Syllabus for Computational Neuroscience, NEUR 4030/6030

Class information: T/R 2:50-4:35pm, GCB 707
Instructor: Dr. Robert Clewley, PSC 812, (tel) 3-6420, (email) rclewley@gsu.edu
Office Hours: T/R 4:45-5:45pm, PSC 812, and by appointment.

Course Description: A project-based course giving maximal exposure to model building and hypothesis testing. Each student will keep an electronic laboratory journal of simulation results, describing the scientific question, the model used, the specific simulations, including all parameter values, the results, analysis and interpretation. This course gives a broad introduction to major topics in the modeling of cellular (single cells and ion channels) and systems (small and large network) in neuroscience, through the use of graphical methods and computational tools. Students will discover the integral role of this field in both experimental and theoretical neuroscience. Grades will be based on project work, quizzes, and in-class presentations.

Target Audience: The course is designed for upper level students with a Neuroscience major or non-majors with an interest in quantitative methods for neuroscience. Students must have had a previous core course in neuroscience at the 3000 level, Calculus I&II (MATH 2211/2) and Principles of Physics I & II (PHYS 2211/2K). Physics II may be taken as a co-requisite in 2012.

LEARNING OBJECTIVES AND EXAMPLE COURSE CONTENT

- Appropriate use of basic concepts for ion channel and single cell modeling, possibly including:
    - I-V curves, the Hodgkin-Huxley model of action potential generation, and simple kinetic models of ion channels, integrate-and-fire approximation
    - Mathematical representations of conductances, currents, and their relationship to dynamic changes in nerve cell behavior, including the measurement of relative time scales, phase response curves, phase plane diagrams, equilibria and oscillatory states (tonic spiking, bursting).
- Appropriate use of basic concepts for network and system modeling, including:
    - Principles of feedforward and feedback connectivity
    - Coding of information in the nervous system – spikes versus rates
    - Firing-rate network models, spatial activity (waves, etc)
    - Central pattern generator networks
    - Learning at the network and synaptic level: Hopfield network, Hebb's rule, plasticity
- Use of these models and associated methods to predict qualitative functional outcomes or quantitative state changes when varying parameters or changing structural properties of the models.
- Competence in one or more software tool that facilitates the calculation of such predictions (PyDSTool environment, see http://pydstool.sourceforge.net, will be

provided via GSU's Virtual Computing Laboratory, for remote login on and off campus).

- Understand and appreciate the integral role of computational techniques and concepts in neuroscience:
    - Study and critique review papers relating the use of computational techniques to the broader development of theories and experimental methods in neuroscience.

ASSESSMENT

Students will write up four simulation-based projects, timed at equal intervals during the semester. The projects will involve studies of model scenarios, chosen from the range of scales of representation that will be discussed in class. **Undergraduate students** will be expected to reproduce a basic modeling result from a list of published studies (under the guidance of the instructor). Each project report submission will include a brief summary of the published study, a rationale for the model, a description of the simulations and mathematical techniques used, results and their interpretations. In addition, **graduate students** and **honors undergraduate students** will be required to make a modest extension of a published result from the same list (with the assistance of the instructor, and possibly through directed reading in the research literature). Furthermore, graduate and honors students will present their study in class. Submissions will be graded based on both content and clarity of communication.

Quizzes given throughout the semester will ensure that students have understood and practiced the theoretical and conceptual principles discussed in class.

Primary textbook: H. Wilson - Spikes, Decisions and Actions, OUP. Other study materials and computer tutorials will be provided by the instructor, as needed. Text is available for free at: http://cvr.yorku.ca/webpages/wilson.htm#book

Reference texts (on 2-hr reserve in the university library):

- T. Trappenberg, Fundamentals of Computational Neuroscience, OUP.
- E. Izhikevich, Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting, Springer
- T. Anastasio, Tutorial on Neural Systems Modeling, Sinauer.

Attendance:

Class attendance is mandatory. Participation in class discussions requires being in class. In addition, important announcements or material that is not contained in the text may be presented in class or by email without advance notice. Students are responsible for information given in class and via their student email account.

Grading:

Letter grades will be determined on the basis of four in-class or take-home quizzes (each worth 10%) and three project submissions (each worth 20%). The grading scale is as follows:

A+ > 95%, A 90-95%, A- 87-89%, B+ 84-86%, B 80-83%, B- 77-79%, C+ 74-76%, C 70-73%, C- 67-69%, D 60-66%, F < 60%

Makeup Policy: In-class tests may be made up **only** in the event of a verifiable excuse (e.g., a doctor's note or a police report is necessary). Absence from the final exam will result in a grade of F for the course unless arrangements are made PRIOR (at least 1 week) to its administration.

Academic Honesty:

Cheating/plagiarism will not be tolerated on any work. A first occurrence will result in a grade of 0 on the assignment for all concerned parties as well as an Academic Dishonesty form being filed with the Dean of Students. A second occurrence will result in a grade of F for the course for the concerned parties and a second Academic Dishonesty form being filed. (See the University's policy on Academic Honesty at http://www.gsu.edu/~wwwdos/codeofconduct.html)

Class evaluation:

Your constructive assessment of this course plays an indispensable role in shaping education at Georgia State. Upon completing the course, please take time to fill out the online course evaluation.

Accommodations for disability:

Students who wish to request accommodation for a disability may do so by registering with the Office of Disability Services. Students may only be accommodated upon issuance by the Office of Disability Services of a signed Accommodation Plan and are responsible for providing a copy of that plan to instructors of all classes in which accommodations are sought.