PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
University of Texas at Arlington

UNCERTAINTY PROPAGATION, CONTROL, AND ESTIMATION OF STOCHASTIC DYNAMIC SYSTEMS USING GENERALIZED POLYNOMIAL CHAOS EXPANSION

By

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Abstract

Recently, uncertainty propagation has been an emerging research area in the field of dynamical systems. The growing interest in this area arises out of a need to develop computationally efficient approaches to predict the evolution of a system subject to uncertainties. To this end, this dissertation is focused on developing computational frameworks for uncertainty propagation, control, and state estimation of stochastic dynamical systems using the generalized polynomial chaos (gPC) expansion technique.

In the first part of this dissertation, the construction of gPC expansion is presented in general. The novelty of this dissertation lies in developing a mixed sparse grid quadrature technique to carry out computationally efficient uncertainty propagation in dynamical systems wherein the random variables are governed by different (or a mixture of) probability distribution types. Additionally, the proposed quadrature technique in the gPC expansion framework is utilized to study the sensitivity of the system output to the input uncertain variables. Further, this dissertation integrates the idea of uncertainty propagation with that of model data fusion for state estimation and optimal control theory for robust control in stochastic systems with parametric uncertainties. The proposed frameworks are applied to various benchmark problems and real applications, including the motion of satellites in low-Earth orbits, aeroelastic systems, hypersonic reentry of a spacecraft to Earth, synchronization in the states of short-period dynamics of aircraft, among others.

Further, this dissertation examines the stability margin of a group of cooperative unmanned vehicle systems in a multi-agent system setting. In this regard, a unified framework is proposed to study the consensus of the multi-agent system when subject to multiplicative uncertainties in the feedback path of agents. The proposed framework provides performance indices that measures the robustness of the networked group of agents to gain, phase, and input delay perturbations. Finally, the dissertation studies the consensus problems in multi-agent systems wherein the information exchange between the agents is affected by non-uniform time-varying delays in the network.