

Neuro-AI: Neuroscience meets Artificial Intelligence

EEL 6935

Class Periods: Tuesdays 1:55pm – 2:45pm, Thursdays 1:55pm – 3:50pm

Location: MAEA0327

Academic Term: Fall 2021

Instructor:

Shreya Saxena

shreya.saxena@ufl.edu

(352)-392-2651

Office Hours: Tuesdays 2:45pm-3:50pm

Course Description

The design and implementation of methods to model static and dynamical neural data, including dimensionality reduction as well as encoding and decoding models. The history, design, and importance of neuroscience-inspired artificial intelligence. Credits: 3.

Course Pre-Requisites / Co-Requisites

Prerequisites:

EEL 5840 (Fundamentals of Machine Learning) or equivalent

Course Objectives

This course has two distinct parts, which broadly cover (1) the influence of Artificial Intelligence (AI) on the field of neuroscience, and (2) the influence of neuroscience on the field of AI. After completing the course, students should be able to:

- Perform dimensionality reduction of neural data;
- Construct encoding and decoding models of neural data, both static and dynamic in nature;
- Understand the influence of neuroscience on AI;
- Integrate building blocks inspired by neuroscience in neural networks.

Materials and Supply Fees: None

Required Textbooks and Software: None

Recommended Materials

- Theoretical Neuroscience
 - Author: Peter Dayan and Larry Abbott
 - Publisher: MIT Press (2005)
 - ISBN number: 0262041995
- Pattern Recognition and Machine Learning
 - Author: Christopher Bishop
 - Publisher: Springer (2006)
 - ISBN number: 0387310738
- Dive into Deep Learning
 - Author: Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola
 - Publication: 2021
 - Website: <https://d2l.ai>
- EEL 6935 Course notes
 - Author: Shreya Saxena

Recommended Software: Python

Course Schedule

| Date\Day | | Monday | Tuesday | Thursday | Friday |
|----------|----------------|---|---|--|-----------------------|
| 08/23 | Week 1 | | Intro to course and to neuroscience | Signals from Recordings | <i>Homework 1 out</i> |
| 08/30 | Week 2 | | Guest Lecture: Erdem Varol (Columbia University): Spike Sorting | Dimensionality Reduction (Linear and Nonlinear) | |
| 09/06 | Week 3 | <i>Homework 1 due: Signals from Recordings</i> | Guest Lecture: Fabio Stefanini (Facebook Reality Labs): Population Methods | Nonlinear Dimensionality Reduction (contd.) + Latent Variable Models | |
| 09/13 | Week 4 | | Guest Lecture: Josh Glaser (Columbia University): Latent Variable Models | Nonlinear Dynamical Models | <i>Homework 2 out</i> |
| 09/20 | Week 5 | | Guest Lecture: Anqi Wu (Georgia Institute of Technology): Latent Variable Models | Encoding Models (Regression / GLM) | |
| 09/27 | Week 6 | <i>Homework 2 due: Dimensionality Reduction</i> | Guest Lecture: Ella Batty (Harvard University): Encoding Models | Nonlinear Encoding Models + Intro to Decoding | <i>Homework 3 out</i> |
| 10/04 | Week 7 | | Guest Lecture: Matt Whiteway (Columbia University): Decoding Behavior | Decoding: Behavioral Pose Estimation | |
| 10/11 | Week 8 | <i>Homework 3 due: Encoding Models</i> | Guest Lecture: Nancy Padilla-Coreano (UCSD / UF): Behavioral Pose Estimation | Decoding: Linear Dynamical Systems (Expectation Maximization) | <i>Homework 4 out</i> |
| 10/18 | Week 9 | | Guest Lecture: Vivek Athalye (Columbia University): Brain Machine Interface | Decoding: Nonlinear Models | |
| 10/25 | Week 10 | <i>Homework 4 due: Behavioral Pose Estimation</i> | Guest Lecture: Ramon Nogueira (Columbia University): Linear vs. Nonlinear Models | History of Neuroscience in AI: Part 1 | <i>Homework 5 out</i> |
| 11/01 | Week 11 | | History of Neuroscience in AI: Part 2 | Attention in Neural Networks | |
| 11/08 | Week 12 | <i>Homework 5 due: Decoding for Motor Control</i> | Guest Lecture: Jose Principe (UF): Attention in Neural Networks | <i>(Veteran's Day)</i> | |
| 11/15 | Week 13 | <i>Project Proposal Due</i> | Guest Lecture: TBD | Memory in Deep Learning | |
| 11/22 | Week 14 | | Guest Lecture: Kenny Kay (Columbia University): Memory | <i>(Thanksgiving)</i> | |
| 11/29 | Week 15 | | <i>Project Presentations</i> | <i>Project Presentations</i> | |
| 12/06 | Week 16 | | <i>Project Presentations</i> | | |

Attendance Policy, Class Expectations, and Make-Up Policy

This class will be presented both in-person and simultaneously cast online using Zoom. Accessing the online class requires access to a working webcam and stable internet connection. I prefer that students keep their camera on during the class so that I can see you as I would during normal face-to-face classes. Studies show that if we can see each other's faces then we will have more engagement, more student success, and more faculty success. However, this is not a requirement. I understand if on certain days you can't have your camera on due to internet bandwidth limitations, other family members, health issues, or any other reasons.

Attendance & Participation:

While attendance is not graded, lectures will include regular homework help and in-class discussions and demonstrations on the subject material. Participation is graded, and is an integral part of each class that can help you learn the material.

Slack Page:

We have a Slack page for the course, the link for which will be shared at the beginning of the course. This is an *optional* resource for students to discuss the course amongst each other and occasionally with the Professor. This resource is intended to supplement office hours and student interactions. **No official communication / submission happens over Slack.** No assignments submissions will be accepted over Slack.

Excused absences must be in compliance with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation.

Evaluation of Grades

Homework (5 in total)

- When:** Assigned roughly once in two weeks (see course schedule).
- What:** Tutorial style in Google Colab: a combination of analytical problems that can be solved by hand, and implementation problems solved with Python.
- Why:** Homework guides you through course material and presents you with questions that will require time to think about and complete. Homework assignments are not meant to be completed in a single day.
- Grading:** Each homework is worth 10% of the total grade. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section.
- Submission:** Homework will be submitted on canvas before class on the due date. Please ensure that your submission is readable.

Project

- When:** There is one project, due at the end of the semester.
- What:** The projects can be performed in groups. Neural datasets that can be used will be provided for the project.
- Why:** Projects are an opportunity to apply concepts that you have learnt in class to a research setting.
- Grading:** The final project shall be on the topics of neuroscience and AI learned throughout the course, and is worth 40% of the total grade. Projects are graded on a 100-percentage scale. The final grade will be based on (a) a written report 70%, (b) project presentations 20%, and (c) evaluation of the contribution of all group members 10%. The written report consists of the following parts (i) Motivation (ii) Background, (iii) Technical Approach (iv) Results, (v) Conclusion. It will be graded according to the following percentages: 30% for parts (i) and (ii), 60% for parts (iii) and (iv), 10% for part (v). The project report should also state which work was done by each student in the project team.

This course is co-listed with the undergraduate section. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. Grading for the homework and project are different from the undergraduate course. The graduate and undergraduate sections will be graded separately, for which the graduate section has additional problems and different weights for all problems.

Evaluation of Grades

| Assignment | Percentage of Final Grade |
|---------------------|----------------------------------|
| Homework Sets (5) | 50% (10% each) |
| Class Participation | 10% |
| Project | 40% |
| Total | 100% |

Grading Policy

| Percent | Grade | Grade Points |
|----------------|--------------|---------------------|
| 90.0 - 100.0 | A | 4.00 |
| 87.0 - 89.9 | A- | 3.67 |
| 84.0 - 86.9 | B+ | 3.33 |
| 81.0 - 83.9 | B | 3.00 |
| 78.0 - 80.9 | B- | 2.67 |
| 75.0 - 79.9 | C+ | 2.33 |

| | | |
|-------------|----|------|
| 72.0 - 74.9 | C | 2.00 |
| 69.0 - 71.9 | C- | 1.67 |
| 66.0 - 68.9 | D+ | 1.33 |
| 63.0 - 65.9 | D | 1.00 |
| 60.0 - 62.9 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Conduct Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation

of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](https://title-ix.ufl.edu), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.