in IEEE ethics and safety guidelines we have all parts of the project will be looked over by all team members, credit all sources we use/draw inspiration from, and will ensure the high quality of our work and keep each other responsible. Furthermore we will also be open to criticism and suggestions from our TA and our peers and make necessary adjustments to our methods, design, and practices if quality or a breach of ethics is called into question.

In accordance with Section 1.3 in the ACM code of ethics we will make sure to gain the knowledge or seek out help when working on technical aspects that we have never tried before. In doing this we ensure the safety of our users.[6.4]

6 References:

6.1 “IEEE code of Ethics,” *IEEE*. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 09-Feb-2023].

6.2 “Hand and Forarm,” *InMoov*. [Online]. Available: https://inmoov.fr//hand-and-forarm/. [Accessed: 09-Feb-2023].

6.3 J. N. Ingram, K. P. Körding, I. S. Howard, and D. M. Wolpert, “The statistics of Natural Hand Movements,” *Experimental brain research*, Jun-2008. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2636901/. [Accessed: 09-Feb-2023].

6.4 “The code affirms an obligation of computing professionals to use their skills for the benefit of society.,” *Code of Ethics*. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 09-Feb-2023].