Introduction

Stroke, spinal cord injury, cerebral palsy, and other medical conditions can strongly affect the ankle flexor and extensor muscles, which are crucial to provide vertical support and forward progression of the body during walking [1]. The use of control technology has been under active research during the last decades for the development of active (robotic) orthoses to assist patients with mobility problems and to increase the physical strength of healthy subjects [2, 3]. The present study focuses on the development of an active ankle orthosis applying the state-of-the-art rapid prototyping and manufacturing processes, wireless electronics, new control algorithms, and new neurological interfaces that are being developed in the core of the Biomedical Manufacturing project (FEDER No. 2029).

Design

The design started with a 3D scan of the leg followed by a custom-fit construction according to the subject’s morphology. The actuator was selected according to simulation results and typical values of the mechanical power developed by a healthy ankle.

Control algorithm

Control of the foot position during the swing phase (for drop foot patients in this preliminary stage) without disturbing the stance phase.

Stance phase: To allow “free motion” around an equilibrium point using a virtual stiffness

\[ \frac{dy}{dt} = q(f - kv(y - y_{ref})) \]

Swing phase: To achieve enough foot clearance to initiate the next gait cycle using a predefined trajectory.

Proof-of-concept prototype

Dynamic model

\[ P_{ext} = \frac{d}{dt} \left( \frac{1}{k} \left( T_{\phi} \alpha + c \dot{\alpha} + (h + r^2 k) \alpha + 2l \right) \right) \]

Ongoing work

• Design of new control algorithms for the different gait phases.
• Integration of gait pattern generation algorithms.
• Optimization of the mechanical design.
• Construction of functional prototypes for experimental evaluation.

References