**BE 780: Brain Machine Interfaces**

**Instructor:** Jason Ritt  
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**Class meetings:**  
Tue.-Thurs. 12-2 pm. PSY B42

**Office hours:** TBA

**Summary:** BE780 will introduce major approaches and central challenges in BMI applications. An initial overview will cover low-level details of interfacing with neural tissue, including electrode and optical designs, types of neural signals, and issues of biocompatibility and signal degradation. The core of the course will consider applications, with topics focused on (1) signal decoding approaches in motor control applications, signal to noise requirements, and effects of training and plasticity; and (2) neural stimulation, including choice of peripheral vs. central targets, consequences of topographic organization, types of perceptual responses, and limits to control of distributed systems. Special emphasis will be placed on comparing and critiquing the expanding range of applicable technologies, from in-dwelling microelectrodes to cutting edge neurophotonic tools.

**Readings:** BMI textbooks are beginning to appear, but without a comprehensive text appropriate to an interdisciplinary course. To follow rapid changes in the field, course materials will be drawn largely from research literature. Assigned readings and additional references will be posted to Learn.

**Grading:** Assignments consist of readings, discussion, homework and computational exercises, a mid-semester paper, and a final project. All students will present the readings for an assigned class.

Homework 30%  
Mid-semester Report 30%  
Class Participation 10%  
Final project 30%.

Homework will be assigned approximately weekly, and collected the following week. No late assignments will be accepted. The assignment with the lowest score (or a single missing assignment) will be dropped before computing the Homework average. Students may discuss homework in general terms with each other, but **may not share answers, written materials, code, or files of any kind.** Reports and final projects must be completed individually. When in doubt, speak with the instructor.
### Fundamentals: Jan. 19 - Jan. 21
- Introduction of BMI applications and approaches.
- Neural organization and function. Pathologies relevant to BMI.

### At the tissue interface: Jan. 26 – Feb. 2
- Types of signals.
- Electrode and optical designs.
- Long term implantation, power considerations, biocompatibility.

### Reading out from the nervous system: Feb. 4 - Mar. 3
- Common goals:
  - Restoration of motor control
  - Communication/Speech
  - Monitoring for pathological states
  - Psychological evaluation
- Decoding approaches: filters, classifiers, and the kitchen sink.
- Where should we look for signal?
- Signal drift.
- Training and plasticity.

**SPRING BREAK (No class Mar. 8 and 10)**

### Writing into the nervous system: Mar. 15 - Apr. 19
- Common goals
  - Restoration of sensation/proprioception
  - Control of pathological states
  - "Replacement parts for the brain"
  - Adjunct to pharmacology
- Control theory. Where should we drive the system?
- Topological vs. geometric stimulation.
- Underactuation and distributed systems.
- Perceptual vs. functional information.
- Long term issues, plasticity, kindling.

### The last mile: Apr. 19 - Apr. 26
- Patient needs, clinical limitations.
- Power, maintenance, calibration, cost.
- Social concerns in BMI use and acceptance.

**Note:** No class on Feb. 16 (BU Monday)

### Final Project Presentations: Apr. 28 and second session TBA