M5: Dynamics and Control of Neurons
01/03/2010 - 05/03/2010
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1. Basics of Neuroscience
2. The Hodgkin-Huxley Equations
   a. “derivation” of the equations
   b. a dynamical systems perspective
   c. reduction of the Hodgkin-Huxley equations to a planar system, including canards
3. Isochrons and Phase Response Curves
   a. definitions
   b. calculation methods
4. Coupled Neurons
   a. phase reduction
   b. existence and stability of phase-locked solutions
   c. other solutions for phase models
4. Response Dynamics of Neural Populations
   a. modeling a visual discrimination task
   b. response to step function stimulus
   c. response to sinusoidal stimulus
   d. response to random Poisson stimuli
5. Bursting Neurons
6. Control of Individual Neurons
   a. optimal control, without and with charge balance constraint
   b. impulsive and quasi-impulsive control
7. Control of Populations of Neurons
   a. Hamilton-Jacobi-Bellman approach
   b. hybrid control
   c. control using delayed inputs

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Jeff Moehlis received the B.S. degree in Physics and Mathematics from Iowa State University in 1993, and the Ph.D. degree in Physics from the University of California, Berkeley, in 2000. He was a Postdoctoral Researcher in the Program in Applied and Computational Mathematics at Princeton University from 2000-2003. He joined the Department of Mechanical Engineering at the University of California, Santa Barbara, in 2003, and received tenure in 2007. He has also held visiting research appointments in the Department of Physics at the University of Marburg, Germany (summer 2003), and in the Department of Engineering Mathematics at the University of Bristol, England (fall 2007). He is a recipient of a Sloan Research Fellowship in Mathematics and a National Science Foundation CAREER Award. From 2008-2009 he was the Program Director for the Society for Industrial and Applied Mathematics Activity Group on Dynamical Systems. His research interests involve using techniques from dynamical systems theory to understand and control natural and technological systems, including applications from neuroscience, fluid dynamics, MEMS devices, and fish schooling.