PSY513
Introduction to computational cognitive neuroscience

Lectures: Tu & Th, 9:00-10:15AM, Psychology 2102

Instructor

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Office hours: Email for appointment.

Course objectives

Computational cognitive neuroscience is a new field of study that lies at the intersection of computational neuroscience and the similar fields of machine learning, neural network theory, connectionism, and artificial intelligence. Like computational neuroscience, computational cognitive neuroscience strives for neurobiological accuracy and like connectionism, a major goal is to account for behavior. Covered topics include feature extraction / optimization, connectionism, computational neuroscience, and computational cognitive neuroscience applications.

Recommended pre-requisite

Basic calculus (required), linear algebra (optional), differential equations (optional).

Course format

This course includes lectures, reading assignments, and student presentations. The first two months of class will be mostly lectures while the last month will be mostly student presentations. Reading assignments will be ongoing throughout the whole semester.

Bibliography (relevant chapters/papers are posted on Brightspace)

[AH11] Ashby, F. G. & Hélie, S. (2011). A tutorial on computational cognitive neuroscience: Modeling the neurodynamics of cognition. *Journal of Mathematical Psychology, 55*, 273-289.

[B97] Ballard, D. H. (1997). *An Introduction to Natural Computation*. Cambridge, MA: MIT Press.

[DK96] Diamantaras, K. I., & Kung, S. Y. (1996). *Principal Component Neural Networks: Theory and Applications*. John Wiley & Sons. [Available on Blackboard]

[H09] Haykin, S. (2009). *Neural Networks and Learning Machines. Third Edition*. Prentice Hall.

[HKP91] Hertz, J., Krogh, A., & Palmer, R. G. (1991). *Introduction to the Theory of Neural Computation*. Redwood City, CA: Addison-Wesley.

[I07] Izhikevich, E. M. (2007). *Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting*. MIT Press.

[RCH17] Ross, M., Chartier, S., & Hélie, S. (2017). The neurodynamics of categorization: Critical challenges and proposed solutions. In H. Cohen & C. Lefebvre (Eds.). *Handbook of Categorization in Cognitive Science. 2nd Edition* (pp. 1053–1076). Oxford: Elsevier.

[SB98] Sutton, R. S., & Barto, A. G. (1998). *Reinforcement Learning*. MIT Press.

[W10] Wang, X. -J. (2010). Neurophysiological and computational principles of cortical rhythms in cognition. *Physiological Reviews*, *90*, 1195-1268.

Evaluation

All coursework, including take-home exams, is expected to be done individually. You are required to cite or reference any source used in your work.

Short take-home exam on connectionist networks (10/08).....20%
Short take-home exam on computational neuroscience (11/10).....20%
Oral presentation (~30 minutes; mid November to end of semester).....20%
Written assignment (max 10 pages; 12/05).....40%

Grading scheme

Grade	Letter	Grade	Letter
≥ 90%	A	65% - 69%	C+
85% - 89%	A-	60% - 64%	C
80% - 84%	B+	55% - 59%	C-
75% - 79%	B	< 55%	F
70% - 74%	B-		

Class etiquette

I expect you to be respectful and polite to me and the other students in the class. Here are some of my specific expectations:

- **Arrive On Time.** Class starts at 9:00 AM. If you arrive late, do not be disruptive. Take a seat in the back of the class to minimize disruption.
- **Turn Off Technology.** Turn off all phones, PDAs, and all other noise-making things before the beginning of class.
- **Don't Chitchat.** Talking distracts me and other students. Of course, if you have a question or comment during a lecture, please raise your hand and ask. But other chitchat is disruptive to me and everyone else.

- **Purdue Honors Pledge.** Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breeches of this value by either emailing integrity@purdue.edu or by calling 765–494–8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern. As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together – we are Purdue.

Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, wearing a mask in classrooms and campus building, disinfecting desk/workspace prior to and after use, maintaining proper social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

Attendance Policy during COVID-19

Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment. Only the instructor can excuse a student from a course requirement or responsibility. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email. When the student is unable to make direct contact with the instructor and is unable to leave word

with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, quarantine, or isolation, the student or the student's representative should contact the Office of the Dean of Students via email or phone at 765-494-1747.

Academic Guidance in the Event a Student is Quarantined/Isolated

If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

CAPS Information

Purdue University is committed to advancing the mental health and well–being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765) 494–6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

Tentative schedule (flexible – may change as we go along)

Date	Topic	Reading
08/25	Introduction	DK – Chap. 2-2.2.8
08/27	Information theory	B97 – Chap. 2
09/01	Feature extraction	DK – Chap. 3.1, 3.4
09/03	Optimization and the simple perceptron	HKP91 – Chap. 5
09/08	MLP and backpropagation learning	HKP91 – Chap. 6
09/10	MLP and backpropagation learning	
09/15	Competitive learning	HKP91 – Chap. 9
09/17	Competitive learning	
09/22	Hebbian learning	[RCH17]
09/24	Hebbian learning	
09/29	Reinforcement learning	SB98 – Chaps. 3, 4
10/01	Reinforcement learning	SB98 -- Chap. 6
10/06	Kernel models	H09 – Chap. 5
10/08	SVM	H09 -- Chap. 6
10/13	Neurodynamics	H09 – Chap. 13
10/15	Computational neuroscience	I07 – Chaps. 1
10/20	Hodgkin-Huxley model	I07 – Chap. 2
10/22	The Izhikevich simple model	I07 – Chap. 8
10/27	The Izhikevich simple model	
10/29	Network oscillations	[W10]
11/03	Computational cognitive neuroscience	[AH11]
11/05	Student presentations	
11/10	Student presentations	
11/12	Student presentations	
11/17	Student presentations	
11/19	Conference – no lecture	
11/24	Thanksgiving week – no lecture	
11/26	Thanksgiving break – no lecture	
12/01	Virtual Q&A for written assignment	
12/03	Virtual Q&A for written assignment	