Development of an Intelligent Functional Electrical Stimulation Cycling System

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Introduction

A spinal cord injury (SCI), by definition, is an injury that affects the nervous system in the spinal cord. The main functions of the spinal cord are completely or incompletely impaired. This means that the nerve pathways from the central nervous system (CNS) to the peripheral nervous system (PNS) are interrupted. Individuals suffering from SCI may have secondary disorders in the cardiovascular, respiratory, gastrointestinal, genitourinary, dermatologic, and musculoskeletal systems. They suffer not only physically, but SCI also has significant psychological and psychosocial effects [1]. Several methods have been developed to improve the health of people living with SCI. One of them is arm ergometry exercise. Another method is functional electrical stimulation (FES)-cycling. At the moment one can adjust the FES stimulation intensity while riding a tricycle but mostly ignoring users' voluntary intentions [2]. This voluntary effort is of decisive value if one wants to improve the neuro-plasticity of disabled people [3].The aime of this thesis is to develop and test an intelligent functional electrical stimulation system, to be fully integrated with GBY's GO-TRYKE® product. The control system will use data from the hand cranks to automatically adjust the intensity of stimulation to the paralysed limbs.

Materials and Methods

The system consists of a GO-TRYKE® from GBY AG. This is equipped with sensor pedals. These sensors using Bluetooth Low Energy (BLE) protocols for data transmission. The most important parameters that are transmitted are the time stamp, the crank angle, the angular velocity and the tangential force acting on the pedals. A notebook processes this input. The output generated is sent to a stimulator. The signal generated by the stimulator is than applied to the body via electrodes, causing the muscles to contract (Figure 1).

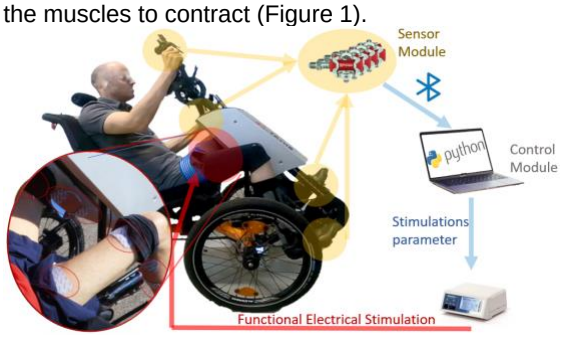

Figure 1: Technical overview of the system

Results

In the end, software is now developed that adapts the FES parameters according to the force applied by the arms, taking into account factors such as muscle fatigue and the target angle of the stimulation. The software has also been tested outside the laboratory.

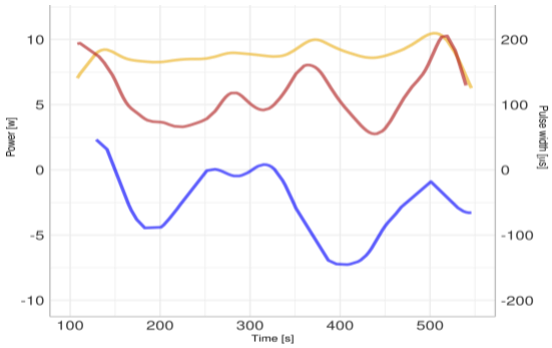

Figure 2: Shows the power of the arms (red), the legs (blue) and the pulse width (yellow) at the slopes of the Chasseral.

Discussion

Various tests in the lab as well as outdoors show that the leg force approximately matches the arm forces. The pulse width is one of the key parameter modulated, to achiev this.(Figure 2).
In this thesis a large field of application for this form of rehabilitation therapy has been opened. This offers a great potential for optimization.

References

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