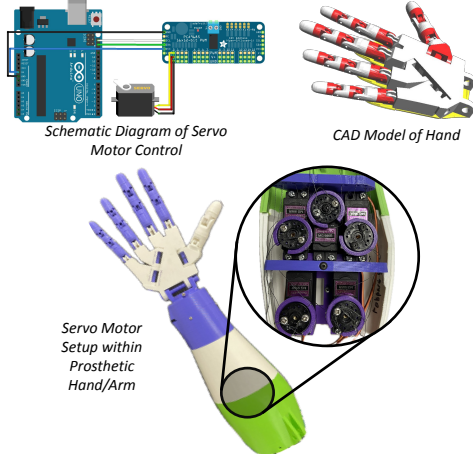


Introduction

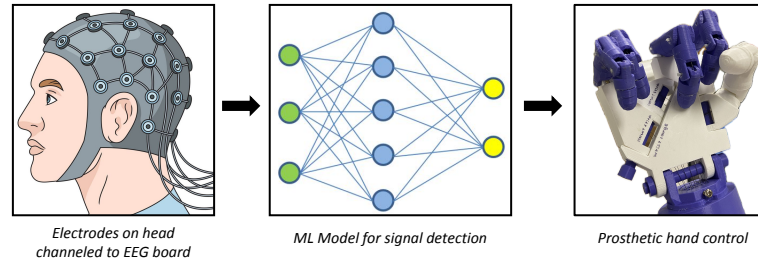
Loss of mobility due to paralysis is a devastating condition. Paralysis can stem from injuries (spine and brain), neurological disorders, and even diseases (such as brain tumors). Some severe injuries can leave patients immobilized even if they are not paralyzed. Thus, our team proposed a mind-controlled prosthetic hand to address the limitations caused by this issue. Previous research indicates that electroencephalograms (EEGs) can detect brain signals for more obvious thoughts such as clenching one's jaw, but signals from the opening and closing of one's hand are more difficult to detect. We utilized various machine learning (ML) tools including a Convolutional Neural Network + Long Short-Term Memory model to detect these fainter signals, which can be translated into controlling a prosthetic hand. With our ML-assisted EEG, mobility can be reintroduced in those suffering from paralysis through prosthetic limb control.

Hardware (Prosthetic Hand)

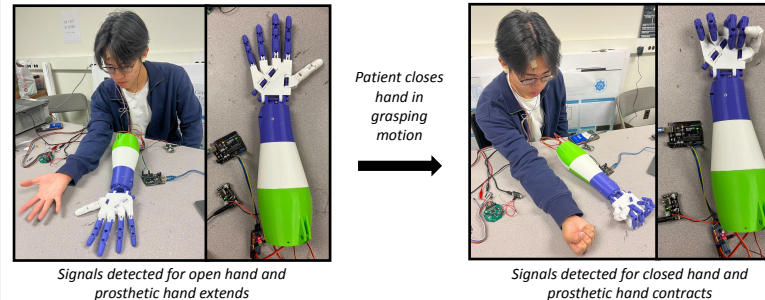
The prosthetic hand was modeled off of InMoov, an open-source robotics site, and adjusted according to our project. Individual parts were 3D printed with Prusa printers, then assembled using super glue, screws, and fishing wire. The fingers consist of hinge joints and are threaded with fishing wire. Contraction and extension are initiated by rotation of MG996R servo motors connected to the fishing wire. Five servo motors (one for each finger) are controlled with a PCA9685 I²C-controlled PWM driver, allowing for precise pulse-width modulation (PWM) output to each motor. The driver is controlled with an Arduino Uno microcontroller to allow for synchronous contraction and extension of all five fingers for a grabbing motion, replicating the lost functionality of limbs in paralyzed patients.



Final Design



Expected Results & Future Improvements



The diagram above depicts our expected results. A patient would have eight electrodes placed on the earlobes, back and top of the head, and temples of the forehead to allow for brain signal detection with our EEG board. Signals would be processed using our machine-learning model. Opening and closing of the hand would be characterized to provide a corresponding actuation (contraction or relaxation) based on the thoughts of the immobilized patient.

Future improvements include using springs and stronger wire within the prosthetic hand for cleaner and more robust actuation. The training of our models with actual patients could have also allowed for the actuation of individual fingers to further replicate the functionality of actual human limbs.

Team and Device in Action!

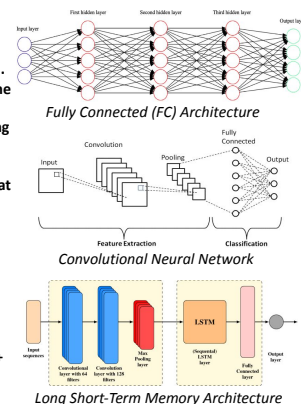


Team Members

Project Manager: Evan Bird
Software/ML: Martin Bourdev, Aryan Singh, Anthony Wu, Ganesh Koka
Hardware/Circuitry: Aaron Li, Maddie Doi, Joseph Moon, Helen Ran

Software (Machine Learning)

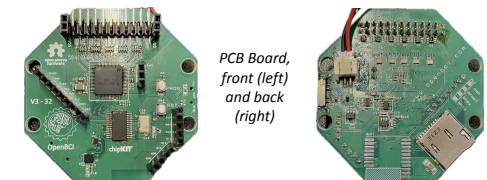
Our machine learning model was trained on Kaya, a comprehensive dataset compiled by OpenBCI. Because of limitations with the data collection process, we focused our efforts on working with a pre-existing dataset to evaluate the efficacy of the different models. We looked at more traditional machine learning models, such as Support Vector Machines (SVM), as well as multiple neural network-based architectures, including the following: Fully Connected Network, Convolutional Neural Network (CNN) + Long-short term Memory (LSTM).



Circuitry (EEG Board)

Our team modeled the printed circuit board (PCB) from an OpenBCI design intended for either 8 or 16 leads, adapting parts from their design to be more tolerant for different uses. For board assembly, 80+ components were ordered separately and soldered on by the team. To integrate the system, we used an FTDI Serial to universal asynchronous receiver/transmitter (UART) converter chained with an isolator to protect users that are connected to the EEG board.

Several challenges included converting the communication protocol utilized by the board to enable a wired connection. This wired connection would allow for a higher bit rate when changing the baud rate of our FTDI chip in unison with the 24-bit analog-to-digital converter (ADC). Additionally, maintaining tension in the fingers when the hand is fully contracted had to be addressed both in the code itself and by using a motor driver that could supply sufficient current.



Acknowledgements

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