FEASIBILITY STUDY OF A HAND EXOSKELETON FOR REHABILITATION OF POST-STROKE PATIENTS

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ABSTRACT

This paper illustrates the activity done by the authors for the development of a hand exoskeleton with two degrees of freedom addressed to the rehabilitation of post-stroke patients. The literature is investigated and many design issues are deeply discussed with the purpose to provide a reader who is approaching this problem with useful guidelines. The feasibility study of a one degree of freedom mechanism for one finger, intended as the basic module of the targeted hand exoskeleton, is outlined: two kinematic chains having six and eight links respectively are presented and discussed.

1. INTRODUCTION

Impairment of finger, hand and arm operation is a common outcome following stroke or peripheral nerve injury, often resulting in chronic functional deficits. Well-established rehabilitation techniques rely on thorough and constant exercise [1]. Early initiation of active movements by means of repetitive training proved its efficacy in guaranteeing a good level of motor capability recovery [2]. The rehabilitation process is generally assisted by physical therapists who make the patients perform proper exercises. Most exercises are mainly focused on strengthening specific muscles and recovering basic mobility skills, such as moving specific joints. More complex exercises may be possibly executed in order to allow the patient to recover some ability in activities of daily living. Quite often, a few months are required to achieve acceptable improvement in arm and hand movements and autonomous control. Therefore, the rehabilitation procedure can be time consuming and costly. Moreover due to the complexity of the neurological aspects involved in the upper-extremity control, permanent disabilities may unfortunately persist in the chronic phase [3].

In the attempt to solve part of these problems, robot-assisted neuro-rehabilitation has known a significant growing in the last two decades. Many studies seem to demonstrate that robotic-aided therapy is more efficient and effective if compared to conventional therapy (see e.g. [4-8]). Although it is not still completely clear which factors specifically enhance neurological recovery, it is commonly accepted that the success of robot-assisted therapy likely relies on the possibility offered by robotic systems to automate training exercises (that can prove exhausting for physical therapists), to deliver them in a highly repeatable way and to objectively estimate the rehabilitation progress by a number of reliable measurements (e.g. range of motion, strength, responsiveness to stimulation,…). Among the various strategies that have been clinically tested so far, the paradigm known as “assist-as-needed” seems to have received the greatest success. In a few words, the robotic device should provide as much force/movement assistance as needed to accomplish a given task, whereas, in order to maximize the patient’s voluntary participation, it should enable the subject who does not need power assistance to move autonomously.

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