Development and Performance Evaluation of a Bi-Pedal Therapy Device

Stefano Molinari

Supervisors: Prof. Dr. Kenneth J. Hunt, Dr. Juan Fang
Institution: Bern University of Applied Sciences, Institute for Rehabilitation and Performance Technology IRPT
Examiners: Prof. Dr. Kenneth J. Hunt, Dr. Juan Fang

Introduction

A spinal cord injury (SCI) is a damage to any part of the spinal cord or the nerves at the end of the spinal canal. That are responsible for sending and receiving signals from the brain to the rest of the body and vice versa. There is no cure for chronic SCI currently known, and activity-based therapy is the only medical treatment that can aid recovery [1]. Novel exercise modalities combining voluntary, actuator-assisted arm movement with actuator-guided leg movement are now being developed. The IRPT/GBY prototype Bi-Pedal therapy device (BiPed) is intended for both functional exercise and scientific research on interlimb neural connectivity of the arms and legs, as well as the influence of this therapy on neurological adaptation and recovery. The aim of this thesis was to complete the technical development of the Bi-Pedal therapy device and to perform systematic functional testing with an SCI participant.

Materials and Methods

The Bi-Pedal therapy device prototype (*Fig 1*) used in the project consists of a frame with an adjustable seat, actuation units for upper and lower limbs, two biofeedback screens, and a control module (user PC/monitor, Beckhoff industrial real-time PC, and maxon motor control hardware).

Fig. 1 Bi-Pedal device set-up

To measure the force applied by the subject with the arms and legs, four pedals with integrated wireless torque sensors and a Raspberry Pi 4 B (for the data acquisition) have been integrated into the BiPed. Those pedals are high-precision power meters designed that measure applied force and cadence in real-time. Python was chosen for the development of the program to communicate with the motors controllers of the device, to create the Graphical Unit Interface (GUI), and to communicate with the pedals

Results

The BiPed device has been completed and is fully functional. Thanks to the new GUI (*Fig. 2*) it is possible, in a simple way, to execute customized rehabilitation programs according to the needs of the subject or of the study. During use, the force and angle values are acquired from the pedals and saved in a document for future use. Similarly, the position and cadence values are taken from the pedals and saved in another document.

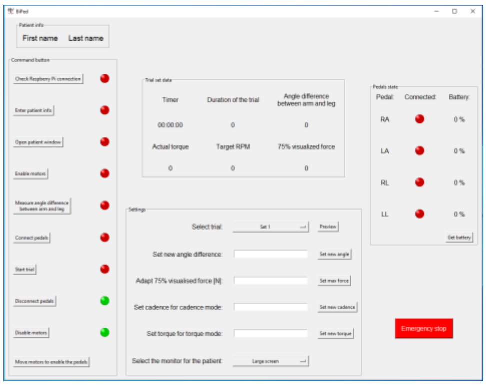

Fig. 2 Graphical User Interface used by the therapist to control the BIPed

Discussion and Conclusions

The technical feasibility of the system has been demonstrated. Communication with all four pedals is stable and the measurements taken are precise. The communication with the motors also works well and the measured values can easily be synchronized with those of the pedals thanks to a synchronization value in all files. The use of the GUI has been tested by multiple people and was found to be fully functional and user-friendly. The motor of the legs follows optimally that of the arms making the whole body move as a single unit and performing the cycling task. The BiPed device is now ready to be used for clinical trials.

Reference

[1] B.-S. F, B. JE, El M. WS. ISCoS-WHO collaboration. International Perspectives of Spinal Cord Injury (IPSCI) report. Spinal Cord. 2011 Jun;4