Internal Models Enhance Accuracy and Reaction Time for a Gait-Aware Knee-Ankle-Foot-Orthosis

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Knee-Ankle-Foot-Orthoses (KAFOs) are modular lower-extremity orthoses prescribed to people with gait disability. KAFOs should support, correct and assist the movement of the corresponding affected joints. Traditional controllers depend on non-adaptive thresholds to switch between selected control values; therefore, they lack flexibility to adjust to common disturbances (i.e., floor unevenness, obstacles, ramps) in a satisfactory way. Novel approaches include active elements, which do not directly act on the movement. Instead they allow continuous adjustment of parameters like the affected joint's damping, leading to new challenges for the controller of such actuators.

To use the full continuous range the active element offers and to overcome shortcomings of traditional control approaches, adaptive methods like artificial neural networks (ANN) are applied. These methods can manage the active element's flexibility and the high neuromuscular variability within specific patient groups, allowing individual support of a wider range of patients. Model based tracking[1,2] of the user's gait allows to overcome the problems of finite state switching.

This study evaluates a combination of reflexive feed forward controller[3] with history dependent internal motion models for gait switching. A reflexive core allows the controller to react immediately to external influences. Gait models continuously track the user's gait and switch gait support accordingly. The controller operates a KAFO based on a controllable hydraulic damper, derived from OttoBock's C-Leg©.

Our investigations indicate, that the presented gait models are an accurate and fast adaptive method for detection of the current gait. They fit well into and extend the used paradigm of adaptive modular neuro-control[3]. The reflexive feed forward controller benefits from the combination with the history dependent gait models in kind of enhanced precision via the motion model's detailed knowledge of the gait dynamics.

Acknowledgements

This research was supported by the BMBF-funded BFNT and BCCN Göttingen with grant numbers 01GQ0810 (project 3A) & 01GQ1005A (project D1), respectively, and the Emmy Noether Program (DFG, MA4464/3-1).

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