Real-time EMG Control of a Robotic Manipulator Using Grasp Hold–Pulse Gesture Recognition

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Abstract:
This paper presents a real-time electromyography (EMG)-based gesture control system for a robotic manipulator using a novel fist grasp hold–pulse detection strategy to improve human–robot interaction reliability. Conventional EMG interfaces are often affected by signal variability, motion artifacts, and unintended activations, limiting their robustness in practical mechatronic applications. To address these challenges, a hybrid gesture interpretation approach combining sustained muscle contraction (hold) and transient activation (pulse) detection is proposed for stable command generation. The system employs dual forearm EMG sensors for bio signal acquisition, with data transmitted via Bluetooth Low Energy (BLE) to an ESP32-based embedded controller for real-time signal processing and actuator control. The detected gestures are mapped to a three-degree-of-freedom robotic manipulator, where independent EMG channels control joint motion while simultaneous muscle activation enables gripper operation. The proposed control architecture enhances gesture discrimination, reduces false triggering, and improves system responsiveness under noisy operating conditions. Experimental validation demonstrated reliable real-time performance and gesture recognition accuracies ranging from 80% to 100% across multiple test scenarios. The results highlight the effectiveness of the proposed EMG-driven mechatronic control framework for assistive robotics, prosthetic interfaces, and advanced human-machine interaction systems.