Math 227C

Mathematical Biology: Stochastic modeling and statistical modeling

Syllabus

Time: MWF 11:00am-11:50pm

Instructor: Jun Allard *jun.allard@uci.edu*

Office hours: By appointment

Course website: https://canvas.eee.uci.edu/

Course repository: https://github.com/allardjun/Math227C/

Textbook: No required textbook. We will draw from:

- **Stochastic Models in the Life Sciences and Their Methods of Analysis by Frederic Wan**
- **Introduction to Statistical Learning using R by James, Witten, Hastie and Tibshirani**, available free online
- **Deep Learning by Goodfellow, Bengio, Courville,** available free online
- **Modern Statistics for Modern Biology by Holmes and Hubert**, available free online

Resources:

- The repository will be updated throughout the course, including with lecture notes. A convenient way to rapidly synchronize a copy onto your computer is using **git**, available openly online.
- In the second part of the course, we will make use of **Jupyter notebooks and the R programming language**. The easiest way to install Jupyter and R on your machine is through Anaconda, available openly online. We plan to start using Jupyter around Week 6. During these weeks, it would be valuable to have a laptop in-class.

Course rationale: This course follows MATH 227A and 227B in establishing mathematical and computational tools useful in modeling the dynamics of biological systems. This course, MATH 227C, is in two parts: the first covers stochastic processes, where randomness plays a role in the system behavior; the second covers statistical modeling, where models, including their attributes such as parameters, are learned from data in the presence of noise or inherent randomness in the model.

Course outline

Part I: Stochastic modeling

1. Probability and random variables *with applications to* protein-protein interaction networks,
2. Discrete-time Markov chains *with applications to* introns, exons and splicing variants
3. Poisson processes and continuous-time Markov chains *with applications to* DNA loci detection, receptor agonist-antagonist interactions
4. Ordinary differential equations with parametric noise *with applications to* cellular heterogeneity

Part II: Statistical modeling

5. The likelihood function and maximum likelihood estimation *with applications to* pediatric pharmacokinetics
6. The variance-bias tradeoff and cross-validation *with applications to* flow cytometry
7. High-dimensional data: Lasso regression and related methods *with applications to* microbiome
8. Bootstrap *with applications to* liver disease
9. Bayesian inference: Metropolis Hastings *with applications to* biochemical rate

Grading scheme: There will be **11 Problem Sets.** You are encouraged to work together to find solutions to the Problem Sets. In-class time will be devoted to this. Every student must hand in solutions, and the solution must be typeset (using e.g., latex, Microsoft Word, Jupyter notebooks, Mathematica notebooks, …) and handed in online through the Canvas system. The final grade will be composed of problem set scores, with the lowest score removed.

Academic integrity: Students are responsible for informing themselves of UCI's policies regarding academic dishonesty. Students found in violation of the code are subject to penalties ranging from loss of credit for work involved to a grade of F in the course, and possible risk of suspension or probation. The academic dishonesty policy will be enforced in all areas of the course, including homework, quizzes, and exams. For more information about the academic dishonesty policy and procedures, including information about your rights and responsibilities as a student, see:
http://www.editor.uci.edu/catalogue/appx/appx.2.htm

Adding and Dropping the Course: During the first two weeks of class, all add/drop changes are made online. There is also an online waitlist for the course if it is full. For more information please see the official guidelines at: http://www.math.uci.edu/courses/policy.php

Special Needs Students: Contact me privately or the UCI Disability Services Center.

Student Wellness: Your professors want you to thrive at UCI, and we believe that your physical and emotional well-being are the pathways to getting there. We encourage you to do your best to maintain a healthy lifestyle this quarter by eating well, exercising, getting educated about the effects of illicit drugs and alcohol, getting enough sleep, and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. If you are interested in what you can do to promote wellness in yourself and others, visit the Center for Student Wellness & Health Promotion (studentwellness.uci.edu; 949-824-9355). This office, along with many other offices at UCI, can point you to campus resources that promote physical activity, good nutrition, and stress management. For other issues, consider reaching out to the Counseling Center (counseling.uci.edu; 949-824-6457). There are professionals there who can help with feelings of anxiety and depression, and who can provide guidance and support on a variety of concerns. Last, if you are concerned about a life threatening situation, we encourage you to contact the UCI Police Department at 9-1-1.