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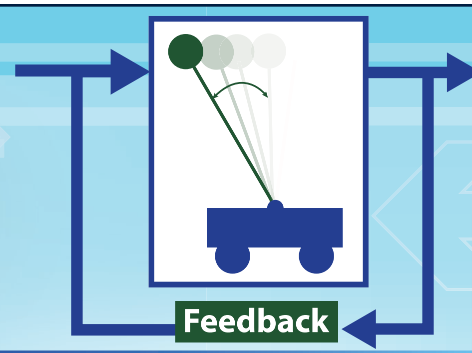
Control Seminar



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From Kinematic to Energetic Design and Control of Wearable Robots for Agile Human Locomotion

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3:30 – 4:30 pm   1500 EECS

ABSTRACT: Even with the help of modern prosthetic and orthotic (P&O) devices, lower-limb amputees and stroke survivors often struggle to walk in the home and community. Emerging powered P&O devices could actively assist patients to enable greater mobility, but these devices are currently designed to produce a small set of pre-defined motions. Finite state machines are typically used to switch controllers between discrete phases of the gait cycle, e.g., heel contact vs. toe contact, and between different tasks, e.g., uphill vs. downhill. However, this discrete methodology cannot continuously synchronize the robot's motion to the timing or activity of the human user. This talk will first present a continuous parameterization of human joint kinematics based on 1) a phase variable that robustly represents the timing of the human gait cycle, and 2) task variables representing ground slope and walking speed. This parameterization is employed for user-synchronized control of a powered knee-ankle prosthesis, which enables above-knee amputee subjects to walk at variable speeds/inclines with reduced compensations of intact joints. This method also allows the user to perform volitional activities like kicking a ball and stepping over obstacles. To fully leverage this control approach, this talk will introduce a quasi-direct drive approach to actuating prosthetic legs for accurate control of joint torque and impedance, enabling more dynamic motions, reducing power consumption, and reducing acoustic noise compared to state-of-art robotic prostheses. While these methods reproduce missing joint function, a different control philosophy is needed for exoskeletons that assist existing joint function. The last part of this talk will introduce an energetic control paradigm for exoskeletons to alter the human body's dynamics without prescribing joint kinematics, e.g., reducing the perceived weight and inertia of the limbs. This control approach is implemented on exoskeletons with high-torque, low-impedance actuators, which provide the necessary backdrivability for volitional human control.

BIO: Robert D. Gregg IV received the B.S. degree in electrical engineering and computer sciences from the University of California, Berkeley in 2006 and the M.S. and Ph.D. degrees in electrical and computer engineering from the University of Illinois at Urbana-Champaign in 2007 and 2010, respectively. He joined the University of Michigan as an Associate Professor in the Department of Electrical Engineering and Computer Science and the Robotics Institute in Fall 2019. Prior to joining U-M, he was an Assistant Professor in the Departments of Bioengineering and Mechanical Engineering at the University of Texas at Dallas. He was also previously a Research Scientist at the Rehabilitation Institute of Chicago and a Postdoctoral Fellow at Northwestern University. Dr. Gregg directs the Locomotor Control Systems Laboratory, which conducts research on the control mechanisms of bipedal locomotion with applications to wearable and autonomous robots. He is a recipient of the Eugene McDermott Endowed Professorship, NSF CAREER Award, NIH Director's New Innovator Award, and Burroughs Wellcome Fund Career Award at the Scientific Interface. Dr. Gregg is a Senior Member of the IEEE.

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