CSE 8803 Statistical machine learning models for neural and behavioral data analysis

Fall 2026

General information

Time: TBD
Classroom: TBD
Instructor: Dr. Anqi Wu, anqiwu@gatech.edu (the best way to reach me)
TA: TBD
Office hours and locations: TBD

For questions or discrepancies regarding grading of your lab, please see the TA who is in charge of grading first. The TA will recommend to me whether your grade should be changed.

Course description information

There has been significant progress in neural recording and behavioral tracking technologies, enabling researchers to gather extensive neural signals from large populations across multiple brain regions and diverse animal behavior videos. The overarching aim is to leverage these extensive neural and behavioral datasets to deepen our understanding of complex neuro-behavioral relationships. With such vast data resources available, it's now feasible to translate neuroscience inquiries, theories, and prior knowledge into statistical models and employ statistical data-driven methods for problem-solving. Hence, in this course, I will introduce a range of statistical machine learning techniques tailored for analyzing neural and behavioral datasets. These techniques encompass generalized linear models, latent variable models, and deep generative models for neural data analysis, as well as pose estimation, behavioral segmentation, and decision-making for behavior analysis, along with neuro-behavioral decoding models. By outlining mainstream machine learning methods, the course aims to demonstrate their applicability in addressing diverse data formats and offering scientific insights for neuroscience research. The course will involve developing the theory underlying these models and algorithms, followed by their application to real datasets in coding labs and the final project.

This course is designed to give students a thorough grounding in the concepts, methods and algorithms needed to do research and applications in statistical methods for neural and behavioral data analyses. Students entering the class with a pre-existing working knowledge of probability, statistics, linear algebra and algorithms will be at an advantage.

Textbooks

Machine Learning: A Probabilistic Perspective, Kevin Murphy: link.
Pattern Recognition and Machine Learning, Christopher M. Bishop: link.
The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani, Jerome: link.
Principles of Neurobiology, Liqun Luo: link.
Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, Peter Dayan and Laurence F Abbott: link.

Grading

The requirements of this course consist 6 in-class labs and a course project.
6 Labs (60%)
Course project (40%)

For the lab course, the grading breakdown is as follows: proposal 5%, presentation 15%, and final report 20%.

For the final grade conversion, if your final grade is between 90%-100%, your grade will be A. If your grade is 80%-90%, you will get a C. If your grade is 70%-80%, you will get a C. If your grade is 60%-70%, you will get a D. If your grade is below 60%, you will get a F.

In-class Lab Policy

All labs are due by the beginning of the next lab. Lab is penalized by 20% for each day that it is late (this applies additively, meaning that no credit is gained after 5 late days). We encourage you to discuss course content, lab problems, and project ideas with your classmates. However, all answers and codes should be prepared independently. If you refer to any material, it should be properly cited. If you discussed lab problems with your classmates, indicate which problems you discussed with whom. Any kind of academic misconduct is subject to F grade will be reported to the Dean of Students.

Communications

Any changes to the above rules or other logistical matters will be communicated by announcements on Canvas. It is the participants' responsibility to check these announcements regularly throughout the semester.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Academic Misconduct

All students are expected to comply with the Georgia Tech Honor Code. Any evidence of cheating or other violations will be referred to the Dean of Students with a recommendation that the penalty be an award of zero points for the graded requirement, and a one letter grade reduction in the course. Cheating includes, but is not limited to: using unauthorized references or notes; copying directly from any source, including friends, classmates, tutors, or a solutions manual; allowing another person to copy your work; taking an exam or handing in a graded requirement in someone else's name, or having someone else take an exam or hand in a graded requirement in your name; or asking for a re-grade of a paper that has been altered from its original form.

Tentative Syllabus and Schedule

Date	Lecture/Topics
08/18	Introduction and Logistics, Linear Regression
08/20	Linear Model Fitting and Cross Validation
08/25	Generalized Linear Model
08/27	Lab 1: PyTorch Primer, Generalized Linear Models
09/01	Holiday (No Class)
09/03	Density estimation
09/08	GMM
09/10	GMM and EM
09/15	Lab 2: Density estimation and GMM
09/17	Dimensionality reduction: Principal component analysis

09/22	Dimensionality reduction: Autoencoders
09/24	Dimensionality reduction: GPFA, tSNE
09/29	Lab 3: Linear and nonlinear dimensionality reduction
10/01	Spike Sorting, Basic Neurobiology
10/06	Fall break
10/08	Demixing Calcium Imaging Data
10/13	Lab 4: Spike Sorting and Calcium Deconvolution
10/15	Hidden Markov model
10/20	Hidden Markov model and Kalman filter
10/22	Hidden Markov model and Kalman filter
10/27	Lab 5: Autoregressive HMMs
10/29	Reinforcement learning
11/03	Reinforcement learning
11/05	Lab 6: Reinforcement learning
11/10	Advanced methods
11/12	Advanced methods
11/17	Advanced methods
11/19	Project presentation
11/24	Project presentation
11/26	Holiday break
12/01	Project presentation