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Lab 4: Prosthetic hand control

Introduction

This lab is about human-robot interaction. There are many different levels of human- robot interactions and has changed due to advancement in technology. The first level of human-robot interaction (HRI) would be no interactions, co-existence, physical interaction, and physical collaboration.

The first stage is when there are no interactions between robots and humans. An example would be machines in factories that are designed to complete one or two tasks. Co-existence is when human and robots come together to complete a task. For instance, doctors work with a lot of machinery to make surgery flow smoothly and make incisions as small as possible for the patient to get the max time for recovery. Physical interaction involves both humans and robots interacting with each other, typically robots that are human-like can talk or move. Physical collaboration is when machines/robots are attached to humans to make humans lives easier or better.

This lab would focus on physical collaboration. An example of such, would be prosthetics. As technology improves, one was able to move the prosthetics using their own muscles and nerves. The two sensors that are mainly used are electromyography sensor (EMG) and inertial measurement unit sensors. To control a prosthetic, one would need to connect it to not only their muscles but also the nerves.

In this lab we will be working with an electromyography sensor (EMG). EMG is a sensor that measures senses electrical signals provided by the muscles in our body when we move it. To fully test the EMG sensors, one would need to know about the muscles in our body and which part is the best location for different tasks.

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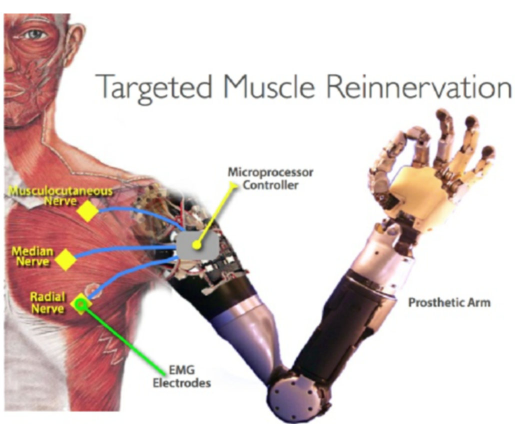


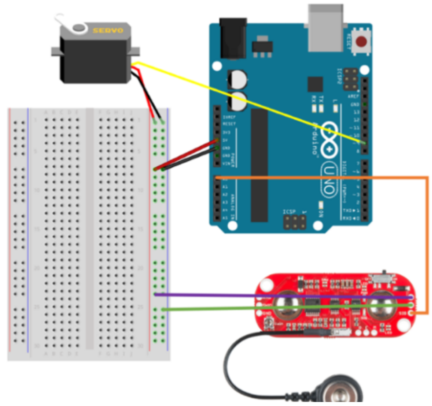
Photo taken from evolving science

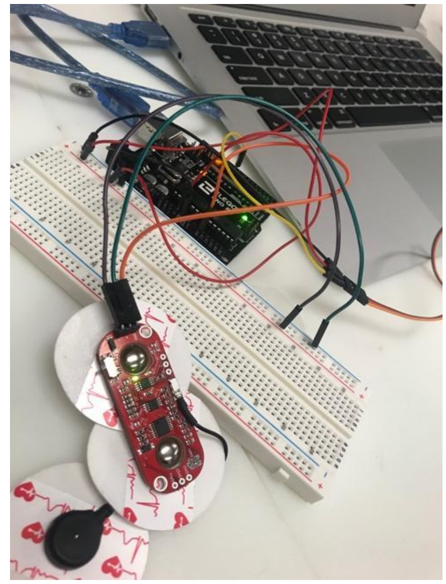
This lab has two objectives.
And 2-3 experiments (refer to procedure) base on time constraints. Objective one is to map the robot's movement using the EMG sensor and a servo motor as a proxy for movement and control.
Objective two would be to analyze the finding and see if the EMG sensor is a reliable sensor to be used for prosthetics.

Procedure

Laboratory Equipment:

1. Arduino Uno
2. EMG sensor
3. Disposable Sticky pads
4. Jumping wires
5. Breadboard





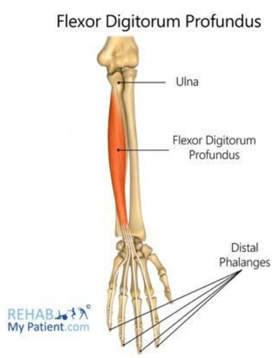
To test the experiments, we will consider 3 different task that would target different movements.

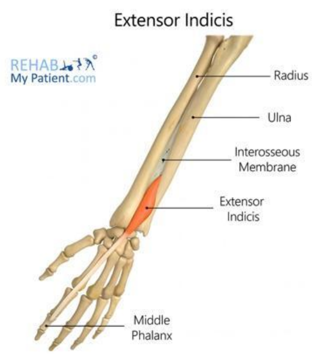
1. Gripping and holding and object
2. Waving hello
3. Touching fingers to thumb

Experiment 1: mapping and identifying best fit for the EMG sensor

1. identify the sensor location, explain and justify the sensor location

To identify, the best fit to place the sensors, my partner and I looked up the muscles on our arms and see which part affects what to help us complete the task.
We concluded that we should test the extensor indicis proprius, flexor digitorum profundus and the anconeus:





Photos taken from Rehab my patient

We picked these three muscles out of the others because according to an article by Dr. Arun pal Singh, titled "Forearm Muscles- Anatomy and Function".
The extensor indicis proprius (2nd pic) is "an independent extensor muscle of the index finger."

We think it might fulfill task: 1(maybe), 3

The flexor digitorum profundus (1st pic), "ends in four tendons one to each of the second to fifth fingers". It also stated that the action it causes is it flex the joints of the fingers and the wrist

We think it might fulfill task: 1(maybe),3

The anconeus (3rd pic), although the anconeus if located by the elbow, when we clench our hand, we can feel that muscle tends up

We think it might fulfill task: 1,3(maybe)

2. What data will be collected

We will be collecting the sensor value that was given to us when we ran the software. The data comes out as a measurement of current, since that's what the Arduino is reading from the EMG sensor, which picks up electrical signals made by the muscles

Human interaction and robot motion

1. Configure the breadboard according to picture located above
2. Located the muscle and attach the sticky pad to it
3. Attached the EMG on the area of interest
4. The 3rd sticky pad would be located at an area away from the targeted sites as an control value
5. Run the software on Arduino
6. Collect data

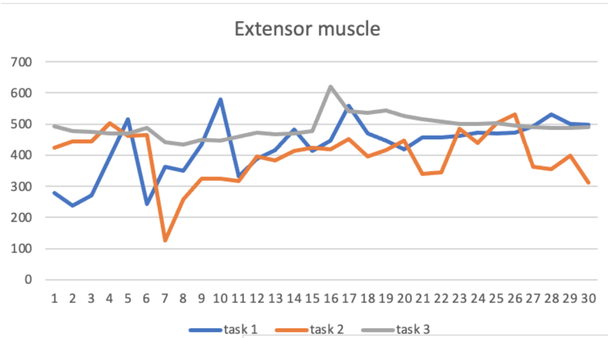
Experiment 2 : Servo motor using EMG signal

Factors to consider with the servo motor and EMG: Time and speed of the servo motor

- Need to consider if the servo motor can replicate the muscle input and output.
    - Time: will it stop if muscle is relaxed?
    - Speed: will it move according to the muscle and by how much?
- When doing the experiment, a second time with the servo motor, I had to consider how much the servo moves and if it correlates with the actions and by how much.
- A different algorithm to control the servo motor while using the same sensor

Results

Experiment 1



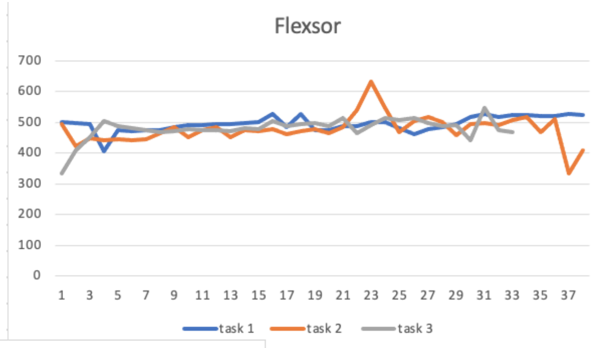


Figure 1

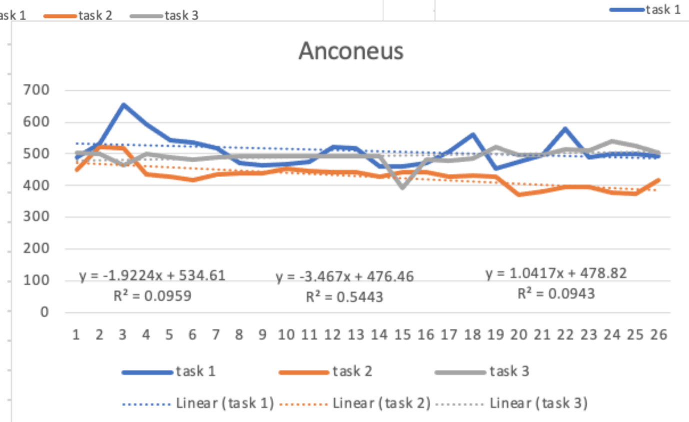


Figure 2

Figure 3

Figure 1

- To analyze the graph, I took the average of the tasks.

  Task 1: 428.57, Task 2: 396.93, Task 3: 491.133

  Based on the average, we can tell that task 1 has the highest spike, which means It was able to read the most electric signal while performing that task

Task 1:

After analyzing the graph, I notice that the average isn't the best way to compare. Based on the graph, I can see that there is a high spike for task 1.

When we grip our hand, more energy is being used by the muscle, so the EMG was able to pick up that signal and translate it into a value.

When one grip, it has a higher value then compared to a relaxed hand, which is why task one went up and down.

Task 2:

Based on the graph we see that at 6 seconds it dips down from the 400s to 125, I think that is the signal it receives when one turns their hands while waving.

Task 3:

From the graph, I noticed that there isn't much of a difference among all the fingers, although there is a spike from 15 seconds to 17 seconds. Unfortunately, I don't know the finger that we were testing

Figure 2

- Average of tasks

    Task 1: 496.55, Task 2: 476.84, Task 3: 479.61

Task 1:

No reading, a flat line

Task 2:

small spikes here and there, which means it is responding to the wrist movement made by the hand, when waving

Task 3:

Also, no reading, flat line

Figure 3

- Average of tasks

    Task 1: 508.65, Task 2: 429.65, Task 3: 492.88

Task 1:

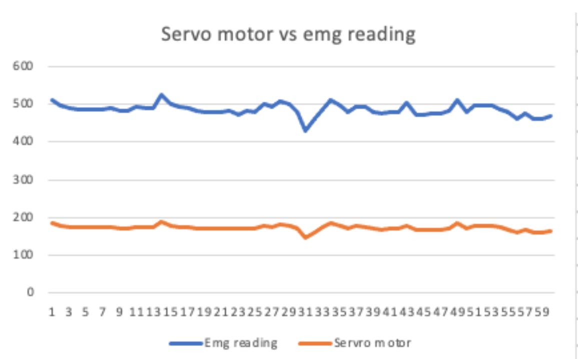
A couple of spikes

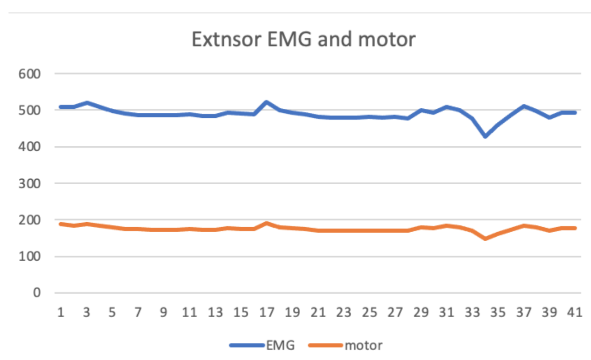
Task 2:

Not a lot of spikes, goes down linearly

Task 3:

One or two spikes





Experiment 2

Flexsor | Extensor

I graphed the EMG sensor compared to the servo motor and noticed that the two sensors match up. They have the same spikes that goes up and down. Which shows that the sensors correlate with each other.

Discussion and Conclusions
The objective of this experiment was to map the robot movement using the EMG sensor, and the objective has been met. We were able to figure out which part of the muscle's controls, by completing the tasks that were given to us.

I think the EMG is a reliable sensor if there are multiple sensors. Based on my data, I noticed that the sensor isn't as reliable when it comes to the fingers.
It picks up the reading for the fingers but can't differences the fingers. As for bigger movements like the wrist, it can easily pick that single up since it is also just one entity.

In the future, I would accurately time the start and end time. I measured the start and time for these experiments as well, but it wasn't as accurate. Some reading had more values than others because they didn't start and end at the same time. If I had more time.

References

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Singh, D. A. P., & About Dr Arun Pal SinghArun Pal Singh is an orthopedic and trauma surgeon. (2020, February 24). *Forearm muscles - anatomy and function*. Bone and Spine. Retrieved November 9, 2021, from https://boneandspine.com/forearm-muscles/.