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

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LOCOLAB NEUROBIONICS

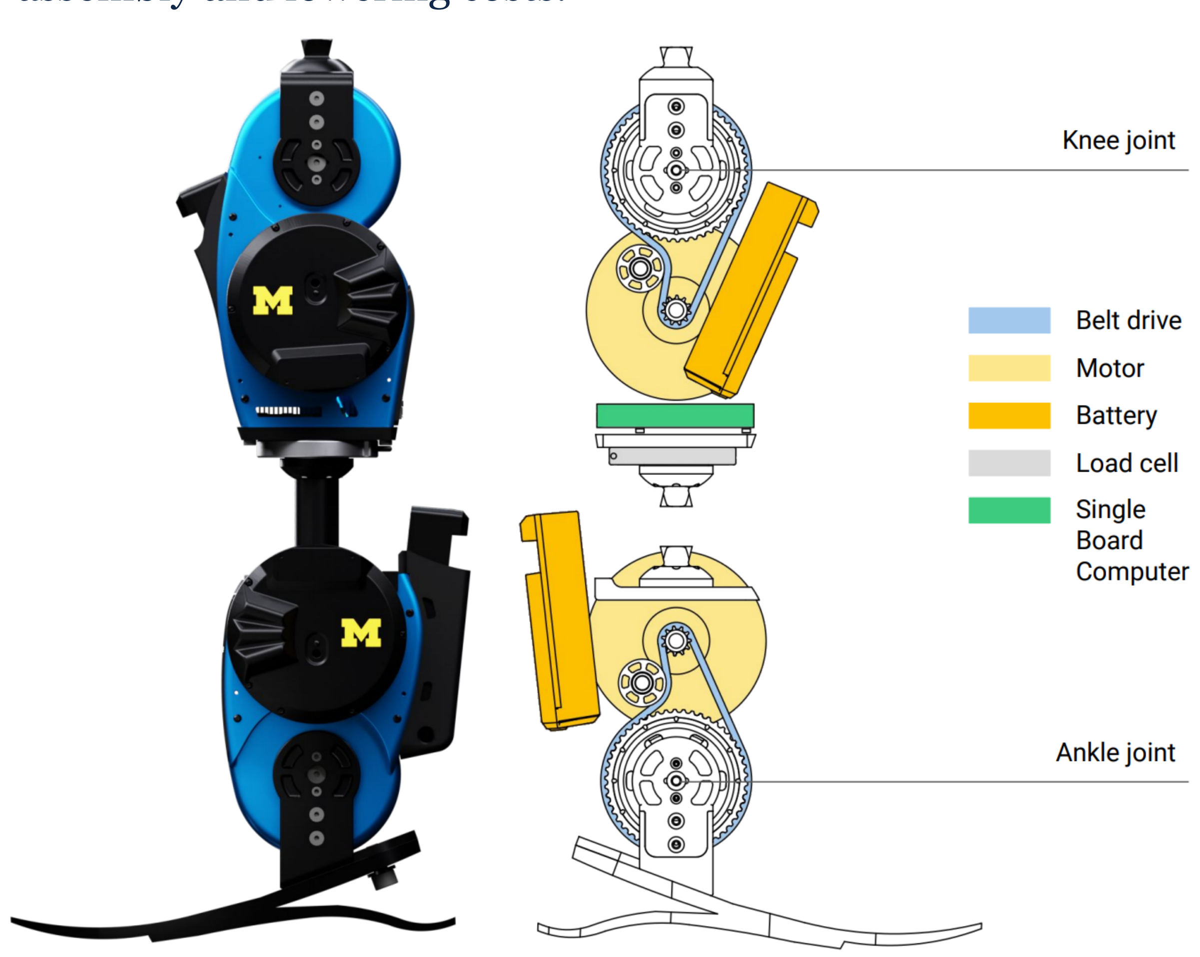
Motivation

We seek to utilize the Second-Generation Open Source Leg (OSL V2) to develop and test novel torque and impedance controllers for knee-ankle prostheses. These controllers provide seamless joint behaviors that are synchronized to the movement of the body.

Design

We further developed the OSL V2, including **open-source design files** and a **public control code library**. We have characterized the OSL's dynamics and proposed a method to **improve impedance control accuracy**.

The OSL V2 drivetrain includes an off-the-shelf actuator (with internal 9:1 planetary gearbox) and a single-stage belt reduction. The knee and ankle joints have identical drivetrains aside from range of motion, simplifying assembly and lowering costs.

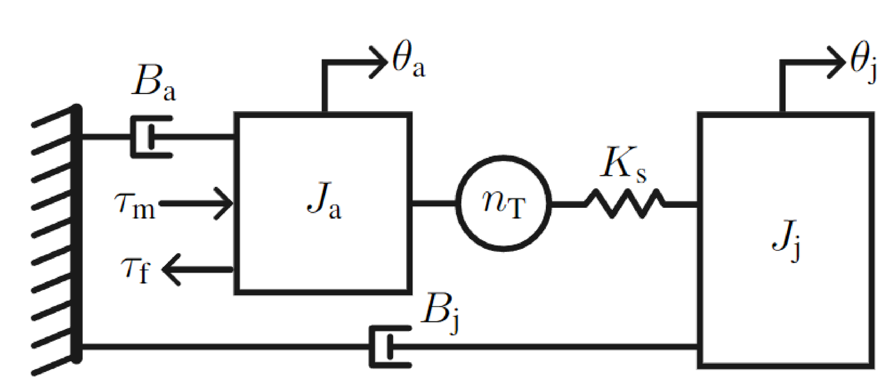


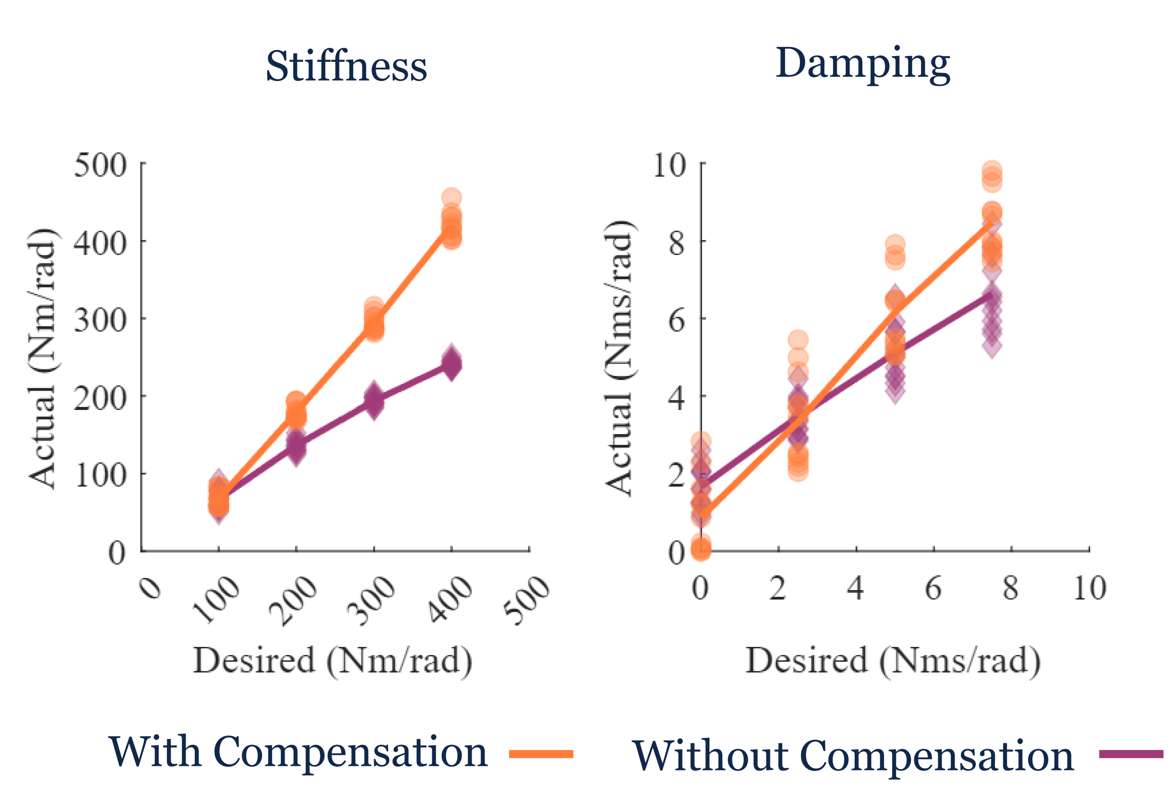
We are developing an open-source Python software library used to control the OSL. The library is in development and is available on GitHub and PyPI.

```
class OSL:
    """
    OSL object:
    - Contains 2 joint objects for control of the Open Source Leg
```

GitHub https://github.com/neurobionics/opensourceleg

We developed a dynamical model of the OSL's drivetrain and validated it on a mechanical dynamometer. We used this model to improve the joint impedance accuracy by selecting optimal motor feedback gains in a frequency domain analysis.

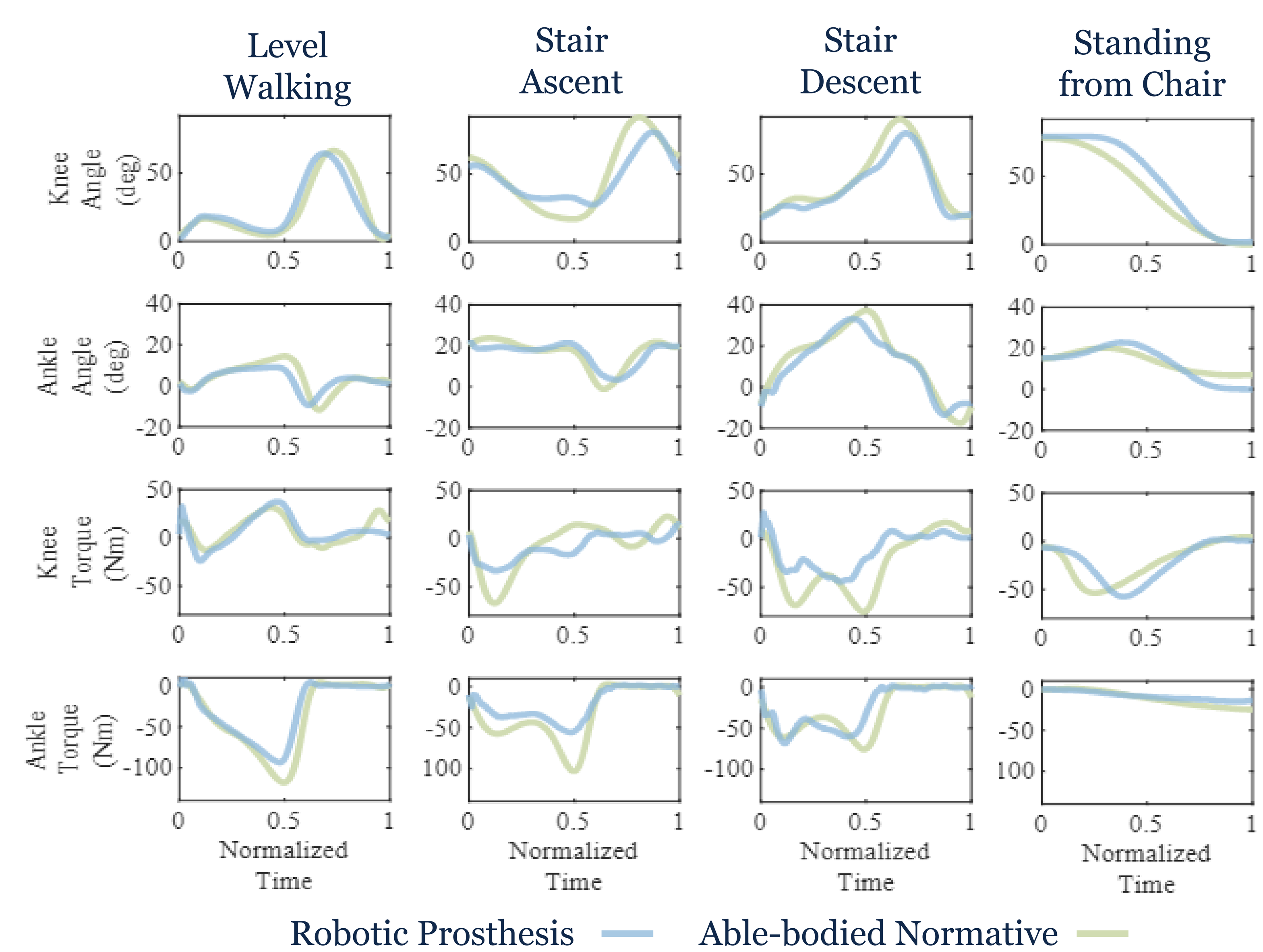




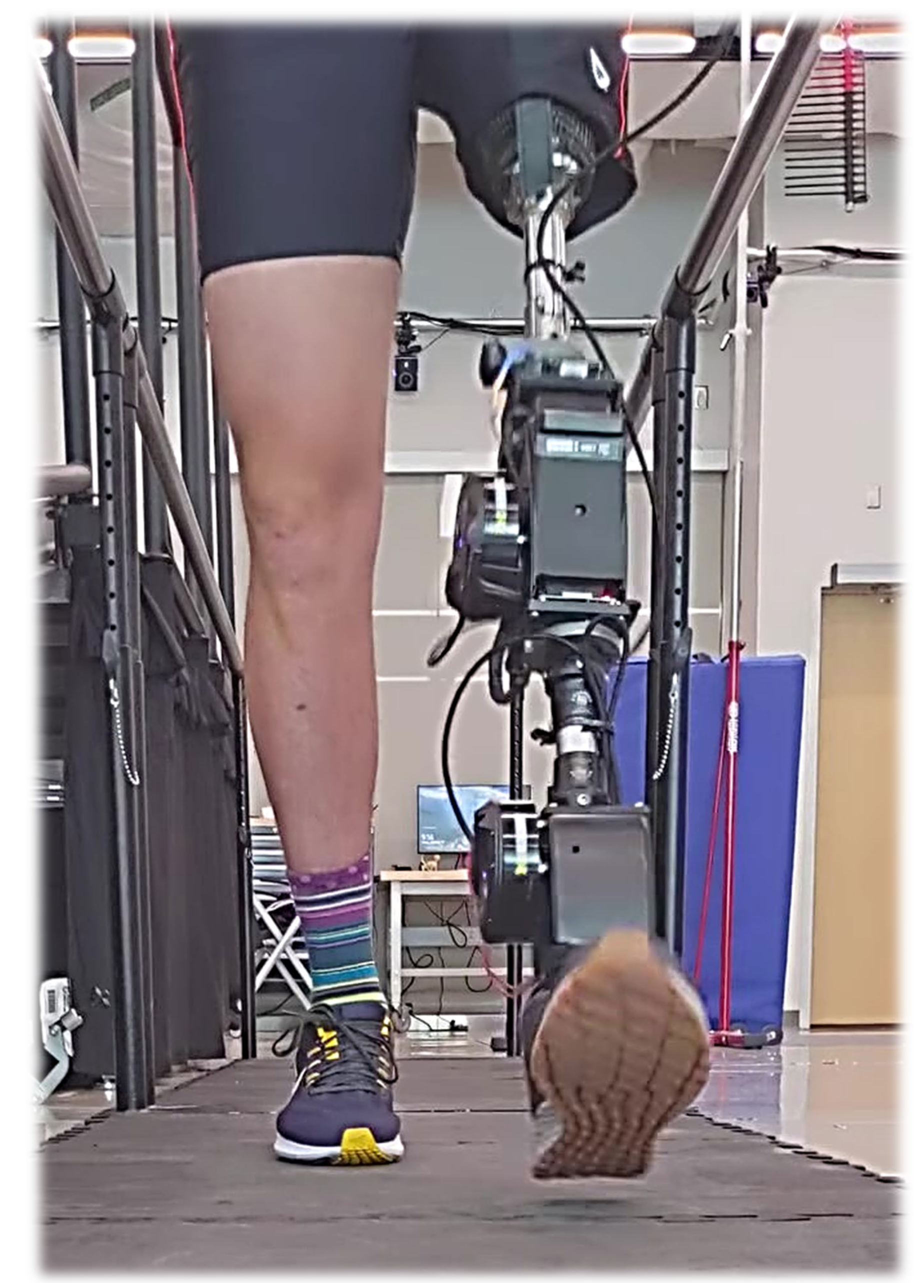
Control

We developed **data-driven** impedance controllers that reproduce normative kinematics and kinetics during **variable-incline walking, stairs, and sit/stand**. Unlike existing impedance controllers, our approach does not require **manual tuning.**

We developed a framework to calculate variable impedance parameter models based on able-bodied demonstrations of various locomotion activities. Combined with a new task-invariant phase variable, these models elicit normative gaits that intuitively synchronize to the user's behavior. Both the kinematic and kinetic trajectories resemble those of able-bodied gait, suggesting that the prosthesis appropriately supplies torque in place of the missing limb.



Initial tests using these control approaches on the OSL V2 have demonstrated normative walking gaits when used by a person with an above-knee amputation.



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