MA666: Advanced Modeling and Data Analysis in Neuroscience

(Fall 2012)

Instructor:	Mark Kramer (mak@bu.edu)
Course Hours:	October 25 - December 6/11 [7 weeks] 12:30-2:00 PM / TTh, MCS B23
Office Hours:	2:00-3:30 PM / TTh, Math & Stats Room 224, or by appointment
Textbook:	*MATLAB for Neuroscientists*, Academic Press; 1 edition + Handouts . . .
Course Website:	http://math.bu.edu/people/mak/MA666/
Prerequisites:	Graduate standing and calculus or consent of instructor.

This course is intended for neuroscience graduate students with more advanced mathematics backgrounds (including specifically an undergraduate course in differential equations) and interest in learning mathematical concepts in neuroscience. We will use experimental observations in neuroscience to motivate the study of mathematics, both to quantify the observed data and build biophysical models. The course will build on the material covered in MA665, and provide a focused overview of mathematical neuroscience, with emphasis on quantifying neurophysiological time series and developing mathematical models of the activity observed. Neuroscience topics will span the spatial scales of brain activity from spike trains of individual neurons, to local field potentials of small neural populations, to the electroencephalogram recorded at the scalp surface. The mathematical models will include both simple statistical models and dynamical systems models utilized in neuroscience research. An important component of the course will include an introduction to scientific computing in MATLAB and specialized dynamical systems software. Students completing this course will develop computational skills essential in interdisciplinary neuroscience research and in more advanced neuroscience courses offered at BU.

Course goals

To introduce more sophisticated mathematical concepts encountered in neuroscience research and more advanced neuroscience graduate courses. To teach basic programming skills in MATLAB. To think about neuroscience in a quantitative way.

Course requirements

You are required to attend lecture and a computational laboratory section each week, and complete weekly readings (assigned in the textbook, provided as handouts, or posted on the course website). The computational lab will be held in LSEB Room B03. **Homework** will be assigned each week, sometimes in lecture but usually during lab. Most assignments will involve "Challenge Problems": executing and interpreting computer code in MATLAB. You will be asked to complete one or more Challenge Problems each week. Typically the Challenge Problems will be assigned in Lab (on Thursday) and due within one week. You are encouraged to work in groups, but please submit your own written or typed solutions to each homework problem and a list of your collaborators. Please arrange with me late assignment submissions in advance of the due date. There will be no exams in this course.

Grades

To earn an "A", the general requirements are: attend all lectures and labs, correctly complete all assigned challenge problems. To earn an "A-", the general requirements are: attend all lectures and labs, attempt seriously all assigned challenge problems. To earn a "B+", the general requirements are: attend all lectures and labs, attempt seriously most assigned challenge problems. To earn a "B", the general requirements are: attend all lectures and labs, attempt seriously some assigned challenge problems. To earn a "B-/C", the general requirements are: miss lecture and lab, fail to seriously attempt challenge problems.

Tentative Course Schedule

(NOTE: All readings are optional, unless otherwise indicated.)

Week 1 (8)
Oct 23 - NO CLASS
Oct 25 - *Lecture*: Linear measures of coupling, cross correlation and coherence.
Oct 30 - *Lab*: Computing cross correlation and coherence.
Reading: Pereda et al. Prog Neurobiol, 2005: First 3 pages!
Bruns. J Neurosci Methods, 2004: First 3 pages!
Handout #4.

Week 2 (9)
Nov 1 - *Lecture*: Cross-frequency coupling and bicoherence
Nov 6 - *Lab*: Application of cross frequency coupling and bicoherence
Reading: Tort et al. J Neurophysiol, 2010.
Canolty and Knight. Trends Cogn Sci, 2010.
Kramer et al. J Neurosci Methods, 2008.
Handout #5

Week 3 (10)
Nov 8 - *Lecture*: Relating spikes and fields through coherence.
Nov 13 - *Lab*: The spike train spectrum and spike-field coherence.
Reading: Jarvis and Mitra. Neural Comp, 2001.
Gregoriou et al. Science, 2009.
Handout #6

Week 4 (11)
Nov 15 - *Lecture*: Fixed points and nullclines in a simple neuronal model.
Nov 20 - *Lab*: Fitzhugh-Nagumo and XPPAUT.
Reading: Koch, 7.1 and 7.2
XPPAUT Help = http://www.math.pitt.edu/~bard/xpp/help/xpphelp.html

Week 5 (12)
Nov 27 - *Lecture*: Bifurcations, and the zero eigenvalue, in a simple neuronal model.
Nov 29 - *Lab*: More Fitzhugh-Nagumo and XPPAUT.
Reading: Koch, 7.1 and 7.2
XPPAUT Help = http://www.math.pitt.edu/~bard/xpp/help/xpphelp.html

Week 6 (13)
Dec 4 - *Lecture*: Real-life models: gamma (ING, PING, sparse PING).
Dec 6 - *Lab*: Constructing network rhythms.
Reading: Whittington et al., Int J Psychophysiol (2000) vol. 38 (3) pp. 315-336

Your conduct in this course, as with all BU courses, is governed by the BU Academic Conduct Code. A copy of the code is available,

http://www.bu.edu/academics/files/2011/08/AcademicConductCode.pdf

Violations of the code are punishable by sanctions including expulsion from the University.

Week 7 (14)
Dec 11 - ? Data Challenge Open Mike? Networks in neuroscience ?