SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

STATE SPACE ANALYSIS OF DOMINANT STRUCTURES IN DYNAMIC SOCIAL SYSTEMS

DISSERTATION DEFENSE

By

Jeremy Sato
PhD Candidate

Preston M. Green Department of Electrical and Systems Engineering
Washington University in St. Louis

Abstract: Many systems involving human relationships are modeled as dynamic systems, as diverse as urban population growth, diffusion of innovations, spread of viruses, and supply chain management. A fundamental assumption is that these systems contain variables which accumulate and deplete over time (people, innovation adoptions, infections, and orders), and whose dynamics are determined by societal rules and human decision making processes. These assumptions allow the system to be formally expressed by ordinary differential equations which are often nonlinear and contain multiple state variables and feedback loops. Analytical methods have been developed to identify the dominant feedback loops which primarily influence the behavior of the system. However, these dominance methods can produce conflicting results and are often performed in the time-domain under specific initial conditions. This thesis takes a state-space approach to dominance analysis and, in the process, re-examines the definition of dominance.

A formal, mathematical definition of dominance is proposed and an analytical procedure is developed and applied to previously studied models. The method produces results consistent with previous analyses and is able explain inconsistencies between other methods. The procedure is then applied in the state-domain and used to identify state-space regions in which certain feedback loops dominate behavior. The procedure is then used to identify the stability properties of equilibria, and a theorem is developed to provide a necessary condition for stability, based on the dominance of balancing (negative) feedback.

Lastly, the method is applied to a problem in public health in which a model of the supply and demand of cancer control services is analyzed. The dominant feedback loops are identified for the purpose of revealing potential sources of health disparities between distinct population segments. The analysis revealed the existence of a tipping point condition associated with a single unstable equilibrium point which influences population health outcomes. Furthermore, trajectories near the unstable equilibrium point are dominated by reinforcing (positive) feedback loops which affect the proportion of people seeking cancer control services. These loops result in either virtuous or vicious cycles, depending on which side of the tipping point the system is operating in the state-space. The methods were then used to identify potential leverage points in the system in which small parameter changes cause significant behavior changes.

Potential avenues for future dominance research are discussed as well as future transdisciplinary research in public health and implementation science.

DATE: **Monday August 29, 2016**
TIME: **9:00 am**
PLACE: **Green Hall, Room 0120**

Dissertation advisors:
Dr. Peter Hovmand
Dr. Joseph O'Sullivan

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