PSY513
Introduction to computational cognitive neuroscience

Lectures: Friday, 11:30-2:20AM, PSYC 3187

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)

[ACI23] Ashby, F. G., Crossley, M. J., & Inglis, J. B. (in press). Mathematical models of human learning. In F. G. Ashby, H. Colonius, & E. Dzhafarov (Eds.). *The New Handbook of Mathematical Psychology. Volume 3.* Cambridge University Press.

[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.

[GBC16] Goodfellow, I., Bengio, Y., Courville, A. (2016). *Deep Learning*. MIT Press.

[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.

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 (10/07).....20%
Short take-home exam on computational neuroscience (11/11).....20%
Oral presentation (~30 minutes; November to end of semester).....20%
Written assignment (max 10 pages; 12/12).....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 11:30 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, and 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.

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
08/26	General introduction Information theory	B97 – Chap. 2
09/02	Feature extraction Optimization and the simple perceptron	[GBC16] – Chap. 2 [HKP91] – Chap. 5
09/09	MLP and backpropagation learning	[HKP91] – Chap. 6
09/16	Competitive learning	[HKP91] – Chap. 9
09/23	Hebbian learning	[RCH17]
09/30	Reinforcement learning Neurodynamics	[SB98] – Chap. 3 [H09] – Chap. 13
10/07	Computational neuroscience Hodgkin-Huxley model	[I07] – Chaps. 1, 2
10/14	The Izhikevich simple model	[I07] – Chap. 8
10/21	Computational cognitive neuroscience Computational models of learning	[AH11] [ACI23]
10/28	Example CCN models	TBD
11/04	Example CCN models	TBD
11/11	•Ben McAteer •Aly Randez	TBD
11/18	•Caitlin Pessolano •Sarah Zhang •Arbaaz Mukadam	TBD
11/25	**Thanksgiving / No class**	**--**
12/02	•Soyol Enkh-Amgalan •Yesol Kim •Ethan Yu	TBD

12/09	•Rey Gonzalez •Alex Cuadra	TBD