Biomathematics 98T – Spring 2007

***In Silico* Man: Simulation of the human body in biomedical research**

Instructor: Robert Rovetti, Department of Biomathematics
Location: CHS AV-139, Tuesday/Thursday 12:30 – 1:50 pm
Office Hours: CHS AV-528 (as posted or by appt)
Class Webpage: Accessed via `http://www.lsic.ucla.edu/classes/spring07/`
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Course Description

There is an exciting, cutting-edge interface between mathematics and medicine, where today's scientists use powerful computers and their extensive knowledge of biology to push the boundaries of research into how the human body works. This course will be an exploration into the use of computer simulation in biomedical research in both academic and commercial settings. We will look at the use of mathematical and statistical modeling to analyze and understand the molecular, cellular and systems biology of human physiology.

Although the field of biomedical simulation is vast and rich in detail, in this introductory seminar we will focus on developing a familiarity with general approaches of the field and what possibilities exist. The goal is to open your eyes to the future of biomedical research. Emphasis is placed upon understanding how a complex biological systems is translated, or "mapped", onto a modeling framework, and how that process is reflected both in the history of medicine as well as current representations of simulation and technology in popular culture.

We will also emphasize practical skills. A successful career in scientific research requires one to not only be smart, but to work well in a team environment and to communicate your ideas to others. While we will learn about the methodology of modelling through various example applications, we will also strive to strengthen our skills in communication and comprehension, such as:

1) reading a scientific essay or scholarly paper and summarizing the main points even when you don't understand all the details
2) creating an effective presentation: the rewrite process and getting help from others
3) delivering an effective presentation: what to say and how to say it

Course Requirements: Overview

<u>Writing and presentation assignments</u>

This couse places an emphasis on weekly reading and writing. Weekly reading selections (either popular science/historical essays or scholarly research articles) will give each student the chance to formulate discussion questions to bring to the class. In addition, two special projects will be assigned: (1) a short essay on the public perception of simulation, and (2) a term reseach project on a commerical application of computer simulation in biomedicine.

In conjunction with the term research project, we will also develop 10-min oral/visual presentations to be presented at the end of the quarter. We will take some time during mid-quarter to evaluate each other's progress.

See the expanded section on "Writing Assignments" below for details.

Weekly in-class discussions

One (or several) persons will be selected each week for each reading to share his/her summary and questions and begin the discussion. When it is your turn to present, you are more than welcome to come to the instructor beforehand to discuss the assignment. All students are expected to have read the material before class and to contribute to the discussion. The discussion is an opportunity for all of us (including the instructor!) to learn about the topic at hand.

"Hands-on" computer activities

On specified days we will meet at an alternative location where will be explore the use of various computer software programs and get a taste of how modeling really works. You are responsible for remembering when and where these computer lab activities occur.

Evaluation

Class participation in discussion / in-class and extramural activites	15%
Weekly reading summaries	25%
Short Essay	10%
Term project – written report (draft)	10%
Term project – written report (final)	20%
Term project – oral presentation	20%

Required Texts

Course Reader: "Biomathematics 98T (2007)", available at Course Reader Materials (Westwood)
Text: Boorstin, Daniel. "The Discoverers" New York: Vintage Books, 1983.

Academic Policies

Attendance at every class is expected and mandatory; an absence may affect your class participation grade. Assignments are due **at the beginning of class** on their due day. No late work will be accepted without prior approval or a documented emergency. In cases where group/team projects are assigned, each student must demonstrate equal participation; or the entire team is subject to a lower grade for that project. You may find UCLA's policies on academic dishonesty at
http://www.deanofstudents.ucla.edu/studentconduct.htm

Course Requirements: Writing Assignments

Weekly readings

The readings will be of two types: (1) published texts or scientific research articles published in peer-reviewed journals, meant to provide scientific knowledge, and (2) essays on various aspects of scientific thinking or philosophy. A one-page single-spaced summary of each the assigned readings for that day will be due at the beginning of class. It is normal to not understand everything you read; thus your summary should include at least two questions about the material you would like to have answered ("I did not get it" is too broad; try to be specific!).

Short Essay on "Simulation in the Public Eye"

Computer simulation plays an important but largely obscured role in the popular media over the current studies on global climate change. Based on readings provided by the instructor and additional reading you will seek out on your own, reflect upon how simulation plays a role in the current controversy over global warming. How does the public understand and react to the phrase "scientists predict that…."? What kind of explanation of computer modeling is ever offered to the public? Do politicians take advantage of public ignorance?

Then, take your observations and creatively extend them to the use of simulation in medicine – what future issues might develop as simulation becomes more widespread and has more impact?

Term Projects

During the quarter students will work in pairs to develop a research paper and oral presentation on a topic related to this course. The orientation of the research topic should be a particular computer or mathematical modeling application or technology that is in *current actual use* in medical practice, biomedical industry, or as depicted in popular media (television or movies). Your paper should give details on the background of the biological problem or question, what technology is used to solve the problem and how it is implemented, and some actual results or consequences of the practical use of the technology.

Your research should focus on existing simulation methods and known problems in medicine or biology. You are not expected to develop new computational methods or discover a new disease! Rather, you should demonstrate understanding of available simulation methods, how to connect them to novel biological problems, and the general issues surrounding simulation in medicine. Be creative! Again, you are encouraged to come speak to the instructor if you find yourself becoming stuck.

There will be a series of assignments for this term project, to be turned in at various times throughout the quarter. All writing assignments should be double-spaced with one-inch margins and 12 pt font. The final report should be 12 pages long. Students will work in teams of two; you should present your findings as a pair, and write a joint report.

The following milestones should be met:

April 19 (Week 3): Turn in to instructor:
1) A one-page summary of chosen biological area and related technology.
2) A draft list of sources of information (journal references, news articles, web pages, etc).
3) A short "team plan" (less than one page) on how you and your partner will divide up / coordinate responsibility for the project.

May 3 (Week 5): Turn in to instructor:
Five-page progress report / draft. By this time you should have summarized the main elements of the biological area and the modeling technology.

May 22 (Week 8):	Bring draft of presentation slides to class for group review. Each group will choose one representative to informally present the material to another group, who will *politely* offer their comments about how it can be improved. This in-class activity is meant to foster communication skills as well as skills in editing other people's work.
Weeks 9/10:	Give 10-minute oral presentation of project to class. Both members of each pair should divide up the speaking responsibilities equally. During each presentation, the remaining students in the audience should take brief notes on the other presentations, focusing on what especially impressed you about each presentation.
Tuesday, June 12:	Turn in 15-page written final package. The final report will include: 1) Your 12-page research paper (written together as a team) 2) A one-page evaluation of how your team worked together as a group, and how you felt the other member contributed to the project 3) Two pages containing short (one paragraph) evaluations of the oral presentations of the other teams.

Tentative Course Outline

Class Date	Topics/Activites
Tue, April 3 Week 1	Introductions, Orientation
Thu, April 5	**Lecture**: (1) Computers, algorithms, and simulations. (2) On reading research papers. **Discussion**: "The Relativity of Wrong" (Reader, p. 3) **Discussion**: "On Number Numbness" (Reader, p. 19)
Tue, April 10 Week 2	**Discussion**: "Models of Systems" (Reader, p. 123) **Discussion**: "The Modelling Process" (Reader, p. 137) **Discussion**: Boorstin, Part 9 **Lecture**: Models with random numbers
Thu, April 12	**Discussion**: "A Stochastic Model of Pulmonary Platelet Production"
Tue, April 17 Week 3	**Discussion**: "Life, Love and Death: Models of Biological Reproduction and Aging" **Discussion**: "Why Sex – Are Men Useful for Anything?"
Thu, April 19	**Lab**: Simulating random processes with Excel (Group A)
Tue, April 24 Week 4	**Lab**: Simulating random processes with Excel (Group B)
Thu, April 26	**Discussion**: "Breathing at Depth: Physiologic and Clinical Aspects of Diving while Breathing Compressed Gas" **Discussion**: "The Physiological Kinetics of Nitrogen and the Prevention of Decompression Sickness" **Discussion**: "A Theoretical Model for the Computation of Decompression Tables for Divers" **Discussion**: "Numerical Phase Algorithm for Decompression Computers and Application" **Lecture**: First-order ODEs – understanding, and simulation. In-class demo of software.
Tue, May 1 Week 5	**Discussion**: "Hormonal Control in Mammals" (Reader, p. 153) **Discussion**: Boorstin, Part 10 **Lecture**: Statistics, Regression, and Optimization
Thu, May 3	**Discussion**: "A Mathematical Model of the Time Course of Myelosuppression Resulting from Cancer Chemotherapy" (Reader, p. 227)

Tue, May 8 Week 6	**Discussion**: "Simulation in the Public Eye" writing assignment
Thu, May 10	**Discussion**: "Mathematical Chaos and Strange Attractors" (Reader, p. 41) **Discussion**: "Integrative biological modeling *in silico*"
Tue, May 15 Week 7	**Discussion**: Paper on Cardiac Modelling (TBD) **Lecture:** On making an oral/visual presentation
Thu, May 17	**Discussion**: "Procedural Simulation: A Primer" **Discussion**: "A Brief History of the Development of mannequin simulators for clinical education and training"
Tue, May 22 Week 8	**Discussion:** Boorstin, Part 11 **Presentations**: Group Review and Editing
Thu, May 24	**Discussion**: "Mathematics, Clinical Decisions, and Public Health" (Reader, p. 167) **Discussion**: "A computer model for the study of breast cancer"
Tue, May 29 Week 9	**Discussion**: "The Radon Transform and Its Applications to Medicine" (Reader, p. 191)
Thu, May 31	**Begin Group Presentations** **Discussion:** Boorstin, Part 12
Tue, June 5 Week 10	**Finish Group Presentations**
Thu, June 7	**Discussion**: "The Turing Test: A Coffeehouse Conversation" (Reader, p. 75) **Discussion**: "The Soul of the Mark III Beast" (Reader, p. 103) **Discussion**: "The Seventh Sally, *or* How Trurl's Own Perfection Led to No Good" (Reader, p. 111)

Additional Reading List – Research Articles

Carter KJ, Castro F, Kessler E, Erickson B. A computer model for the study of breast cancer. Comput Biol Med. 2003 Jul;33(4):345-60.

Cooper JB, Taqueti VR. A brief history of the development of mannequin simulators for clinical education and training. Qual Saf Health Care. 2004 Oct;13 Suppl 1:i11-8.

Dawson S. Procedural simulation: a primer. J Vasc Interv Radiol. 2006 Feb;17(2 Pt 1):205-13.

Doolette DJ, Mitchell SJ. The physiological kinetics of nitrogen and the prevention of decompression sickness. Clin Pharmacokinet. 2001 Jan;40(1):1-14.

Gorensson A, Lundgren C, Lundin G. A theoretical model for the computation of decompression tables for divers. 1963; Nature, 27 July

McCulloch AD, Huber G. Integrative biological modelling in silico. Novartis Found Symp. 2002;247:4-19

Stauffer D. Life, Love and Death: Models of Biological Reproduction and Aging. Institute for Theoretical physics, Koln, Euroland, 1999.

Stauffer D. Why sex-are men useful for anything? Comp Sci Eng. 1999;1(78)

Tetzlaff K, Thorsen E. Breathing at depth: physiologic and clinical aspects of diving while breathing compressed gas. Clin Chest Med. 2005 Sep;26(3):355-80

Trowbridge EA, Harley PJ. A stochastic model of pulmonary platelet production. IMA J Math Appl Med Biol. 1988;5(1):45-63.

Wienke BR. Numerical phase algorithm for decompression computers and application. Comput Biol Med. 1992 Nov;22(6):389-406.