SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

ROBUST ENGINEERING OF DYNAMIC STRUCTURES IN COMPLEX NETWORKS

DISSERTATION DEFENSE
By

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Abstract: Populations of nearly identical dynamical systems are ubiquitous in natural and engineered systems, in which each unit plays a crucial role in determining the functioning of the ensemble. Robust and optimal control of such large collections of dynamical units remains a grand challenge, especially, when these units interact and form a complex network. Motivated by compelling practical problems in power systems, neural engineering and quantum control, where individual units often have to work in tandem to achieve a desired dynamic behavior, e.g., maintaining synchronization of generators in a power grid or conveying information in a neuronal network; in this dissertation, we focus on developing novel analytical tools and optimal control policies for large-scale ensembles and networks. To this end, we first formulate and solve an optimal tracking control problem for bilinear systems. We developed an iterative algorithm that synthesizes the optimal control input by solving a sequence of state-dependent differential equations that characterize the optimal solution. This iterative scheme is then extended to treat isolated population or networked systems. We demonstrate the robustness and versatility of the iterative control algorithm through diverse applications from different fields, involving nuclear magnetic resonance (NMR) spectroscopy and imaging (MRI), electrochemistry, neuroscience, and neural engineering. For example, we design synchronization controls for optimal manipulation of spatiotemporal spike patterns in neuron ensembles. Such a task plays an important role in neural systems. Furthermore, we show that the formation of such spatiotemporal patterns is restricted when the network of neurons is only partially controllable. In neural circuitry, for instance, loss of controllability could imply loss of neural functions. In addition, we employ the phase reduction theory to leverage the development of novel control paradigms for cyclic deferrable loads, e.g., air conditioners, that are used to support grid stability through demand response (DR) programs. More importantly, we introduce novel theoretical tools for evaluating DR capacity and bandwidth. We also study pinning control of complex networks, where we establish a control-theoretic approach to identifying the most influential nodes in both undirected and directed complex networks. Such pinning strategies have extensive practical implications, e.g., identifying the most influential spreaders in epidemic and social networks, and lead to the discovery of degenerate networks, where the most influential node relocates depending on the coupling strength. This phenomenon had not been discovered until our recent study.

DATE: **Tuesday, August 7, 2018**
TIME: **10:00 a.m.**
PLACE: **Green Hall, Room 0120**

Dissertation advisor:
Dr. Jr-Shin Li

This seminar is in partial fulfillment
of the Doctor of Philosophy degree

Washington University in St. Louis
SCHOOL OF ENGINEERING & APPLIED SCIENCE