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Design and Construction of a Home-Based, Patient-Led, Therapeutic, Post-Stroke Recovery System Using Iterative Learning Control

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Abstract : Stroke is a devastating illness that is the second biggest cause of death in the world (after heart disease). Where it does not kill, it leaves survivors with debilitating sensory and physical impairments that not only seriously harm their quality of life, but also cause a high incidence of severe depression. It is widely accepted that early intervention is essential for recovery, but current rehabilitation techniques largely favor hospital-based therapies which have restricted access, expensive and specialist equipment and tend to side-step the emotional challenges. In addition, there is insufficient funding available to provide the long-term assistance that is required. As a consequence, recovery rates are poor. The relatively unexplored solution is to develop therapies that can be harnessed in the home and are formulated from technologies that already exist in everyday life. This would empower individuals to take control of their own improvement and provide choice in terms of when and where they feel best able to undertake their own healing. This research seeks to identify how effective post-stroke, rehabilitation therapy can be applied to upper limb mobility, within the physical context of a home rather than a hospital. This is being achieved through the design and construction of an automation scheme, based on iterative learning control and the Riener muscle model, that has the ability to adapt to the user and react to their level of fatigue and provide tangible physical recovery. It utilizes a SMART Phone and laptop to construct an iterative learning control (ILC) system, that monitors upper arm movement in three dimensions, as a series of exercises are undertaken. The equipment generates functional electrical stimulation to assist in muscle activation and thus improve directional accuracy. In addition, it monitors speed, accuracy, areas of motion weakness and similar parameters to create a performance index that can be compared over time and extrapolated to establish an independent and objective assessment scheme, plus an approximate estimation of predicted final outcome. To further extend its assessment capabilities, nerve conduction velocity readings are taken by the software, between the shoulder and hand muscles. This is utilized to measure the speed of response of neuron signal transfer along the arm and over time, an online indication of regeneration levels can be obtained. This will prove whether or not sufficient training intensity is being achieved even before perceivable movement dexterity is observed. The device also provides the option to connect to other users, via the internet, so that the patient can avoid feelings of isolation and can undertake movement exercises together with others in a similar position. This should create benefits not only for the encouragement of rehabilitation participation, but also an emotional support network potential. It is intended that this approach will extend the availability of stroke recovery options, enable ease of access at a low cost, reduce susceptibility to depression and through these endeavors, enhance the overall recovery success rate.

Keywords : home-based therapy, iterative learning control, Riener muscle model, SMART phone, stroke rehabilitation
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