CIVIL AND ENVIRONMENTAL ENGINEERING

UCONN | COLLEGE OF ENGINEERING

School of Civil and Environmental Engineering

Structures and Applied Mechanics Seminar Series

Present

Machine Learning Applications in Structural Dynamics Modeling, Control, and Sensing

Speaker:

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Professor, Sonny Astani Department of Civil & Environmental Engineering
Interim Director, Technology and Applied Computing program
Vice Dean for Academic Programs, USC Viterbi School of Engineering

Advances in machine learning (ML) have provided new tools for solving a wide array of civil engineering problems. This seminar briefly explores three applications of ML in the control, modeling, and sensing of structural dynamical systems.

1. Optimal controllable damping has no closed-form solution. Model predictive control (MPC) can come close, but the resulting mixed integer-quadratic programming (MIQP) problem is too computationally intensive for real-time application. We use a set of neural networks to predict the integer variables in the MIQP, reducing the optimization to a quadratic programming (QP) problem that can be solved in real time. Application to a building structural model demonstrates the approach.
2. Rare event simulation (e.g., failure of reliable systems) is computationally costly. We use normalizing flows, which are diffeomorphic generative network models defined with invertible functions with efficiently computed Jacobians, to “learn” a quasi-optimal importance sampling distribution that reduces this cost. Reliability estimation benchmark problems demonstrate the efficacy, handling complex and extremely unlikely rare-event domains and high dimension.
3. Optimal placement of heterogeneous sensor arrays, even without uncertainties, is an NP-hard problem. We use a Markov decision process formulation, using deep reinforcement multiagent Q-learning, to determine a near-optimal heterogeneous sensor array configuration that accounts for the input and noise uncertainties with a stochastic reward function, and can accommodate sensor failure. Application to building models is discussed.

Friday, October 25, 2024
12:20 – 1:10 PM
CAST 204

Erik A. Johnson, Ph.D., is a Professor at the University of Southern California, currently serving as USC Viterbi’s Vice Dean for Academic Programs and the Interim Director of its Technology and Applied Computing Program. He earned B.S., M.S., and Ph.D. degrees in Aeronautical & Astronautical Engineering from the University of Illinois at Urbana-Champaign, and a Certificate in Biblical Studies from Trinity Evangelical Divinity School. Prior to joining USC in 1999, Dr. Johnson was a visiting research assistant professor at the University of Notre Dame. He was the recipient of a 2001 National Science Foundation CAREER award, and has served as the chair of two ASCE EMI technical committees. He is a senior member of AIAA and a member of ASCE and ASME, is on the Advisory Board for *Structural Control & Health Monitoring*, and represents ASCE on the Board of Directors of the American Automatic Control Council. Dr. Johnson's research interests include “smart” structures, control of structural vibration, controllable damping devices, monitoring structural health, random vibration, probabilistic model validation, and computationally efficient simulation algorithms for dynamical systems.