rombolabs

LOCOLAB

NEUROBIONICS

Collaborative Research: NRI: INT: An Open-Source Framework for Continuous Torque Control of Intuitive Robotic Prosthetic Legs

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Motivation

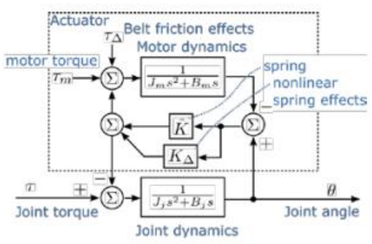
We seek to develop torque and impedance control for the Open Source Leg (OSL) and to exploit this new capability using new controllers. These provide seamless control trajectories based on the movement of the body.

Design

We have created a new OSL v2 with improvements in design and control

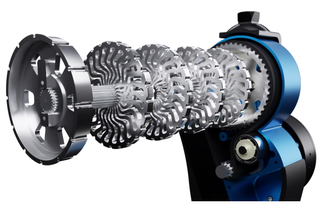
OSL v2

The new version of the Open Source Leg implements newly-released actuators with an internal 9:1 planetary gearhead. Thus, the belt-drive transmission with the OSL now only includes a single 5:1 stage. In addition, we have included onboard batteries and increased the ROM for the ankle, with both joints using the same internal components.



Torque and Impedance

Torque and impedance control is achieved using series elastic actuation and a full state feedback controller. We are extending disturbance observer theory to compensate for belt dynamics and spring behavior.

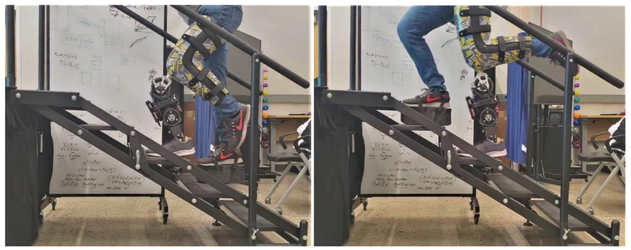


Hardware and low-level controller details

We are refining the design of our novel torsion springs to enable closed loop torque control from the spring deflection (SEA). We have developed both linear and non-linear torsion springs.

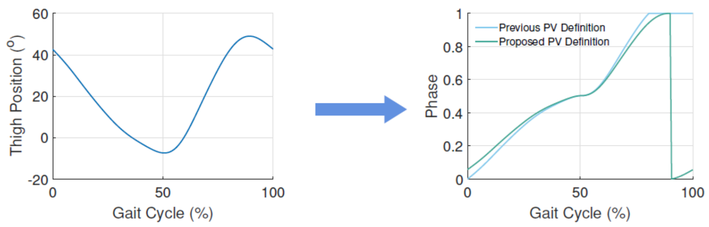
Control

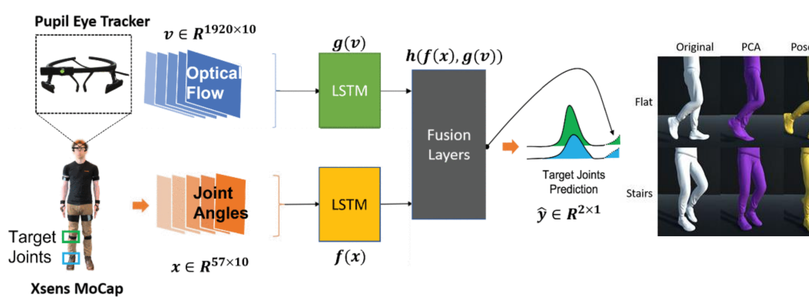
We have created methods to estimate joint trajectories from wearable sensors, enabling indirect volitional control of powered prostheses during locomotor tasks such as stair ascent.



Stair Ascent Phase-Variable Control

We extended our prior phase-variable methodology for controlling walking to stair ascent. The residual limb angle provides a phase variable to control the timing of joint patterns.





Wearable MoCap and Vision for Trajectory Estimation

Optical flow net: Neural network architecture for generating knee and ankle trajectories using egocentric vision and wearable motion trackers. We combine these methods with unsupervised representation learning for dimensionality reduction.

- Cortino et al., "Stair Ascent Phase-Variable Control of a Powered Knee-Ankle Prosthesis," *ICRA* 2022
- Sharma et al. "Improving IMU-based prediction of lower limb kinematics in natural environments using egocentric optical flow," *IEEE TNSRE*, 2022
- Boe et al. "Dimensionality Reduction of Human Gait for Prosthetic Control" *Frontiers in Bioengineering and Biotechnology*, 2021

opensourceleg.com
rombolabs.github.io
web.eecs.umich.edu/locolab/
neurobionics.robotics.umich.edu

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