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. We need to integrate neural signals in the robotic prosthesis control system.

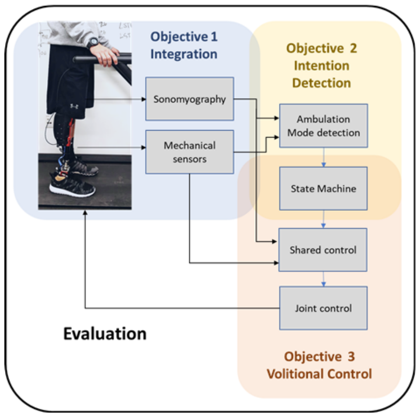
Solution Statement

Integrate muscle ultrasound, namely **sonomyography**, and **shared robot control**.

Central Hypothesis

By integrating **sonomyography** with **shared control**, robotic leg prostheses can achieve *volitional* behavior, leading to unprecedented ubiquitous ambulation performance in complex, uncertain real-world environment.

- **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



Scientific Impact

This proposal will advance knowledge of how to integrate the user's intention with the robot control to develop *volitional* control systems.

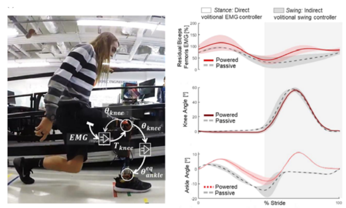
Broader Impact

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 of robotics through STEM camps, design projects for college seniors, including a joint internship program between the University of Utah and Ottobock Salt Lake City.

Results

We have developed volitional stance and swing controllers that continuously adapt the mechanics of the prosthesis to the movement of the user. These controllers enable individuals to walk while seamlessly crossing over obstacles and climb stairs with different stair heights, cadences and gait patterns. We have also developed volitional controllers that incorporate neural signals (electromyography) to control walking, sit-to-stand, lunges and squats. In addition, we have developed regression-based models that can continuously predict joint torque and velocity profiles of the knee and ankle, and show sonomyographic sensing can outperform electromyography. We show these systems can be trained to be task independent. Finally, we demonstrate that sonomyography collected during the stance phase can predict future joint position trajectories of swing, and that sonomyography collected during the swing phase can predict future joint torque profiles of stance, during consecutive strides.



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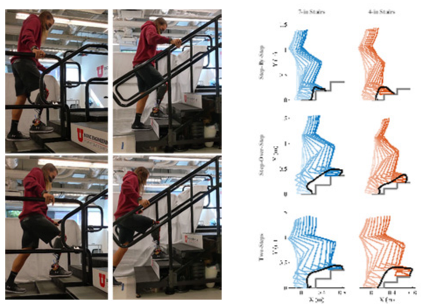

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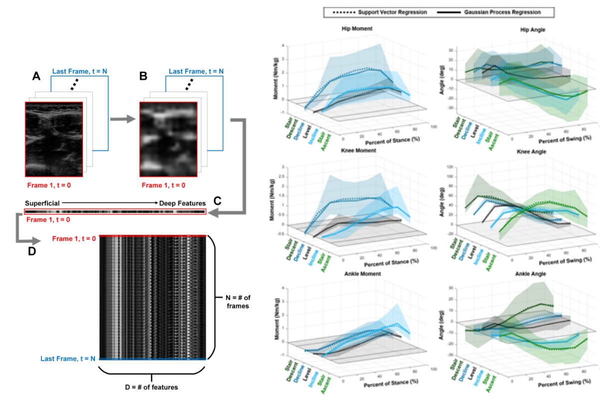

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