

# SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

## INFORMING THE DESIGN OF LINEAR SYSTEMS FOR STIMULUS REPRESENTATION AND DECODING

PhD Preliminary Research Examination

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**Abstract:** Linear dynamical models have served as an analytically tractable approximation for a variety of natural and engineered systems. Recently, such models have been used to describe high-level diffusive interactions in the activation of complex networks, including those in the brain. In this regard, classical tools from control theory, including controllability analysis, have been used to assay the extent to which such networks might respond to their afferent inputs. However, for natural systems such as brain networks, it is not clear whether advantageous control properties necessarily correspond to useful functionality. That is, are systems that are highly controllable (according to certain metrics) also ones that are suited to computational goals such as representing, preserving and categorizing stimuli?

This dissertation will introduce analysis methods that link the systems-theoretic properties of linear systems with informational measures that describe these functional characterizations. First, we assess sensitivity of a linear system to input orientation and novelty by deriving a measure of how networks translate input orientation differences into readable state trajectories. Next, we explore the implications of this novelty-sensitivity for endpoint-based input discrimination, wherein stimuli are decoded in terms of their induced representation in the state space. We develop a theoretical framework for the exploration of how networks utilize excess input energy to enhance orientation sensitivity (and thus enhance discrimination ability). Next, we conduct a theoretical study to reveal how the background or 'default' state of a network with linear dynamics allows it to best promote discrimination over a continuum of stimuli. Specifically, we derive a measure, based on the classical notion of a Fisher discriminant, quantifying the extent to which the state of a network encodes information about its afferent inputs. This measure provides an information value quantifying the 'knowability' of an input based on its projection onto the background state. We subsequently optimize this background state, and characterize both the optimal background and the inputs giving it rise.

DATE: Wednesday, May 23, 2018  
TIME: 1:00 p.m.  
PLACE: Green Hall, Room 0120

Dissertation advisor:  
Dr. ShiNung Ching

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