NRI: INT: COLLAB: Accelerating Large-Scale Adoption of Robotic Lower-Limb Prostheses through Personalized Prosthesis Controller Adaptation

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BACKGROUND:

- With powered joint actions, robotic lower-limb prostheses may help amputee users to walk more easily and naturally, and also provide power to support activities previously unattainable with existing unpowered prostheses.
- However, powered robotic prostheses are significantly more complex than the existing unpowered prostheses, so tuning such a prosthesis to fit an individual user is challenging and time-consuming, requiring numerous office visits with a clinician over a long period of time.
- **Objective:** Developing a new method to automate the prosthesis tuning process.

RESEARCH OVERVIEW

- Develop novel wearable sensors to provide the desired human movement information to support the automatic tuning algorithms.
- Conduct fundamental studies on robotic prosthesis-assisted walking and prosthetist-conducted controller tuning.
- Develop a machine learning algorithm to conduct automatic tuning of the prosthesis motion controller.
- Develop a quasi-supervised adaptation approach for the intent recognizer of the prosthesis control system.

Wearable Sensor Development

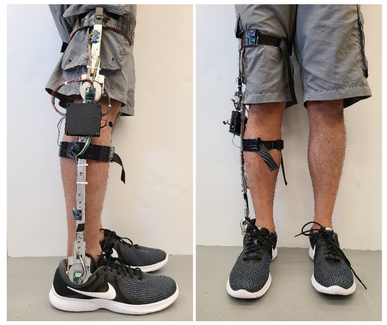
- Chest-worn IMU is able to measure the user's upper-body movement, including lateral sway.
- We also developed a novel shoe-attached sensor to measure foot motion and estimate the ground reaction force.
- A pilot study shows that, utilizing the information provided by the shoe sensor alone, a machine learning algorithm is able to recognize 9 activity modes with 94.8% accuracy.

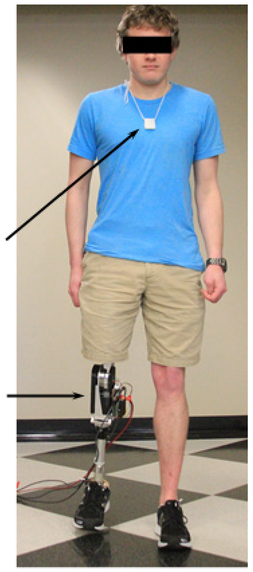
Intent Recognizer Adaptation

- We developed a portable exoskeleton-based gait data collection system to facilitate the data collection outside research labs.
- We are conducting a multi-modal locomotion study to collect gait data in a typical daily living environment.
- Utilizing the gait data from this study, a quasi-supervised adaptation approach is being developed.

Automatic Motion Controller Tuning -1

- GT researchers' biomechanical study shows that lateral sway and impulse asymmetry provide good indication of gait quality when subject to asymmetrically applied constraints.
- We are developing a direct-acting, ground reaction force (GRF) asymmetry-based tuning algorithm to regulate the ankle push-off power and restore balanced walking gait for amputee users.





Automatic Motion Controller Tuning -2

- GT researchers is also conducting a prosthesis-tuning study to collect a full set of biomechanical and control parameter adaptation data.
- Utilizing the data, we are developing a multi-class support vector machine (SVM) algorithm to emulate an experienced prosthetist's decision making: for each parameter, the SVM-identified class represents the adjustment action: maintain, increase/decrease slightly, or increase/decrease significantly.

Broader Impacts

- The research results may accelerate the adoption of new robotic prosthesis technology and benefit the over 800,000 lower-limb amputees in the U.S..
- New course materials are being developed to strengthen the curriculum in the prosthetics and orthotics education.
- Undergraduate research intended for K-12 outreach activities is also being conducted in this project.

2021 NRI & FRR Principal Investigators' Meeting
March 10-12, 2021

Award ID#: *1734501/1734416*