NEUROSCI 612: Networks and Computational Neuroscience

November 5 – December 10, 2013, Tues, Thurs & Friday 10am-12pm

Coordinators:
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Description: This module focuses on network activity in the brain and provides an introduction to computational modeling of neurons and neural networks. Neuroscience faculty lectures will cover brain functions and activity that result from network interactions in a variety of brain regions, including cortex, hippocampus and basal ganglia. Lectures will also discuss how analyses of EEG rhythms can help understand network-dependent brain processes such as motor control and consciousness. Computational modeling projects will focus on understanding how networks of coupled neurons generate the dynamics underlying these network-dependent brain processes.

Modeling projects will be implemented in Matlab. Experience in programming or Matlab is not required. Computer labs will cover the following topics:

1) Single neuron models (Hodgkin-Huxley, I & F); current clamp simulations, computation of rheobase current, f-I curves
2) Synaptic currents; small networks; synchrony, phase-locking, anti-phase firing; central pattern generators
3) Activity and synchrony in large excitatory networks, influence of synaptic connectivity and neural firing properties
4) Activity and synchrony in large inhibitory networks, influence of synaptic current and connectivity properties
5) Rhythm generation in networks

Team paper discussions: In 2-person teams, students will identify a paper from the literature that uses computational modeling to investigate a neural/brain process that has been discussed in the faculty lectures. The team will write a synopsis and analysis of the paper and give a brief, oral presentation to the class.

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Office Hours: Wednesdays 4-5pm, Thursdays 3-5pm

Date/Location	Topic
Tues 11/5 East Hall B743	**Computer lab 1: Single neuron models**
Thurs 11/7 USB 2234	**Cultured Networks as a First Approximation for Brain Dynamics** **Elizabeth Shtrahman**, *Applied Physics Program* How do networks of neurons encode for information? This lecture will introduce the study of brain function from a networks perspective. I will give a brief introduction to network theory and dynamical systems. Then we will look at some examples of neuronal dynamics in cultured networks, and see how these networks self-organize into complex spatiotemporal patterns capable of representing information.
Fri 11/8 East Hall B743	**Computer lab 2: Synapses and small networks**
Tues 11/12	**Society for Neuroscience meeting – no class**
Thurs 11/14 USB 2234	**Brain states and memory formation - a view from the hippocampus** **Sara Aton**, *Assistant Professor of Molecular, Cellular and Developmental Biology* In this lecture I will briefly cover network-level changes occurring in the hippocampus during wakefulness vs. sleep, and how these changes contribute to encoding and consolidation of new memories. Various theories about the role of sleep in hippocampally-mediated (*e.g.*, episodic) memory formation will be discussed.
Fri 11/15 USB 4152	**Neural Networks and Machine Learning** **Cindy Chestek**, *Assistant Professor of Biomedical Engineering and Electrical Engineering and Computer Science* This lecture will discuss how to use a variety of types of neural networks as machine learning algorithms. Neural networks have been used in this way since the perceptron in the 1950s. This work led to a variety of feed-forward network models, and the Hopfield "attractor" network. Recently there have been advances in methods for training fully recurrent, randomly connected neural networks to generate multiple complex patterns from simple inputs, including a method called "FORCE" learning. One particularly interesting application is using these neural networks to generate motor behavior from the activity of neural ensembles in cortex for brain machine interfaces. ***Computer Lab 1 Due by 5pm***
Tues 11/19 Science Learning Center Computer Lab 1720 Chemistry Building	**Computer lab 3: Activity and synchrony in large excitatory networks** ***Computer Lab 2 Due by 5pm***
Thurs 11/21 USB 2234	**Electroencephalography and the Assessment of Consciousness** **George Mashour**, *Associate Professor of Anesthesiology & Neurosurgery* The first part of the lecture will provide a historical background on the electroencephalogram (EEG), a basic review of the physiology underlying EEG signals, and an introduction to EEG interpretation/ analysis. The

	second part of the lecture will focus on how EEG is used to assess consciousness, both by conventional interpretation as well as emerging techniques in connectivity and graph-theoretical analysis.
Fri 11/22 USB 4152	**Distributed control of human movement** **Dan Ferris**, *Professor of Kinesiology and Biomedical Engineering* When humans walk, or run, or juggle, or perform any type of motor activity, they rely on many different parts of their nervous system to coordinate the movement. We usually think about the brain as being the main command center controlling movement, but the spinal cord possesses neural networks that contribute substantially to the coordination of motor tasks. In fact, most of the coordination of muscle forces is done at the level of the spinal cord, with motor primitives or synergies being put together to generate smooth movements. At the supraspinal level, there are many locations in the brain and brain stem that contribute to motor control. The sensorimotor cortex, basal ganglia, and cerebellum are three areas of importance. Many more areas are also involved in motor control as well. I will talk about the distributed nature of motor control and some of the computational processes we can use to study them in humans.
Tues 11/26 East Hall B743	**Computer lab 4: Activity and synchrony in large inhibitory networks** ***Computer Lab 3 Due by 5pm***
Tues 12/3 East Hall B743	**Computer lab 5: Rhythm generation in networks** ***Computer Lab 4 Due by 5pm***
Thurs 12/5 USB 2234	**The basal ganglia: functions, dynamics and computations** **Josh Berke**, Associate Professor of Psychology This lecture will provide an introduction to the organization of the basal ganglia, their normal and abnormal dynamic states, and their computational contributions to adaptive decision-making. At the macro-circuit level I will discuss how convergence between different basal ganglia pathways may compute expected rewards and reward prediction errors, and how these errors can guide reinforcement-based learning. At the microcircuit level I will address how networks of interacting striatal neurons may contribute to the selection and initiation and actions. Further, I will discuss evidence that molecular-level alterations to the basal ganglia produce pathologies of movement and choice through altered circuit dynamics.
Fri 12/6 USB 4152	**Team paper discussions**
Tues 12/10 USB 2234	Parag Patil: DBS in Parkinson's Disease ***Computer Lab 5 Due by 5pm***
Tues 12/17	***Team Paper Reports Due by 5pm***