CSE941 Selected Topics in Artificial Intelligence: Developmental Vision

CSE, Michigan State University Fall 2009

The topics lie at the intersection of artificial intelligence, brain science, and cognitive science, with an emphasis on vision, but not limited to vision. The course was designed to suit graduate students in engineering as well as computationally oriented graduate students in neuroscience, cognitive science, and mathematics. Theories of epigenesis; brain architectures; mental architectures; developmental mechanisms for functions and integration; dorsal and ventral pathways; biological basis of short-term, long-term, working, episodic memories; autonomy in learning; pathways for vision, audition, touch and motor behaviors; bottom-up and top-down attention; incremental learning; scaffolding; skill transfer; motivational systems; and autonomous reasoning. The subject matter cuts across levels of cells, circuits, cortices, brain, experience and functions, and is intended for high-dimensional natural stimuli. Compared with traditional computer vision methods, the biologically inspired techniques appear to be more computational efficient and more robust.

A prior similar offering at MIT: http://stellar.mit.edu/S/course/9/sp07/9.915J/

Lectures: Mondays and Wednesdays 5:00pm - 6:20pm Room 3400 Engineering Building

Instructor: Juyang (John) Weng

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Office hours: Tuesdays and Thursdays 5:00pm-6:00pm.

Prerequisites: Knowledge comparable to that taught in the following courses or permission of the instructor.

1. CSE 331 Algorithms and Data Structures
2. MTH 314 Linear algebra
3. STT 441 Probability and Statistics

Text: Working manuscript: Juyang Weng, *Developmental Robotics*

Presentations: Each student will give three presentations, two paper presentations and a project presentation.

Assignments: We will have papers assigned to read, project proposal, project progress report and final report.

Projects: Each student will work on a project and write a research report (about 8 pages of conference proceedings format).

Exam: There is no examination.

Grading: Presentations: 30%; Assignments: 60%; Participation of discussion: 10%.

Topics: The planned topics are

1. Muddiness of tasks
2. Overview of AI approaches — knowledge-based, learning-based, behavior-based, evolutional and the new developmental approach.
3. Human mental development, results from neuroscience and developmental psychology
4. Overview of animal learning theories and models
5. Supervised, reinforcement and communicative learning (how to enable robots to acquire language and learn through language)
6. Architectures for automatic mental development
7. Automatic generation of representation from data
8. Sensory hierarchy (principal component analysis, independent component analysis and Lobe component analysis)
9. Attention selection: bottom-up and top-down
10. Motor hierarchy and robot body for mental development
11. Dorsal and ventral pathways in the brain and the visual where-what problem
12. Motivational system
13. Unification and integration of mental capabilities through development, including vision, audition, touch, language, reasoning, decision making, planning, object manipulation and navigation (information fusion and sensor fusion)
14. Machine and human autonomous thinking and its development
15. Examples of experimental developmental robots
16. Applications, impacts and future directions

Supplemental Readings

The following readings are on reserve at the Engineering Library.

- W. K. Purves, D. Sadava, G. H. Orians and H. C. Heller, *Life: The Science of Biology,* 7th edition, Sinauer, Sunderland, MA, 2004.
- M. Cole, S. R. Cole and C. Lightfoot *The Development of Children,* Freeman, New York, 2004.
- M. Domjan, *The Principles of Learning and Behavior: Active learning edition*, Thomson/Wadsworth, Belmont, CA, 2006
- K. Richardson, *Models of Cognitive Development*, Psychology Press, East Sussex, UK, 1998.
- E. R. Kandel and J. H. Schwartz and T. M. Jessell, *Principles of Neural Science*, 4th edition, McGraw-Hill, New York, NY, 2000.
- J.L. Elman and E. A. Bates and M. H. Johnson and A. Karmiloff-Smith and D. Parisi and K. Plunkett, *Rethinking Innateness: A Connectionist Perspective on Development*, MIT Press, Cambridge, MA, 1996.
- T. R. Shultz, *Computational Developmental Psychology*, MIT Press, Cambridge, MA, 2003.

Time Schedule

- Week 1, 09/02/2009: Introduction, Ch1 Muddiness of tasks
- Week 2, 09/09/2009: Ch2 Where are we? (9/7 holiday)
- Week 3, 09/14/2009: Ch3 What is development?
- Week 4, 09/21/2009: Ch4 Learning Modes
- Week 5, 09/28/2009: Ch5 Mental architectures
- Week 6, 10/05/2009: Ch6 Neurons and representation
- Week 7, 10/12/2009: Ch7 Sensory and motor cortices I
- Week 8, 10/19/2009: Ch7 Sensory and motor cortices II
- Week 9, 10/26/2009: Ch8 Cognitive cortex
- Week 10,11/02/2009: Ch9 Integration (Project proposal due)
- Week 11, 11/09/2009: Ch10 Autonomous thinking
- Week 12, 11/16/2009: Presentation and discussion I (Project progress report due)
- Week 13, 11/23/2009: Presentation and discussion II
- Week 14,11/30/2009: Presentation and discussion III
- Week 15, 12/07/2009: Presentation and discussion IV
- Week 16, 12/14/2009: Project final report due