Toward Drift-Resistant Assistive Device Control via sEMG–SMG Fusion

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We investigated **whether surface electromyography (sEMG) can reduce optical-flow-based sonomyography (SMG) signal drift** by restricting SMG tracking to periods of muscle activation. While our naive sEMG–SMG signal did not mitigate drift, our findings motivate our continued development of hybrid biosensing control interfaces to enable all-day use of assistive devices.

Motivation

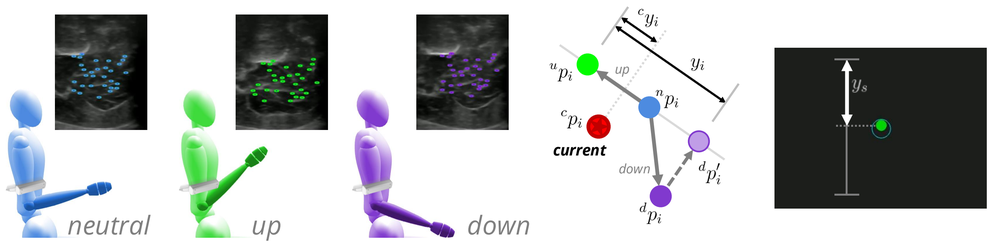
- Assistive technology enables spinal cord injury survivors to recoup individual autonomy, but **current biosensing interfaces are limited**.
- **Surface electromyography (sEMG)** is most commonly used as a **discrete control signal** and requires frequent recalibration.
- Optical-flow-based **sonomyography (SMG)** provides a continuous control signal [1] but is **susceptible to drift over time**.

→ **GOAL: Develop a hybrid sEMG–SMG control interface** where the sEMG signal serves as an activation threshold for the continuous SMG signal, reducing SMG-induced drift by locking tracking when the user is not activating their muscles.

Previous Work [1]

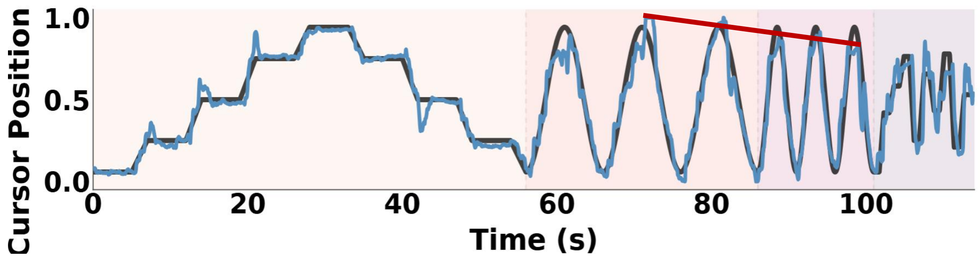
We developed a **novel SMG system** that can be placed anywhere on the upper body and provides **continuous 1-DOF control** after minimal 3-point calibration.

Paper TuO5T2.5 *(Sueltz et al. 2026)*

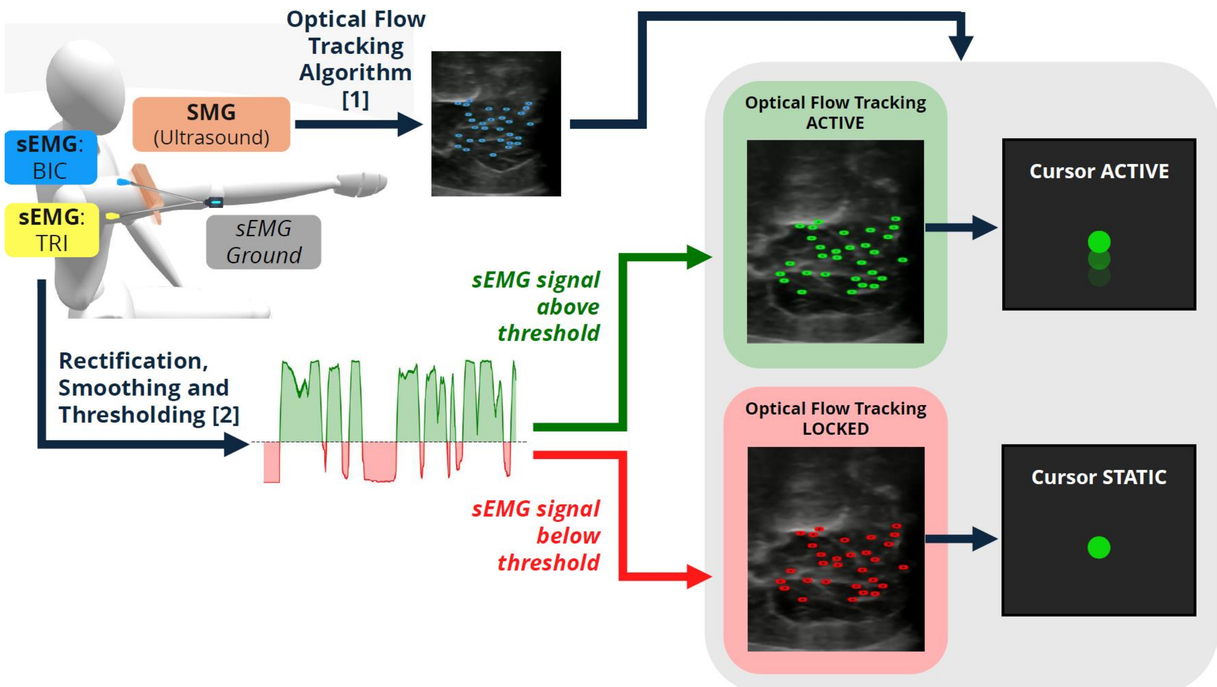


Ultrasound image features are tracked using Lucas–Kanade sparse optical flow. The position of the points at some instant, relative to the 3 poses defined in the calibration, results in the continuous 1-DOF control signal.

***Prolonged use resulted in signal drift** as optical flow tracking gradually accumulated error, as shown by how the maximum value slowly decreases over time.*

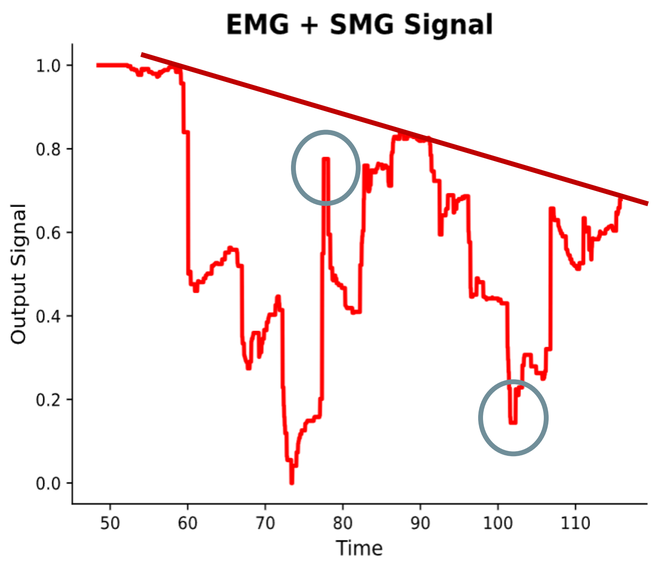


System Design



Results

- **The sEMG–SMG system reduced high-frequency noise compared with the SMG-only system, but not signal drift.**
- The accumulation of signal drift was actually increased, as we did not consider the contributions of non-measured muscles and external forces on muscle deformation.
- Users described the cursor as feeling "sticky," indicating that the sEMG activation threshold was unintuitive.



The reduced controllability is reflected as spikes (overshoots) in the signal vs. time plot. The increase in signal drift is shown by the maximum value decreasing over time.

Current Extensions

While our sEMG filter did not improve SMG control performance, our generated data set **provides insights into the time series behavior of sEMG and SMG signals**, motivating further development of hybrid control interfaces, including:

- **Developing an sEMG–SMG velocity controller**
  - SMG still provides a continuous signal, but **controls the speed of movement** rather than absolute position.
  - Surface EMG still provides an activation threshold, but **slows down the speed of movement** rather than fully halting when it does not detect activation.
  - This **ensures that the continuity assumption of optical flow is always validated** as the flow points would be continuously tracked without interruption from the sEMG, which only affects the output speed.
- **Creating an IMU–SMG hybrid controller**
  - Instead of sEMG, use inertial measurement unit (IMU) signals as activation thresholds or in other sensor fusion frameworks (e.g., Kalman filtering).
  - As SMG and IMU both provide a continuous, kinematics-based signal, we expect them to better correlate with each other as compared with sEMG and SMG.

Poster SuPO1P.13 *(Padgen et al. 2026)*

Poster MoPO1P.13 *(Wynn et al. 2026)*

Acknowledgments / Sponsors

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[1] G. Sueltz, V. Athithan*, E. Ferran*, M. Herrera*, C. J. Wynn*, and L. A. Hallock, "Sensor-placement-agnostic sonomyography: Toward continuous high-dimensional control by users with tetraplegia," in *IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*. IEEE, 2026. *Equal contribution.

[2] K. T. Özgünen, U. Çelik, and S. S. Kurdak, "Determination of an Optimal Threshold Value for Muscle Activity Detection in EMG Analysis," *Journal of Sports Science & Medicine*, vol. 9, no. 4, pp.620–628, Dec. 2010.