A Low-Power Event-Driven Gesture Recognition System Based on MoS_2 Charge Trap Memory Reservoir Computing

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Surface electromyography (sEMG) signals have been widely used for neuromuscular interfacing applications, such as gesture recognition and prosthetic control, but practical wearable implementation remains challenging due to the need for high accuracy, low latency, and ultra-low power consumption [1]. Existing approaches, like Transformer-based methods [2], often rely on computationally intensive feature extraction or complex neural network architectures, which limit their suitability for edge computing. In contrast, neuromorphic approaches like reservoir computing (RC) provide a low-complexity framework that leverages the intrinsic dynamics of nonlinear systems for temporal feature extraction, enabling efficient processing with reduced training overhead. Recently, charge trap memory (CTM) devices based on molybdenum disulfide (MoS_2) have been successfully adopted to realize an RC-based seizure detection system, thanks to their ultra-low current operation, nonlinear dynamics, and short-term memory [3], making them promising candidates for physical RC.

This work presents an event-driven online gesture recognition system for multichannel sEMG processing using MoS_2-based CTM devices. Acting as a nanowatt-level physical reservoir [3], the CTM can directly convert sEMG dynamics into current responses with improved linear separability. In this way, temporal information processing is performed at the device level, reducing the reliance on elaborate, power-hungry neural network models. With the discriminative feature representation, the classification can be implemented with a low-cost linear support vector machine (SVM) rather than a complex network model. To further reduce the power consumption of our system, we adopt an asynchronous, event-based strategy that activates readout, ADC conversion, and classification only when informative gesture activity is detected and the applied gate voltage falls within a predefined read window. This event-driven strategy avoids unnecessary ADC conversion and computation during rest states, thereby improving energy efficiency.

Simulation results on the Ninapro dataset [4] show that the proposed system can perform online multichannel sEMG recognition with a favorable tradeoff among accuracy, latency, and power consumption. Compared with prior representative works [2,5], it achieves comparable accuracy with more than one order of magnitude lower power consumption by integrating a CTM reservoir with an asynchronous readout strategy. These results suggest that combining device-level temporal signal processing with event-driven architectures provides an efficient path toward practical low-power, wearable biomedical interfaces.

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