NRI: INT: COLLAB: Muscle Ultrasound Sensing for Intuitive Control of Robotic Leg Prostheses

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https://belab.mech.utah.edu/sonomyography/

Problem Statement

Robotic prostheses can mimic virtually any motor behavior exhibited by the healthy limb. However, achieving this goal depends on the ability of the control system to coordinate with the user's neuromuscular system. For proper adaptation of the robotic leg to the *user* and *environment*, the control signal should precede the movement. Neural signals generated by the user's neuromuscular system precede movement and can therefore provide information on the user's movement intention as necessary for a *volitional* control strategy. Electromyography (EMG) provided by the residual limb has been shown to benefit the control of robotic leg prostheses. However, its performance is negatively affected by the poor signal to noise ratio, the lack of specificity to individual deep-seated muscles, and poor reliability over an extended period.

Central Hypothesis

By integrating **sonomyography** with **shared control**, robotic leg prostheses can achieve *volitional* behavior thus leading to unprecedented ubiquitous ambulation performance in complex, uncertain real-world environment compared to conventional *reactive* control strategies that rely on mechanical sensors alone.

Scientific Impact

This proposal will advance knowledge of how to integrate the user's intention with the robot control to develop *volitional* control systems. Beyond prostheses, the proposed paradigm can be used to improve the performance of other wearable robots such as powered exoskeletons to assist individuals with neurological impairments.

Broader Impact

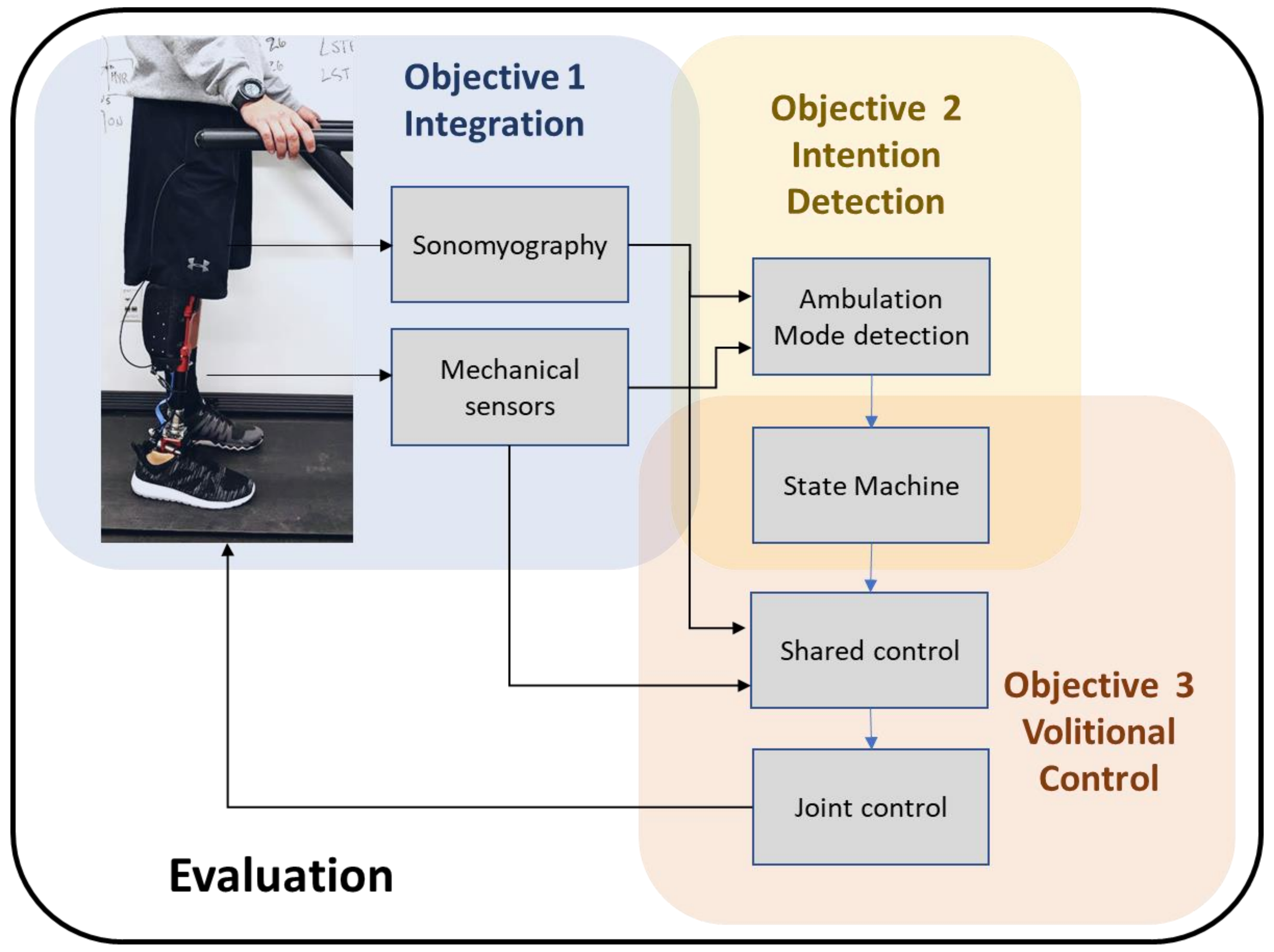
Societal Impact: enabling a new generation of robotic leg prostheses that provide greater mobility and independence to individuals with lower-limb amputation.

Educational Impact: Advance knowledge and understanding of robotics and design concepts through STEM camps, design projects for college seniors, including a joint internship program between the University of Utah and Ottobock Salt Lake City.

Solution Statement

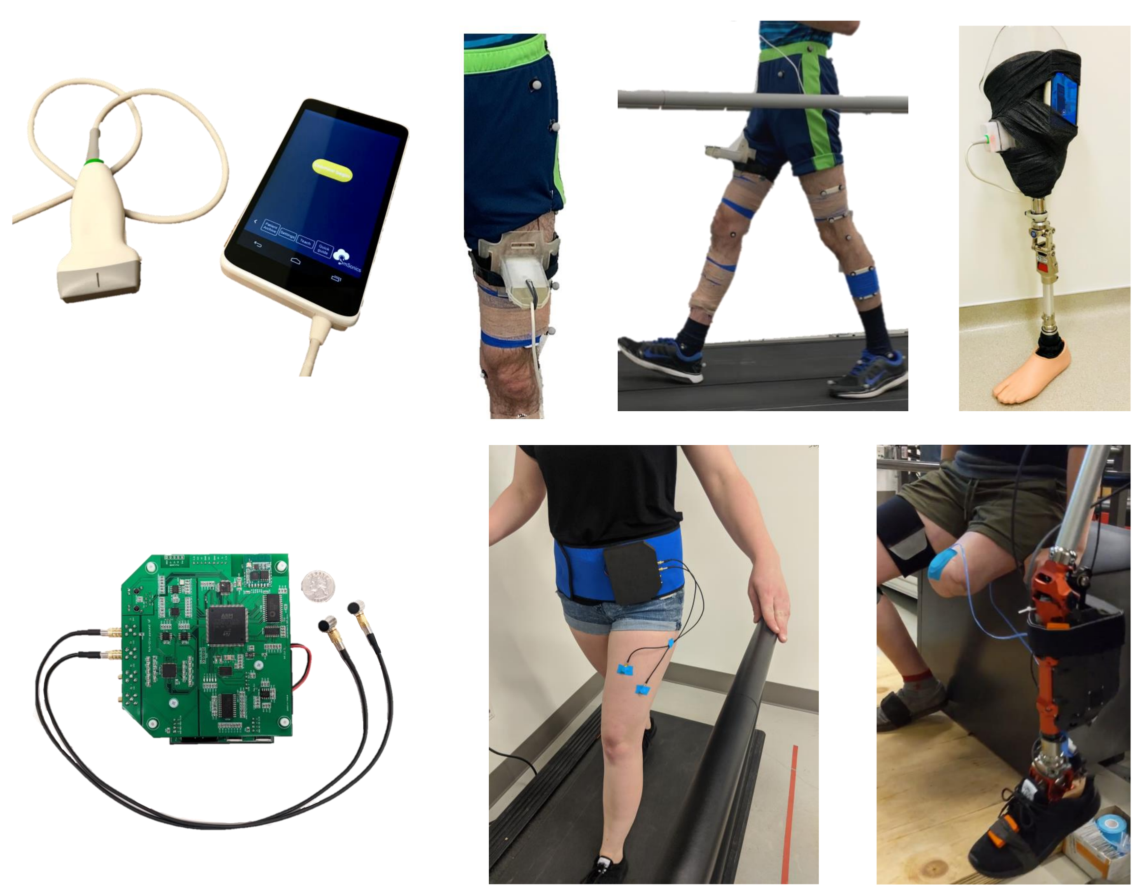
This proposal aims to improve the coordination between a robotic let prosthesis and the user's neuromuscular system by integrating a novel sensing technique, namely **sonomyography**, and **shared robot control**.

- **Sonomyography** can provide rich information on the user's movement intention through depth-resolved imaging of specific muscles and functional muscle compartments.
- **Shared control** has the potential to integrate the user's volition into the robotic leg control system, while guarantying the levels of robustness and intuitiveness necessary for ambulation.

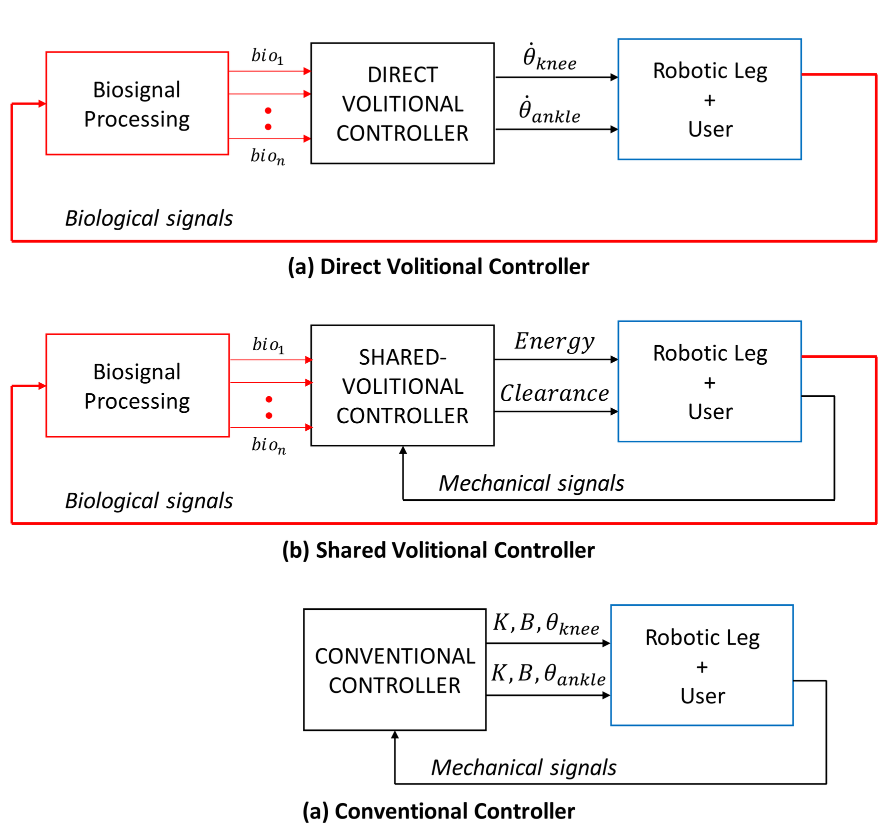


Robotic Leg Prosthesis

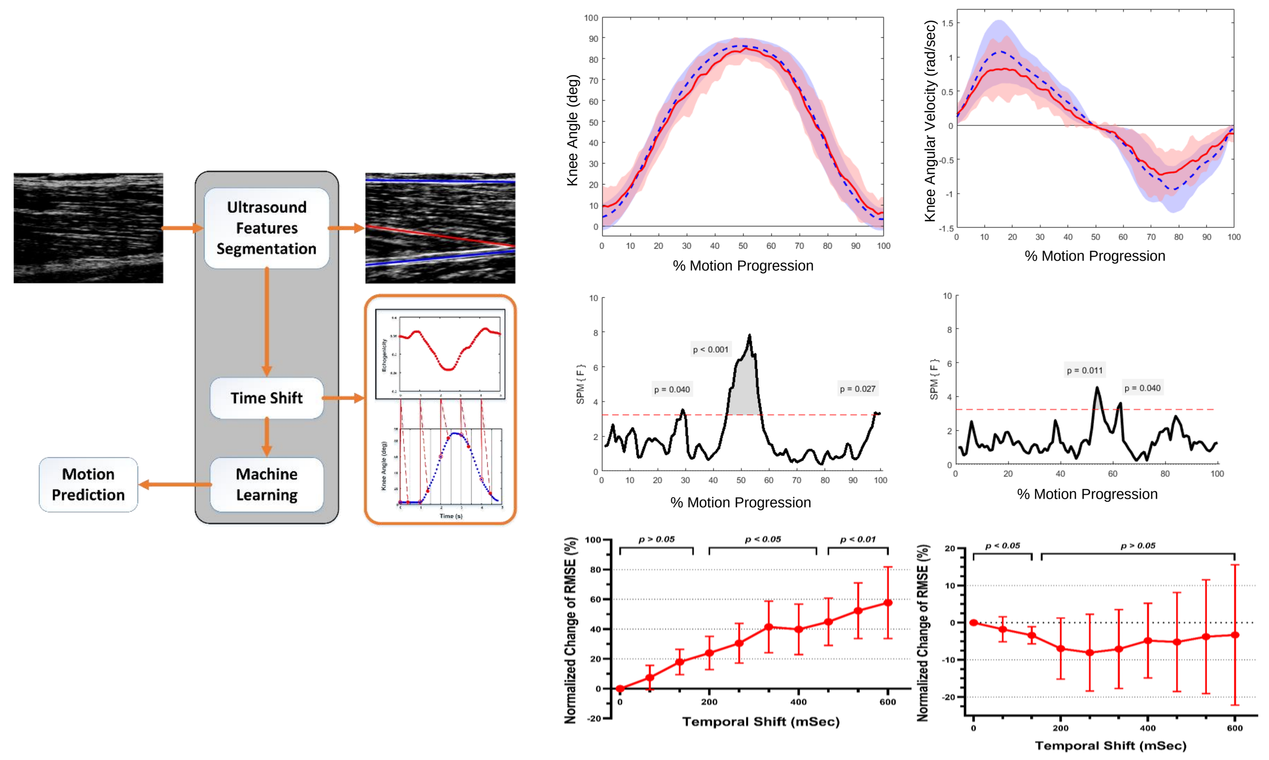
B-mode and A-mode Sonomyographic Sensing



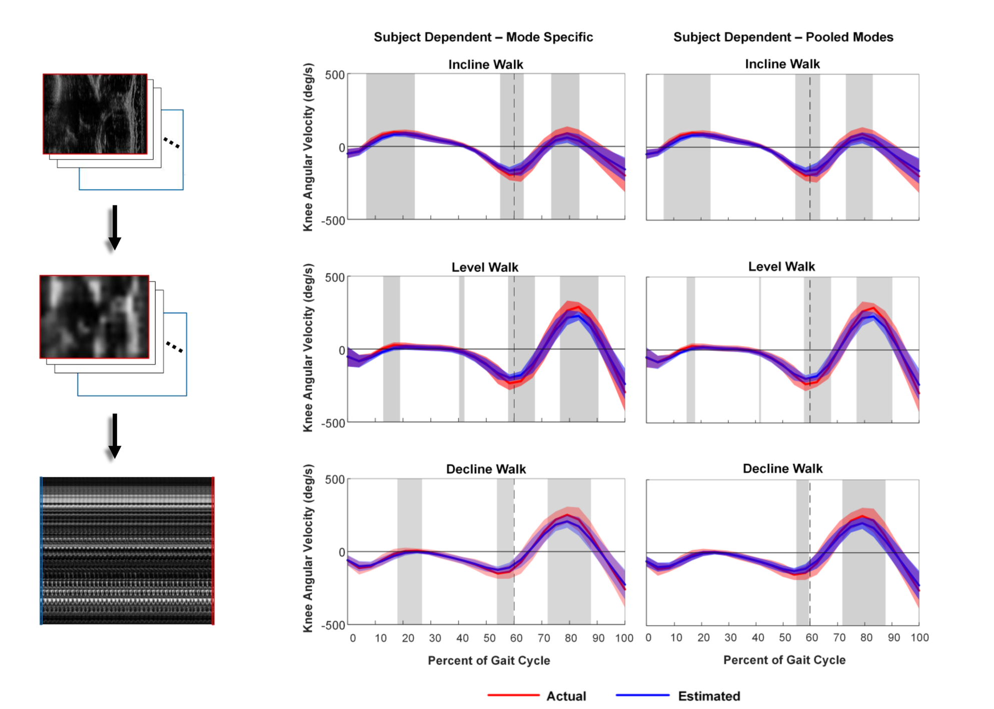
Shared-Control Strategies



Predicting Joint Motion with Longitudinal Sonomyography



Predicting Joint Motion with Transverse Sonomyography



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