Controlling Prosthetic Grip Strength with NeuroSky

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Introduction and Motivation

Upon reading the BCI review paper sections on BCI applications, we were especially interested in those applications helping with Motor Restoration. The paper mentioned a “novel neuroprosthetic device for the restoration of the grasp function for people spinal cord injuries”, and we wanted to create a simplified version of this. We worked with Triton Prosthetics, a club at UCSD with the aim of providing low-cost prosthetics to the community, and aimed to improve upon their prosthetic designs and potentially reach and help more clients. Past expanding our knowledge and experience with EEGs and BCIs in general, this project can help amputees and those with limb differences by providing them with a more robust prosthetic at a possibly lower price.

Related Work and Literature

1. BCI Review Paper:
http://documents.scribd.com.s3.amazonaws.com/docs/6pngcqg0ow21mte8.pdf?t=1357882803

2. Control of an Electrical Prosthesis with an SSVEP-based BCI
https://www.ncbi.nlm.nih.gov/pubmed/18232384

3. Brain-Computer Interface for a Prosthetic Hand Using Local Machine Control and Haptic Feedback
https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4428487

4. Prosthetic Control by an EEG-based BRain-Computer Interface (BCI)
https://pdfs.semanticscholar.org/c864/6a15245732a8f91fb74294562b99d19628df.pdf

Methods: Data Collection

-Used NeuroSky with mindwave-python library for collecting attention and meditation level data

-Measured headset.attention and headset.meditation once every second while the headset is connected (i.e. headset does not have poor signal)

-Compared using attention and meditation data separately to see which one gave better results (attention to close hand vs. meditation to open hand)

Methods: Smoothing

-Used a moving average with a window size of 5 to smooth the data in real time, helping eliminate noise

-Compared a normal average vs. a weighted average shown to the right, where time 5 is the most recent and time 1 is furthest in the past

-Stored the average values in an array that were written to the Arduino

Time	Weight
1	1
2	1
3	2
4	3
5	3

Methods: Smoothing (not used)

-LOESS (locally estimated scatterplot smoothing) and LOWESS (locally weighted scatterplot smoothing) are regression methods used for smoothing data

- -Generalization of moving average and polynomial regression
- -Not a good option for smoothing data in real-time

-Looked into SciPy smoothing method for signal processing using numpy.convolve, but it seemed unnecessary since we were using the attention values from the NeuroSky, not raw data
https://scipy-cookbook.readthedocs.io/items/SignalSmooth.html

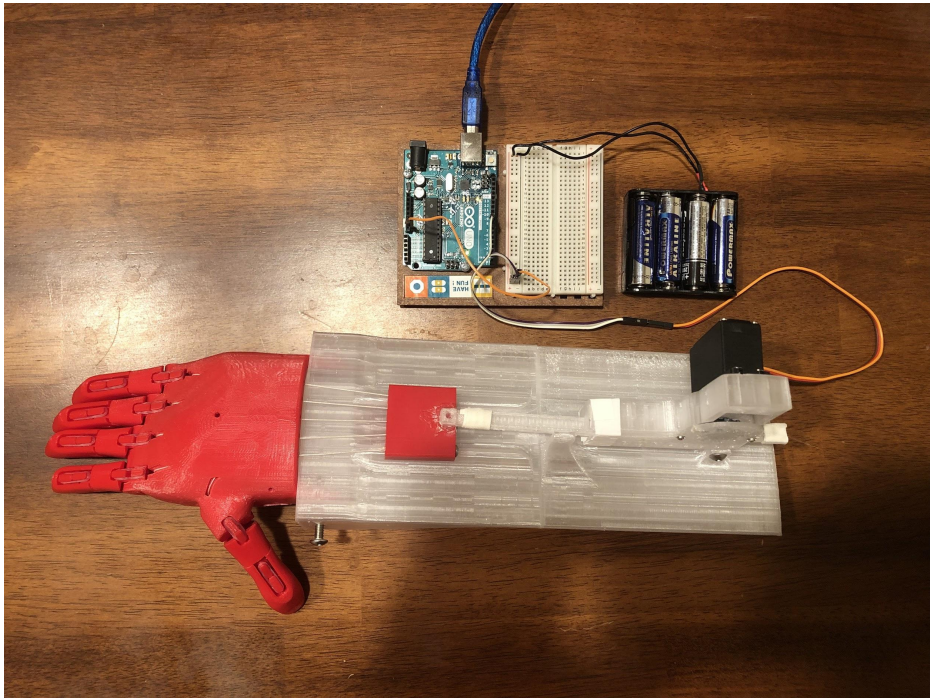
Methods: Arduino and Motor Actuation

Arduino Uno:

- While Serial Port is Available:
  - Read Values from Computer
  - Write to Port with 15ms Delay
- No Scaling Necessary

Motor Actuation:

- Linear Servo
- Modified Phoenix V.2 Prosthetic
  - Whipple Tree
- External Power Source



Thanks to Justin Burger (TP Engineering Lead) for Mechanical and Electrical Designs

Results

- What did you discover?
- How well did it work?

Results: What Did You Discover

- We discovered a lot about the problem we tasked ourselves with
- There were a lot of mechanical constraints that posed a problem
- Software wise, we were getting meaningful data we could use
- The communication between the software, Arduino and arm worked well
- However with all these discoveries did we reach a meaningful result?

Results: Did It Work?

- The Neurosky was able to return values that were normalized
  - Our “smoothing” did its job
  - This ensures that our hand does not shift rapidly
- The Motor moved properly based on the value of attention but this came with problems
  - The materials our hand was made of created too much friction
  - The motor was not strong enough to pull the servo
  - It was moving the proper degree however
- In the end we discovered a way of converting EEG signals to control a mechanical device
  - So in the end the conceptual task was accomplished
  - However was this accomplishment a step-forward in neural prosthetics?

Video

Discussion

- What did you learn?
    - Familiarize ourselves with the hardware and software
    - Combined our prior knowledge and our research from this project to communicate the Neurosky to the computer and the computer to the arduino which controlled the motor.
- What could you do better/ what would be a followup development? Give Two extensions or improvements with justification
    - Reduce noise - more gradual values
    - Implement meditation values
    - Two justifications:
        - Improve Hardware, less friction, better materials, better aesthetics
        - Explore different BCIs, more channels, more functionality