Introduction to Neural Interfaces and Systems
EEL 5934   Section 0011
Class Periods: M,W,F 3:00 PM – 3:50 PM
Location: MAEA 0327
Academic Term: Spring 2024

Instructor:
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Office Hours: TBD

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
- NA

Course Description
Delve into the interdisciplinary field of neural engineering, an emerging field that combines engineering disciplines with biological, chemical, and material sciences to access, manipulate, and possibly enhance the nervous system and its information. The interdisciplinary course focuses on invasive neural implants that electrically interface with the nervous system and covers various types of recording and stimulating neural interface technologies used in animal research and humans. The course examines the neurophysiological principles as well as the tissue-electrode interface, to better understand how electrical signals and information are transmitted between the devices and neurons. The course will also cover block diagrams of circuits commonly utilized in neural implants. Additionally, the course briefly presents practical and ethical considerations for translating these neural interface technologies into humans. Students will complete a group project analyzing an existing neural interface system in depth and proposing solutions to roadblocks.

Course Pre-Requisites / Co-Requisites
- Introductory electronic circuits course or permission from the instructor

Course Objectives
By the end of the semester, students are expected to have sufficient background to pursue continuous learning and education in neural interfaces, conduct research on this topic in engineering laboratories, and apply to industry jobs related to the skills developed during the course. To achieve these objectives, the students will learn to:
- Define, derive, and use formulas to model the generation and propagation of action potentials, including the Hodgkin-Huxley experiments and model. They will also be able to describe the anatomy of neurons and synapses.
- Derive and describe the recorded extracellular potential in terms of membrane potential and current, categorize extracellular stimulation methods, and compare the technical properties of these methods. Students will also be able to describe the membrane's response to stimulation by an applied extracellular current or voltage.
- Develop the equivalent circuit model of the interface formed between tissue (electrolyte) and metal (electrode) and explain the electrochemical methods to assess the safety of the electrodes. They will also be able to calculate the impedances and noise and compare the microfabrication techniques for electrodes.
- Explain how recorded neuronal signals are processed electronically and describe the general block diagram of circuits used to stimulate or record these neural signals. Students will also be able to explain the working principles of retinal, cochlear, and cortical implants.
- Understand the current challenges in developing neural interface technologies and the directions in which the area is headed.

Materials and Supply Fees
N/A

Required Textbooks and Software
Textbook: None required
Software: Access to MATLAB and online circuit simulator: https://everycircuit.com/

Recommended Materials
1. Fundamental Neuroscience (3rd Edition)
   o Larry R. Squire et al.
   o Link:
     https://www.hse.ru/data/2013/10/09/1280379806/Fundamental%20Neuroscience%20(3rd%20edition)%202008.pdf

2. Foundations of Analog and Digital Electronic Circuits
   o Anant Agarwal and Jeffrey H. Lang
   o Link:
     https://neurophysics.ucsd.edu/courses/physics_120/Agarwal%20and%20Lang%20(2005)%20Foundations%20of%20Analog%20and%20Digital.pdf

3. Handbook of Neuroengineering
   o Nitish V. Thakor
   o Link: https://link.springer.com/referencework/10.1007/978-981-15-2848-4

4. Neural Engineering
   o Bin He
   o Link: https://link.springer.com/book/10.1007/978-1-4614-5227-0#toc

Course Schedule

Week	Topic	HW/Exam/Project
1	Motivations and Applications. Neuroanatomy	
2	Diseases and Injuries	
3	Neurophysiology	HW1
4	Neural Stimulation	HW1 due
5	Neural Recording	
6	Basic Circuits	
7	Circuit Components in Neural Implants (e.g., amplifiers, filters)	HW2
8	Tissue-Electrode Interface and Electrode Design	HW2 (due)
9	Electrode Microfabrication and Packaging	Midterm Exam
10	Wireless Technologies	
11	State-of-the-art Brain Implants (Clinical and Research)	HW3
12	Cochlear and Retinal Implants	HW3 (due)
13	Non-Invasive Technologies (e.g., TMS, tACS)	
14	Invited Talks	
15	Project Presentations	Final Exam

Attendance Policy, Class Expectations, and Make-Up Policy
Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Evaluation of Grades

This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve additional questions for the graduate section with respect to the undergraduate section.

The final group project revolves around a selected topic on neural interfaces. The output will be a grant proposal, crafted in the style of an NIH R21 format with a limit of 6 pages. This project will be carried out in teams of three, fostering collaborative research and problem-solving. The grant proposal will be structured as follows:
  (i)   Motivation and Background - The reasons for undertaking this project and the background information that contextualizes the project.
  (ii)   Innovation - Outlining the novel aspects of the proposed project, distinguishing it from existing works.
  (iii)   Approach - Elaborating on the methodologies to be employed to achieve the goals of the project.

Each group will be evaluated through the project report and oral presentation. Each member of the team needs to describe their contribution to the report. The distribution of points is listed below:

Project Work	Report Quality	Engineering Insight	Completeness
1. Report	10	20	20

Project Work	Q/A	Engineering Insight	Presentation Skill
2. Oral Presentation	10	30	10

Assignment	Total Points	Percentage of Final Grade
Homework Sets (3)	100 each	15%
Midterm Exam	100	20%
Final Exam	100	25%
Final Project	100	40%
		100%

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

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 Honor 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. 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.

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**, 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 Connections 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: *https://distance.ufl.edu/state-authorization-status/#student-complaint*.