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Thesis title

Analysis of biomechanical and bioelectric parameters for the needs of automation of diagnostics and rehabilitation of patients

Abstract

The complexities and challenges of patients' treatment inherent in the current rehabilitation and physical therapy landscape, highlight the critical role of accurate assessment, active patient participation, adherence to prescribed regimens, and continuous health monitoring for optimal outcomes of theraphy. It underscores the heavy reliance on the expertise of therapists and the challenges posed by patient engagement in repetitive exercises. The motivation behind this research is the pressing need to address these challenges amidst the growing demands on healthcare systems worldwide and the potential of advanced technologies, such as machine learning and robotics, to revolutionize diagnostics and rehabilitation through automation. The expert systems powered by AI to automate diagnostic and therapy parameters and the exploration of feedback loops within rehabilitation processes are highlighted as promising yet under-researched areas.

This dissertation tackled a significant scientific issue: the lack of conclusive evidence supporting the effectiveness of methodologies, assessments, and treatment protocols in robotic-assisted diagnostics and therapeutic interventions. The primary goal is to lay down the methodological foundation for an automated expert platform aimed at supporting, enhancing, and automating the diagnostic and rehabilitation processes. Utilizing machine learning and robotic technologies, the research develops a feedback mechanism that integrates electromyography (EMG), torque, and limb position data. This integration facilitates a more objective, efficient, and personalized approach to patient care. The study focuses on the analysis of upper limb movements, specifically elbow flexion and extension, involving the biceps and triceps muscles during isokinetic muscle force assessments, as well as tests for spasticity and muscle stiffness. Furthermore, there were explored the application of EMG biofeedback for pelvic floor muscles within a telerehabilitation framework and investigated EMG-triggered movement for knee rehabilitation using a rehabilitation robot.

The methodology centers on selecting established bioelectrical and biomechanical parameters and verifying their effectiveness and objectivity in diagnostic and therapeutic applications through robot-assisted techniques. This research aims to bridge the gap in evidence regarding the efficacy of robotic-assisted diagnostic and therapeutic interventions, proposing a novel approach that combines technological advancements with clinical practices to improve patient outcomes in rehabilitation. The research validates its hypotheses through extensive evaluations, comparing control and stroke groups for muscle force tests, assessing muscle spasticity in healthy and stroke survivors, and exploring the effectiveness of telemedicine in urinary incontinence rehabilitation and EMG-triggered movement therapy for knee rehabilitation post-stroke. These researches focus on utilizing electromyography (EMG), torque, and positional data to derive biomechanical and bioelectrical parameters. By applying machine learning algorithms, the research aims to objectively evaluate and distinguish between healthy subjects and those with conditions, and to tailor rehabilitation exercises based on a feedback loop mechanism.

This comprehensive approach not only confirms the potential of robotic-assisted methods based on analysis of biomechanical and bioelectrical parameters in automatic diagnostic and therapeutic processes but also advances the field of biomedical engineering by providing a methodological framework for future developments in automated patient care.

Key words

analysis and processing of EMG signals, rehabilitation robot, neurorehabilitation, automatic diagnostics