Team BCIPRO: Brain-Computer Interfaces Prosthetics

UNIVERSITY OF MARYLAND HONORS COLLEGE

Nora Fadul, Seyed Mohammad Ghaemi, Nicholas Gresh, Zach Gurwitz, Wensen Liu, Daniel Lopez, Nikhil Mittu, Abhay Patel, Khadija Shah, Micaela Wolcott

Team Mentor: Dr. Anil Deane   Team Librarian: Ms. Sharona Ginsberg

GEMSTONE Honors College University of Maryland

Research Goals

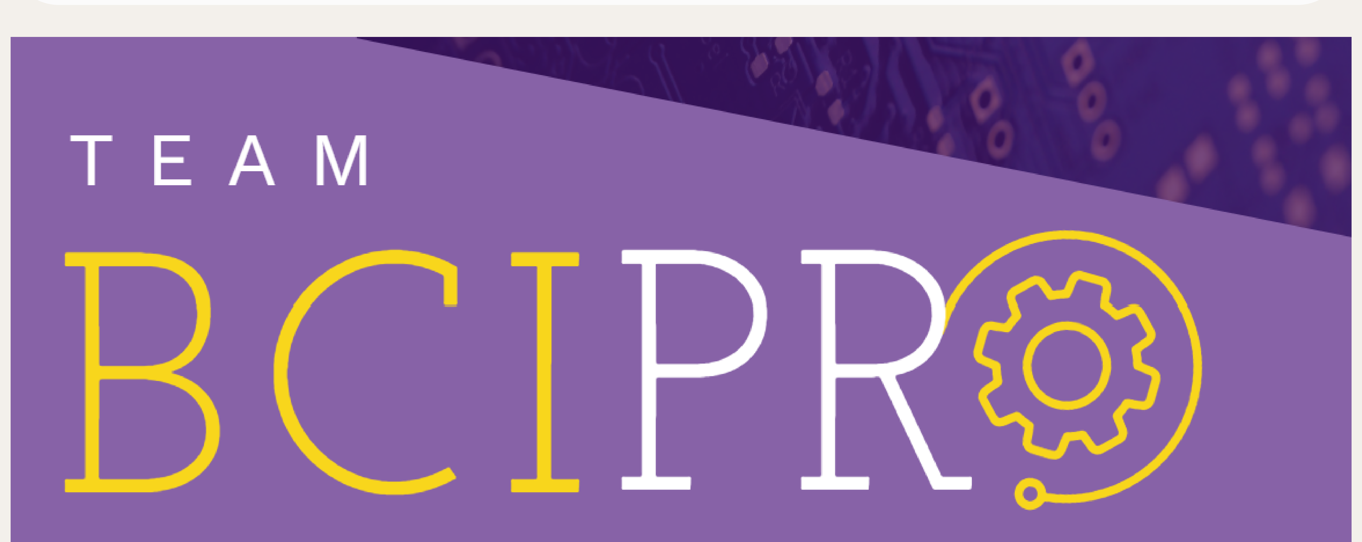
Currently, body-powered and externally-powered myoelectric prostheses, or a hybrid of the two, are the most popular and widely available options. We want to maintain the non-intrusive aspects of these prosthetics while improving the accuracy and control of conventional prosthetics. By leveraging an external BCI we can process EEG signals in real time to provide a better experience for the user.

Through a machine learning assisted BCI, we are working to offer a more functional and practical prosthesis for individuals with limb loss that operates intuitively and naturally. Our aim is to provide individuals with limb loss greater accessibility to affordable prosthetic devices that would increase quality of life.

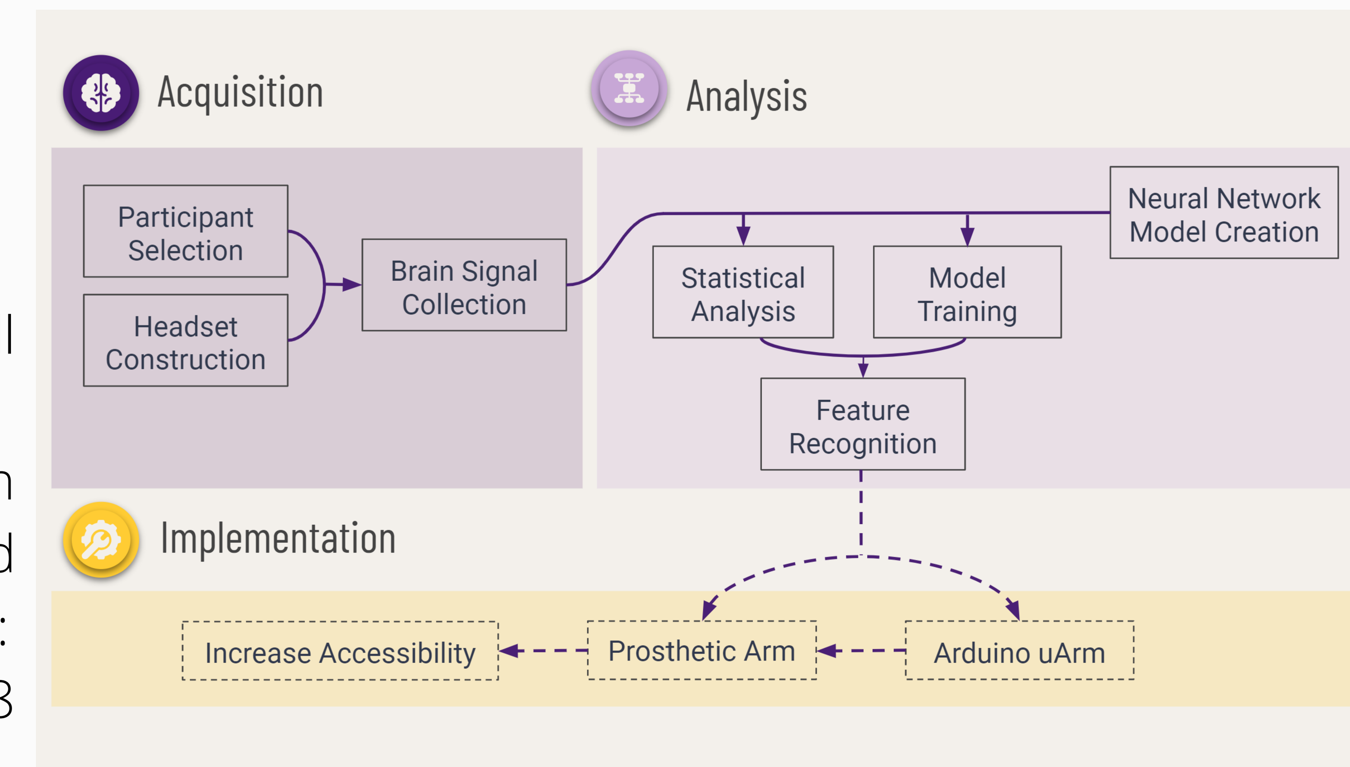
We recognize that limb loss disproportionately affects minority populations. Another one of our goals is to address this disparity by relying on 3D printing for our device and use open source data to increase affordability and not unintentionally contribute to health inequities.

Research Questions

1. How can we enhance conventional prosthetics in an non-intrusive way?
2. How can we leverage BCI with real-time data processing?



Methodology



Acquisition

- 3D-print EEG headset and assemble
- Recruit participants
- Participants are first asked to fill out a demographics survey
- An EEG with 8 electrodes is then placed on participants to record the execution of hand exercises:
  - open/close right hand for 8 rounds and 50 repetitions
  - open/close thumb and each finger one at a time for 40 repetitions

Analysis

- Normalize EEG data to remove noise
- Fourier analysis is used to transform time-series data into the frequency domain
- Deep Neural Networks for Neuro-physiology (DN3) is a python library that combines training deep neural network models with neuroscientific data.
- **Next Steps:** Investigate and build our own models based off of LSTMs, CNNs, etc.

Implementation

- **Next Steps:** Build physical model of prosthetic hand using servo motors with Arduino
  - Simulate how translated EEG signals control physical actions
  - Print 3D prosthetic hand

Results So Far

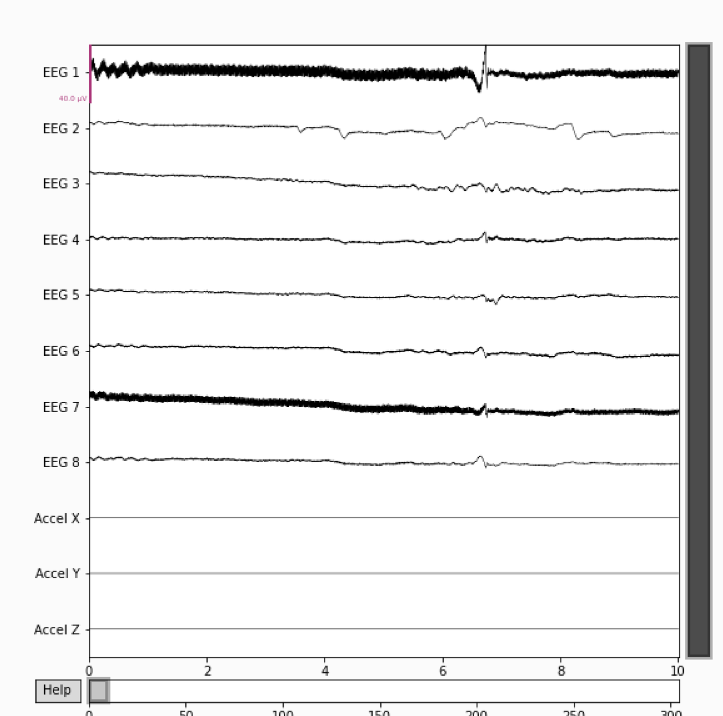


Figure 1. 10 seconds of EEG data from 8 electrodes during no hand movement.

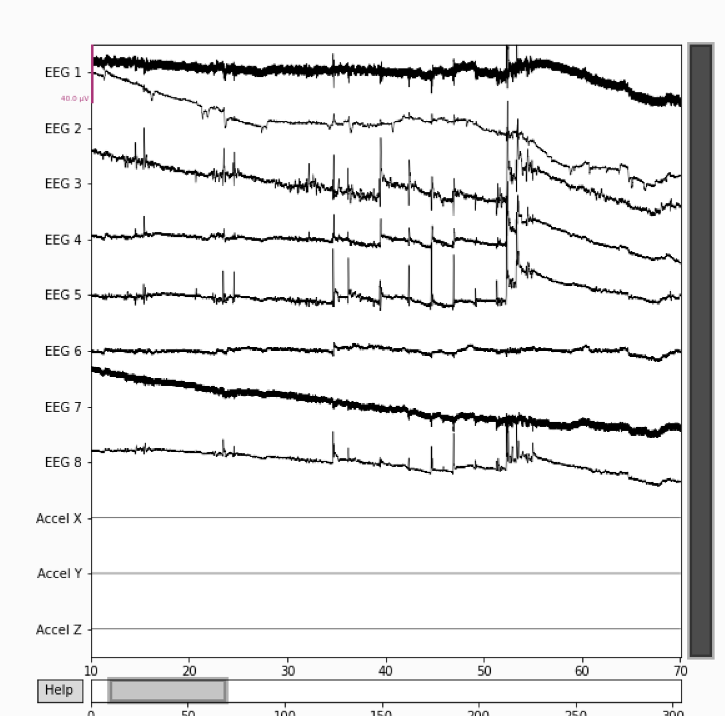


Figure 2. 60 seconds of EEG data from 8 electrodes during opening and closing of the right hand.

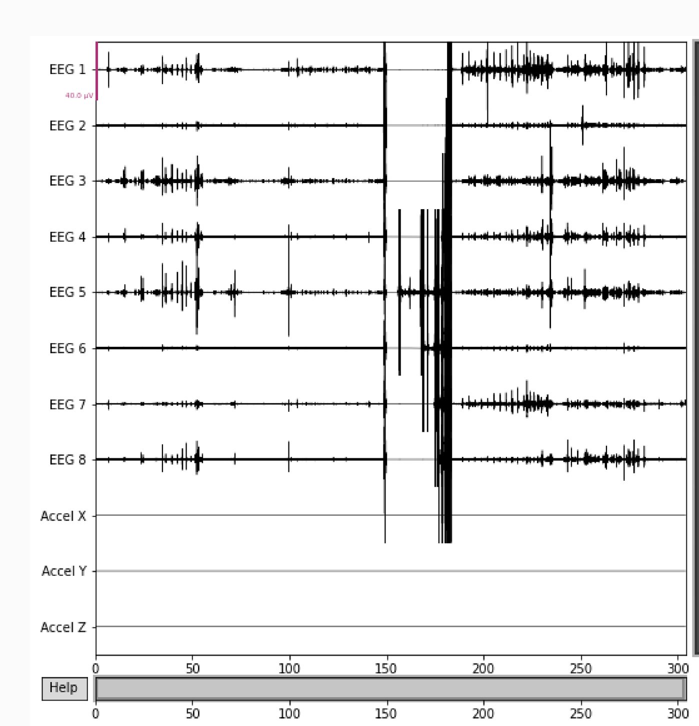


Figure 3. Five minutes of analyzed EEG data collected from 8 electrodes during opening and closing of the right hand.

Future Research

1. Affordable alternative to existing data acquisition devices (ie. 3D printing)
2. Affordable alternatives to prosthetic devices (ie. 3D printing)
3. Refining filtered raw data into readable signals
4. Investigating different types of inputs (ie. degree of grip strength and wrist rotation)

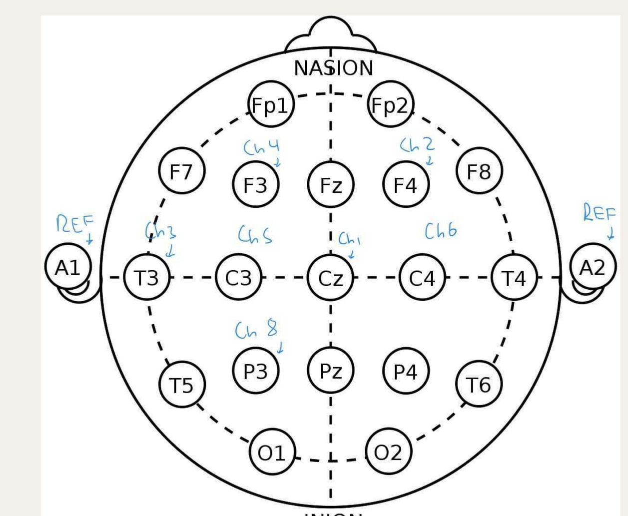


Figure 4. electrode placements

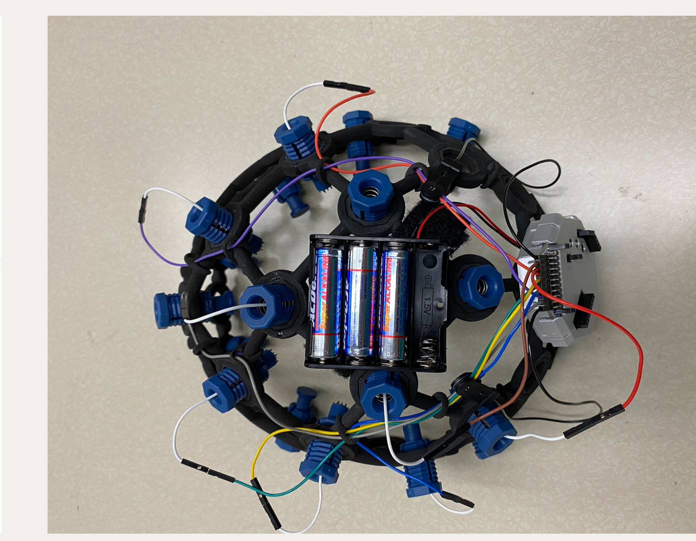


Figure 5. 3D-printed EEG

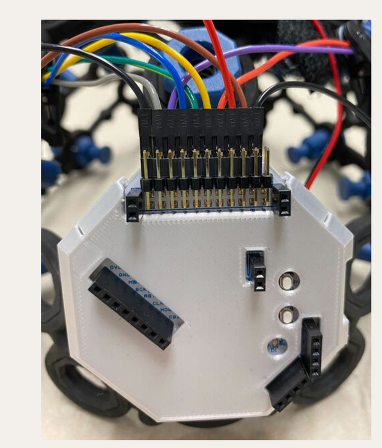


Figure 6. 8 channel ganglion board

Figure 7. Pre-testing the BCI paradigm; collecting EEG data from 8 electrodes while performing opening and closing exercises with the right hand at one second intervals.

Acknowledgements & References

We would like to thank Dr. David Lovell, Dr. Kristan Skendall, Dr. Vickie Hill, our mentor Dr. Anil Deane, our Librarian Ms. Sharona Ginsberg, Dr. Ryan McKendrick from Northrop Grumman, and the Gemstone Honors Program for supporting this research. We would also like to thank the Do Good Institute and our generous LaunchUMD donors for their financial contributions to our research.