Design of an innovative gait-assistive active orthosis for incomplete spinal cord injured subjects based on human motion analysis

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Abstract

The design of gait-assistive devices is a challenging research field that involves different engineering and medical disciplines. To deal with this objective, researchers from three Spanish universities (UDC, UPC and UEX) and specialists from the Spinal Cord Injury (SCI) Unit of Complejo Hospitalario Universitario de La Coruña (CHUAC) work together in the development of a computer application to virtually test the functionality of an active orthosis prototype on the computational model of SCI subjects. This work presents the two actuation lines of this project.

On the one hand, the computational simulations are based on a parametric multibody model of both a healthy subject and a subject walking with the aid of crutches. On this model, an orthosis module has been added including both actuation and control schemes. A tool to determine muscular efforts from acquired kinematic and dynamic data has been included, so as to compare the muscular behaviour of disabled and able-bodied subjects. A predictive module is under development to compare the expected dynamics with the acquired one in tests on disabled subjects from the SCI Unit of CHUAC.

On the other hand, the designed active orthosis prototype (stance-control knee-ankle-foot orthosis) is being completed with the implementation of its controller, a classic PI that takes into account the information given by ankle encoders and inertial gyroscopes placed at the thigh to guide the knee angle during the swing phase. The objective is to improve the patient gait pattern providing actuation during swing phase and support during stance phase. Electromyography (EMG) signals complete the data acquisition to test muscular forces obtained by the computational model. In a next step, EMG and functional electric stimulation (FES) will be included as control and actuation signals respectively, and their behaviour will be included in the computational simulation. In the future, the obtained simulation tool will be applied to the design of other types of assistive devices for a wide range of gait pathologies.