Biology 160 – From brains to intelligent machines

Instructor: Santiago Jaramillo
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Class time: TBD
Class location: TBD
Office Hours: TBD

Teaching assistants: TBD

Course materials: All course materials will be available through Canvas.
No textbook is required for this course.

Course prerequisites: None.

Catalog description:

Basic concepts on how brains and artificial systems process information. Analysis of the similarities, differences, and complementarity between these systems.

Expanded course description

A course for non-science majors to introduce the concepts necessary to understand how the brain and artificial computing systems process information. The course will introduce students to the process of scientific reasoning, and discuss methodologies used by scientists to gain knowledge about how the nervous system works. The course also covers how scientists and engineers attempt to replicate these processes in computers and artificial intelligence systems. The course will illustrate parallels in information processing and computation between biological and artificial systems.
Readings and videos before class will provide background information. The main concepts and skills will be learned through in-class activities in which students play the role of scientists and engineers solving problems about computation in biological and artificial systems. In the last part of the course, students will discuss the implications to society of intelligent machines and technologies for interfacing brains and machines.

Learning objectives

1. Gain a basic understanding of how the nervous system acquires and processes information.
2. Gain a basic understanding of how every-day computing devices process information and the approaches followed for designing intelligent machines.
3. Analyze and compare approaches for acquiring knowledge about how the brain works.
4. Develop the ability to formulate hypotheses and follow the scientific method to acquire new knowledge.
5. Become a critical reader of popular science writings.
6. Evaluate the impact of brain science and engineering to society.

Student workload

In addition to four hours per week in class, students will spend, on average, eight hours per week on reading and preparing assignments. Work outside class will include assessment of assigned readings and videos, as well as preparing a final project.

Grading

10% – In-class clicker questions
20% – Weekly assignments: each assignment consists of about 10 multiple-choice questions.
10% – Mid-term 1
10% – Mid-term 2
20% – Final project (5% for first part, 5% for second part, 10% for final part).
30% – Final exam

The final project is a written assignment that must be submitted in 3 parts as stated in the schedule. We are using i>clickers as a way to facilitate classroom participation and discussion. This grade will be a mixture of participation and accuracy of answers.

“A” grade corresponds to full participation in all class activities, the ability to apply knowledge from the course (demonstrated by high scores in exams), and high degree of detail in final project. “B” work shows evidence of effort but may not rise to the level of an “A” in one or more areas. “C” work has major deficiencies in several areas but the student had made an effort and mastered the basic topics. “D” work represents effort acceptable in at least one area, but deficient in others. “F” work is not acceptable, either because no aspect of the work rises to acceptable levels or major portions of the assignments are missing.

Course schedule

Week 1 (objectives 1,2,3):

Topics:

1. Introduction: history of computing machines and brain science.
2. Scientific methodologies and engineering approaches.

Video (watch before second class):

- (15 min) Humans need not apply (The future of automation): https://www.youtube.com/watch?v=7Pq-S557XQU

Readings (read before second class):

- (2 pages) Kinds of neuroscience research http://www.brainfacts.org/about-neuroscience/what-is-neuroscience/articles/kinds-of-research/
- (7 pages) Brain Facts. Chapter 1: Brain basics http://www.brainfacts.org/book

Assignments (submit before second class):

- Online quiz about readings.

Week 2 (objectives 1,2,3):

Topics:

1. Architectures and spatial scales of computing systems.
2. How systems acquire information: Transduction. The physics of light and sound.

Readings:

- (3 pages) The brain chip http://www.sciencemag.org/content/345/6197/614.full
- (3 pages) Introducing a Brain-inspired Computer http://www.research.ibm.com/articles/brain-chip.shtml
- (10 pages) The physics of vision. The physics and biology of audition (excerpt). http://www.psypress.co.uk/mather/resources/chapter.asp?chapter=06 http://www.psypress.co.uk/mather/resources/chapter.asp?chapter=04

Assignments (submit before class this week):

- Online quiz about readings.

Week 3 (objectives 1,3,4):

Topics:

1. Representation of information: coding with bits and action potentials.
2. Transformations and computations.

Readings:

- (2 pages) Analog vs digital
  http://www.explainthatstuff.com/analog-and-digital.html
- (6 pages) Visual illusions and neurobiology
  http://eaglemanlab.net/papers/Eagleman.NatureRevNeuro.Illusions.pdf

Assignments (submit before class this week):

- Online quiz about readings.
- (1 page) First report on final project.

Week 4 (objectives 1,2,3,4):

Topics:

- Problem set discussion.
- Mid-term exam #1.

Assignments (submit before class this week):

- Problem set (weeks 1,2,3).

Week 5 (Objectives 1,3,4,5):

Topics:

- Motor control in biological and artificial systems.
- Decision-making in biological and artificial systems.

Readings:

- (4 pages) Motor control: Biological and Theoretical
  http://prism.bham.ac.uk/pdf_files/Miall_2002_HBBT_A153.pdf
- (12 pages) A brief history of Neuroeconomics.
  http://homepages.inf.ed.ac.uk/pseries/CCN10/glimcher08Neuro.pdf

Assignments (submit before class this week):

- Online quiz about readings.

Week 6 (Objectives 1,3,4,5):

Topics:

- Parallels between biological and artificial memory.
- Biological and artificial mechanisms for learning.

Readings:

- (6 pages) Animals in research http://www.brainfacts.org/about-neuroscience/animals-in-research/success-stories/
- (4 pages) Brain Facts. Chapter 4: Learning, Memory, and Language http://www.brainfacts.org/book

Video (watch before class this week):

- (58 min) Mapping Memory in the Brain: http://www.hhmi.org/biointeractive/mapping-memory-brain

Assignments (submit before class this week):

- Online quiz about readings.

Week 7 (Objectives 1,3,5):

Topics:

- Thinking machines: chess programs, IBM's Watson and self-driving cars.
- Statistical approaches to brain computation and machine intelligence.

Readings:

- (12 pages) Searle, John. R. (1980) Minds, brains, and programs. http://cogprints.org/7150/1/10.1.1.83.5248.pdf

Assignments (submit before class this week):

- Online quiz about readings.
- (1 page) Second report on final project.

Week 8 (objectives 1,3,4,5):

Topics:

- Problem set discussion.
- Mid-term exam #2.

Assignments (submit before class this week):

- Problem set (weeks 5,6,7).

Week 9 (Objectives 7):

Topics:

- Technologies (fiction and reality) about memory manipulation.
- Implications of thinking machines.

Audio (listen before second class):

- (4 min) Bursts Of Light Create Memories, Then Take Them Away

http://www.npr.org/sections/health-shots/2014/06/02/318104637/bursts-of-light-create-memories-then-take-them-away

Videos (watch before class this week):

- (49 min) DARPA self-driving car challenge: https://www.youtube.com/watch?v=PXQlpu8Y4fI
- (3 min) Google's self-driving car: https://www.google.com/selfdrivingcar/

Assignments (submit before class this week):

- Online quiz about audio and videos.
- (2 pages) Submit final project.

Week 10 (objectives 6,7):

Topics:

- Neuroprosthetics and brain-machine interfaces.
- Review and conclusions: How far is reality from fiction?

Readings:

- (3 pages) The cyborg in all of us http://www.nytimes.com/2011/09/18/magazine/the-cyborg-in-us-all.html
- (2 pages) Monkeys Think, Moving Artificial Arm as Own http://www.nytimes.com/2008/05/29/science/29brain.html

Assignments (submit before class this week):

- Online quiz about readings.

Academic Honesty

Group discussions outside of class are encouraged. However, all work submitted as part of this course must be your own. The use of sources must be properly acknowledged. Copying or paraphrasing information from any source without citation is plagiarism. For more information, see http://library.uoregon.edu/guides/plagiarism/students/index.html
The consequences of academic dishonesty will be taken seriously (e.g., an 'F' in the course and a report to the Office of Student Conduct) and are noted on student disciplinary records. If you are in doubt regarding any aspect of these issues, please come and speak with me.

Students with disabilities

If you have a documented disability and anticipate needing accommodations in this course, please make arrangements to meet with me. Please request that the Counselor for Students with Disabilities send a letter verifying your disability.