 DOI: 10.3217/978-3-99161-050-2-171

Neuromorphic Processing of sEMG Signals for Finger Position Estimation

C. Piozin[1]*, H. Fares[1], F. Moradi[1]
[1]*Electrical and Computer Engineering Department, Aarhus University, Aarhus, Denmark*
*E-mail: cpiozin@ece.au.dk

Introduction: Neuroprosthetics aim to restore lost motor or sensory function. Upper limb myoelectric prostheses which rely on processing surface electromyography (sEMG) signals from the amputee's residual limb are of the most widely used devices. While traditional control relies on pattern recognition for identifying discrete hand movements, regression-based approaches offer a more intuitive control by modeling hand kinematics with sEMG [1,2]. However, implementing these methods on wearables faces challenges due to resource limitations (memory, power, latency). Neuromorphic computing, with its brain-inspired architecture and energy-efficient spike-based processing, offers a promising solution [3]. While explored in prosthetic control, its application to regression-based approaches remains limited [2]. This paper introduces a neuromorphic regression-based processing method for mapping sEMG signals to finger positions during hand movements, as illustrated in Figure 1.A.

***Methods and Results**:* The regression task involved mapping 16 sEMG electrodes to 5 Degrees-of-Actuation (DoAs) corresponding to the position of the 5 fingers. sEMG signals taken from the dataset in [4] were downsampled from 2kHz to 250Hz, rectified, and normalized between 0 and 1. Each channel was then encoded into spike trains by a Leaky Integrate-and-Fire (LIF) neuron (16 total) [3]. These spike trains were fed into a Spiking Neural Network (SNN) with two hidden layers of 256 LIF neurons and a five-neuron output layer. The SNN was trained using a surrogate gradient and the Adam optimizer using the snnTorch library [5]. Regression accuracy was assessed by comparing the output neurons' membrane potentials to the ground truth DoAs using Mean Absolute Error (MAE). Preliminary results showed an MAE of 6.0 ± 3.3 degrees, comparable to results reported in [2] using a similar dataset (see Figure 1.B for an example of the regression).

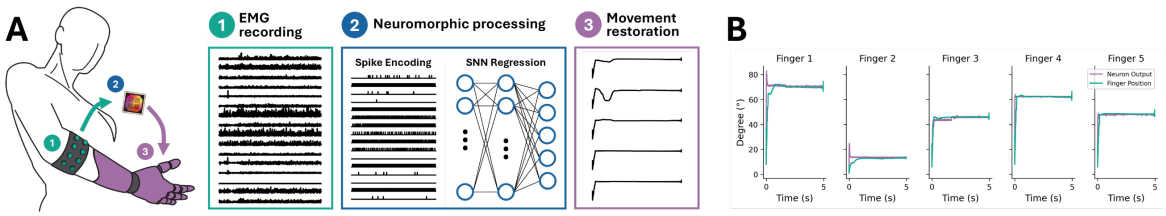

Figure 1: A. Schematic of prosthesis control using the proposed neuromorphic approach, 1: sEMG signal recording, 2: Event-based processing of the sEMG signal composed of spike encoding and SNN regression, 3: Finger movement restoration on prosthesis based on SNN output. B. Finger position (ground truth DoAs represented in green) estimation results for a lateral grasp. Neuron output (in purple) represents the neuron's membrane potential.

Conclusion: Preliminary results using event-based computation demonstrate successful finger position estimation from sEMG signals across six hand gestures, regardless of arm position. This suggests our decoding approach exhibits position invariance. Future work will focus on implementing the model on a 16-core SNN developed by our team [6].

Acknowledgments and Disclosures: This work was supported by the Neuro-Sense project, funded by the Lundbeck Foundation (grant R402-2022-1413).

References:

[1] Hahne, J. M., Wilke, M. A., Koppe, M., Farina, D., & Schilling, A. F. (2020). Longitudinal case study of Regression-Based Hand Prosthesis Control in Daily Life. *Frontiers in Neuroscience*, *14*.
[2] Zanghieri, M., Benatti, S., Benini, L., & Donati, E. (2023). Event-based Low-Power and Low-Latency Regression Method for Hand Kinematics from Surface EMG. In *2023 9th International Workshop on Advances in Sensors and Interfaces (IWASI)*.
[3] Baracat, F., Mazzoni, A., Micera, S., Indiveri, G., & Donati, E. (2024). Decoding gestures from intraneural recordings of a transradial amputee using event-based processing. *TechRxiv*
[4] Kyranou, I., Szymaniak, K., & Nazarpour, K. (2025). EMG Dataset for Gesture Recognition with Arm Translation. *Scientific Data*, *12*(1).
[5] Eshraghian, J. K., Ward, M., Neftci, E. O., Wang, X., Lenz, G., Dwivedi, G., Bennamoun, M., Jeong, D. S., & Lu, W. D. (2023). Training spiking neural networks using lessons from deep learning. *Proceedings of the IEEE*, *111*(9), 1016–1054.
[6] Sadeghi, M., Rezaeiyan, Y., Khatiboun, D. F., Eissa, S., Corradi, F., Augustine, C., & Moradi, F. (2024). NEXUS: A 28nm 3.3pJ/SOP 16-Core Spiking Neural Network with a Diamond Topology for Real-Time Data Processing. *IEEE transactions on biomedical circuits and systems*

CC BY 4.0
https://creativecommons.org/licenses/by/4.0/deed.en
This CC license does not apply to third party material and content noted otherwise.

Published by Verlag der Technischen Universität Graz