Dwight Look College of ENGINEERING
TEXAS A&M UNIVERSITY

SEMINAR

SYSTEMS, CONTROLS, AND ROBOTICS SEMINAR SERIES

Dr. Aaron Ames
Assistant Professor
Mechanical Engineering, Texas A&M University
aames@tamu.edu

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4:00 p.m. / 100 Harrington Education Classroom Center

Controlling the Next Generation of Bipedal Robots

ABSTRACT

Humans have the ability to walk with deceptive ease, navigating everything from daily environments to uneven and uncertain terrain with efficiency and robustness. Despite the simplicity with which humans appear to ambulate, locomotion is inherently complex due to highly nonlinear dynamics and forcing. Yet there is evidence to suggest that humans utilize a hierarchical subdivision among cortical control, central pattern generators in the spinal column, and proprioceptive sensory feedback. This indicates that when humans perform motion primitives, potentially simple and characterizable control strategies are implemented. If these fundamental mechanisms underlying human walking can be discovered and formally understood, human-like abilities can be imbued into the next generation of robotic devices with far-reaching applications ranging from prosthesis to legged robots for space exploration and disaster response.

This talk presents the process of formally achieving bipedal robotic walking through controller synthesis inspired by human locomotion, and demonstrates these methods through examples of experimental realization on numerous bipedal robots. Motivated by the hierarchical control present in humans, we begin by viewing the human as a “black box” and describe outputs, or virtual constraints, that appear to characterize human walking. By considering the equivalent outputs for the bipedal robot, a novel type of control Lyapunov function (CLF) can be constructed that drives the outputs of the robot to the output of the human; moreover, the parameters of this CLF can be optimized so that stable robotic walking is provably achieved while simultaneously producing outputs of the robot that are as close as possible to those of a human. This CLF forms the basis for a Quadratic Program (QP) yielding locomotion that dynamically accounts for torque and contact constraints. The end result is the generation of bipedal robotic walking that is remarkably human-like and is experimentally realizable, together with a novel control framework for highly dynamic behaviors on bipedal robots. This is evidenced by the demonstration of the resulting controllers on multiple robotic platforms, including: AMBER 1 and 2, NAO, ATRIAS and MABEL Furthermore, these methods form the basis for achieving a variety of walking behaviors—including multi-domain and rough terrain locomotion—and have demonstrated application to the control of prosthesis.

BIO

Dr. Aaron D. Ames is an Assistant Professor in Mechanical Engineering at Texas A&M University with a joint appointment in Electrical & Computer Engineering. His research interests center on robotics, nonlinear control, hybrid systems and cyber-physical systems, with special emphasis on foundational theory and experimental realization on bipedal robots. Dr. Ames received a BS in Mechanical Engineering and a BA in Mathematics from the University of St. Thomas in 2001, and he received a MA in Mathematics and a PhD in Electrical Engineering and Computer Sciences from UC Berkeley in 2006. At UC Berkeley, he was the recipient of the 2005 Leon O. Chua Award for achievement in nonlinear science and the 2006 Bernard Friedman Memorial Prize in Applied Mathematics. Dr. Ames served as a Postdoctoral Scholar in the Control and Dynamical System Department at the California Institute of Technology from 2006 to 2008. In 2010 he received the NSF CAREER award for his research on bipedal robotic walking and its applications to prosthetic devices. Dr. Ames is the head of the A&M Bipedal Experimental Robotics (AMBER) Lab that designs, builds and tests novel bipedal robots with the goal of achieving human-like bipedal robotic walking.

Pizza will be served at 4:00 p.m.