Master Course Description for EE-466

Title: Neural Computation & Engineering Laboratory

Credits: 4

E E 466 Neural Engineering (4) *Amy Orsborn*

The Neural Computation & Engineering Laboratory course is designed to provide students with hands-on experience with the techniques and tools of neural engineering. During the course, students will develop deeper understanding of underlying principles and phenomena of engineered systems interacting with the nervous system. The course will also expose students to hardware, software, and techniques that may be useful in their future coursework and careers. Students will work individually and in teams through a series of experiments. Students will also learn and use key concepts in designing experiments and testing neural interface systems, which they will use to propose and conduct a final project of their own design.

Prerequisite: Either Biol 130, Biol 162, Biol 220 or AMATH 342 and

One of the following: MATH 308, AMATH 301, or AMATH 352

Coordinator: Amy Orsborn, Assistant Professor, Electrical and Computer Engineering, Bioengineering.

Goals: This course will expose students to relevant concepts and tools for building engineered systems that interact with the nervous system. Students will leave the course with a greater understanding of the components of closed-loop neural interfaces (signal acquisition, signal processing, information extraction, feedback and control loop definition) and related engineering and physiological concepts. They will also learn principles of experiment design for exploring scientific hypotheses and engineering validation. Students will demonstrate their knowledge in a final project where they design and implement a closed-loop neural interface that they use to test a hypothesis about nervous system function or engineering design.

Learning Objectives: By the end of this course, students will:

- Be familiar with electrophysiology for acquiring signals from the nervous system (neurons and muscles), and the engineering considerations and physiological properties that influence signals.
- Be familiar with electrical stimulation for delivering signals into the nervous system (neuron and peripheral nerves), and the engineering considerations and physiological properties that influence system response.
- Be familiar with signal processing techniques for extracting features and information from physiological data

- Understand the difference between open- and closed-loop neural interfaces
- Be familiar with engineering design considerations and physiological properties that influence closed-loop neural interfaces
- Build a closed-loop neural interface

Textbook: none required, suggested:

- Brain Computer Interfacing: An Introduction, Rajesh P. N. Rao, Cambridge University Press,

  2013 o On reserve in the Engineering Library
- Brain Computer Interfaces: Principles and Practice, Wolpaw and Wolpaw, Oxford Press,

  2012 o Available as an E-book through the UW library: https://allianceprimo.hosted.exlibrisgroup.com/permalink/f/kjtuig/CP51230796490001451

Prerequisites by Topic:

Exposure to Neuroscience and Biology concepts (BIOL 130, BIOL 162, or BIOL 220) Linear models, neural networks & data processing: MATH 308, AMATH 301, or AMATH 352
Topics:

Lecture Topic	Lab Topic
Course intro, principles of electrophysiology	Introduction to matlab and neural data analysis
Principles of electrophysiology measurements	Cockroach leg recordings and data analysis
Electrophysiology to study neural systems	Quantify sensory adaptation, stimulation response
Peripheral nervous system & motor control	EMG & muscle stimulation
Neural signal processing & decoding I	Analyzing motor behavior and encoding
Neural signal processing & decoding II	Motor decoding (linear classification + regression)
Neural signal processing and decoding III	Motor decoding (Wiener and Kalman Filters)
Closed-loop systems	Closed-loop EMG interface I
Closed-loop decoding, Adaptive decoding	Closed-loop EMG interface II
Advanced topics	Independent interface design (advanced closed-loop interface)
Final presentations	Team demonstrations

Course Structure:

<u>Lecture period</u>: One 110-minute class period each week will be devoted to lectures and in-class discussion. This time will be used for presenting core concepts relevant to the laboratory sections.

<u>Laboratory period</u>: Laboratory sections will consist of one 3 hour section per week. Students are expected to use this time to complete all necessary instrumentation and data collection for the guided laboratory experiments. Data analysis and experiment write-ups may require additional time outside of lab periods.

Computer Resources: Computers are provided within the lab space for the required projects.

Grading: Approximate distribution:

- Participation (lectures and laboratory sections, final presentations): 15%
- Written assignments (discussion questions, reports): 65%
- Final lab report: 10%
- Experiment design project: 10%

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(H)** Students identify and solve complex problems in neural engineering via laboratory work, homework assignments, and the final project.

(2) *an ability to communicate effectively with a range of audiences.* **(M)** Students learn to write technical scientific papers through iterative small assignments across the quarter where they receive detailed feedback. The final project report tests these writing skills by requiring a full 4page report in the style of an engineering conference publication. Students also practice oral communication skills through a final project presentation.

(3) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.* **(L)** Students perform laboratory work in small groups and assignments include both individual and team-based submissions. Students work closely with two to three classmates from diverse backgrounds across engineering and neuroscience to complete experimental design and data collection. We set a tone for an inclusive environment respecting gender and racial/ethnic diversity.

(4) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(H)** Laboratory work requires

students to perform data collection, analysis, and interpretation. Students must make experimental design choices during data collection and write programs to analyze collected data. Comprehension questions for each lab require students to interpret their results, assess experimental sources of error, assess limitations of data interpretations, and consider the real-world implications of results for neural engineering applications.

(5) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* **(L)** Students must design a novel closed-loop neural interface system by the end of the course. This requires students to perform independent and self-directed learning to apply concepts from the course to a new application.

Prepared By: Chet Moritz and Amy Orsborn

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