

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

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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.

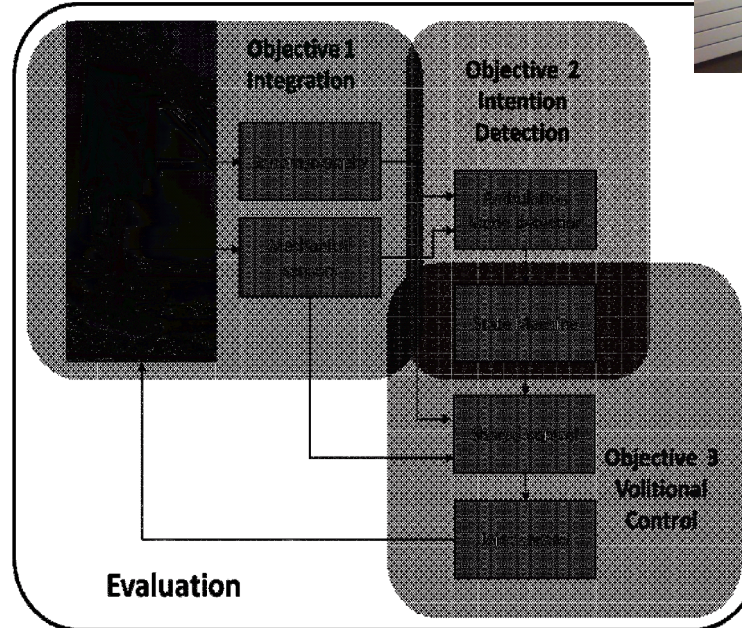
Central Hypothesis

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 scenarios.

Solution Statement

Integrate **sonomyography** and **shared robot control**.

- **Sonomyography** can provide rich information on the user's movement intention through imaging.
- **Shared control** can integrate the user's volition while guarantying the robustness and intuitiveness.

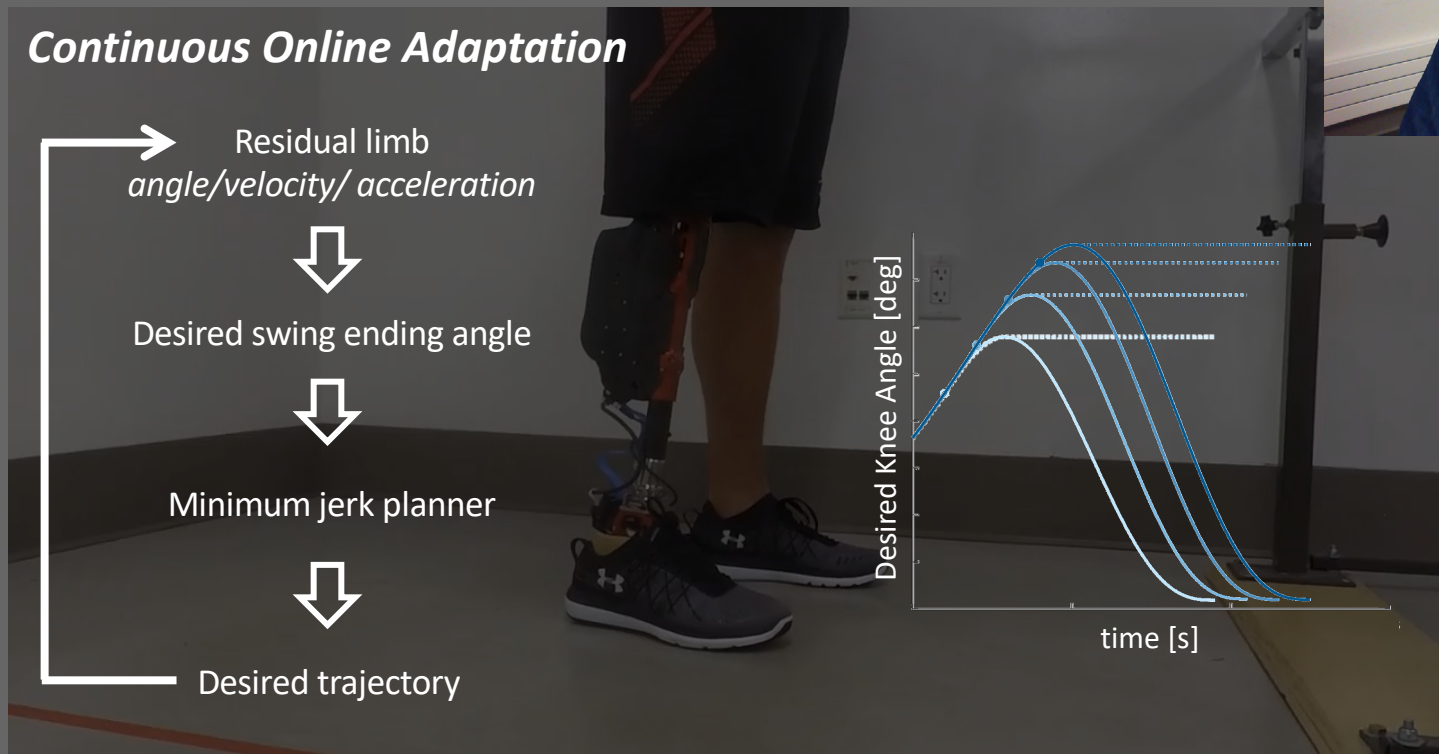




INDIRECT VOLITIONAL CONTROL

INDIRECT VOLITIONAL WALKING CONTROL

- There is no obstacle control. The volitional swing controller adapts the prosthesis trajectory continuously based on the movements of the residual limb



INDIRECT VOLITIONAL STAIR CONTROL



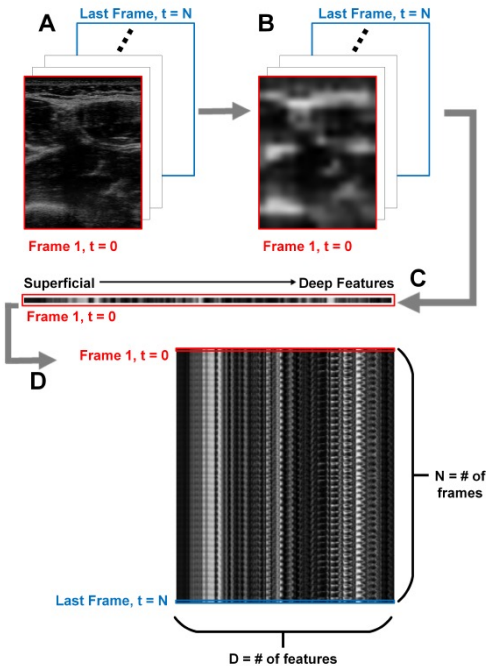
S. Hood, L. Gabert, and T. Lenzi "Powered Knee and Ankle Prosthesis with Adaptive Control Enables Climbing Stairs with Different Stair Heights, Cadences, and Gait Patterns" IEEE Transactions on Robotics (submitted)



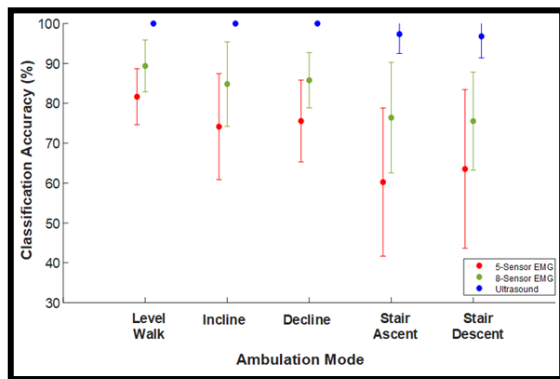
SONOMYOGRAPHIC CONTROL

TRANSVERSE SONOMYOGRAPHY

Real-Time Feature Extraction in Human Ambulation



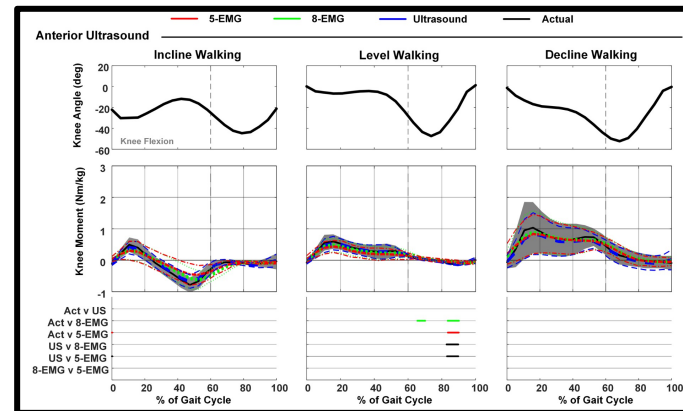
Continuous Prediction of Ambulation Mode Ultrasound vs. EMG



Rabe et al., *IEEE TBME* 2020

Predicting Continuous Joint Torque

Ultrasound vs. EMG



Rabe et al., *IEEE BioRob* 2020, *IEEE EMBC* 2020

Rabe et al., *IEEE TNSRE* in review



TRANSFORMATIVE ROBOTIC LEG PROSTHESIS

- Mechanically-active knee, ankle, and toe prosthesis
- Embedded ultrasound sensing (A-mode)
- Shared control architecture

