# ExoAD
# EMG Controlled Hand Exoskeleton Assistive Device

Michele D'Mello, Diana Harasym, Natalie Hazzouri, Sara Jamil
Electrical and Biomedical Engineering, McMaster University

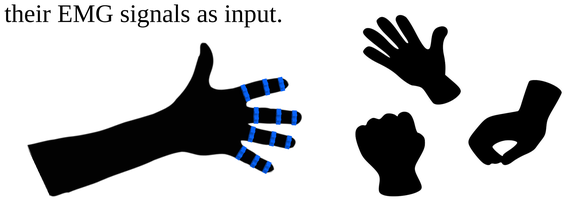
McMaster University

## INTRODUCTION

Loss of hand control is an issue affecting a wide range of individuals as a result of injury, neuromuscular conditions or the effect of age.

In order to maneuver the hand as desired, electromyography (EMG) signals have been explored to control an exoskeletal device. Those with loss of hand control are unable to produce enough action potentials to carry out movement for themselves. An exoskeletal device can be utilized to carry out daily tasks or function as a method of rehabilitation for the individual.

The objective is to design a device fitting the user to control the desired gestures of grasp and pinch using their EMG signals as input.



## METHODS

The overall device consists of signal processing components and mechanical design. The ExoAD acquires EMG data from the user's arm using a Myo armband. The data is then processed in the server and accurately classified as nothing, grasp, pinch or release. The microcontroller activates the actuators on the exoskeleton to execute the user's desired motion.

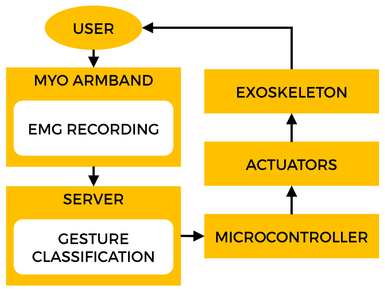
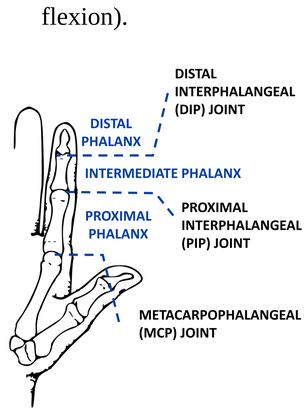


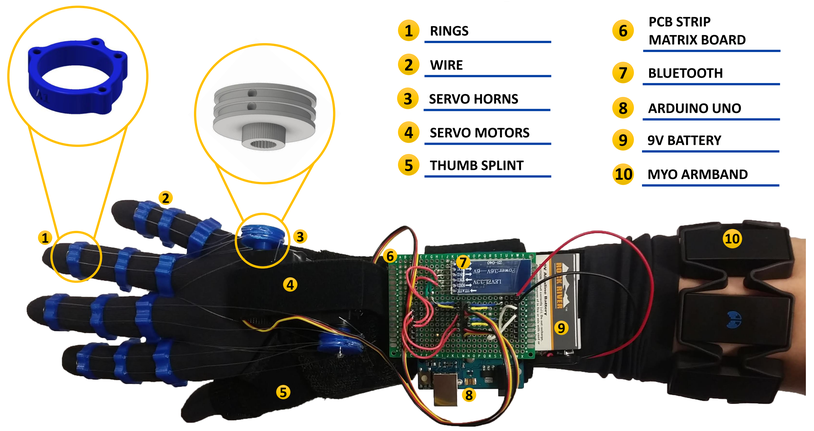

**Figure 1:** Overview of ExoAD Control


**Figure 2:** Communication Platforms

## MECHANICAL DESIGN

- The device uses two servo-motors to control a cable and ring linkage system.
- Rings are placed on the phalanges of each finger.
- For simplicity, the thumb is fixed using a thumb splint.
- Wire is threaded through from the sides (to control extension) and from the bottom (to control flexion).
- One motor controls the first 2 fingers (index and middle) and the other controls the last 2 fingers (ring and little).
- When the first motor is activated the pinch movement can be executed and when both motors are activated at the same time, the grasp movement can be completed.




## SIGNAL PROCESSING

Raw EMG data is indistinguishable and cannot feasibly be resolved using simple thresholding techniques. Therefore, machine learning techniques were employed.

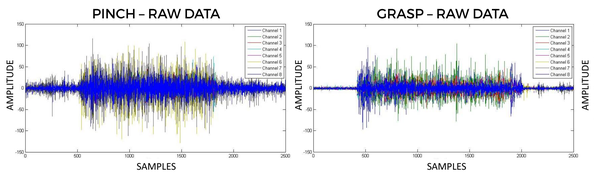



**Figure 3:** Raw EMG Data for Pinch and Grasp

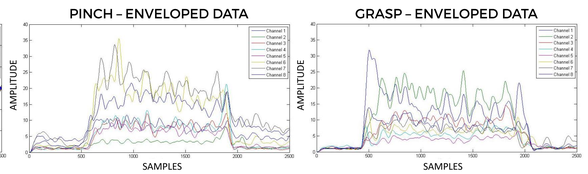



**Figure 4:** Enveloped EMG Data for Pinch and Grasp

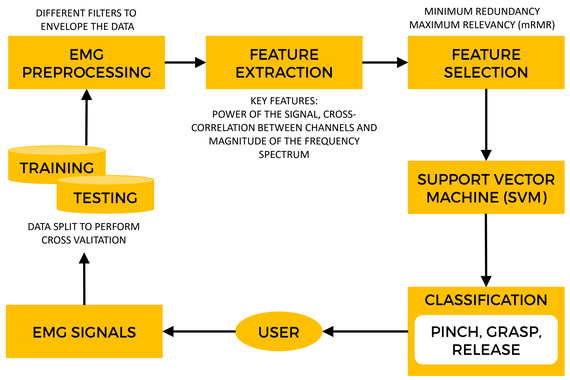



**Figure 5:** Gesture Classification

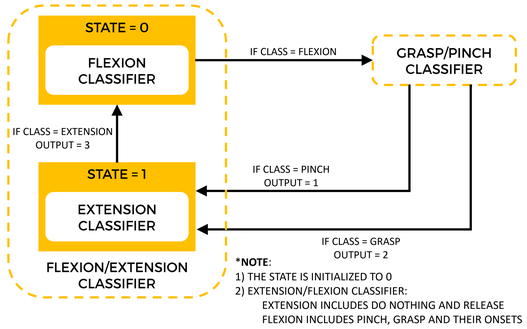



**Figure 6:** State Machine - determines the output using two separate classifiers depending on the current state/gesture of the hand.

## RESULTS

In order to classify between the gestures, single and multiple classifiers were explored. The error rate was obtained using 10-fold cross validation.

The following table displays the classification accuracies for the test data set.

| SINGLE CLASSIFIER | |
|---|---|
| **TYPE** | **ACCURACY** |
| NOTHING VS GRASP VS PINCH VS RELEASE | 86.0% |

| MULTIPLE CLASSIFIERS | |
|---|---|
| **TYPE** | **ACCURACY** |
| EXTENSION VS FLEXION | 91.1% |
| GRASP VS PINCH | 99.4% |

## DISCUSSION

- Using the multiple classifiers provided the lowest error rate that was able to successfully distinguish between the different classes using the test data.
- The classification rate is inherently limited by the specifications of the Myo armband – sample rate is relatively low and the large electrodes allow for crosstalk.
- Mechanical design can effectively produce the desired gestures however limitations in the motor torque does not provide sufficient force.
- Improved real-time performance could be achieved by implementing classification and training with an adequate microcontroller.
- Future improvements include the addition of force feedback by using pressure sensors.

## ACKNOWLEDGEMENTS

Many thanks to Dr. Hubert DeBruin, Dr. James Reilly, Dr. Aleksandar Jeremic, Dr. Colin McDonald, Philip Chrapka and Thalmic Labs for their support.

## REFERENCES

[1] Marcello Mulas, Michele Folgheraiter and Giuseppina Gini, "An EMG-controlled Exoskeleton for Hand Rehabilitation," IEEE, Chicago, 2005.
[2] Matthew DiCicco, Lenny Lucas, Yoky Matsuoka, "Comparison of Control Strategies for an EMG Controlled Orthotic Exoskeleton for the Hand," IEEE, Pittsburgh, 2004.
[3] Lenny Lucas, Matthew DiCicco, and Yoky Matsuoka, "An EMG-Controlled Hand Exoskeleton for Natural Pinching," NSF, Pittsburgh, 2004.
[4] H. Peng, "mRMR (minimum Redundancy Maximum Relevance Feature Selection)," 2005. [Online]. Available: http://penglab.janelia.org/proj/mRMR/. [Accessed 2016].