Topics in Theoretical and Computational Neuroscience II

MATH 6397
Lectures: MW 4-5:30 in 347PGH

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Textbooks:

P. Dayan and L.F Abbott: **Theoretical Neuroscience**
Bialek, et al: **Spikes**
H.R. Wilson: **Spikes, Decisions, and Actions**
C. Koch and I. Segev, eds.: **Methods in Neuronal Modeling - 2nd Edition**
C. Koch: **Biophysics of Computation: Information Processing in Single Neurons**
W. Gerstner and W. Kistler: **Spiking Neuron Models**
P. Tass: **Phase Resetting in Medicine and Biology**
F. Hopppensteadt and E. Izhikevich: **Weakly Connected Neural Networks**
I will also make use of the materials at Bard Ermentrout's website:
http://www.math.pitt.edu/~bard/classes/compneuro
In addition, several papers that we will use during the semester will be posted on the website.

General Remarks:

This course is a continuation of the first semester of the course on mathematical models of neuronal function. During this semester we will discuss two main topics: the neural code, and the dynamics of neuronal networks. Since the present understanding of these topics is much more limited (and controversial), than the ones we covered last semester, I will choose representative examples of several approaches to the problem that have appeared in the literature during the past decade.

The course is designed for advanced undergraduate and graduate students in mathematics, physics, engineering and the biological sciences and will be centered on modeling of neurons.

Computers:

Some homework problems will require the use of Matlab, while others will require the software package XPP.

The software package XPP (available at **http://www.math.pitt.edu/~bard/xpp/xpp.html)** will be used for all simulations which will be assigned as homework. This is a free package with versions that run under UNIX and Windows. I strongly suggest that you install this software on your personal computer. XPP is also installed on the computers in the Mathematics Computer Lab. These computers will be accessible during the week, and I will ask for an account to be created for everybody who needs one.

Please arrange to have some access to XPP by the end of the first week in order to finish the first assignment.

Do not send email to Bard Ermentrout about any problems with this software without asking your systems administrator, computer tech, or myself first. In particular he does not maintain the Windows version actively (I have checked it with several versions of Windows, and it works fine). Also there are several X-windows emulators that you can use to run the UNIX version of XPP (see Prof. Ermentrout's page for details).

Prerequisites:

The only prerequisite is a course on differential equations, such as MATH 3331, and some knowledge of probability theory.

How to get in touch with me:

The best way to get in touch with me is by e-mail. Use it if you have a question that can be answered quickly, or need to set up an appointment to see me outside of my office hours.

Homework:

During this semester the homework will consist of two parts. Each two weeks or so I will assign a paper for you to read, as well as a set of problems. You will need to turn in solutions to the problems as well as a brief report on the paper:

Paper report: This report does not have to be long - about one page or so will suffice. You should try to briefly explain the main ideas of the paper, as well as point out problems with the method or conclusion that you may have thought of during the reading. Think of this as a summary you would keep in your files to remind yourself in 10 years what the paper is about.

There will be 6 homework assignments during the semester. Each assignment will be due approximately two weeks after it was assigned. You are free to work together, however the work you turn in must be your own. In other words you are encouraged to work together on solving the problems, but not simply copy the solutions from other students. You also must each run your own simulations. It is best that you write up the solutions on your own, and not in a group.

Final Project:

In addition to the homework there will be a final project for the class. This will be a project on a topic of your choice. The only requirement is that the project involves theoretical and computational neuroscience. I will be glad to provide suggestions, but feel free to look through the textbooks above for topics that I will not cover in class. If you are currently doing research in neuroscience, feel free to present your work.

You will work on the projects in teams of 2 or 3. Each team will give a 25 minute presentation on this topic during the last class period and during the time that is scheduled for the final.

You will need to submit a topic for your presentation by April 1

Attendance:

Attendance is strongly encouraged.

Grades:

Grades will be assigned on the following basis:

70%	homework
30%	final project

Academic Honesty:

Dishonesty includes cheating on your homework, falsifying data, and misrepresenting the work of others as your own (plagiarism). I will take all instances of academic dishonesty very seriously. I urge you to read the sections of the student handbook discussing academic dishonesty and the disciplinary actions it entails.

List of Topics Covered:

1. Discussion of the neural code, with particular examples from the visual cortex. I will follow the book by Dayan and Abbott, and the book by Bialek, et al, as well as the review article by Koch and Gabbiani (it will be available on the course website).

2. Deterministic models of small networks: phase models. We will discuss the principles of the phase reduction technique, and devote our attention to the implications of the technique to the analysis of the dynamics of small networks (a few oscillators). Notes by Ermentrout and the book by Wilson will be followed.

3. Deterministic models of small networks: geometric singular perturbation theory. In certain models, the oscillators can be assumed to be of the relaxation-oscillation type. I will follow a review by Rubin and Terman of these types of models.

4. Large populations of phase oscillators. I will start by discussing the result of Strogatz and Mirollo on synchrony in a large population of phase oscillators. Following the book by P. Tass we will then focus on Kuramoto type models in neuroscience.

5. Plasticity. This topic will be discussed following the last part of the book by Dayan and Abbott.