G80.2221 – Fall 2002
Mathematical Tools for Neural Science

Course Description

Instructor: Eero Simoncelli

TA: Brian Lau

Brief Description: A graduate course covering basic tools for analysis and modeling of neural systems and data. The goal of the course is to provide basic mathematical and computational tools necessary to solve data analysis and modeling problems, the transformations of raw data into a form in which these tools may be utilized, and the interpretation of such analyses. Lectures on each topic will include some mathematical background, derivation of basic results, and examples relavent to neural science. The course will include weekly problem sets based on the MATLAB software package.

Format: The course consists of two 2-hour lectures per week. A portion of this time is devoted to introducing materials in the computer laboratory. The course includes a sequence of homework assignments (roughly every two weeks), primarily in the form of computer exerercises, to examine the lecture topics in terms of concrete and realistic problems. Grades are based on homework.

Course materials: There is no textbook for this course. Supplementary reading materials will be handed out in class. In addition, all materials will be available as Acrobat (pdf) files from the course web site:

`http://www.cns.nyu.edu/~eero/math-tools/`

Alternatively, they are available on any machine with access to the CNS file system, from directory

`/users/eero/math-tools/`

Topics: **I. Linear Methods in Data Analysis:** Basics of linear algebra, vector spaces, matrices, least-squares fitting, Principal Components Analysis, total-least-squares, linear discriminants.

II. Differential Equations: Basic ODE's, membrane models, Hodgkin-Huxley and other spiking models, coupled diffEQ's.

III. Linear Systems Theory: Convolution, Fourier Transforms, sampling.

IV. Uncertainty & Statistics: basic probability, estimation, bias/efficiency, significance tests, bootstrapping, decision theory / signal detection theory, stochastic models of neurons, experiments and data analysis with stochastic stimuli (e.g. reverse correlation).