EEL 5934: NEURAL SIGNALS, SYSTEMS, AND TECHNOLOGY- Spring 2017

Catalog Description (3-hrs): Biophysical principles of neural signaling, characterization of neural circuits and systems, technology design principles for measuring and manipulating biological neural circuits and systems, overview of clinical applications and industrial opportunities for neurotechnology.

Pre-requisites: While there are no formal prerequisites, it is expected that students interested in this topic will have a graduate standing in engineering and/or neuroscience (or undergraduate senior standing with approval from the instructor). Even if class material may span topics in one discipline unfamiliar to students in the other discipline, it is expected that students will acquire the necessary knowledge during the semester, either by reading supplementary material or through interaction with the instructor.

Course Objectives: To present an in-depth coverage of the biophysical principles of neural signaling, to learn techniques for characterization of neural circuits and systems, and to overview principles of neurotechnology for interfacing with biological neural systems.

Instructor: Karim G. Oweiss, Ph.D.; Email: koweiss@ufl.edu

Office: Rm. 457 NEB; Tel.:(352) 294-1898

Class Schedule: Tuesdays 10:40AM-11:25AM, Thursdays 10:40AM-12:25AM in LAR 239

Office Hours: 3:30PM – 4:30PM Tuesdays

Textbooks: Recommended:

1. *Principles of Neural Science*, Kandel, Schwartz, Jessel, Siegelbaum, and Hudspeth, McGraw Hill, 5th edition, 2013
2. *Statistical Signal Processing for Neuroscience & Neurotechnology,* By Oweiss, 1st edition, Academic Press, Elsevier, 2010
3. Topic-specific lecture slides and review articles will be distributed in class or posted on the class website.

Webpage: https://ufl.instructure.com/courses/326449

Course Outline:

The class is comprised of three parts. PART I discusses the fundamental principles of nerve cell physiology and biophysics, and covers different methods to analyze and model neural signals. PART II provides an overview of neurobiological systems that have been targeted for neuromodulation, neurostimulation and neuroprosthetic applications. PART III introduces state of the art technologies for measuring neural activity, as well as technology to control or perturb this activity to assess its effect on behavior and the extent to which it can treat pathological conditions. Special emphasis is given to neurotechnology design principles for commercialization and entrepreneurship opportunities.

Grading

- Four Homework assignments worth 6% each (24%)
- One essay 16%
- Class Participation, Reading Discussion and Presentation worth (20%)
- Final Project/Term paper (40%)

Attendance: 75% attendance is required to PASS the class, 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. You will need to notify me ahead of time if you will not attend class and provide a reasonable written explanation for your absence. I will record attendance *randomly* throughout the semester.

Honesty Policy – All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Accommodation for Students with Disabilities – Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

UF Counseling Services –Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.
- Career Resource Center, Reitz Union, 392-1601, career and job search services.

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.

Cell phones and other communication devices must be ***on VIBRATE mode and stored out of view to both the student and instructor*** during class. Any behavior or event that interferes with other students' ability to learn or my ability to teach the class will not be tolerated, one polite request to cease and desist will be followed by removal from the classroom if problems persist.

Guidelines and Format

1) Essay and homework guidelines

There will be **four homework** assignments distributed evenly throughout the semester. Some of these will make use of MATLAB®. A substantial portion of the workload will be **reading** assignments that will be used towards your essay and project presentation. It is essential that your essay be concise and well written for broad audience as well as for knowledgeable people in the area.

During the reading discussion session, each student will discuss his/her essay in class during a 12-15 minute period and answer questions by other students. You will choose essay topics that best match your background. Your essay grade will be based on the quality of your essays, your performance and management of the discussion during the Reading Discussion sessions.

2) Final 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. Limit: 2 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, write a proposal that should attract "funding" (aka *a good grade*) from your "sponsor" (instructor). Your proposal should include:

a) Background and Significance
b) Preliminary studies (if any) or relevant work
c) Research Design and Methods
d) 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/simulation.
Limit: 4 pages (not including references), Single spacing, one-inch margins, 12-pt font size Arial font.

c) The Final report:

Based on the feedback as well as additional research you do or ideas you develop, re-write your proposal and include your experimental findings in the form of a final report.

Limit: 8 pages (not including references or figures), Single spacing, one-inch margins, 12-pt Arial font.

Important Dates: Last day to drop 01/10/2017 @ 11:59PM, Last day to drop with a (W) grade 04/07/2017; Classes end April 19th, 2017 (Reading Days April 20-21); Faculty Course Evaluations 04/08/2017- 04/21/2017; Final Exams April 22 & 24-28)

Holidays (no class): MLK Day 01/16/17; Spring Break: 03/04/17 – 03/11/2017

Task	Topic	Grade %	Date
1	Pre-proposal (written)	5%	Feb 16th, 2017
2	Reading Discussion Presentation + Essay	5% + 10%	March 2nd, 2017
3	Proposal (written)	15%	March 22nd, 2017
4	Final Project Report (Written) Final Presentation (Oral)	20%	April 23rd, 2017 April 24th, 2017 (12:30-2:30PM)

Course Outline

Topic	Lectures
Introduction	1
Part I: Neural Signaling 1.1) Fundamentals of Nerve Cell Physiology Elements of Bioelectricity & Conservation Principles Neurons, cell types, ion channels, gap junctions, synapses, neurotransmitters & receptors. 1.2) Deterministic Neural Models Lumped Parameter and Distributed-Parameter Models of Cells Linear Electrical Properties of Cells Action Potentials, Linear Systems (transfer functions) 1.3) Probabilistic Neural Models Hodgkin-Huxley Model Spike Trains, Field Potentials, and Receptive Fields Information Coding	9
Part II: Neurotechnology 2.1) Technology for measuring neural activity (a) Invasive (microcircuits): micro- and nanoelectrode technology, Multiphoton genetically encoded calcium and voltage imaging. (b) Non-invasive (macrocircuits): Neuroimaging (PET, SPECT, MRI, fMRI) (c) Neural Decoding (linear and nonlinear filters) 2.2) Technology for controlling neural activity (a) Invasive (microcircuits): Deep Brain Stimulation, Optogenetics (b) Non-invasive (macrocircuits): electric, magnetic, ultrasonic, pharmacological (c) Neural control (open loop and closed loop control of neural activity)	12
Part III: Neural Systems and Applications **III.A** (a) Sensory systems: Auditory, Visual, Somatosensory (b) Motor Systems: premotor and primary motor systems, basal ganglia (c) Cognitive Systems: Prefrontal Cortex, Hippocampus **III.B** (a) Sensory, cognitive and motor prosthesis (cochlear, retinal, motor, memory) (b) DBS for movement and neuropsychiatric disorders (Parkinson's, essential tremor, epilepsy, major depression) (c) Neurotechnology ventures and commercialization opportunities	9