Fabric Sensing of Intrinsic Hand Muscle Activity

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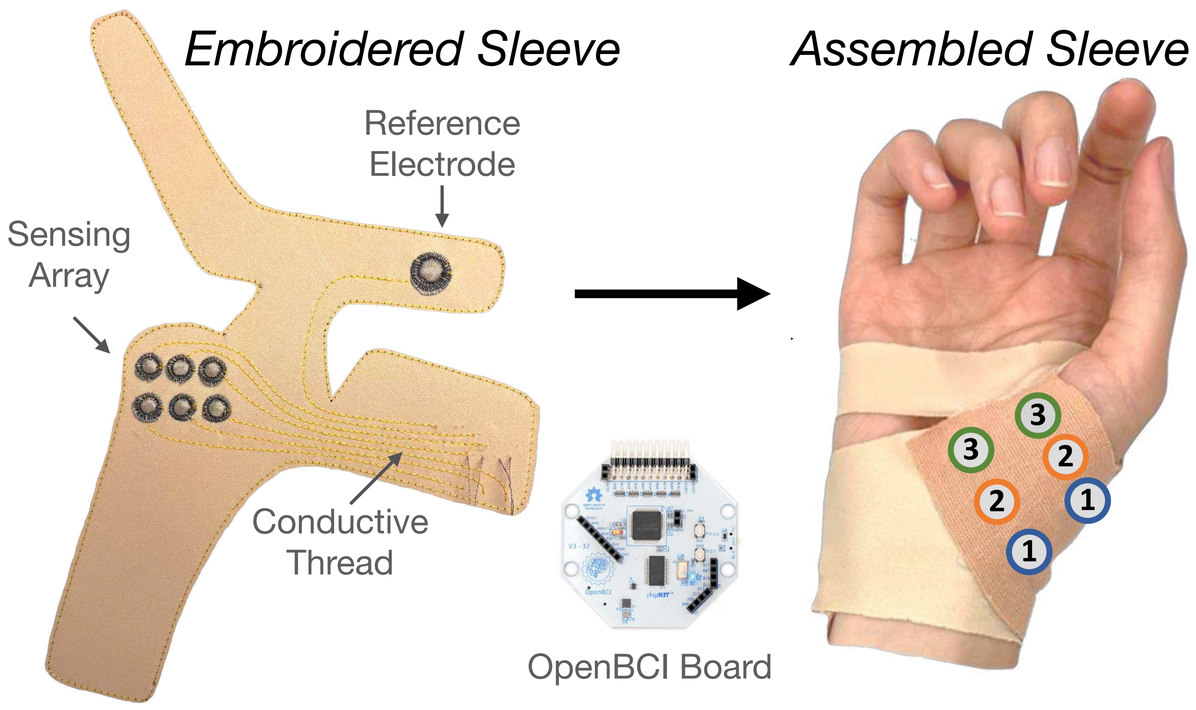
Overview

- 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 can augment current control methods of existing assistive robotic devices that use forearm extensor muscle activity for user intent inferral.

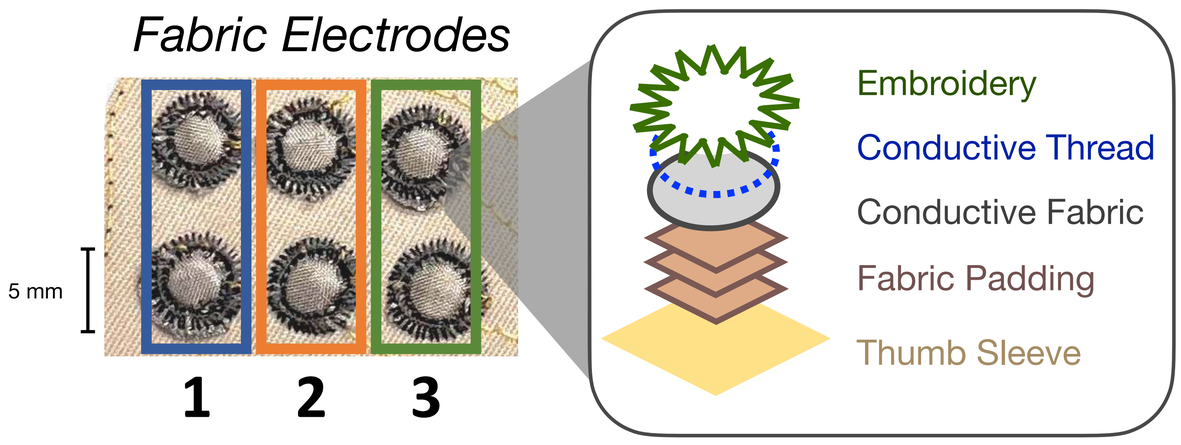
Protocol

Isolated Muscle Movement	**Thumb Abduction**	**Finger Extension**	**Finger Flexion**
			
	move thumb or fingers from rest to an engaged position		
Isometric Muscle Movement			
	statically engage muscles to resist external force (experimenter's hand)		
Hand Gesture Classification	**Hand Open**	**Relax**	**Hand Close**
			
	open and close hand via lumbrical grasp, using a can as a visual aid		

Prototype

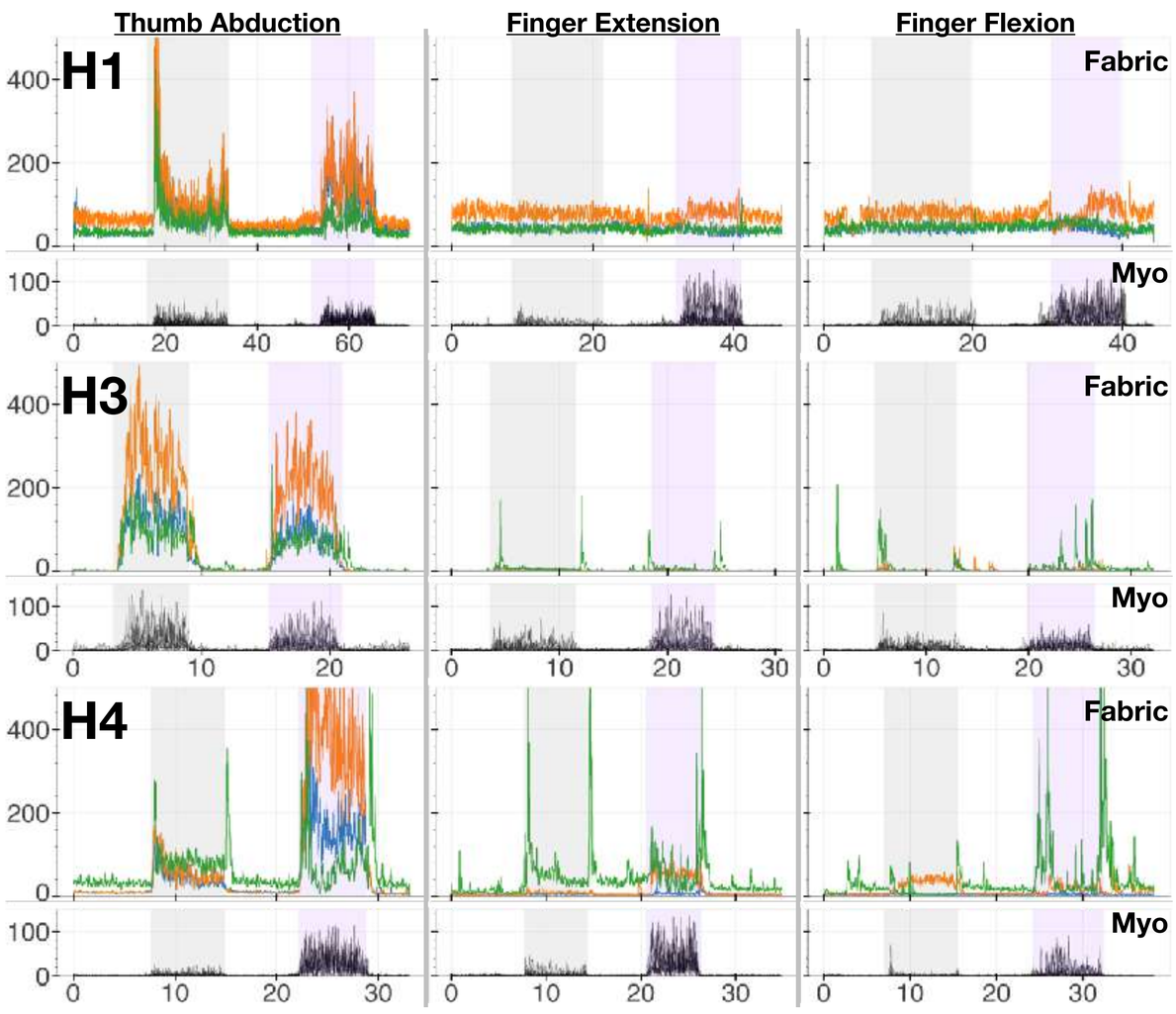


The sensing sleeve is made of fabric electrodes and conductive thread, which act as wires to connect the sleeve to the OpenBCI board. The sensor array is positioned on the thenar eminence of the thumb to detect when the thumb moves into opposition.



Results

Sensing Muscle Movements



Data (n = 8 total participants, H1, H3, H4 pictured here) from fabric sensing sleeve and Myo arm band. Experimental conditions separated by colored bars (grey = isolated, purple = isometric). Each row depicts data from one healthy participant, where the top plot shows fabric sensor activity in µVrms and the top plot depicts corresponding Myo sensor activity in proprietary values (a.u.) with all eight channels plotted in black.

- Fabric sEMG sensors on thenar eminence capture muscle activity during thumb movement and isometric contraction.
- Our sensing sleeve can distinguish between thumb muscle activity and finger muscle activity.

Hand Gesture Classification

CLASSIFICATION ACCURACY OF FABRIC SENSING SLEEVE AND MYO ARMBAND ACROSS 3 CANDIDATE MODELS

Hx	Fabric Sensor			Myo Armband		
	LDA	RF	MLP	LDA	RF	MLP
H1	**70.1%**	68.6%	65.1%	84.6%	**84.7%**	80.4%
H3	**84.7%**	83.8%	79.4%	**84.1%**	83.1%	82.1%
H4	**84.4%**	80.8%	83.0%	**86.6%**	86.3%	81.5%
H5	**81.9%**	69.6%	66.7%	78.7%	**84.8%**	79.0%
H6	13.0%	**67.5%**	42.0%	77.3%	**81.3%**	74.6%
H7	70.1%	46.5%	**70.6%**	88.2%	**91.1%**	89.9%
H8	**92.6%**	91.1%	87.7%	89.3%	**90.7%**	90.0%
H9	77.5%	78.6%	**80.3%**	86.8%	**87.4%**	83.3%
Avg	71.8%	73.3%	71.9%	84.4%	86.2%	82.6%
Std	24.9%	13.6%	14.5%	4.3%	3.4%	5.2%

Classification accuracy results of the fabric sensing sleeve compared to the commercial arm band. We trained three machine learning models (LDA, RF, MLP) for the fabric sensor and the Myo armband.

- Our 3-channel sensing array achieves promising classification accuracy of hand open/close intent.
- For half the participants, the fabric sensing sleeve achieves a maximum classification accuracy within 5% of the Myo armband.
- In future work, the fabric sensing sleeve could augment a forearm sEMG setup for improved intent inferral.

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