BME 6086-017: Advanced Methods for Biomedical Signal Analysis

Credits and Contact Hours: 3 Credits (One 180-minutes lecture per week)

Lectures: Thursdays: 5:00pm – 8:00pm CASTLEMAN – room 204

Instructor: Sabato Santaniello, Ph.D.

Office Hours:
Mondays: 10:30am – 12:30pm (walk-in). BRONWELL – room 308
Otherwise, by appointment as needed.

Textbook:
Analysis of Neural Data, Robert E. Kass, Uri Eden, Emery N. Brown (2014). ISBN: 978-1-4614-9602-1

***Other Supplemental Materials*:**
Course handouts and scientific articles relevant to course topics covered.

Course Website:
Copies of the course syllabus, assignments, and supplemental materials will be posted online at the HuskyCT class site. Students are responsible for announcements and assignments posted on the HuskyCT class site. Please check it regularly.

***Specific Course Information*:**
a. Description:
Biomedical signals like ECG, EEG, and LFP are typically non-stationary and have complex features often masked by noise and other interfering signals. The course will introduce advanced statistical methods to deal with these characteristics and to properly model and analyze biomedical signals in various domains of application. The students will get hands-on experience in applying the methods learnt in class to real world problems and a course project will provide the opportunity to explore current problems in biomedical signal analysis, with specific application to neural and ECG data. Topics will include multivariate probability distributions, estimation, model uncertainty, bootstrap, sequential hypothesis test, nonlinear regression, Poisson and generalized point processes, Markov chains, and Bayesian estimation.

b. Prerequisite: Undergraduate-level knowledge of probability theory, signal processing, electromagnetism, biomedical instrumentation, and MATLAB (equivalent to CSE 1010, ECE 3101, STAT3025Q, and BME 3500)

c. Required, Elective, or Selected Elective*:* Elective.

***Grading*:**
- Homework: 10%
- Midterm Project: 40%

- Final Project: 40%
- Micro-teaching: 10%

Topics Covered:

- Random vectors
- Maximum likelihood estimation
- Generalized linear models
- Poisson processes
- Point processes
- Time-rescaling theorem and Kolmogorov tests
- ROC analysis
- Nonlinear regression
- Nonparametric models
- Bayesian estimation
- Adaptive filtering
- Markov chains and hidden Markov models
- Change-point detection
- Neural networks and graph models
- Numerical analysis in MATLAB

Course Objectives and Outcomes:

The objective of this course is to learn the basic concepts and tools for modeling and analyzing biomedical signals, with specific focus on nonstationary and multivariate physiological time series (e.g., EEG, ECG, single unit neural recordings, and local field potentials). Through a mix of lectures and hands-on experiences, the students will learn how to use advanced statistical tools and numerical methods to describe the temporal dynamics of biomedical signals, how to validate data-driven predictive models, and how to use these models to simulate physiological time series.

Policies:

a. Policy regarding Grading, Assignments, Class Participation, and Attendance:

Ten percent (10%) of the final grade will be based upon the scheduled homework. **Late homework will not be accepted** unless extreme conditions occur (e.g., medical emergency with physician's signature).

Ten percent (10%) of the final grade will be based upon the scheduled micro-teaching assignment. The assignment consist in lecturing the class on a recent methodology to analyze and model biomedical signals. The lecture lasts 60 minutes, is conducted individually by each student, and is chosen in agreement with the instructor at least 3 weeks in advance.

Forty percent (40%) of the final grade will be based upon presentation (written and oral) of an assigned midterm modeling project. Projects will involve a modeling component and a simulation component, with simulations to be conducted in MATLAB.

Forty percent (40%) of the final grade will be based upon presentation (written and oral) of an assigned final modeling project. Projects will involve a modeling component and a simulation component, with simulations to be conducted in MATLAB.

Participation in class includes answering questions (orally or written), participating in class discussions and demonstrations, and providing feedback. Students are responsible for reading assigned material **before** it is covered in class. Even if the content is not clear, the exposure will familiarize the students with the terminology and allow to focus on understanding the concepts discussed during class. Students are responsible for all announcements and other information covered in class. Students who are late or unable to attend class will have the responsibility to obtain missed information from other students.

b. Policy against Discrimination, Harassment and Inappropriate Romantic Relationships:

The University is committed to maintaining an environment free of discrimination or discriminatory harassment directed toward any person or group within its community – students, employees, or visitors. Academic and professional excellence can flourish only when each member of our community is assured an atmosphere of mutual respect. All members of the University community are responsible for the maintenance of an academic and work environment in which people are free to learn and work without fear of discrimination or discriminatory harassment. In addition, inappropriate Romantic relationships can undermine the University's mission when those in positions of authority abuse or appear to abuse their authority. To that end, and in accordance with federal and state law, the University prohibits discrimination and discriminatory harassment, as well as inappropriate Romantic relationships, and such behavior will be met with appropriate disciplinary action, up to and including dismissal from the University. More information is available at http://policy.uconn.edu/?p=2884

c. Sexual Assault Reporting Policy:

To protect the campus community, all non-confidential University employees (including faculty) are required to report assaults they witness or are told about to the Office of Diversity & Equity under the Sexual Assault Response Policy. The University takes all reports with the utmost seriousness. Please be aware that while the information you provide will remain private, it will not be confidential and will be shared with University officials who can help. More information is available at http://sexualviolence.uconn.edu/

Academic Honesty and Student Code:

Academic dishonesty of any type will not be tolerated in this class. Students should refer to the Student Code, section on Academic Integrity at http://www.dos.uconn.edu/student_code.html, for specific guidelines.

Students with Disabilities:

Students who need course adaptations or accommodations because of a disability are invited to notify the instructor as soon as possible. Students with disabilities who believe that they may need accommodations in this class are encouraged to contact the Disability Services Office (http://www.csd.uconn.edu) as soon as possible in order to ensure that such accommodations are implemented in a timely fashion.

Non-Discrimination Policy Statement:

The University of Connecticut does not discriminate on the basis of race, color, religion, national origin, ancestry, disability, genetic information, sex, sexual orientation, gender identity or expression, age, veteran status, marital status or other legally protected characteristics in all programs and activities and supports all state and federal laws that promote equal opportunity and prohibit discrimination, including the provision of reasonable accommodations for persons with disabilities. The University engages in an interactive process with each person making a request for accommodations and reviews the requests on an individualized, case-by-case basis. To request an accommodation or for questions related to the University's non-discrimination policies, please contact: Elizabeth Conklin, J.D. ADA Coordinator, Title IX Coordinator, Associate Vice President, Office of Diversity and Equity, 241 Glenbrook Road, Unit 4175, Storrs, CT 06269 Phone: (860) 486-2943 Email: ode@uconn.edu / Website: www.ode.uconn.edu

Schedule:

A tentative schedule is reported below. Students must check their email for any change.

Week	Date	Subject	Assignment Due On
1	01/21	Probability and Random Variables	HW1: 02/04
2	01/28	Random Vectors	
3	02/04	Maximum Likelihood Estimation	
4	02/11	Generalized Linear Models	Project 1: 03/10
5	02/18	Point Process Theory	
6	02/25	Point Process GLM Fitting	
7	03/03	Adaptive Filtering and Decoding	
8	03/10	**Discussion Project 1** / Change-point Detection	Teaching: 04/14
9	03/17		
10	03/24	Theory of Markov Chains	
11	03/31	Hidden Markov Models and Algorithms	Project 2: 05/04
12	04/07	Neural Networks	
13	04/14	**Micro-teaching Assignment**	
14	04/21	Undirected Graph Models	
15	04/28	In-class discussion	
Finals	**05/05**	**Discussion Project 2**	

Legend:

HW = Homework assignment
Teaching: Micro-teaching assignment
Project = Project assignment