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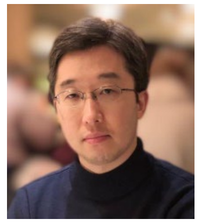
Mechanical Engineering Seminar



Speaker: Professor Joo H. Kim

Department of Mechanical and Aerospace Engineering, New York University

Thursday, September 29, 2022, at 1:30 PM, Room 173 Light Engineering Building

Title: Toward Biped Robots Walking Like Humans: Stability and Efficiency Perspectives

Abstract

Stability and efficiency are two main performance measures for legged locomotion. Quantitative models of these measures are critical in design and control of biped robots. In this talk, rigorous mathematical models of robot balance stability and energy efficiency will be introduced. The balance stability of a biped robot is quantified by partitioning an augmented state space of center-of-mass position and velocity. Based on comprehensive definitions of the states of balance, the partitions are provided by the boundaries of balanced, capturable, and falling states of a biped robot. Whole-body system dynamics with distributed contacts is established and integrated into optimization problems, in which the effects of multi-level momentum and stepping strategies are incorporated. For energy efficiency, power consumption of a robot is derived in terms of state variables, control inputs, and system parameters. The model forms are derived theoretically using the switched electromechanical dynamics of a servomotor, while their parameters are estimated from experiments. The predictive model can accurately evaluate instantaneous power consumption rate without limitations inherent in experimental measurements or other approximation methods. These models are demonstrated with robot walking experiments along with their comparative analyses against human walking. Finally, some preliminary ideas of on-going work on formalizing the stability-efficiency trade-off relationships in bipedal walking, which have only been qualitatively observed in the existing literature, and their potential use in benchmarking human gait for advanced design and control of walking robots will be discussed.

Biography

Dr. Joo H. Kim is an Associate Professor in the Department of Mechanical and Aerospace Engineering at New York University (NYU). Dr. Kim directs the Applied Dynamics and Optimization Laboratory with fundamental disciplinary areas in multibody system dynamics, optimization theory and algorithms, and design and control of mechanical systems. With applications in robotic and biomechanical systems and their intersections such as wearable robots, his current research topics include energetics of dynamic systems, legged balance and gait stability, and integration of dynamics/control with numerical optimization. Dr. Kim's research has been sponsored by NSF, NASA, NYU, and industry. He received the Ph.D. degree in mechanical engineering in 2006, the M.S. degrees in mathematics, mechanical engineering, and biomedical engineering, all from the University of Iowa, and the B.S. degree in mechanical engineering from Korea University, Seoul, South Korea. Before joining NYU in 2009, he was an Adjunct Assistant Professor of Mechanical Engineering and Postdoctoral Research Scholar in the Center for Computer-Aided Design at the University of Iowa. Dr. Kim is a member (elected) of the ASME Mechanisms and Robotics Technical Committee and a Senior Member of IEEE. He has served as an Associate Editor for the ASME Journal of Mechanical Design, and is currently serving as an Associate Editor for the ASME Journal of Mechanisms and Robotics and for the Conference Editorial Board of the IEEE Robotics and Automation Society. Dr. Kim is the recipient of several awards and honors, including the 2007 Top Government Technology of the Year Award from the State of Iowa, the 2014 Advanced Modeling and Simulation Best Paper Award from the ASME Computers and Information in Engineering Division, the 2015 Freudenstein/General Motors Young Investigator Award from the ASME Design Engineering Division, and the 2020 Associate Editor Award from the ASME Journal of Mechanical Design.

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