University of Connecticut

United Technologies

# UTC Institute for Advanced Systems Engineering Seminar Series



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## FORECASTING REGIME SHIFTS IN NATURAL AND MAN-MADE INFRASTRUCTURE

Friday, August 29, 2014 2-3 p.m. Storrs Campus, Bio Physics 130

***Abstract*:** A number of natural and man-made dynamical processes provide essential goods and services to humanity. Both types of processes may be thought of as critical *infrastructure* since they provide a foundation supporting a civil society. Humanity relies on this infrastructure to provide a *consistent* and *predictable* level of services and any disruption to this quality-of-service can have serious implications for the public's health and welfare. This lecture discusses a specific type of infrastructure disruption that is sometimes referred to as a *regime shift*. Regime shifts occur when a process' state shifts from the neighborhood of a *nominal* equilibrium to that of an *alternative* equilibrium. This term has its origins in the ecosystem sciences, but similar shifts occur in several man-made infrastructure systems, of which the electrical power grid is just one example. We're interested in characterizing a system's *distance to regime shift* and taking that as a measure of how resilient a system might be to external disturbances. The approach uses *barrier certificates* to recast the regime shift problem as a polynomial optimization problem whose solution is approximated by a sequence of semidefinite programming (SDP) or linear programming (LP) relaxations. This talk reviews our recent progress with this approach and illustrates it use with examples concerned with the cultural eutrophication of aquatic ecosystems and voltage collapse in electrical power systems. Surprisingly, both of these infrastructure systems were treated within the same modeling framework and the associated regime shift problems were tackled with the same set of computational tools, thereby suggesting that this approach provides a unified framework in which to study resilience in a variety of infrastructure systems.

***Speaker Bio:*** Michael Lemmon did his undergraduate work at Stanford University. After graduating in 1979, he worked for seven years as a guidance and control engineer on several ballistic missile defense projects. He then returned to graduate school and completed his Ph.D. degree in electrical and computer engineering from Carnegie-Mellon University in 1990. Dr. Lemmon joined the University of Notre Dame's Department of Electrical Engineering in 1990 where he currently holds the position as a professor in Electrical Engineering. Dr. Lemmon's current research interests revolve about the management and control of cyber-physical systems. His recent work has explored the impact that limited communication and computational resources have on a networked control system's performance. Most recently he has begun exploring the resilience of cyber-physical systems to environmental disturbances.