ARISE: An Adaptive Robotic Exoskeleton Regarding Physical and Cognitive Rehabilitation To Reduce Energy Expenditure and Injury

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Workers in physically demanding fields—such as healthcare, manufacturing, and logistics—face high rates of musculoskeletal disorders (MSDs) due to repetitive lifting and sustained strain. Cumulatively, ~2.6 million workplace injuries occur in these sectors, costing employers ~$171 billion annually. Existing support systems offer limited assistance and fail to address all risks. To address these issues, an adaptive robotic exoskeleton (ARISE) was designed, developed, and programmed to provide real-time support in high-load operations to the upper body, increase power from torque-based applications based on input, utilize bio-feedback sensors to provide real-time support in high-load operations, and reduce energy expenditure by >15% compared to unassisted movement. A robotic exoskeleton with the advantage of real-time load sensitivity is a novel concept that was pioneered through ARISE. Development began with CAD modeling to create a robust robotic exoskeleton. Following assembly, kinematic modeling was integrated with EMG, force, and pulse oximeter sensors, alongside physics-based algorithms, to enable real-time adaptive control and optimize energy efficiency. ARISE was evaluated through 30 trials using three different loads (5 kg, 10 kg, 15 kg), comparing performance metrics with and without the exoskeleton. Key indicators—time taken, rate of perceived exertion (RPE), pulse, and EMG voltage—showed notable improvements: time decreased by ~84.7%, RPE by ~77.1%, pulse by ~53.85%, voltage by ~13%, and energy exertion by ~53.7%. ARISE revealed that an adaptive robotic exoskeleton could assist in demanding fields, but several design and testing considerations are necessary. ARISE additionally shows potential in numerous fields: emergency response, rehabilitation, etc.

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