IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Spreading Processes over Networks: Theory and Applications

Philip Pare

Division of Decision and Control Systems
KTH Royal Institute of Technology

December 5, 2019 11:00 AM Black 2004

Abstract

The study of spreading processes has been a topic of interest for many years over a wide range of areas, including computer science, mathematical systems, biology, physics, social sciences, and economics. More recently, there has been a resurgence of interest in the study of spreading processes focused on spread over networks, motivated not only by security threats posed by computer viruses, but also recent devastating outbreaks of infectious diseases and the rapid spread of opinions and misinformation over social networks. Up to this point these network-dependent spread models have not been validated by real data.

In this talk, I present and analyze mathematical models for network-dependent spread, providing necessary and sufficient conditions for uniqueness of the healthy state and prove the existence of an endemic equilibrium. I use the endemic equilibrium results to estimate the healing and infection parameters of the model. Using this technique I validate the spread model by employing John Snow's classical work on cholera epidemics in London in the 1850's, with surprisingly good results. Given the demonstrated validity of the model, I discuss several control strategies for mitigating spread, and formulate a tractable antidote administration problem that significantly reduces spread. Motivated by competing USDA farm subsidy programs, I present and analyze a model for multiple competing viruses spreading over multi-layered networks. Further, I present a technique for estimating the healing and infection parameters of the model from time series data. I validate the multi-virus model by applying this technique to the USDA farm subsidy dataset, and improve upon the results by employing an online learning algorithm. Finally, motivated by recent contaminated water-related outbreaks in Scandinavia, I propose a layered infrastructure network model and explore when the source of an outbreak can be detected. I conclude the technical part of my talk by discussing various directions for compelling future work, including combining the online learning algorithms with the control techniques to develop data-driven mitigation strategies.

Biography

Philip E. Paré received his B.S. in Mathematics with University Honors and his M.S. in Computer Science from Brigham Young University, Provo, UT, in 2012 and 2014, respectively, and his Ph.D. in Electrical and Computer Engineering (ECE) from the University of Illinois at Urbana-Champaign (UIUC), Urbana, IL in 2018. He is currently a postdoctoral scholar in the Division of Decision and Control Systems in the School of Electrical Engineering and Computer Science at KTH Royal Institute of Technology in Stockholm, Sweden. Philip was the recipient of the 2017-2018 Robert T. Chien Memorial Award for excellence in research from the UIUC ECE Department and named a 2017-2018 UIUC College of Engineering Mavis Future Faculty Fellow. His research interests include the modeling, control, and security of dynamic networked systems, such as, epidemiological, infrastructure, biological, economic systems, and social networks.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

www.me.iastate.edu