BMED 4400 Neuroengineering Fundamentals

Credit: 2-6-4

Prerequisite(s): BMED 3500 and BMED 4752

Catalog Description
Lab and Lecture on current topics in NeuroEngineering, including electrophysiology, clinical and diagnostic neuroengineering, neural prosthetics, sensory-motor integration, neuromorphic VLSI, neurodynamics, neurorobotics.

Text
Neuroscience, 3rd ed. by Purves et al.

Objectives
In this course students will gain the knowledge and laboratory skills necessary for the study of feedback and dynamics of neural systems. Each laboratory module will incorporate literature searching, experimental design, modeling of some aspect of the system under study, data visualization and analysis, scientific writing. The teaching approach will build on problem-based learning (PBL) skills in small groups.

Outcomes

1. To become conversant in all of the fields where technology and neural tissue meet, in both clinical and basic research settings (Program Outcomes 1 and 9).
2. To hone self-directed inquiry skills through the design and execution of laboratory experiments (Program Outcomes 4 and 8).
3. To learn and apply modeling and data analysis tools to real data obtained during lab (Program Outcomes 2 & 4).
4. To hone group skills, working as small teams in and out of the lab (Program Outcome 6).
5. To learn both single-unit and multi-unit neurophysiology (Program Outcomes 1 and 2).
6. To develop an appreciation of neural dynamics, including sensory-motor integration and feedback (Program Outcome 1).

Topical Outline

Lecture

1. Review of basic neurobiology
    a. The nervous system, its inputs and outputs
    b. Basic cellular neurobiology
    c. Neuron activity, neurodynamics, oscillations and bursts

2. Neuromorphic engineering: VLSI silicon (electronics) models of neural systems
3. Hybrid neural microsystems
4. Neural interfacing for sensory and motor prosthetics
5. Neural interfacing for treatment of disease (functional electrical stimulation)
6. Neural interfacing for in vitro brain models
7. Real-time neural data analysis and feedback;
8. Neurally-controlled robots
9. Diagnostic neural interfacing
10. Optical recording in research and the clinic
11. Models of neural trauma and neuropathology
12. Neural tissue engineering, repair and regeneration
13. Motor control
14. Neuromuscular and neuromechanical systems

Laboratory Modules

The Laboratory component will include three modules that will emphasize feedback and the dynamics of neural systems. We will begin at the single-neuron level of analysis in the first module, get into networks in the 2nd module, and look at the Big Picture in the 3rd module:

1. Single-unit recording and stimulation with sharp microelectrodes. This will utilize ganglia from Helisoma (pond snail) and/or Aplysia (sea hare), and will be advised by Prof. Butera, who applies these ideas and methods in his research. Emphasis will be on cellular dynamics.
2. Multi-unit recording and stimulation with multi-electrode arrays. This will use cultured mammalian neurons . Emphasis will be on network dynamics. It will be advised by Prof. Potter, who uses these techniques in his research.
3. Sensory-motor integration. Here the students will conduct psychophysical experiments on each other. It will be advised by Prof. Ting, who studies such issues in her research. Emphasis will be on whole-organism dynamics.

Each module will incorporate literature searching, experimental design, modeling of some aspect of the system under study, data visualization and analysis, scientific writing and oral presentation. The teaching approach will build on problem-based learning (PBL) skills in small groups.