SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

OPTIMAL CONTROL OF WEAKLY FORCED NONLINEAR OSCILLATORS

DISSERTATION DEFENSE

by

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Abstract: Optimal control of nonlinear oscillatory systems poses numerous theoretical and computational challenges. Motivated by applications in neuroscience, we develop tools and methods to synthesize optimal controls for nonlinear oscillators described by reduced order dynamical systems. Control of neural oscillations by external stimuli has a broad range of applications, ranging from oscillatory neurocomputers to deep brain stimulation for Parkinson’s disease. In this dissertation, we investigate fundamental limits on how neuron spiking behavior can be altered by the use of an external stimulus (control). Pontryagin’s maximum principle is employed to derive optimal controls that lead to desired spiking times of a neuron oscillator, which include minimum-power and time-optimal controls. In particular, we consider practical constraints in such optimal control designs including a bound on the control amplitude and the charge-balance constraint. The latter is important in neural stimulations used to avoid from the undesirable effects caused by accumulation of electric charge due to external stimuli. Furthermore, we extend the results in controlling a single neuron and consider a neuron ensemble. We, specifically, derive and synthesize time-optimal controls that elicit simultaneous spikes for two neuron oscillators. Robust computational methods based on homotopy perturbation techniques and pseudospectral approximations are developed and implemented to construct optimal controls for spiking and synchronizing a neuron ensemble, for which analytical solutions are intractable. We finally validate the optimal control strategies derived using the models of phase reduction by applying them to the corresponding original full state-space models. This validation is largely missing in the literature. Moreover, the derived optimal controls have been experimentally applied to control the synchronization of electrochemical oscillators. The methodology developed in this dissertation work is not limited to the control of neural oscillators and can be applied to a broad class of nonlinear oscillatory systems that have smooth dynamics.

DATE:	Wednesday, March 20, 2013
TIME:	10:10 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