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AI-based methodologies for exoskeleton-assisted rehabilitation of the lower limb: a review

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Over the past few years, there has been a noticeable surge in efforts to design novel tools and approaches that incorporate Artificial Intelligence (AI) into rehabilitation of persons with lower-limb impairments, using robotic exoskeletons. The potential benefits include the ability to implement personalized rehabilitation therapies by leveraging AI for robot control and data analysis, facilitating personalized feedback and guidance. Despite this, there is a current lack of literature review specifically focusing on AI applications in lower-limb rehabilitative robotics. To address this gap, our work aims at performing a review of 37 peer-reviewed papers. This review categorizes selected papers based on robotic application scenarios or AI methodologies. Additionally, it uniquely contributes by providing a detailed summary of input features, AI model performance, enrolled populations, exoskeletal systems used in the validation process, and specific tasks for each paper. The innovative aspect lies in offering a clear understanding of the suitability of different algorithms for specific tasks, intending to guide future developments and support informed decision-making in the realm of lower-limb exoskeleton and AI applications.

KEYWORDS

artificial intelligence reinforcement learning, support vector machine, neural network, decision tree, lower extremeties

1 Introduction

Lower-limb rehabilitation is a field of great clinical relevance, dealing with the rehabilitation of individuals with motor disabilities in the lower-limbs a result of trauma, or neurological or musculoskeletal heath conditions. Shi et al. (2019); Zhou et al. (2021). Globally, in 2019, 2.41 billion individuals had conditions that would benefit from rehabilitation, contributing to 310 million YLDs (years of life lived with disability). This number increased by 63% from 1990 to 2019. The disease area that contributed most to prevalence was musculoskeletal disorders (1.71 billion people) (Cieza et al., 2020).

Traditionally, lower-limb rehabilitation has been conducted by human therapists through physical therapy including specific exercises. However, the integration of wearable robotic technologies, i.e., the lower-limb exoskeletons, and Artificial Intelligence (AI) is paving the way for the design of new tools and approaches to improve the quality