A Wearable System Using Micro:bit and Machine Learning to Monitor Upper-Limb Rehabilitation for Stroke Recovery

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Abstract

Stroke patients are often discharged with home exercise programs but minimal clinical supervision, resulting in compensatory movement strategies that impede neurological recovery. With over 75% experiencing upper-limb impairment post-stroke, ensuring movement quality, not just quantity, is clinically critical. The gap between “doing the exercise” and “doing it correctly” has never been more consequential. This project sets out to build a low-cost wearable system using Micro:bit that identifies compensatory movement patterns, exercise smoothness, and fatigue across three clinically validated upper-limb rehabilitation exercises: arm lift (stimulates neuroplasticity via residual corticospinal pathways), shoulder rotation (prevents frozen shoulder, affecting 70–84% of hemiplegia patients), and elbow flexion (counteracts biceps spasticity and prevents fixed flexion contracture). Approximately 20 accelerometer samples per exercise were acquired via Micro:bit, encompassing both correct executions and compensatory patterns to construct a balanced labeled dataset. A machine learning classifier was trained to discriminate between movement categories, with validation performed to assess performance before the model was integrated into the wearable device. The system integrates three key features: a Micro:bit accelerometer to capture multi-axis motion data, a machine learning classifier to assess movement quality based on acceleration signatures, and real-time corrective feedback. Results show the system successfully identifies compensatory movements that would otherwise be logged as correct repetitions. This provides patients and therapists with meaningful feedback, addressing the clinical risk of reinforcing incorrect patterns. Future developments include real-time audio alerts for self-correction and high-frequency oscillation analysis to detect spasticity, ultimately enabling remote monitoring through a physical therapist dashboard.

Keyword: Stroke recovery, Wearable technology, Micro:bit, Machine learning, Upper-limb rehabilitation