Collaborative Research: Closed-loop Hybrid Exoskeleton utilizing Wearable Ultrasound Imaging Sensors for Measuring Fatigue

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Siddhartha Sikdar, George Mason University; Nitin Sharma, North Carolina State University; Kang Kim, University of Pittsburgh

Challenge:

- Functional electrical stimulation (FES) is a promising technique that promotes active muscle contractions after paralysis
- Rapid loss of muscle force due to FES-induced fatigue is a major hurdle
- FES can be combined with powered exoskeletons to compensate for FES-induced muscle fatigue
- Lack of a sensing modality to detect muscle fatigue state, and thus difficult to coordinate exoskeleton and FES use

Solution:

- Wearable imaging sensors to detect fatigue
- Ultrasound Doppler and strain imaging to quantify muscle fatigue effects and coordinate FES and exoskeleton

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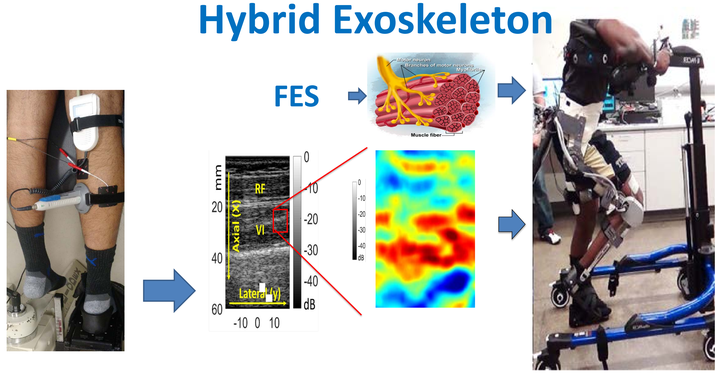
George Mason University, ssikdar@gmu.edu

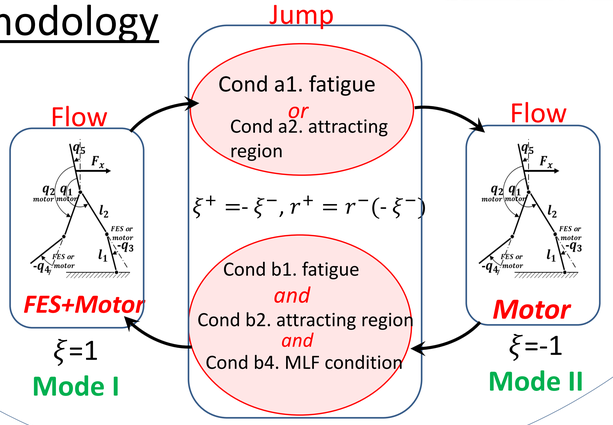
NC State University;nsharm23@ncsu.edu

University of Pittsburgh; kangkim@upmc.edu

Wearable ultrasound for Fatigue Feedback in a Hybrid Exoskeleton



Control Methodology



Scientific Impact:

- Wearable fatigue sensors can be integrated into Human CPS systems
- Better evaluation metrics to better control FES
- New switched and cooperative control methods stabilize interaction between a wearable rigid robot and a human.

Broader Impact:

- This CPS technology benefits approximately 800,000 people in the united states who suffer from stroke and benefits persons with spinal cord injury, where 17,000 new cases are added each year on average
- The technology would be used in rehabilitation clinics and physical therapists
- We did public demonstrations of ultrasound imaging and powered exoskeleton and mentored undergraduate students as part education and outreach