Data-Driven Variable Impedance Control of a Powered Knee-Ankle Prosthesis for Variable Activities

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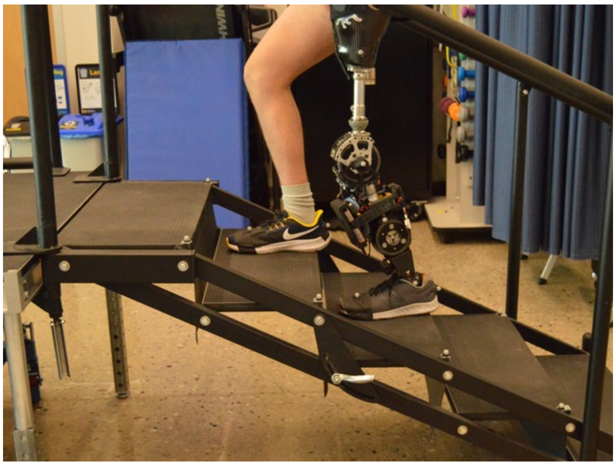

OVERVIEW

Open-source prosthesis controller enables intuitive sitting, standing, and walking transitions.

- Prosthesis controller enables intuitive sitting, standing, walking, and stair ambulation.
- Supports prosthetic research, device development, and biomechanics testing

BACKGROUND

This software package contains a simplified version of our multi-activity knee-ankle prosthesis controller compiled to run on the Open Source Leg. In automatic mode, the controller allows the user to sit, stand, and walk across level ground while automatically switching between walk and sit/stand modes. Configurable walking speed and ground incline inputs allow the controller to handle walking speeds between 0.6 and 1.4 m/s and ramps between -10 and 10 deg. In manual mode, the controller also enables stair ascent and descent on staircases with slope between 19 and 30 deg. We provide a starter python script, allowing anyone with an Open Source Leg to run our controller with minimal upfront effort.

It is our hope that this software release helps accelerate the field's research in the control of robotic leg prostheses. Potential uses of this software release include but are not limited to: 1) using our controller as a comparison point for a novel controller, 2) using our controller as a

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component in a larger, more complex controller, 3) using our controller when researching other related topics, such as balance or metabolic cost.

INNOVATION

Many impedance controllers for robotic leg prostheses utilize discrete, heuristically-tuned parameters and finite state machines to achieve desired locomotion behaviors. These finite state machine approaches can be lengthy to tune and can result in jerky, robotic-looking gaits if tuned inappropriately. Despite these drawbacks, they are still broadly used in both academic research and commercial products due to their simplicity and relative ease of implementation.

To mitigate the drawbacks of finite state machine controllers, our lab has pioneered a new approach utilizing a phase variable and continuous impedance parameter functions in lieu of a finite state machine. We use convex optimization to automatically identify optimal impedance parameter functions based on able-bodied ambulation data, resulting in biomimetic joint kinematics and kinetics without manual tuning. Our controller works out-of-the-box for a novel user, requiring only their weight in terms of configuration and is thus even easier to implement than most finite state machine controllers. In addition to joint position sensors, it only requires sensor measurements of ground contact and the global orientation of the thigh segment. We have demonstrated our new approach's efficacy for walking over various speeds and inclines, stair ascent and descent, and sit/stand motions.

ADDITIONAL INFORMATION

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