NeuroGait: A Low-Cost, Mind-Controlled Pneumatic Exoskeleton With CNN-Based Control for Individuals With Lower-Limb Mobility Impairments Using Brain Computer Interface

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Globally, tens of millions of people suffer from lower body impairments, including spinal cord injuries, cerebral palsy, stroke, and muscular dystrophies, leading to loss of independent mobility. Current aids like wheelchairs and walkers are limited, as they fail to support natural gait patterns. Exoskeletons have been shown to be significantly more effective but currently face three key limitations: a prohibitively high cost, a lack of seamless interaction with the human body, and a lack of compliance and backdrivability. My project, NeuroGait, is designed to solve these challenges by predicting patient movements with a brain-computer interface and providing assistance via a low-cost pneumatic exoskeleton. NeuroGait analyzes brain intent signals two seconds before voluntary movement, known as the bereitschaftspotential (BP). A custom 3D-printed EEG headset was developed to capture brain signals with three EEG electrodes placed across the brain's motor cortex. Using a convolutional neural network trained on the BP brain signal data of five essential lower-limb movements, my algorithm has a 99.9% prediction accuracy. From there, a 3D-printed lower-limb exoskeleton completes the detected movement in real time through a novel pneumatic artificial muscle (PAM) design and a feedback control mechanism, allowing NeuroGait to be ultra-compliant and backdrivable. The total system achieved a high 95.2% accuracy in detecting and executing key lower-limb movements and is significantly more cost efficient compared to existing exoskeletons. Through the development of NeuroGait, this study aims to develop an affordable, user-adaptive pneumatic exoskeleton that bridges the gap between thoughts and physical mobility in real time.

Awards Won:
Second Award of $2,400
International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE
IEEE Foundation: Second Place Award of $600