PATIENT-COOPERATIVE GAIT NEURO-REHABILITATION WITH THE LOWER-EXTREMITY EXOSKELETON ANDROS

Ozer Unluhisarcikli, Maciej Pietrusinski, Constantinos Mavroidis†
Mechanical and Industrial Engineering, Northeastern University
360 Huntington Avenue, Boston, MA, 02115, USA

Paolo Bonato
Motion Analysis Laboratory, Spaulding Rehabilitation Hospital
125 Nashua St., Boston, MA, 02114, USA

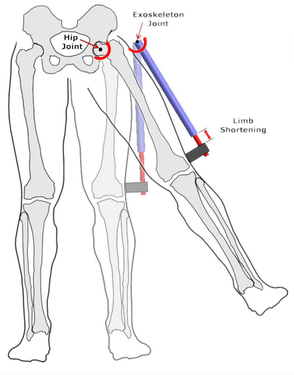
Northeastern University
Biomedical Mechatronics Laboratory
†email : mavro@coe.neu.edu
webpage : www.robots.neu.edu
phone : (617) 373 - 4121

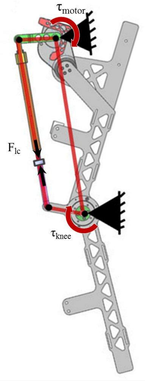
ABSTRACT

Ambulatory stroke survivors display substantial alterations in their gait patterns because of the compensatory strategies adopted to compensate for their impaired motor control skills. Rehabilitation of gait after a stroke requires physical training, which is labor-intensive for the therapist(s) administering it. The Active Knee Rehabilitation Orthotic System (ANDROS) is a robotic exoskeleton that automates this process by applying a corrective force field to the patient's leg to reinforece a desired gait pattern. The impedance controller of ANDROS is synchronized with the patient's walking phase which is estimated from the kinematic measurements of the healthy leg.

MECHANICAL DESIGN

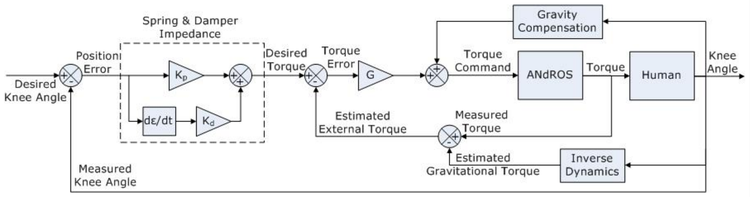
ANDROS displays an anthropomorphic exoskeleton frame design and operates in parallel with the patient's body. The brushless DC motor actuating the knee joint is located proximal to the human center of gravity to minimize inertial forces, and the torque generated by the motor is transferred via a four-bar linkage. A load-cell located in between the motor and the human interface measures the interaction forces and provides feedback to the controller.





CONTROLLER

ANDROS reinforces a desired gait pattern by applying a corrective torque field to the wearer's knee using an impedance controller based on the deviations from a reference trajectory. The gravity and friction compensation forces are estimated and removed from the force feedback to render the system sensitive to external forces only (i.e. to those applied by the user).



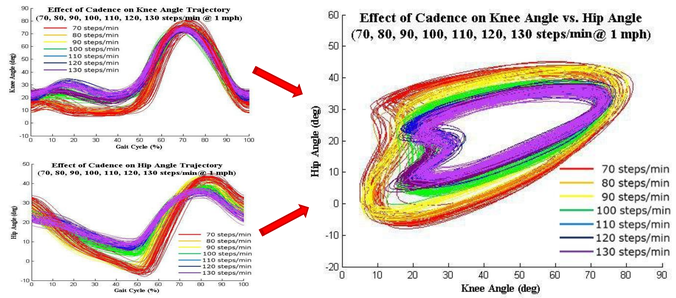
SPECIFICATIONS

Peak Torque	Peak Power	Actuated DoFs
22.88 Nm	179 W	1 at the knee

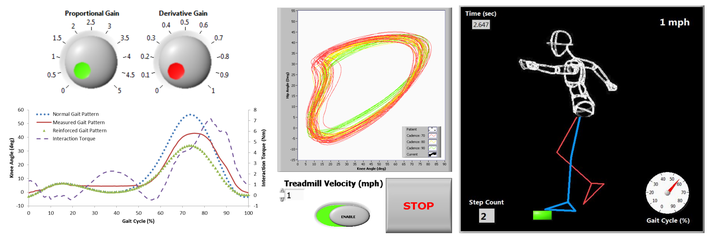
The lower extremity exoskeleton ANDROS is a wearable and portable assistive tool for gait rehabilitation and monitoring of people with motor control deficits due to a neurological ailment, such as stroke. ANDROS reinforces a desired gait pattern by continually applying a corrective torque around the knee joint, commanded by the impedance controller. A sensorized yet unactuated brace worn on the unimpaired leg is used to generate and synchronize the desired trajectory based on the user's intent.

GAIT PHASE ESTIMATION

Training algorithms of rehabilitation robots are constantly evolving as we gain a more in-depth understanding of the mechanisms underlying motor recovery. One such understanding is the positive effect of kinematic variability on the outcomes of motor learning. In light of these recent findings, we have moved away from training patterns that are fixed in the spatiotemporal space, and more towards a "patient-in-charge" paradigm in which the patient influences the reference trajectory of ANDROS.



The LABView Graphical User Interface (GUI) of ANDROS provides the therapist a virtual control panel, allowing them to change parameters of the exercise in real-time. The GUI also displays related information such as estimated gait phase, joint angles, and interaction forces.



CONCLUSIONS & FUTURE WORK

A wearable robotic lower-extremity exoskeleton that serves as an assistive tool for gait rehabilitation and monitoring was developed. Robotic devices provide a valuable asset for rehabilitation hospitals, but their high cost limits the number of training sessions the patients receive during rehabilitation. Thus there exists a technological gap for a new breed of rehabilitative orthotic devices that maintain the positive attributes of the treadmill devices while downplaying their high cost. Our long term goal is that ANDROS becomes a low cost and portable gait retraining exoskeleton that is available to the rehabilitation market.

ACKNOWLEDGEMENTS

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