Fabric EMG Sensing for Robotic Orthosis Control

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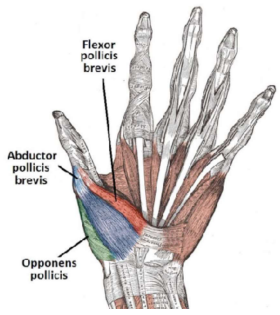
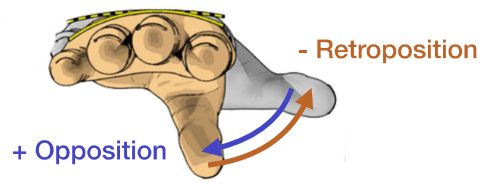
Overview

- We present a prototype for a fabric thumb sleeve with fabric surface electromyography sensors to measure intrinsic muscle activity of the hand.
- The fabric sEMG sensors are made with low-cost (<$5), off the shelf conductive fabric and conductive thread.
- Fabric sEMG sensors are:
  - highly adaptable, allowing for a wide range of sizes and shapes
  - flexible and easily able to conform to contours of the body
  - non-adhesive, enabling reuse
  - comfortable to don, doff, and wear

- Fabric sEMG sensors offer a means to augment current control methods of existing assistive robotic devices that use forearm extensor muscle activity for user intent inferral.

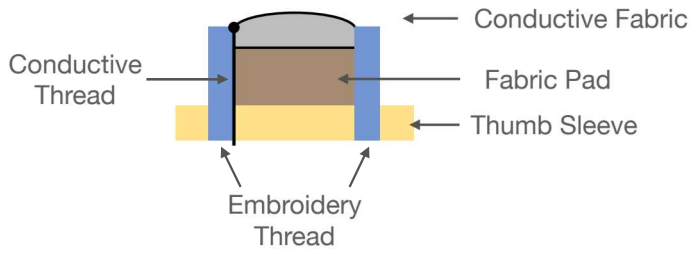
Hand Anatomy



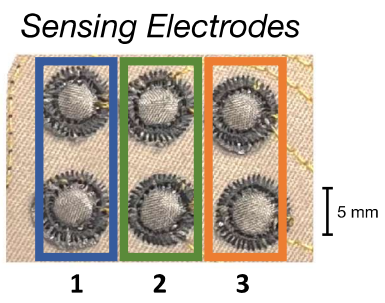


The muscles that control thumb abduction, opposition, and flexion lie in the thenar eminence, a bundle of intrinsic hand muscles at the base of the thumb [1, 2].

Fabric Electrode

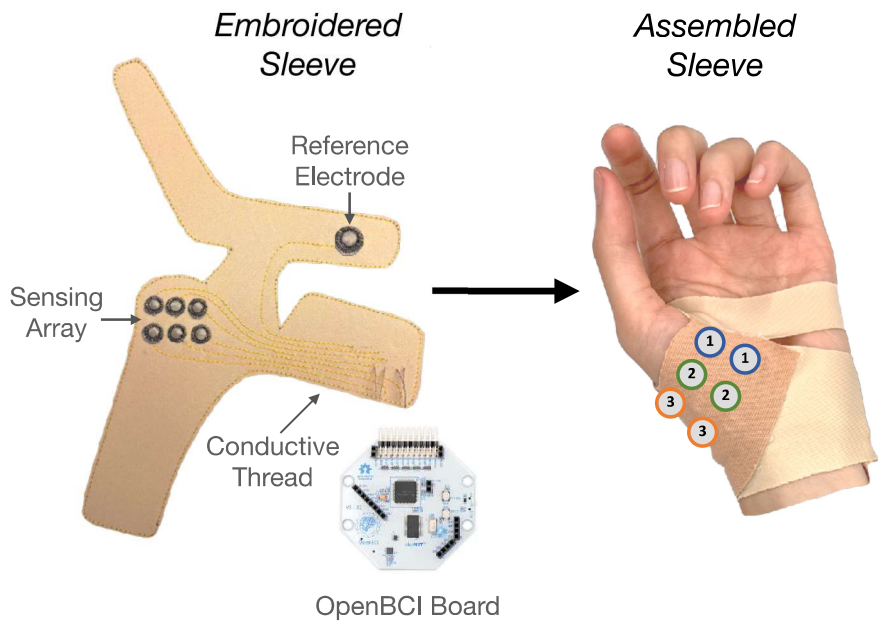


Each electrode is made of a layer of conductive fabric on top of a thick fabric pad to improve skin contact. The sensors are embroidered to an elastic fabric thumb sleeve and connected via conductive thread to the OpenBCI Cyton board for biopotential sensing [3].



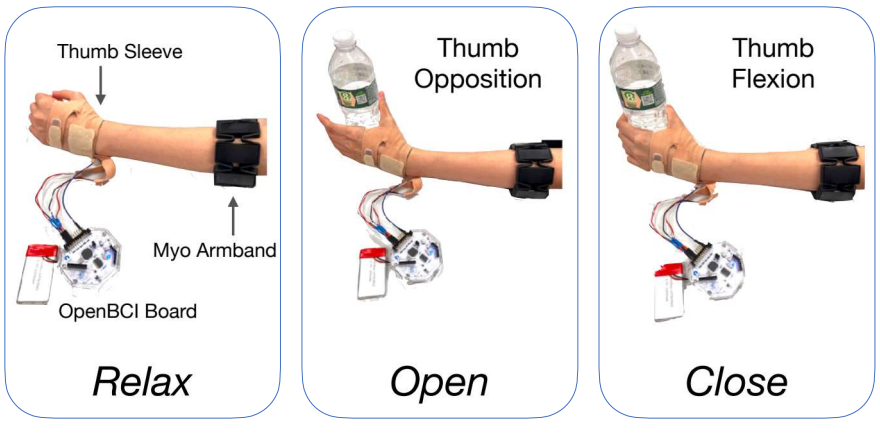
The electrodes are organized into an array of three vertical pairs, with each pair corresponding to a single EMG signal measurement channel. Each electrode is 5 mm in diameter.

Prototype

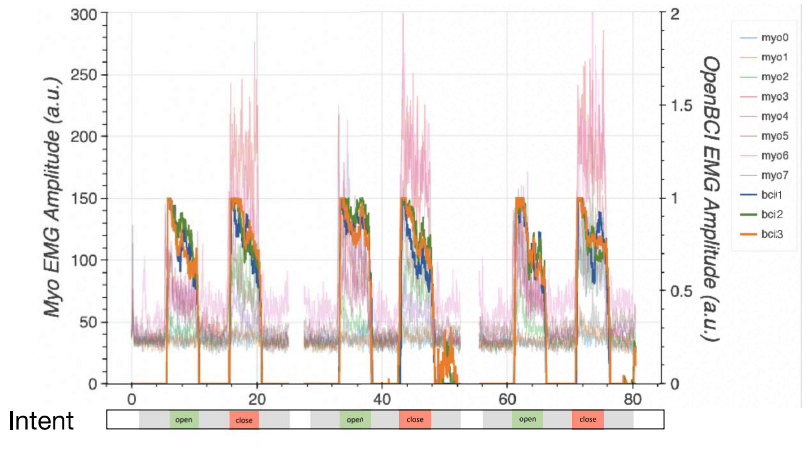


After embroidering the fabric electrodes and conductive thread, which act as wires to connect the sleeve to the OpenBCI board, the sleeve is assembled into a wearable form. The sensor array is positioned on the thenar eminence of the thumb to detect when the thumb moves into opposition, while the reference electrode is placed on the back of the hand.

Data Collection & Ongoing Work



We ask healthy participants to wear the thumb sleeve and a commercial sEMG armband on their forearm. To collect data, participants are instructed to relax, open, and close their hands three times. A water bottle is used as a prompt to encourage and target thumb opposition during hand opening.



Using a bandpass filter (50 Hz to 125 Hz), preliminary testing of the fabric sEMG sensor data alongside the commercial sEMG armband in a healthy participant demonstrates its capacity as an EMG sensor for intrinsic muscle activity.

References

[1] TeachMeAnatomy. The intrinsic muscles of the hand. TeachMeSeries Ltd. Retrieved August 28, 2024, from https://teachmeanatomy.info/upper-limb/muscles/hand/
[2] Farag, A., Fahmy, H., & Abbas, A. (2021). Suitability of the openly accessible 3D printed prosthetic hands for war-wounded children. *Journal of Rehabilitation and Assistive Technologies Engineering, 8*, 2055668320982788.
[3] Liu, R., Shao, Q., Wang, S., Ru, C., Balkcom, D., & Zhou, X. (2019). Reconstructing human joint motion with Computational Fabrics. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 3(1), 1–26. https://doi.org/10.1145/3314406
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