Graduate Colloquium, Aerospace Engineering

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Covariance Steering and Density Control for Discrete-time Stochastic Systems and their Applications in Coverage Control of Large-Scale Multi-agent Systems

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In this talk, I will present some of our recent results on covariance steering / density control problems for discrete-time stochastic systems subject to additive and / or multiplicative noise. First, I will discuss different formulations of the covariance steering problem for discrete-time stochastic linear systems (density control problem over the set of Gaussian distributions) based on the utilization of either a hard positive semidefinite constraint on the state covariance of the system or the Wasserstein distance (also known as the earth mover's distance) as the metric that measures the distance between the actual probability density function (PDF) of the (uncertain) system's state and the desired (goal) Gaussian distribution. Subsequently, I will present ways to design feedback controllers for this class of problems based on different control policy parametrizations whose utilization can allow one to reduce the stochastic optimal control problems into tractable optimization problems. I will also present new results on more general density steering problems in which the PDF of the uncertain system can be approximated by a Gaussian mixture model. I will show that the corresponding density problem can be reduced to a finite number of covariance steering problems and a tractable (finite-dimensional) linear program. Finally, I will discuss how the previously described covariance steering / density control methods can be used for the design of combined macroscopic and microscopic control algorithms for large-scale multi-agent coverage problems in dynamic environments.

Efstathios Bakolas received the Diploma degree (Highest Hons.) in Mechanical Engineering from the National Technical University of Athens, Athens, Greece, in 2004 and the M.S. and Ph.D. degrees in Aerospace Engineering from the Georgia Institute of Technology, Atlanta, Atlanta, GA, USA, in 2007 and 2011, respectively. He is currently an Associate Professor (Eli H. and Ramona Thornton Centennial Fellowship in Engineering) with the Department of Aerospace Engineering and Engineering Mechanics, University of Texas at Austin, Austin, TX, USA. His research is mainly focused on stochastic optimal control theory, control of uncertain systems, data-driven control of complex systems (e.g., fluid flows), and control of multiagent systems. Other interests include differential games, optimal decision making, nonlinear control theory, and optimization-based control.