PERCEPTION AND ACTION

COGS 6420

COURSE INFORMATION

COGS 6420: Perception & Action (Section 01)

Spring 2023	M 2:00 – 5:50 PM	LOW 4034
Lecture	4 credits	

INSTRUCTOR

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COURSE DESCRIPTION

How do people navigate along a crowded sidewalk, reach for and pick up a glass of water, balance a tray of dishes, or type on a keyboard? How do highly skilled athletes, musicians, and dancers move with such efficiency and coordination? What goes wrong when our ability to move becomes impaired and how can this ability be restored? Why is it so difficult to build machines to perform the same activities that most of us carry out effortlessly? This course is a graduate-level introduction to the topic of perception and action. It is designed to be of interest to students in psychology and cognitive science, as well as those in other fields who want to better understand how humans and non-human animals interact with the world. Students will learn how the perceptual and motor systems work, how they contribute to the performance of both routine, everyday tasks and highly practiced skills, and how perceptual and motor impairments affect our ability to move. We will also consider applications for robotics, human-machine interaction, and the training and rehabilitation of perceptual-motor skills.

STUDENT LEARNING OUTCOMES

Students who successfully complete this course will be able to:

1. summarize and critically evaluate published research in the field of perception and action.
2. explain how the perceptual and motor systems work.
3. describe major theories, recall key findings that support or refute those theories, and evaluate positions on key theoretical issues in the study of perception and action.
4. synthesize ideas and findings from multiple studies into a cohesive story.
5. explain how knowledge from the study of perception and action has been and could be used to address practical problems.
6. communicate useful and interesting ideas from the study of perception and action to a general audience.

GRADING

Your final grade will be based on:

⇒ Reports (4)..... 50%
⇒ Paper presentations (# TBD) 30%
⇒ Participation in class discussions..... 20%

Percentage	Grade		Percentage	Grade
93 ≤ % of grade	A		77 ≤ % of grade < 80	C+
90 ≤ % of grade < 93	A-		73 ≤ % of grade < 77	C
			70 ≤ % of grade < 73	C-
87 ≤ % of grade < 90	B+			
83 ≤ % of grade < 87	B			
80 ≤ % of grade < 83	B-			

Students who earn less than 70% of the total number of points will be given a final grade of F.

COURSE ASSESSMENT MEASURES

Assessment	Due Date(s)	Learning Outcome #s
Reports	See schedule	1, 2, 3, 4, 5
Paper presentations	TBD	1, 2, 3, 4, 5
Participation	Each class	1, 2, 3, 4, 5

COURSE FORMAT

The format of this course will be a combination of lecture and class discussion. In general, the first half of each class will be set aside for student presentations and class discussions of reading material related to the topic of the lecture from the previous class. During the second half, I will give a lecture to introduce the next topic on the syllabus.

READING MATERIAL

There is no textbook for this course. The reading material for each class will be divided into background reading and reading for class discussion. For the most part, background reading will be optional or recommended but not required. It is provided in case you want to follow up on one of the lecture topics. Occasionally, background reading will be mandatory to fill in gaps in the lecture. This will be stated in class. The reading for class discussion will include one (occasionally two) target article(s), which everyone should

read, and 2-3 additional papers, each of which will be read and presented by one student. Occasionally, you will be asked to watch a video of a talk rather than or in addition to reading a paper. All required reading material will be available on LMS.

LECTURE SLIDES

An electronic version of the Powerpoint slides used in each lecture will be posted on LMS shortly after class.

PAPER PRESENTATIONS

Each week, I will assign 2-3 papers related to the class discussion topic to students, who will be responsible for presenting brief summaries of the papers and helping to moderate the class discussion. In general, the time allotted for discussion will not be sufficient time to cover all of the details of a given study, so be selective and focus on the aspects of the study that are most relevant to the discussion topic and most interesting. Presentations should be created in Powerpoint (or equivalent) and submitted via LMS before class for grading purposes. Presentations will be graded as follows: excellent (3 points), acceptable (2 points), unacceptable (1 point). If you are scheduled to present and either show up without a presentation or skip class, you will receive zero points.

REPORTS

Each student must write four reports during the semester on topics from the lectures, readings, and weekly class discussions. The decision about which of the topics on the syllabus to write about is up to you. To encourage you to think about the course material from different perspectives, you must submit one of each of the following types of reports:

- a mini-review (~2000 words)
- an opinion or reaction paper (~1500-2000 words)
- an application of basic P&A research to some practical/real-world problem (~1500-2000 words)
- an essay on P&A aimed at a general audience (readable and of interest to an educated layperson) (~1000-1500 words)

Each report should be well written, clearly organized, informative, and insightful. There are no specific requirements for the format of the reports, except that they should include a title, a brief abstract (3-5 sentences), and a list of references. The type of report and word count should also be clearly indicated. Reports should cite and refer to some of the background readings and readings for class discussion, as well as other relevant papers that you find while searching the literature. Due dates for reports are listed on the schedule. The order in which you complete the four report types is up to you. Please save the file as a PDF and include your last name and report type in the filename (e.g., fajen_MiniReview.pdf). Submit via LMS before class on the due date.

EXAMS

There are no exams for this course.

POLICIES

Attendance and participation. Students are expected to attend all classes and participate in class discussions. Each new topic will be introduced in lecture. So if you skip class, you will have to spend a great deal more time outside of class to keep up with the material. If you must miss class for a legitimate reason, you should contact me beforehand by e-mail or in-person during my office hours.

Email. For the purposes of this course, email should be used as a tool for scheduling a time to meet with me if office hours conflict with your schedule. Please include times during which you are available to meet and a brief (1-2 sentence) description of the purpose of the meeting. In general, I will not respond to emails asking for further explanation of material covered in class or the reading material, or for clarification on assignments. This policy encourages you to ask questions about these matters during class time and to seek help by meeting with me in person, which is far more effective than trying to get help via email.

Use of electronic devices. Use of laptops, cell phones, and other electronic devices during lectures is strongly discouraged, even for the purposes of note-taking. These devices interfere with learning and can be a distraction to other members of the class. Recent research suggests that students learn more effectively when they take notes by hand using paper and pencil (or possibly, a tablet with a stylus) than on a laptop. Laptops and tablets may be used during class discussions for viewing the reading materials.

Academic integrity: Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts that violate this trust undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities and The Graduate Student Supplement define various forms of Academic Dishonesty and you should make yourself familiar with these. In this class, all assignments that are turned in for a grade must represent the student's own work. In cases where help was received, or teamwork was allowed, a notation on the assignment should indicate your collaboration. Violations of academic integrity may also be reported to the appropriate Dean (Dean of Students for undergraduate students or the Dean of Graduate Education for graduate students, respectively). If you have any question concerning this policy before submitting an assignment, please ask for clarification. In addition, you can visit the following site for more information on our Academic Integrity Policy: Students Rights, Responsibilities, and Judicial Affairs.

Disability services: Rensselaer Polytechnic Institute strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on a disability, please let me know immediately so that we can discuss your options. To establish reasonable accommodations, please register with The Office of Disability Services for Students. After registration, make arrangements with the Director of Disability Services as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. DSS contact information: dss@rpi.edu; +1-518-276-8197; 4226 Academy Hall.

Support Services: RPInfo contains various resource links for students, academic resources, support services, and safety & emergency preparedness.

CLASS SCHEDULE

Date		Lecture (L) and Discussion (D) topics	REPORT DUE
1/9	L	Course introduction; (Re-)acting quickly	
1/16		MARTIN LUTHER KING DAY: NO CLASSES	
1/23	D	Does prediction play a role in the execution of fast interceptive actions?	
	L	Open-loop control	
1/30	D	How and why is performance affected by visual occlusion?	
	L	Motor planning and decision making	
2/6	D	Is motor decision-making optimal? How does motor decision making compare to economic decision making?	Report 1 due on 2/9
	L	Internal models	
2/13	D	Does the brain have an internal model of gravity?	
	L	Neural perspectives	
2/20		PRESIDENT'S DAY: NO CLASSES	
2/21	D	What's going on inside the brains of elite athletes?	
	L	Motor learning and development	
2/27	D	How do people learn to cope with noise and variability?	Report 2 due on 3/2
	L	Coordination	
3/6		SPRING BREAK: NO CLASSES	
3/13	D	How do two or more individuals coordinate their actions to achieve a common goal?	
	L	Behavioral dynamics	
3/20	D	How does globally coherent motion emerge from local interactions among individuals in a crowd?	
	L	Visual space and model-based control	
3/27	D	Does steering rely on internal models?	Report 3 due on 3/30
	L	Embodied approaches	
4/3	D	What role does active gaze play in the control of action?	
	L	The ecological approach and perception of affordances	
4/10	D	Do humans use optic flow to perceive and control heading?	
	L	Perception-action coupling	
4/17	D	How do humans negotiate complex terrain?	
	L	Navigation and cognitive maps	
4/24	D	Do insects have cognitive maps?	Report 4 due on 4/24
	L	Optic flow-based robotics and ML models of control	
	D	Discussion of cross-cutting themes	

DETAILED CLASS SCHEDULE

Topic 01 (Jan 9, 23): (Re-)acting quickly

Lecture topics:

- Simple and choice reaction time
- Latency to use visual feedback
- Proprioceptive feedback loops

Background reading (optional):

- Bootsma & van Wieringen (1990); van Soest et al. (2010a); Bootsma et al. (2010); van Soest et al. (2010b)
- Schmidt RA, Lee TD, Winstein, C, Wulf, G, & Zelaznik (2018) Motor Control and Learning: A Behavioral Emphasis (6th edition). Champaign, IL: Human Kinetics. (Ch. 3, 5)
- Smeets, J. B., Wijdenes, L. O., & Brenner, E. (2016). Movement adjustments have short latencies because there is no need to detect anything. *Motor Control*, *20*(2), 137-148.
- Tresilian J (2012) Sensorimotor Control & Learning. London: Palgrave MacMillan. (§1.2-1.4, 2.3, 3.3, 3.4, 5.2, 5.3)

Discussion topics: Does prediction play a role in the execution of fast interceptive actions?

- Fiehler, K., Brenner, E., & Spering, M. (2019). Prediction in goal-directed action. Journal of Vision, 19(9):10, 1–21, https://doi.org/10.1167/19.9.10.

Topic 02 (Jan 23, 30): Open-loop control

Lecture topics:

- Deafferentation studies
- Lessons from case study of proprioceptive loss (Ian Waterman)
- Central pattern generators
- Motor programs

Background reading (optional):

- Schmidt RA & Lee TD (2011) *Motor Control and Learning: A Behavioral Emphasis (5th edition)*. Champaign, IL: Human Kinetics. (Ch. 6)
- Tresilian J (2012) *Sensorimotor Control & Learning*. London: Palgrave MacMillan. (Selected sections of Ch. 2, 3, 5, 6, 11)
- The Man Who Lost His Body (BBC Documentary about Ian Waterman). (Link: https://www.dailymotion.com/video/x12647t)

Discussion topic: How and why is performance affected by intermittent and persistent visual occlusion?

- Zhao H, & Warren WH (2015). On-line and model-based approaches to the visual control of action. *Vision research*, *110*, 190-202.

Topic 03 (Jan 30, Feb 6): Motor planning and decision making

Lecture topics:

- Motor planning and end-state comfort
- Motor planning under risk
- Motor planning under sensory uncertainty
- Dynamic integration of noisy sensory information

Background reading (optional):

- Rosenbaum, DA (2013). Cognitive foundations of action planning and control. *Action science: Foundations of an emerging discipline.* pp. 89-111.
- Rosenbaum DA, Chapman KM, Coelho CJ, Gong L, Studenka BE. (2013) Choosing actions. *Frontiers in Psychology*. 4, 1–14.
- Wolpert DM, Diedrichsen, J. & Flanagan JR (2011). Principles of sensorimotor learning. *Nature Reviews Neuroscience*, 12, 739-751.
- Wolpert DM & Landy MS (2012). Motor control is decision-making. *Current opinion in neurobiology*, *22*(6), 996-1003.
- Wong, A. L., Haith, A. M., & Krakauer, J. W. (2015). Motor planning. *The Neuroscientist*, *21*(4), 385-398.
- Wu, Delgado, & Maloney (2014). Motor decision-making. In AW Toga & RA Poldrack [Eds], *Brain Mapping: An Encyclopedic Reference*, Amsterdam: Elsevier.

Discussion topic: Is motor decision making optimal? How does motor decision making compare to economic decision making?

- Gallivan et al. (2018). Decision-making in sensorimotor control. Nature Reviews Neuroscience, 19(9), 1-16.

Topic 04 (Feb 6, 13): Internal models

Lecture topics:

- Forward and inverse models
- Learning an internal model
- Neural basis of internal models

Background reading (optional):

- Davidson, PR & Wolpert DM (2005). Widespread access to predictive models in the motor system: A short review. *Journal of Neural Engineering*, 2, 8313-8319.
- Diedrichsen, J. Shadmehr, R., & Ivry, R. B. (2010). The coordination of movement: Optimal feedback control and beyond. *Trends in Cognitive Sciences*, 14(1), 31-39.
- Jordan, MI & Wolpert, DM (1999). Computational motor control. In M. Gazzaniga (Ed.) *The cognitive neurosciences*. Cambridge, MA: MIT Press. (pp. 601-620).

- McNamee, D & Wolpert, DM (2019). Internal models in biological control. Annual Review of control, robotics, and autonomous systems. 339-364.
- Shadmehr R, and Mussa-Ivaldi FA (1994) Adaptive representation of dynamics during learning of a motor task, *Journal of Neuroscience* 14:3208-3224.
- Shadmehr, R., Smith, M. A., & Krakauer, J. W. (2010) Error correction, sensory prediction, and adaptation in motor control. *Annual Reviews of Neuroscience*, 33, 89-108.
- Wolpert, DM & Ghahramani, Z (2000). Computational principles of movement neuroscience. *Nature Neuroscience*, 3, 1212-1217.

Discussion topic: Does the brain have an internal model of gravity?

- Zago, M., McIntyre, J., Senot, P., & Lacquaniti, F. (2009). Visuo-motor coordination and internal models for object interception. *Experimental Brain Research*, *192*(4), 571-604.

Topic 05 (Feb 13, 21): Neural perspectives

Lecture topics:

- Affordance competition hypothesis
- Lessons from the study of movement disorders
- The mirror neuron hypothesis

Background reading (optional):

- Cisek P, Kalaska JF. (2010) Neural Mechanisms for Interacting with a World Full of Action Choices. *Annual Reviews of Neuroscience*, 33, 269-298.
- Jax, S. A., & Coslett, H. B. (2009). Disorders of the perceptual-motor system. In Dagmar Sternad (Ed.), Progress in Motor Control – A multidisciplinary perspective (pp. 377 - 391). Springer
- Purves et al. (2008). *Principles of Cognitive Neuroscience*. Sinauer. (Ch. 8, 9)
- Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Reviews of Neuroscience*, 27, 169-192.
- Rizzolatti, G. et al. (2009). The mirror neuron system: A motor-based mechanism for action and intention understanding. In: *The Cognitive Neurosciences*, MS Gazzaniga (ed.) MIT Press, pp. 625-640.

Discussion topic: What's going on inside the brains of elite athletes?

- Yarrow K, Brown P & Krakauer JW (2009). Inside the brain of an elite athlete: The neural processes that support high achievement in sports. *Nature Reviews Neuroscience*, 10, 585-596.

Topic 06 (Feb 21, 27): Motor learning and development

Lecture topics:

- Stages of motor learning

- Synergies
- Skill acquisition and training
- Motor development: How infants learn to move

Background reading (optional):

- Adolph, K. (2008). The growing body in action: What infant locomotion tells us about perceptually guided action. In *Embodiment, ego-space, and action: Carnegie Mellon Syposium*. Erlbaum Press.
- Adolph, K. E. (2008). Learning to move. *Current Directions in Psychological Science*, *17*(3), 213-218.
- Feigenberg, I. M., & Latash, L. P. (1996). N. A. Bernstein: The reformer of neuroscience. In M. L. Latash & M. T. Turvey (Eds.) *Dexterity and its Development* (pp. 247-275).
- Gray, R. (2021). How we learn to move: A revolution in the way we coach and practice sports skills. Perception Action Consulting & Education LLC.
- Latash ML, Scholz JP, Schöner G. (2007). Toward a new theory of motor synergies. *Motor Control*, 11: 275-307
- Tresilian, J. (2012). *Sensorimotor Control & Learning.* London: Palgrave MacMillan. (Ch. 14-15)

Discussion topic: How do people learn to cope with noise and variability?

- Sternad, D. (2017). Human Control of Interactions with Objects–Variability, Stability and Predictability. In *Geometric and Numerical Foundations of Movements* (pp. 301-335). Springer International Publishing.

Topic 07 (Feb 27, Mar 13): Coordination

Lecture topics:

- Coordination dynamics
- Social coordination
- Joint action

Background reading (optional):

- Amazeen, P. G., Amazeen, E. L., & Turvey, M. T. (1998). Dynamics of human intersegmental coordination: Theory and research. In D. A. Rosenbaum & C. E. Collyer (Eds.), *Timing of behavior: Neural, computational, and psychological perspectives.* (pp. 237-259). Cambridge, MA: MIT Press.
- Kelso, J. A. S. (1995). *Dynamic Patterns: The Self-Organization of Brain and Behavior.* Cambridge: MIT Press.
- Turvey, M. T. (1991). Coordination. *American Psychologist*, 45(8), 938-953.
- Turvey, M. T., & Carello, C. (1996). Dynamics of Bernstein's level of synergies. In M. Latash. & M. T. Turvey (Eds.), *Dexterity and its development* (pp. 339-376). Hillsdale, NJ: Erlbaum.

- Turvey, Fitch, & Tuller (1982). The Bernstein perspective: I, II, and III. In J. A. S. Kelso (Ed.) *Human Motor Behavior: An Introduction.* Hillsdale, NJ: Erlbaum (pp. 239-281).

Discussion topic: How do two or more individuals coordinate their actions to achieve a common goal?

- Nalepka P, Kallen RW, Chemero A, Saltzman E, Richardson MJ. (2017). Herd Those Sheep: Emergent Multiagent Coordination and Behavioral-Mode Switching. *Psychological Science*, 28(5), 630-650.

Topic 08 (Mar 13, 20): Behavioral dynamics

Lecture topics:

- Active and passive modes of control in ball bouncing and walking
- Behavioral dynamics of steering and obstacle avoidance
- Behavioral dynamics of crowds

Background reading (optional):

- Fajen, B. R., & Warren, W. H. (2003). Behavioral dynamics of steering, obstacle avoidance, and route selection. *Journal of Experimental Psychology: Human Perception and Performance*, *29*(2), 343.
- Siegler, I. A., Bardy, B. G., & Warren, W. H. (2010). Passive vs. active control of rhythmic ball bouncing: the role of visual information. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(3), 729.
- Warren, W. H. (2006). The dynamics of perception and action. *Psychological Review*, 113(2), 358-389.
- The Dynamics of Perception and Action I: Locomotor Behavior. Talk presented at the University of Alberta Department of Psychology by William H. Warren.
- The Dynamics of Perception and Action II: Crowd Behavior. Talk presented at the University of Alberta Department of Psychology by William H. Warren.

Discussion topic: How does globally coherent motion spontaneously emerge from local interactions among individuals in a crowd?

- Warren, W. H. (2018). Collective Motion in Human Crowds. *Current Directions in Psychological Science*, *27*(4), 232–240. https://doi.org/10.1177/0963721417746743

Topic 09 (Mar 20, 27): Visual space and model-based control

Lecture topics:

- Theoretical approaches: Constructivist and indirect perception; Marr's computational approach
- Visual space perception: air vs. ground theory; lessons from 3d shape perception
- Model-based control
- Visually directed action

Background reading (optional):

- Epstein, W. (1995). The metatheoretical context. In W. Epstein & S. Rogers (Eds.) *Perception of Space and Motion.* Elsevier. (pp. 1-22)
- Glennerster, A. (2016). A moving observer in a three-dimensional world. *Phil. Trans. R. Soc. B*, *371*(1697), 20150265.
- Loomis, J. M. & Beall, A. C. (2004). Model-based control of perception/action. In L. Vaina, S. Beardsley, and S. Rushton (Eds.). *Optic Flow and Beyond* (pp. 421-441). Boston: Kluwer Academic Publishers.
- Loomis, J. M. & Philbeck, J. W. (2008). Measuring perception with spatial updating and action. In R. L. Klatzky, M. Behrmann, & B. MacWhinney (Eds.), *Embodiment, ego-space, and action* (pp. 1-43). Mahwah, NJ: Erlbaum.
- Palmer, S. E. (1999). *Vision Science: Photons to phenomenology*. MIT Press (Ch. 1 and 2).
- Warren, W. H. (2012). Does this computational theory solve the right problem? Marr, Gibson, and the goal of vision. *Perception*, 41(9), 1053-1060.
- Warren, W. H., Rothman, D. B., Schnapp, B. H., & Ericson, J. D. (2017). Wormholes in virtual space: From cognitive maps to cognitive graphs. *Cognition*, *166*, 152-163.

Discussion topic: Does steering rely on internal models?

- Lappi, O & Mole, C (2018). Visuomotor control, eye movements, and steering: A unified approach for incorporating feedback, feedforward, and internal models. *Psychological Bulletin*, 144(10), 981-1001.

Topic 10 (Mar 27, Apr 3): Embodied approaches

Lecture topics:

- The two visual systems hypothesis
- Embodied perception
- Action-specific perception
- The natural environments and tasks perspective

Background reading (optional): The two visual systems hypothesis

- Ganel, T., Tanzer, M., & Goodale, M. (2008). A double dissociation between action and perception in the context of visual illusions: Opposite effects of real and illusory size. *Psychological Science*, 19(3), 221-225.
- Goodale, M. (2011). Transforming vision into action. *Vision Research*, 51, 1567-1587.
- Goodale, M. A., & Humphrey, G. K. (2001). Separate visual systems for action and perception. In E. Bruce Goldstein (Ed.). *Blackwell Handbook of Perception*. Malden, MA: Blackwell. (pp. 311-343)
- Milner, AD & Goodale MA (2008). Two visual systems re-viewed. *Neuropsychologia*, 46(3),774-85.

Background reading (optional): Embodied perception, action-specific perception

- Firestone, C. (2013). How "paternalistic" is spatial perception? Why wearing a heavy backpack doesn't -- and couldn't -- make hills look steeper. *Perspectives on Psychological Science*, 8 (4), 455-473.
- Proffitt, D.R. (2006). Embodied perception and the economy of action. *Perspectives on Psychological Science*, 1(2), 110-122.
- Proffitt, D. R. (2008). An Action Specific Approach to Spatial Perception. In R. L. Klatzky, B. MacWhinney & M. Behrmann (Eds.), *Embodiment, Ego-Space, and Action*. New York: Psychology Press.
- Proffitt, D. R. (2013). An embodied approach to perception: By what units are visual perceptions scaled? *Perspectives on Psychological Science*, 8(4), 474-483.
- Proffitt, D.R. and Linkenauger, S. A. (2012). Perception viewed as a phenotypic expression. In W. Prinz, M. Beisert, & A. Herwig (Eds.), Tutorials In Action Science, MIT Press.
- Witt, J. K. (2011). Action's effect on perception. *Current Directions in Psychological Science, 20,* 201-206.

Background reading (optional): The natural environments and tasks perspective

- Diaz, G., Cooper, J., & Hayhoe, M. (2013). Memory and prediction in natural gaze control. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *368*(1628), 20130064.
- Hayhoe, M., & Ballard, D. (2005). Eye movements in natural behavior. *Trends in cognitive sciences*, *9*(4), 188-194.
- Hayhoe, M. M., & Matthis, J. S. (2018). Control of gaze in natural environments: effects of rewards and costs, uncertainty and memory in target selection. *Interface focus*, *8*(4), 20180009.
- Land, M., & Tatler, B. (2009). *Looking and acting: vision and eye movements in natural behaviour*. Oxford University Press.

Discussion topic: What role does active gaze play in the control of action?

- Hayhoe, M. (2017) Vision and action. *Annual Review of Vision Science*, 3 (4), 1-25.

Topic 11 (April 3, 10): The ecological approach and perception of affordances

Lecture topics:

- Sensory ecology
- Information and ecological optics
- Direct perception
- Affordance perception

Background reading (optional):

- Blau, J. J., & Wagman, J. B. (2022). *Introduction to Ecological Psychology: A lawful approach to perceiving, acting, and cognizing*. Taylor & Francis.
- Epstein, W. (1995). The metatheoretical context. In W. Epstein & S. Rogers (Eds.) *Perception of Space and Motion.* Elsevier. (pp. 1-22)
- Gibson, JJ (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.
- Michaels C F, Carello C. (1981). *Direct Perception*. New York: Prentice Hall. (Chapter 2)
- Turvey, MT (2013). Ecological perspectives on perception-action: What kind of science does it entail?
- Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance,* 10, 683-703.
- Warren, W. H. (2010). Direct Perception. In Goldstein, E. (Ed.) *Encyclopedia of Perception*. Sage Publications.
- Warren, W. H. (2005). Direct perception: The view from here. *Philosophical Topics,* 33, 335-361.
- Warren, W. H., Kay, B. A., Duchon, A. P, Zosh, W., & Sahuc, S. (2001). Optic flow is used to control human walking. *Nature Neuroscience*, 4, 213-216.

Discussion topic: Do humans use optic flow to perceive and control steering?
- Warren, W. H. (2021). Information is where you find it: Perception as an ecologically well-posed problem. *i-Perception*, *12*(2), 20416695211000366.

Topic 12 (April 10, 17): Perception-action coupling

Lecture topics:
- Control strategies
- Information-based and affordance-based control

Background reading (optional):
- Fajen, B. R. (2021). *Visual control of locomotion*. Cambridge University Press.
- Srinivasan, M. V., & Zhang, S. (2004). Visual motor computations in insects. *Annu. Rev. Neurosci.*, *27*, 679-696.
- Warren, W. H. (2007). Action-scaled information for the visual control of locomotion. In G. J. Pepping & M. A. Grealy (Eds.) *Closing the gap: The scientific writings of David Lee*, Mahwah, NJ: Erlbaum (pp. 243-278).
- Zhao, H., & Warren, W. H. (2015). On-line and model-based approaches to the visual control of action. *Vision research*, *110*, 190-202.

Discussion topic: How do humans negotiate complex terrain?

- Barton, S. L., Matthis, J. S., & Fajen, B. R. (2017). Visual regulation of gait: Zeroing in on a solution to the complex terrain problem. *Journal of Experimental Psychology: Human Perception and Performance*, *43*(10), 1773.

Topic 13 (April 17, 24): Navigation and cognitive maps

Lecture topics:

- Cognitive maps
- Neural basis of spatial navigation
- The geometry of spatial knowledge

Background reading (optional):

- Banino, A., Barry, C., Uria, B., Blundell, C., Lillicrap, T., Mirowski, P., ... & Kumaran, D. (2018). Vector-based navigation using grid-like representations in artificial agents. *Nature*, *557*(7705), 429-433.
- Epstein, R. A., Patai, E. Z., Julian, J. B., & Spiers, H. J. (2017). The cognitive map in humans: spatial navigation and beyond. *Nature neuroscience*, *20*(11), 1504-1513.
- Moser, M & Moser, E. (2016). Where am I? Where am I going? *Scientific American*, January 2016, pp. 26-33.
- Warren, W. H. (2019). Non-euclidean navigation. *Journal of Experimental Biology*, *222*(Suppl_1), jeb187971.
- Warren, W. H., Rothman, D. B., Schnapp, B. H., & Ericson, J. D. (2017). Wormholes in virtual space: From cognitive maps to cognitive graphs. *Cognition*, *166*, 152-163.
- The Dynamics of Perception and Action III: Navigation. Talk presented at the University of Alberta Department of Psychology by William H. Warren.

Discussion topic: Do insects have cognitive maps?

- Webb, B. (2019). The internal maps of insects. *Journal of Experimental Biology*, *222*(Suppl_1), jeb188094.

Topic 14 (April 24): Optic flow-based robotics and ML models of control

Lecture topics:

- Implementing information-based control strategies on mobile robots
- How human-like are ML models of visual control?

Background reading (optional):

- De Croon, G. C. H. E., Dupeyroux, J. J. G., Fuller, S. B., & Marshall, J. A. R. (2022). Insect-inspired AI for autonomous robots. *Science Robotics*, *7*(67), eabl6334.
- Escobar-Alvarez, H. D., Johnson, N., Hebble, T., Klingebiel, K., Quintero, S. A., Regenstein, J., & Browning, N. A. (2018). R-ADVANCE: Rapid Adaptive Prediction

for Vision-based Autonomous Navigation, Control, and Evasion. *Journal of Field Robotics*, *35*(1), 91-100.
- Floreano, D., Zufferey, J. C., Klaptocz, A., Germann, J., & Kovac, M. (2017). Aerial locomotion in cluttered environments. In *Robotics Research* (pp. 21-39). Springer, Cham.
- Rigoli, L. M., Patil, G., Stening, H. F., Kallen, R. W., & Richardson, M. J. (2021). Navigational Behavior of Humans and Deep Reinforcement Learning Agents. *Frontiers in psychology*, 4096.
- Srinivasan, M. V. (2011). Visual control of navigation in insects and its relevance for robotics. *Current opinion in neurobiology*, *21*(4), 535-543.

Discussion topics: Cross-cutting themes
- Reading TBD