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A REVIEW ON INTERFACING STRATEGIES USED FOR ROBOTIC UPPER LIMB PROSTHESES

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Abstract

Robotic upper limb prostheses continue to gain dexterity, yet their widespread adoption will depend on solutions that respect both user needs and environmental constraints. This review synthesises recent advances in human-machine interfacing - from surface and intramuscular EMG to peripheral nerve electrodes, cortical implants, and bidirectional sensory motor feedback - and compares them in terms of invasiveness, signal bandwidth, training effort, and power demand. A clear taxonomy is introduced to support like-for-like evaluation of interface classes. In parallel, we provide a concise appraisal of environmental footprints - material circularity, manufacturing related carbon output, and end-of-life e-waste to help balance technical performance against ecological impact. Finally, we examine promising low-power neuromorphic controllers and biodegradable electrode assemblies that modelling suggests could cut energy use by over 40 % and reduce landfill mass by roughly 60 %. Database searches in IEEE Xplore, PubMed, and Scopus yielded 176 peer-reviewed studies published between 2019 and 2025. After normalisation, the data show that state-of-the-art myoelectric systems classify intended movements with 94 ± 3 % accuracy at power budgets below 20 mW, while emerging spinal cord stimulation platforms achieve multimodal sensory feedback with sub-millisecond latency. Only 11 % of the surveyed literature, however, reports any quantitative environmental metrics, and none offers a full life-cycle assessment. Greater collaboration between prosthetics engineers and environmental scientists is therefore needed to close the gap between functional excellence and sustainability. By coupling these two perspectives, the present review offers clinicians, designers, and policy-makers an evidence-based guide to selecting upper limb interfaces that serve both the user and the planet.

Key words: environmental footprint, neural interface, neuromorphic control, sensory feedback, upper limb prosthesis

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