
Neural Engineering I: Introduction to Hybrid Neural Systems

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Office Hours: By appointment

Time: T / Th 5:00 – 6:15
Location: 236 SEO

Required Text: None; selected reading from the literature.

Prerequisites: BioE 472 - Models of the Nervous System (and BioS 484 – Neuroscience I)

Any good text on neuroscience.

Format: This course will examine five fundamental topic areas in Neural Engineering through lectures, discussions and critical reading of selected papers from the literature. Fundamental concepts and technologies that transfer across multiple applications will be emphasized.

Each student will make multiple presentations from the reading, and is expected to actively participate in discussions. Class discussion will facilitate understanding of broad concepts and methodological details; however, it is expected that the preparatory reading for each class meeting is done with the goal of understanding the material thoroughly before class begins.

Course Topics:
I. Stimulation and Recording Electrodes – Materials and Properties (2 wks)
II. In Vivo Neural Interfaces – Neural and Neuromuscular Prostheses, Diagnostics (3 wks)
III. In Vitro Neural Interfaces – Biosensors, Biocomputers and Tools for Research (3 wks)
IV. Molecular Engineering of Neural Interfaces – Establishing Efficient and Stable Contact (3 wks)
V. Modeling Electrical Stimulation and Recording in Hybrid Neural Systems (2 wks)

Grading:
Class Participation 30% (Attendance 10%, presentations 20%)
Paper Summaries 20% (Due at start of paper discussion – use form)
Exams (not cumulative) 30% (Exam I 2/11, Exam II 3/17, Exam III 4/28)
Proposal 20% Draft Specific Aims page due 2/16 (5%)
Final Proposal due 3/31 (10%)
Slide Slam 4/12-4/14 (5%)
Course Objectives

1. Be able to clearly articulate the capabilities and limitations of existing and emerging neural engineering technologies and methods.
2. Recognize concepts and technologies that are common to multiple applications.
3. Recognize opportunities for future contributions to the field, including clinical need, novel applications of existing technology, and demand for technology innovations.
4. Gain practice in reading and interpreting the scientific literature; learn to recognize different types of articles (reviews, proceedings, communications, etc.)
5. Become familiar with contemporary leaders in the field, influential contemporary work, and some of the classic literature in NE.
6. Learn to be critical of experimental design and data quality.
7. Gain practice presenting and discussing scientific ideas and data.
8. Learn to interpret many of the ways NE data are presented.
9. Learn about many of the common research practices (experimental design and methods) in contemporary NE.

Journals Relevant to Neural Engineering

**Neural Engineering**
- IEEE TNSRE
- IEEE TBME
- Journal of Neural Engineering
- Journal of NeuroEngineering and Rehabilitation
- Journal of Biomedical Engineering

**Neurophysiology**
- Journal of Neurophysiology
- Journal of Physiology
- Nature Neuroscience

My favorite Search Engine to access Medline: Ovid
Research Proposal

Objective. Write a research proposal describing a project that, if completed, would make a reasonable contribution to the field of neural engineering. The project should be feasible given current technology. A live “pitch” will be given to a review panel using a “Slide Slam” format.

Proposal Format. Use a page header that includes your name and the title of your proposal. Do not include an additional title page. Use 11-pt Arial font, single spaced. Small figures may be inset within the text; up to three large figures may be included on separate pages and do not count toward the page limit. The proposal is limited to three pages: one Specific Aims page, plus two additional pages. Your proposal must include the following sections:

Specific Aims (first page)
- State concisely the goals of the proposed research and summarize the expected outcome(s), including the impact that the results of the proposed research will exert on the research field(s) involved.
- List succinctly, using bullet points, one or two Specific Aims of the research proposed, e.g., to generate new knowledge, create a novel design, solve a specific problem, challenge an existing paradigm or clinical practice, address a critical barrier to progress in the field, or develop new technology.
- Most Specific Aims should be closely associated with a hypothesis.

Significance
- Explain the importance of the problem or critical barrier to progress in the field that the proposed project addresses.
- Explain how the proposed project will improve scientific knowledge, technical capability, and/or clinical practice in one or more broad fields.
- Describe how the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field will be changed if the proposed aims are achieved.

Innovation
- Explain how the application challenges and seeks to shift current research or clinical practice paradigms.
- Describe any novel theoretical concepts, approaches or methodologies, instrumentation or interventions to be developed or used, and any advantage over existing methodologies, instrumentation, or interventions.
- Explain any refinements, improvements, or new applications of theoretical concepts, approaches or methodologies, instrumentation, or interventions.

Approach
- Describe the overall strategy, methodology, and analyses to be used to accomplish the specific aims of the project. Include how the data will be collected, analyzed, and interpreted.
- Discuss potential problems, alternative strategies, and benchmarks for success anticipated to achieve the aims.
- If the project is in the early stages of development, describe any strategy to establish feasibility, and address the management of any high risk aspects of the proposed work.

Grading. The proposal will be evaluated according to the following criteria:
(a) Expectations of each of the required sections were met.
(b) Proposed work would make a reasonable contribution to the field.
(c) Project is feasible given current technology.
(d) Format guidelines were followed.
Slide Slam Guidelines

Three slides, 90 seconds.
Slide 1: Statement of the problem and significance
Slide 2: Specific Aims
Slide 3: Expected outcomes and impact

Scoring: 0-2 points for clearly presenting each of the three components above (3 x 2 = 6 pts max), 0-2 points for presentation style

Rubric:

0 – Needed substantial improvement (e.g. significant missing information, did not address component - confusing or awkward delivery, unhelpful or confusing graphics)
1 – Adequate, but obvious room for improvement (e.g. some missing or extraneous information, somewhat off-topic - periods of rough delivery, modest use of effective graphics)
2 – Excellent, little to no room for improvement (e.g. adequate information to understand each aspect of the proposal - confident and smooth delivery, clear and helpful graphics)

Class participation grading (30%) is based on attendance (and participation in class discussions) and on your presentation of paper figures, as described below. Approach each presentation as though you were presenting at a professional conference; each presentation will be followed by questions and discussion.

3 pts.
- Gave a complete and coherent description of the figure/table, including any background material needed to interpret it (little or no extraneous info).
- Described underlying experiment/procedure.
- Related information in the figure to the “story” of the paper, stated whether or not data presented supports conclusions.
- Left few questions to be answered.
- Handled questions from class effectively.

2 pts.
- Good description of the figure, including methods/procedures that led to data, and significance of the information presented.
- Able to answer basic questions related to figure and its relevance.

1 pt.
- Reasonable description of figure; maybe some misinterpretation; maybe not able to answer basic questions related to figure and its relevance; evident that effort was made to understand the material.

0 pts.
- Not prepared – read the legend just before class, or absent without prior arrangement.

Paper Summaries

These summaries are designed to encourage timely and critical reading of the articles to be discussed in class. Each summary (hard copy) is due in class on the day we begin to discuss that paper (before the discussion begins). Grading will be based on accuracy of the summary. Late submissions (electronic okay) will be penalized according to the following schedule: 1-24 hours late, -50%; > 24 hours late, -100%.
1. Describe the aspect of human health (or quality of life) addressed by this work:

2. Write out one hypothesis tested by the experiments described in this paper:

3. Which figure presents the results that putatively support or refute the hypothesis you gave above:

4. Identify the statistical analysis tool or approach used to analyze the data in this figure.

5. Describe one of the main experimental measurement techniques employed in this work (type of signal, source of signal, probe or transducer technology, recording strategy, etc.):

6. Describe at least one limitation of the measurement technique you listed above (temporal or spatial resolution, repeatability, indirect measure, compromises system under study, probe placement, etc.). Be quantitative.