 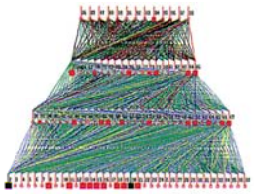 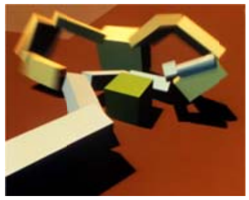 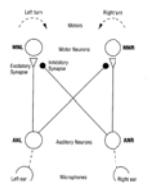 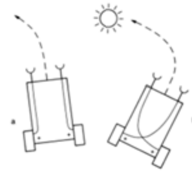 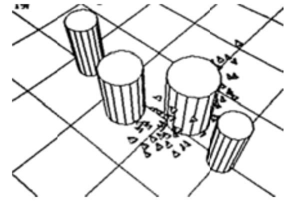

Embodied Cognition and The Philosophy of Artificial Life

Philosophy 321f, Winter 2012

G50 Pettengill / The Imaging Center, Bates College
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Course Description:

The term *artificial life* refers to research in artificial intelligence that uses computer simulations of simple sensiromotor systems, robotics, and genetic algorithms to model the kinds of flexible and adaptive autonomous behavior constitutive of our conception of intelligence. Standard computational theories of mind model intelligent behavior on the human capacity for rational decision making and general problem solving. On this account thoughts are constructed from abstract symbols that represent aspects of the environment, and minds are treated as general purpose symbol manipulation systems that can be realized in any of a potentially infinite number natural organisms or artificial systems. Although the computational model of mind has been a powerful research tool in cognitive science, it has proven difficult to implement in computer simulations and mobile robotics. For instance, general purpose problem solvers fall prey to what is called *the frame problem* in artificial intelligence: they have difficulty filtering task salient information out of noisy signals and so often follow inefficient procedures or get stuck in blind alleys. This and other difficulties have inspired researchers in embodied cognition and artificial life to look towards insect and animal models for alternatives. Bodies evolve in lock step with cognitive systems, and both can be thought of as adaptations fine-tuned to the kinds of environmental features necessary to help satisfy an organisms' basic needs and interests. As a result the general structure of an organisms body (i.e., its effectors and the structure and placement of its peripheral sensory organs) is a strong constraint on the ways it acquires, manipulates, and uses information from its environment - a constraint that focuses cognitive systems on task salient information in the environment, simplifying the computational demands of flexible and adaptive behavior. Researchers in embodied cognition and artificial life therefore challenge the assumption that minds are general purpose symbol manipulation systems. They argue instead that intelligent behavior emerges from the interaction between (well adapted) bodies and the environment. To this end research in autonomous (sometimes called agent- or behavior-based) robotics is used to explore the role of agent-environment interactions in the production of intelligent behavior. *Embodied Cognition and The Philosophy of Artificial Life* explores this approach to understanding intelligence. Readings are drawn from contemporary sources in philosophy, psychology, neuroscience, and computer science. In addition to course readings and written assignments, students use a range of computer simulations and robotics exercises to explore the ideas introduced in class. Topics covered include: the nature of intelligence, the computational theory of mind, embodied cognition, representation, classic AI, behavior-based robotics, neural networks, genetic algorithms, dynamic systems, and the role played computer simulations and robotics in cognitive science.

Texts:

- Andy Clark, *Being There* (Cambridge, MA: MIT Press, 1997). ***(BT)***
- Rolf Pfeifer and Christian Schier, *Understanding Intelligence* (Cambridge, MA: MIT Press, 2001). ***(PSUI)***
- Valentino Braitenberg, *Vehicles: Experiments in Synthetic Psychology* (Cambridge, MA: MIT Press, 1984). ***(VESP)***

Requirements:

- A 1200 word paper due at the end of January (10%).
- A 1200 paper due at the midterm (20%).
- A 2400 word final paper (30%).
- Behavior-based robotics exercises and team projects: hands-on experience with autonomous agents (30%).
- Artificial Neural Network and Evolutionary Robotics exercises (10%).

Course Work: Research in artificial intelligence, artificial life, and behavior based robotics has sometimes been called *synthetic psychology*. Why adopt such a science fiction name for a research program? Well, because the methodology within these fields involves constructing models to explore and evaluate theoretical approaches to understanding intelligece. We are not interested in what intelligence ought to be, how it ought to be ideally constructed to support our best understanding of ourselves as rational, deliberating, intelligtent moral agents. Rather we are interested in whether our best models for intelligence are the kinds of things the bodies we have could really realize…or whether the bodies we have are vehicles that could actually run the those models. We will, as a result, combine a range of writing assignments with hands on work with simulations and rudimentary robotics exercises.

We will focus our attention on three kinds of exercises:

1. We will use the Lego Mindstorms platform to build a range of *Braitenberg Vehicles*. These are autonomous robotic creatures that explore and engage simple environments, much like William Grey Walter's *Turtles* (http://www.youtube.com/watch?v=lLULRlmXkKo). The Mindstorms systems uses a graphical programming environment (NXT-G). This is a very accessible teaching tool. But it can get clunky as things get complicated. Robot-C is a, not surprisingly, C based language that can be used to enhance the flexibility of the system. Once we are comfortable with NXT-G we will work on translating the routines we have developed to Robot-C.

One trouble with these kinds of cretaures is that they are programmed to their environment - their autonomy is really just part of the global design of the environment. It is artificial in that regard. One way to overcome this would be to give them a capacity for learning. A critical aspect of the Braitenberg Vehicles exercises will be to explore that possibility. The goal will be to move from simple solutions in NXT-G, to more flexible solutions in Robot-C, and finally to a simple artificial neural network.

2. Of course we are wired to our environments too, it's just we aren't artifacts, we have no designer, rather we have evolved routines that exhibit a sensitivity to just those aspects of our environments necessary for survival. A second solution to the methodological problem with Braitenberg Vehicles therefore is to let the creatures evolve. We will use a program called *Ludobots* to explore the use of genetic algorithms to develop and evolve simulated creatures. These same basic methods are used to optimize solutions to design problems in reearch with autonomous robots. If anyone were interested in exploring this possibility with our Mindstorms creatures it would make a great final project.

3. Finally, we will need to learn a little bit about connectionist models of intelligent behavior and artificial neural networks. We will explore two online resources too bootstrap our way into this material: The Mind Project (http://www.mind.ilstu.edu/curriculum/connectionism_intro/connectionism_1.php & http://www.mind.ilstu.edu/curriculum/neurons_intro/neurons_intro.php) and the software developed for Michael Dawson's Biological Computation Project (http://www.bcp.psych.ualberta.ca/~mike/Software/).

You can find tutorials to help you start exploring the potential of the software we will use at the following webpages:

http://www.ortop.org/NXT_Tutorial/flexibly
http://www.robotc.net/
http://kovan.ceng.metu.edu.tr/~ilke/Braitenberg/BraitenbergEN/Simulator.html

Assignments:

Analysis Paper: 1200 words - double spaced - 1" margins - (please). The purpose of an ***analysis paper*** is for you to evaluate a standard argument in the literature. This is not an opinion paper. The method of philosophy is critical analysis. We are interested in understanding the reasons behind values and beliefs, or better, the reasons that provide rational support for the beliefs that we hold. These reasons, if good, ought to provide logical support for our values and beliefs. In the following paper you should: identify the theoretical problem at hand; rehearse the standard argument for the position identified; and evaluate whether these reasons genuinely support that position. The first step identifies the problem space that you are addressing. The second step should have the form of a ***rational reconstruction***. In a rational reconstruction one does their best to give an argument a fair shake. You should do your best to make the standard argument as plausible as you can. The final step is to respond. Your response should identify a step in the standard argument that you find to be in error. The key here is that you are not arguing for the truth or falsity of the target position per se. Rather you are arguing that the reasoning offered does not suffice to establish that position as a conclusion. In other words, your analysis IS your argument.

Midterm Assignment - 1200 words - double spaced - 1" margins - (please). The purpose of this paper is twofold: a) identify & evaluate a range of views surrounding a standard problem in the literature; and b) demonstrate that you can synthesize the diverse range of material covered in the first half of the semester into a coherent position.

Final paper: 2400 words - double spaced - 1" margins - (please). There is no final exam; your final paper is due on the scheduled exam date; you must submit a 600 word (one page single spaced) topic proposal by March 27th.

Ludobots: genetic algorithms & evolutionary robotics: Please work through all of the the videos and exercises following the “Playing track” link on Josh Bongards Ludobots webpage: http://www.uvm.edu/~ludobots/. You must submit a journal describing your success (or not) in these exerciseas and the strategies you adopted to solve the problems for credit for these exercises.

Students interested are encouraged to push on and a) explore the power of artificial evolution as a research tool in AI and b) evaluate the claim that evolutionary explanations of symbol grounding dissolve difficulties associated with Searle’s Chinese Room argument and the frame problem.

Robot Exercises & Rodeo: We will divide ourselves into teams of three students each and work through a range of robotics exercises in class using the Lego Mindstorms system. These exercises are derived from Valentino Braitenberg’s book *Vehicles* The goal is to explore the power (and shortcomings) of behavior based animat approaches to AI using our robots to model some simple intelligent and cooperative behavior. Out of class teams will work independently on these projects and we will gather during the exam period for a robot rodeo to display our solutions.

Scoring for these exercises will largely be determined by the work you put in. Simulation and modeling exercises like these are tools used in synthetic psychology to test theories by trying them out in actual behavioral contexts. A failure can often be as, if not more, meaningful and productive than a success if it teaches the researcher something about models of intelligence. Working groups should keep a technical record of all of their brainstorming, programming, and testing, including iPhone video clips if possible. Each student’s final grade for the group work component of the course will be calculated as a factor of:

team meetings with the professor
team reports due at the end of the last day of the semester

Date	Schedule of Readings	Assignments
01/07	Course Introduction	
01/09	Haugeland, What is mind design?: 1-28. ***(LYCEUM)***	
01/14	Searle, Minds, brains, and programs: 183-204. ***(LYCEUM)*** Pfeifer & Scheir: The symbol grounding problem: 69-71 ***(PSUI)*** The Mind Project: Searle and the Chinese Room http://www.mind.ilstu.edu/curriculum/searle_chinese_room/searle_chinese_room.php	
01/16	Dreyfus, From Micro-worlds to knowledge representation: 143-182. ***(LYCEUM)*** Boden, Some philosophical problems: 769-775. ***(LYCEUM)*** Pfeifer & Scheir, Situatedness & the Frame Problem: 65-69; 71-73 ***(PSUI)*** Supplememntal: Dennett, Cognitive wheels: 147-170. ***(LYCEUM)***	
01/21	Brooks, Intelligence without representation: 395-420. ***(LYCEUM)*** Brooks, New Approaches to Robotics: 59-65. ***(LYCEUM)*** Clark, Autonomous Agents: 11-33. ***(BT)***	
01/23	Discussion: Animats, Symbol Grounding, & the Frame Problem Agre & Chapman, An Implementation of a Theory of Activity ***(LYCEUM)*** Braitenberg, Vehicles 1-7. ***(VESP)***	1st Paper Due Friday @ 5pm
01/28	Robots I: Working with NXT-G Pfeifer & Schier, Braitenberg vehicles: 181-198. ***(LYCEUM)*** Braitenberg, Vehicles 1-7. ***(VESP)***	Imaging Center
01/30	Robots I: Working with NXT-G Pfeifer & Schier, The subsumption architecture: 199-225. ***(LYCEUM)*** Hogg, Martin, & Resnick: Braintenberg Creatures: 1-11. ***(LYCEUM)***	Imaging Center
02/04	Robots I: Working with NXT-G http://www.verena-hafner.de/teaching/didabots.pdf Swiss Robots	Imaging Center
02/06	Webb, A cricket robot: 94-99. ***(LYCEUM)*** Webb & Harrison, Phonotaxis in crickets and robots: 533-552. ***(LYCEUM)*** ***** Webb, Cricket phonotaxis: 3-20. ***(LYCEUM)***	
02/11	Webb, Do insects have forward models: 278-282. ***(LYCEUM)*** Hayhoe & Rothkopf, Vision in the natural world: 158-166. ***(LYCEUM)***	
02/13	Webb, Can robots make good models: 1033-1050. ***(LYCEUM)*** Webb, Validating biorobotic models: 2-20. ***(LYCEUM)***	2nd paper due Friday @ 5pm.
02/15 - 02/23	**WINTER BREAK**	
02/25	Clark, The situated infant: 35-52. ***(BT)*** Clark, Mind and world: 53-70. ***(BT)*** Pfeifer & Scheir, A framework for embodied cognitive science: 81-138. ***(PSUI)*** Mataric, Navigating with a rat brain: 169-175. ***(LYCEUM)***	
02/27	The Mind Project: Connectionism http://www.mind.ilstu.edu/curriculum/connectionism_intro/connectionism_1.php Pfeifer & Scheir, Neural networks for adaptive behavior: 139-177. ***(PSUI)***	
03/04	Sims, Evolving virtual creatures: 1-8. ***(LYCEUM)*** Clark, Evolving robots: 87-102. ***(BT)***	

	Pfeifer & Schier, Artificial Evolution and Artificial Life: 227-276. ***(HBSWT)***	
03/06	Reynolds, Flocking behavior: http://www.red3d.com/cwr/boids/ Clark, Emergence and Explanation: 103-128. ***(BT)*** van Gelder, Dynamics and cognition: 420-433. ***(LYCEUM)*** Pfeifer & Scheir, Other approaches (excerpt): 275-283. ***(PSUI)***	Ludobot journal reports due Friday @ 5pm
03/11	Robots II: Robot C turorials with Matt Duvall Braitenberg Vehicles and Subsmumption Architectures (again) Flocking I	Imaging Center
03/13	Robots II: Robot C turorials with Matt Duvall Squirt: multi-modal cues The Wall-Finder Problem: crossmodal perception	Imaging Center
03/18	Clark, The neuroscientific image ***(BT)*** Pfeifer & Bongard. Puppy: modeling quadrapedal locomotion ***(LYCEUM)***	
03/20	Clark, Being, computing, representing: 143-176. ***(BT)*** Glenberg, What memory is for: 1-19. ***(LYCEUM)*** Pfeifer & Scheir, Human memory: a case study: 503-534. ***(PSUI)***	
03/25	Clark, Language: the ultimate artifact ***(BT)*** Symbols & embodiment ***(tba)***	final paper proposals due
03/27	Robots III: Team Projects Flocking II	Imaging Center
04/01	Robots III: Team Projects Wall Finder	Imaging Center
04/03	Robots III: Team Projects Team Work	Imaging Center Team Project Reports due Friday @ 5pm
Exam Week	Robot Rodeo: Final Exam Date: Friday April 11, 3:45-5:45 site TBA	Robot Rodeo Final Papers Due

!Robot Rodeo!

/*LOOK MA, NO PLANS*/

{
Place: Chase Hall
Time: Wednesday April 11, 1:15-3:15
Rain Location: 300 Dana
}

BASIC BRAITENBERG VEHICLES:

BV2a:
fearful light avoider
BV2b:
aggressive light seeker
BV3a:
curious light seeker
BV3b:
curious but cautious explorer

HYBRID BRAITENBERG VEHICLES:

BV3a-BV2a:
curiously approaches light to a threshold and then races away.
BV2b-BV3b:
races into the light to a threshold and then cooly walks away.

ANIMATS:

Swiss Robots:
tidy ultrasound avoiders with serious blindspot
Squirt:
it would be preferable if the subroutine for seeking shadow wasn't a preset motor path –
e.g. compare the light sensor value at t_1 & t_2 to determine how to always move into the shadows
Flocking:
Search/Track/Flock
Alignment/Separation/Cohesion
WallFinder:
use auditory-visual crossmodal cues to differentiate the reflectance/luminance value of walls from pools of light in the corral environment

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REMEMBER: the goal is to explore the animat/embodied strategies that we have been discussing in class. Braitenberg architectures lend themselves to this project because the actuator-control systems are always separate. Behavior emerges from *morphological computations* – agent/environment dynamics or the way the sensor input varies with agent movements. Behaviors are not directly programmed, but emerge from agent interactions with their environments. Where your solutions deviate from this strategy you need to understand how and whether this is justified by Webb's criteria for biorobotic modeling.

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