

Neural Signals, Systems and Technology

EEE 5283/4800

Class Periods: Tu 3rd period, Th 3rd and 4th period

Location:

Academic Term: Fall 2022

Instructor:

Prof. Karim Oweiss

Email Address: koweiss@ufl.edu

Office Phone Number: 352-294-1898

Office Hours: Tuesdays and Thursdays 2-3 pm

Teaching Assistant: TBD

Course Description

(3 credits) Biophysical principles of neural signaling, characterization of biological neural circuits and systems, principles of biological intelligence in neural systems, overview of applications in artificial intelligence.

Course Pre-Requisites / Co-Requisites

EEL 3850- Data Science for ECE

Course Objectives

The student will be able to describe the techniques for characterization of neural circuits and systems, and explain the principles of biological intelligence that could be useful for foundational artificial intelligence and machine learning applications.

Materials and Supply Fees

N/A

Required Textbooks and Software

a. Recommended Textbooks

- Title: Statistical Signal Processing for Neuroscience & Neurotechnology (SSPNT)
Editor: Karim Oweiss
Publication date and edition: 1st edition, 2010, Academic Press. ISBN number: 9780123750273
- Title: Theoretical Neuroscience (TNS)
Author: Dayan Peter and Abbott, L.
Publication date: 2001. ISBN: 9780262318723
- Title: Principles of Neural Science (PNS)
Author: Kandel, Schwartz, Jessel, Siegelbaum, and Hudspeth
Publication date and edition: 5th edition, 2013, McGraw Hill. ISBN number: 9780071390118
- Title: Machine Learning – A First Course for Engineers and Scientists (IML)
Authors: Andreas Lindholm, [Niklas Wahlström](#), [Fredrik Lindsten](#), and [Thomas B. Schön](#)
Publication date and edition: 1st edition, Cambridge University Press 2022
- Title: Pattern Recognition and Machine Learning (PRML)
Author: Christopher Bishop
Publication date and edition: 2013, ISBN number: 978-0387310732

b. Software

1. Python or Matlab

- Title: Foundations of Data Science with Python
Author: John M. Shea, Publication Date and edition: 1st, e-book, Publisher: GitHub Pages.

Course Schedule

Part I. Fundamentals of Biophysics, Neural Signaling & Modeling

- Week 1: Nerve cells, ion channels, synapses, neurotransmitters & receptors/PNS Ch 4-5
Week 2: Passive and Active Properties of Nerve Cells/PNS ch. 6-7/HW 1 due
Week 3: *Neural Modeling*: deterministic and stochastic models/in Class material/HW 2 due, Quiz 1

Part II. Introduction to Detection and Estimation, Linear Regression and Machine Learning

- Week 4: *Neural Signal Processing*: detection and estimation theory/SSPNT ch. 2-3/HW 3 due
Week 5: Principles of Linear Regression/Neural Coding/IML ch 3/HW4 due
Week 6: Fundamentals of Machine Learning/PRML ch. 3/
Week 7: Bayes Theory and Gaussian Processes/IML ch 9/Project pre-proposal Due
Week 8: Bayesian Inference/PRML ch 4, 5/Mini Project Assigned
Week 9: *Neural Coding in Sensory and Motor Systems*/PNS chs 21, 33/Quiz 2

Part III. Biological and Artificial Intelligence in Consumer and Clinical Applications

- Week 10: *Neural Decoding*: Brain Machine Interfaces for motor prosthesis/Mini Project Due
Week 11: *Neuromodulation and Neurostimulation*: Brain Machine Interfaces for cognitive prosthesis/
Final Project Proposal Due
Week 12: *Applications*: Biologically Inspired Learning
Week 13: *Applications*: Deep brain Stimulation for neurological disorders
Week 14: Wrap up/Project previews
Week 15: Final exam week: Final project presentation and report due

Evaluation of Grades

| Assignment | Percentage of Final Grade |
|-----------------------------------|---------------------------|
| In class activities/participation | 5% |
| Homework (4) | 20% |
| Quiz (2) | 20% |
| Mini project (1) | 20% |
| Final Project/Term Paper | 35% |
| Total | 100% |

Grading rubric

This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts than the undergraduate section. The exams will also involve additional questions for the graduate section compared to the undergraduate section. Grading for the homework and projects 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. The final project shall be on a topic chosen from among the topics learned throughout the course, and the final report should consist of the following parts (i) Motivation (ii) Background, (iii) Technical Approach (iv) Results, (v) Discussions, and (vi) conclusions. It will be graded according to the following percentages: 30% for parts (i) and (ii), 45% for parts (iii) and (iv), 25% for parts (v) and (vi). Parts (i), (ii) and (v) shall discuss relations and comparisons between various related approaches which need to be comprehensive, and parts (ii) and (iv) can focus specifically on one particular approach.

Guidelines and Format

1) Mini-projects, essay and homework guidelines

There will be homework assignments testing your analytical skills. The miniproject will test your analytical and basic programming skills (Matlab or Python). Data for the miniproject will be provided by the instructor. Quizzes will test your knowledge of the lecture notes and specific reading assignments.

2) Project Guidelines

a) The Pre-proposal:

Write a brief description of the research topic that you plan to pursue for your project/term paper, as well as the specific problems or questions you plan to address in your proposal. You will be provided with guidelines and resources on how to gain access to data to be used for your project.

Your pre-proposal should include:

- a) Background and Significance
- b) Research Design and Methods

Limit: 4 pages, 12-pt font size, 1.5-line spacing (no references), font type: Arial, one-inch margins.

b) The Proposal:

Based on the feedback I give you on your pre-proposal, rewrite the proposal to include:

- a) Background and Significance
- b) Preliminary studies**
- c) Research Design and Methods**
- d) Milestones, Metrics of Success and Timeline**

You should introduce the area of investigation, explain the “big picture” or significance of the specific problem that you will tackle, provide a list of the particular questions you intend to address in your experiments/simulation, and the methods you will use to conduct these experiments/simulations. It is very important to include all the details about how the data you will be working with has been/will be collected.

Limit: 7 pages (not including references), Single spacing, one-inch margins, 12-pt font size Arial font.

c) The Final report:

Based on the actual implementation of the proposal, write a concise, yet detailed summary of all your experimental findings in the form of a final report. A key element of this report is your discussion section and how it relates to topics learned in class and challenges specific to the problem you addressed in your project.

Based on the feedback I give you on your proposal, rewrite the proposal to include:

- a) Background and Significance
- b) Preliminary studies
- c) Research Design and Methods
- d) Results**
- e) Discussion**

Limit: 10 pages (not including references or figures), Single spacing, one-inch margins, 12-pt Arial font.

| Task | Topic | Grade % | Date |
|------|---------------------------|---------|--|
| 1 | Pre-proposal (written) | 5% | October 9 th , 2022 |
| 2 | Proposal (written) | 10% | November 10 th , 2022 |
| 3 | Project Report (Written) | 10% | December 12 th , 2022 |
| 4 | Final Presentation (Oral) | 10% | December 14 th , 2022 (5:30p-7:30p) |

Grading Policy

| Percent | Grade | Grade Points |
|-------------|-------|--------------|
| 93.4 - 100 | A | 4.00 |
| 90.0 - 93.3 | A- | 3.67 |
| 86.7 - 89.9 | B+ | 3.33 |
| 83.4 - 86.6 | B | 3.00 |
| 80.0 - 83.3 | B- | 2.67 |
| 76.7 - 79.9 | C+ | 2.33 |
| 73.4 - 76.6 | C | 2.00 |
| 70.0 - 73.3 | C- | 1.67 |
| 66.7 - 69.9 | D+ | 1.33 |
| 63.4 - 66.6 | D | 1.00 |
| 60.0 - 63.3 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Class Participation & Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is required as a considerable portion of your grade depends on class participation and discussion. Because the class covers a multi-disciplinary topic, questions and discussions during class are strongly encouraged. I will record **class participation** throughout the semester that will count towards your 5% class activities grade. Participation include summarizing a key topic discussed in previous lecture(s), responding to questions on current topic, and regularly participating in online discussions about select topics the instructor provides on the course website.

Cell phones and other electronic devices are to be silenced. No text messaging during class or exams unless in the case of emergency.

Requirements for class participation and attendance, make-up exams, assignments, and other work in this course are consistent with university policies that can be found in the online catalog at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx> .

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure 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/>.

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 Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff and student 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.

Campus Resources:

Health and Wellness

U Matter, We Care:

If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.

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

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://www.crc.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://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

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