MECHANICAL ENGINEERING SEMINAR



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WALKING WITH PURPOSE: GOAL DIRECTEDNESS AND THE CONTROL STRUCTURE OF HUMAN WALKING

ABSTRACT

When people walk, they don't merely take steps. Instead, they try to accomplish certain tasks, such as maintaining a desired speed or direction. Laboratory observations of human walking support the general hypothesis that stepping regulation is optimal with respect to task-dependent goals. This hypothesis has been tested by analyzing stepping time series with linear update models based on multi-objective error minimization. We review these experimental findings and discuss how such stepping regulation strategies can be grounded in physics-based dynamic walking models. The resulting integrated template models reveal that goal-directed stepping in the sagittal plane greatly enhances a walker's ability to reject large disturbances, and suggests a mechanism for fall recovery by a process of task switching. Models for lateral stepping capture and explain the observed statistical structure in terms of competing costs, and demonstrate the existence of semistable goal-equivalent sets of steady gaits: perturbations off of any one gait typically return to a different gait in the set satisfying the same stepping goals. Semistable dynamics provides a walking paradigm that is less constraining than provided by asymptotically stable limit cycles and, therefore, is more suitable for biological walking, which is characterized by its flexibility and adaptability.

ABOUT THE SPEAKER

Joseph P. Cusumano is a Professor in the Department of Engineering Science and Mechanics at Penn State University. He holds a B.S. in Mechanical & Aerospace Engineering from Cornell University (1979), an Sc.M. in Applied Mathematics from Brown University (1982), and a Ph.D. in Theoretical & Applied Mechanics from Cornell University (1990).

Professor Cusumano is primarily interested in the study of nonlinear dynamical systems, with applications ranging from biomechanics and human movement to structural health monitoring and experimental nonlinear dynamics. Over the past decades, he has worked with colleagues in biomechanics and movement physiology to develop control-theoretic models and data analysis methods for the study of human locomotion. Other multidisciplinary work during his career has resulted in new algorithms for machinery and structural health monitoring, the experimental characterization of complexity and chaos in systems with noise, multiscale damage evolution, and the dynamics of hill slope hydrology. Prof. Cusumano has a long-standing fascination with the creative interplay between art and engineering, particularly as represented by the kinetic and interactive art developed since the middle of the last century; he maintains an active interest in projects combining technological and artistic perspectives.