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RESEARCH ARTICLE

Muscle weakness assessment tool for automated therapy selection in elbow rehabilitation

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Abstract

Clinical observations and subjective judgements have traditionally been used to evaluate patients with muscular and neurological disorders. As a result, identifying and analyzing functional improvements are difficult, especially in the absence of expertise. Quantitative assessment, which serves as the motivation for this study, is an essential prerequisite to forecast the task of the rehabilitation device in order to develop rehabilitation training. This work provides a quantitative assessment tool for muscle weakness in the human upper limbs for robotic-assisted rehabilitation. The goal is to map the assessment metrics to the recommended rehabilitation exercises. Measurable interaction forces and muscle correlation factors are the selected parameters to design a framework for muscular nerve cell condition detection and appropriate limb trajectory selection. In this work, a data collection setup is intended for extracting muscle intervention and assessment using MyoMeter, Goniometer and surface electromyography data for upper limbs. Force signals and human physiological response data are evaluated and categorized to infer the relevant progress. Based upon the most influencing muscles, curve fitting is performed. Trajectory-based data points are collected through a scaled geometric Open-Sim musculoskeletal model that fits the subject's anthropometric data. These data are found to be most suitable to prescribe relevant exercise and to design customized robotic assistance. Case studies demonstrate the approach's efficacy, including optimally synthesized automated configuration for the desired trajectory.

1. Introduction

Robotic treatment is becoming increasingly popular among patients suffering from neurological and musculoskeletal problems. Rehabilitation devices are used to help patients restore lost motor abilities. Manual or mechanical treatment is usually the only option for such patients to regain their motor abilities. Since there is repetition in specified exercises, manual assistance is difficult, time-consuming, and uncomfortable for the physiotherapist. Robotic rehabilitation is, therefore, a viable option [1, 2, 3]. It can deliver high doses of motor instruction at a reasonable cost. Nonetheless, training is dependent on one-on-one interaction between a therapist and a patient in the historical setting; as a result, rehabilitation is expensive and time-consuming. In addition, the dosage is usually insufficient for adequate recovery. Previous research has focused on building robotic rehabilitation systems for patients with muscular and neurological disorders, but their practical application in clinics and homes has been limited. Robotic training is considered less effective than dose-matched motor training, provided by therapists [4].

Task-oriented training is a research paradigm for upper extremity rehabilitation that includes three design concepts: skill development for functional activities, active participation training, and customized adaptive training. Recognizing a patient's weakness and assigning appropriate tasks is challenging [5, 6]. To understand a patient's functioning capability is essential to give appropriate therapy [7, 8]. Constructive muscular engagement suited to the patients' needs would help manage and adjust