BioE332A

Large-Scale Neural Modeling

**Catalog Description:** Emphasis is on cortical computation, from feature maps in the neocortex to episodic memory in the hippocampus, looking at the role of recurrent connectivity, rhythmic activity, spike synchrony, and synaptic plasticity, as well as noise and heterogeneity. Techniques to predict and quantify network behavior introduced in lectures are applied to data recorded from models programmed and ran in labs. Models run in real-time on neuromorphic hardware developed for this purpose, facilitating learning and discovery by exploring the model’s parameter space.

**Prerequisites:** Psych 120, Math 51 and Stats 110. Biology students with no background in engineering are welcome. Engineering students should have an introductory neuroscience course. Undergraduates need the instructor’s permission.

**Goals:** To develop computational models of neural computation by emulating the structure as well as the function of the nervous system. These models are simulated and tested in weekly lab exercises.

**Target Audience:** This course is intended to draw students from multiple disciplines with an interest in interdisciplinary approaches. Students are encouraged to pool their expertise in different areas by working in groups.

**Instructor:** Kwabena Boahen, Bioengineering Dept (boahen@stanford.edu).
**Website:** brainsinsilicon.stanford.edu

**Textbooks:** None required. But, the monograph, *Dynamical Systems in Neuroscience*, by Eugene M. Izhikevich, is a good introduction to brain modeling.

**Grading:** Based on weekly *three-hour laboratory exercises* performed in groups of two. There will a *write-up* due each week, as well as a *data blitz*, where one group will present their results to the class.

**Late policy:** Lab write-ups are due at the beginning of the following week’s lab session. It is a third of a grade off the first day an assignment is late, and another third of a grade off the second day. Assignments more than two days late will not be accepted. Prelabs are also due at the beginning of your lab section; it is a full grade off that lab if they are not completed by then.
Topics:

Overview
- Systems Neuroscience and Neural Modeling

Synapse and Neuron Models
- Synaptic Cleft and Receptor
- Integrate-and-Fire Neuron
- Accounting for Positive-feedback

Neuron Behaviors
- Frequency Adaptation
- Bursting

Neuron Interactions
- Phase Response Curve
- Two-Neuron Example

Inhibitory Networks
- Rhythms and Synchrony
- Role of Delay

Excitatory-Inhibitory Networks
- Entrainment
- Binding

Synaptic Plasticity
- Spike-Timing Dependent Plasticity
- Poisson Spike Trains

Plasticity in Action
- Enhancing Synchrony
- Sources of Variability

Associative Memory
- Storing Patterns
- Recall Performance

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