EMG-Controlled Hand Exoskeleton With an Ensemble Machine Learning Model for Real-Time Assistive and Rehabilitative Control

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Certain neuromuscular disorders, such as stroke, Parkinson's Disease, multiple sclerosis, and spinal cord injuries, can disrupt neural pathways between the brain and the muscles, leading to limited hand function. The use of a hand exoskeleton helps rebuild connections between the brain and muscles by reinforcing intended movements through repeated, assisted motion that strengthens neuromuscular pathways. The objective of this project was to create a wearable hand exoskeleton with integrated, non-invasive electromyography (EMG) technology that utilizes an ensemble machine learning model to predict and perform a user's hand movements. The hand exoskeleton was designed in CAD with optimized finger joints and compact linear actuator placement. Surface EMG signals from forearm flexor muscles were processed and segmented to extract features used to train a random forest classifier, which was then integrated to convert classified gestures into actuator control for the exoskeleton. The hand exoskeleton was successfully fabricated with compact components that enabled consistent finger motion, and forearm EMG signals were reliably acquired and processed into stable features for real-time control. The random forest classifier performs with an overall accuracy of 85%, with an accuracy of at least 75% for each intended classification, exhibiting reliable differentiation between multiple hand gestures. This project demonstrates the potential of a compact, EMG-controlled hand exoskeleton for aided and therapeutic recovery. By combining real-time machine learning with efficient mechanical design, the system enables intent-driven hand support. With further refinement, clinical testing, and device optimization, this approach could improve functional at-home recovery and accessibility.

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