EE599: Signal Processing and Control in Neural Systems
Units: 3
Fall 2017—Tue/Thu—9:30-10:50

Location: TBA

Instructor: Maryam Shanechi
Office: EEB408
Office Hours: Tuesdays 11:15-1:15

Contact Info: shanechi@usc.edu, 213-740-1377

Teaching Assistant: TBA
Office: TBA
Office Hours: TBA
Contact Info: TBA
Course Description
This course teaches the signal processing, machine learning, and control methods used to study neural systems and analyze neural data. Topics include state-space modeling, theory of point processes, Bayesian inference, machine learning methods, expectation-maximization (EM), and optimal control. Applications include construction of neural encoding models, system-identification in neural systems, decoding neural data, analyzing neural receptive field plasticity, algorithms for neural prosthetic control, and closed-loop control of brain states. This is a graduate-level course that is of interest to electrical engineering, computer science, biomedical engineering, and neuroscience students.

Learning Objectives
Student will learn advanced machine learning, signal processing, and control methods that can be used in various applications in general, and in the analyses of biomedical and neural data in particular.

Prerequisite(s): EE503, or equivalent, or permission of the instructor.
Co-Requisite(s): NA
Concurrent Enrollment: NA
Recommended Preparation: EE441

Course Notes
Copies of lecture slides and other class information will be posted on Blackboard. Slide presentations will be used throughout the course.

Technological Proficiency and Hardware/Software Required
NA.

Required Readings and Supplementary Materials
The following papers and books will be used as reference reading material and can be accessed through the libraries. The books will be put on reserve at the libraries but will not be required for purchase.


Description and Assessment of Assignments
This is an advanced graduate class. There will be no problem sets or exams. The course grade will be on the basis of participation, a class project, a 20min final presentation, and a final report. The final project and presentation could be on a related theoretical algorithm or on the application of the learned algorithms to neural or biological datasets. The topic should be submitted for approval by the end of the 6th week of class. The final report will be due on the last lecture.
**Grading Breakdown**
How will students be graded overall, including the assignments detailed above. Participation should be no more than 15%, unless justified for a higher amount. All must total 100%.

<table>
<thead>
<tr>
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<th>Grade</th>
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<tbody>
<tr>
<td>Participation</td>
<td>10</td>
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<tr>
<td>Final Presentation</td>
<td>35</td>
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<tr>
<td>Final Report</td>
<td>55</td>
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**Assignment Submission Policy**
The project topic should be submitted for approval by the end of the 6th week of class. The final report will be due on the last lecture. Student presentations will be in the last 3 weeks of the semester.

**Additional Policies**
NA.
Course Schedule: A Weekly Breakdown

<table>
<thead>
<tr>
<th>Week 1</th>
<th>1/11-1/15</th>
<th>Topics/Daily Activities</th>
<th>Readings and Homework</th>
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<tbody>
<tr>
<td>Week 2</td>
<td>1/18-1/22</td>
<td>State-space models</td>
<td>[1-4]</td>
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<tr>
<td>Week 3</td>
<td>1/25-1/29</td>
<td>Estimation of Gauss-Markov models, Kalman filtering, Kalman Smoothing</td>
<td>[1-6]</td>
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<tr>
<td>Week 4</td>
<td>2/1-2/5</td>
<td>Introduction to point process theory</td>
<td>[7-12]</td>
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<tr>
<td>Week 5</td>
<td>2/8-2/12</td>
<td>Estimation of static point process models</td>
<td>[11,12]</td>
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<tr>
<td>Week 6</td>
<td>2/15-2/19</td>
<td>Point process filtering and smoothing</td>
<td>[13,14]</td>
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<td>Week 7</td>
<td>2/22-2/26</td>
<td>Granger causality</td>
<td>[15-17]</td>
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<tr>
<td>Week 8</td>
<td>2/29-3/4</td>
<td>Expectation-Maximization Algorithm and Application to learning neural encoding models</td>
<td>[13,18,19]</td>
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<tr>
<td>Week 9</td>
<td>3/7-3/11</td>
<td>Application to hippocampal dynamics, application to open-loop neural decoding</td>
<td>[13, 14, 20]</td>
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<td>Week 10</td>
<td>3/14-3/25</td>
<td>Dynamic programming, Linear quadratic regulator, Linear Gaussian regulator</td>
<td>[21,22]</td>
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<tr>
<td>Week 11</td>
<td>3/28-4/1</td>
<td>Application to closed-loop neural prosthetic algorithms</td>
<td>[23-28]</td>
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<tr>
<td>Week 12</td>
<td>4/1-4/18</td>
<td>Application to closed-loop control of burst-suppression</td>
<td>[29]</td>
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<tr>
<td>Week 13</td>
<td>4/11-4/15</td>
<td>Student presentations</td>
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<tr>
<td>Week 14</td>
<td>4/18-4/22</td>
<td>Student presentations</td>
<td></td>
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<tr>
<td>Week 15</td>
<td>4/25-4/29</td>
<td>Student presentation</td>
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<tr>
<td>FINAL Date</td>
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<td>Final report is due on the first day of the final exam period.</td>
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Statement on Academic Conduct and Support Systems

Academic Conduct
Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu or to
the Department of Public Safety [http://adminopsnet.usc.edu/department/department-public-safety](http://adminopsnet.usc.edu/department/department-public-safety). This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men [http://www.usc.edu/student-affairs/cwm/](http://www.usc.edu/student-affairs/cwm/) provides 24/7 confidential support, and the sexual assault resource center webpage [http://sarc.usc.edu](http://sarc.usc.edu) describes reporting options and other resources.

**Support Systems**

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute [http://dornsife.usc.edu/ali](http://dornsife.usc.edu/ali), which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs [http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html) provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information [http://emergency.usc.edu](http://emergency.usc.edu) will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.