COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
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Mechanical Engineering Seminar Series

What does a muscle sense? Multiscale interactions governing muscle spindle sensory signals

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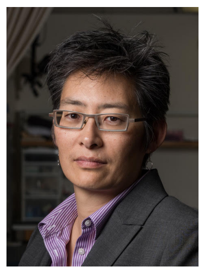

Tuesday, February 2, 2021

4:00 p.m.

ME Seminar Zoom link (QR Code below)

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Abstract

Muscle spindles in vertebrate muscles provide rich sensory information about the body's mechanical interactions with the environment necessary for neural control of movement. Muscle spindle afferent firing patterns have been well-characterized experimentally, but not fully explained mechanistically. I will present a biophysical model of a muscle spindle that demonstrates how well-known firing characteristics of muscle spindle Ia afferents – including a dependence on prior movement history, and nonlinear scaling with muscle stretch velocity – emerge from first principles of muscle contractile mechanics. The model provides a computational framework that address tension between the common understanding of muscle spindles as providing readouts of muscle kinematics, i.e. length and velocity (primarily obtained in passive muscle stretch conditions) with a variety of evidence from more naturalistic and behavioral conditions that defy this classic description of muscle spindle function. In particular, the role of efferent drive to muscles within the mechanosensory region of the muscle spindle cannot be ignored. Simulations of the mechanical interactions of the muscle spindle with muscle-tendon dynamics reveal the differential and interacting effects of motor commands to the muscle (alpha drive) and muscle spindle (gamma/fusimotor drive) on Ia firing, explaining highly variable and seemingly paradoxical muscle spindle sensory signals during human voluntary force production and active muscle stretch. While in certain conditions, muscle spindle sensory signals may provide a good proxy for muscle length, velocity, force, and/or yank, the common denominator is that muscle spindles reflect the interactions between internally and externally-generated forces on the body and the resulting movement. As such, we propose that muscle spindles are situated to perform physical computations that enable the effects of external forces to be dissociated from internal forces (re-afference), providing a signal perhaps best described as sensory prediction error. Our multiscale muscle spindle model provides an extendable, multiscale, biophysical framework for understanding and predicting movement-related sensory signals in health and disease.

Bio

Dr. Ting studied mechanical engineering at the University of California at Berkeley (BS) and at Stanford University (MSE, PhD). Her postdoctoral training was in neurophysiology at the University of Paris V and Oregon Health and Sciences University. Currently she co-directs the Georgia Tech and Emory Neural Engineering Center. Her research in neuromechanics focuses on complex, whole body movements such as walking and balance in healthy and neurologically impaired individuals, as well as skilled movements involved in dance and sport. By drawing from neuroscience, biomechanics, rehabilitation, computation, robotics, and physiology her lab has discovered exciting new principles of human movement. Her work has revealed sensorimotor control mechanisms for control of muscle activity during gait and balance and how they change in stroke, spinal cord injury, Parkinson's disease, and with rehabilitation and training. Her work forms a foundation that researchers around the world are using to understand normal and impaired movement control in humans and animals as well as to develop better robotic devices that interact with people. She also developing musculoskeletal modeling techniques to better predict the contributions of muscle properties and muscle spindle sensory feedback to muscle activity in movement. Dr. Ting is a Fellow of the American Institute of Medical and Biological Engineers (2016), she was awarded the Arthur C. Guyton Award for Excellence in Integrative Physiology by the American Physiological Society (2007), the Atlanta Business Chronicles, Healthcare Hero Award (2018) and several teaching and mentoring awards from Georgia Tech and Emory University. Dr. Ting's research is highlighted the follow in textbooks: Principles of Neural Science, Motor Control: Translating Research into Practice, The Neurobiology of Motor Control: Fundamental Concepts and New Directions, and featured in a popular science book entitled Balance: a Dizzying Journey Through the Science of our Most Delicate Sense; her work on flamingo balance has been featured in several children's science publications.