MATH 728B, Spring 2013 (Syllabus)

Modeling and Computation for Complex Biological Systems

Instructor Information

Xinfeng Liu
Email: xfliu@math.sc.edu
Phone: 576-5849
Office Hours: MW 10:30-12:00
Meeting Time: MWF 12:20-1:10
Meeting Location: LC 303B

Reference Textbooks

1. An Introduction to Systems Biology: Design Principles of Biological Circuits, by Uri Alon.
2. Mathematical Biology II: Spatial Models (3rd Ed.), by J.D. Murray, Springer-Verlag, New York, (2002).
3. Mathematical Models in Biology, by Edelstein-Keshet.
4. An introduction to Stochastic Modeling, (4th Ed.), by Samuel Karlin and Howard Taylor.

Subject Materials

This course introduces the interdisciplinary topics for graduate students at the interface of mathematics and biology, and it covers very comprehensive techniques for mathematical modeling and computations which arise from various biological applications, ranging from cell biology, signaling networks to pattern formation, cancer cells and tumor growth. This course is self-contanied, and no prerequisite is needed. It will mainly focus on various models for biomedical processes based on discrete models and ordinary/partial differential equations on the continuous level.

Tentative Schedule

1. Week 1-2: Review of ordinary/partial differential equations: mechanics, chemical kinetics, fundamental laws and constitutive relations.
2. Week 3-4: Signal transduction, signaling networks and systems biology perspective.

3. Week 5: Turing model and pattern formation.
4. Week 6-7: Stochastic modeling, Monte Carlo (MC) methods and Molecular Dynamics (MD) simulations.
5. Week 8: Introduction of simulation packages for MD (Amber).
6. Week 9: Numerical schemes for solving ODEs.
7. Week 10: Numerical methods for reaction-diffusion equations.
8. Week 11-12: Numerical methods for convection-diffusion equations.
9. Week 13: Convergence and stability analysis.
10. Week 14-16: Modeling and computation of cancer stem cells and tumor growth.

Learning Outcome

This course will expose the students with start-of-the-art mathematical modeling and computational tools to study complex systems that arise from a great variety of biological and engineering applications. At the end of this course the students will have a comprehensive understanding of fundamental mathematical concepts and numerical techniques for solving complex systems. The students are also expected to master the skills to build mathematical models, and develop fast numerical solvers to efficiently solve these models, and perform data analysis to explain biological phenomena.

Projects

There will be weekly take-home projects, two midterm projects and a comprehensive final project.

Grades

Weekly Projects (25%)
Midterm Project 1 (25%)
Midterm Project 2 (25%)
Final Project (25%)

Reading

Reading the reference textbooks **in advance** of the lecture is strongly encouraged. Benifits of this preparation include obtaining a familiarity with the terminology and concepts that will be encountered (so you can distinguish major points from side issues), being able to formulate questions about the parts of the presentation that you do not understand, and having a chance to review the skills and techniques that will be needed to apply the new concepts.

Attendance

Attendance at every class meeting is important - and expected. Students missing more than 10% of the class meetings (4 days) can have their grade lowered.

Academic Dishonesty

Cheating and plagiarism in any form is not tolerated. If a student is caught cheating, I will follow the guidelines as set forth in the USC Honor Code and other University guidelines.