Stephen W. Hart

CONTACT INFORMATION

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RESEARCH SYNOPSIS

During my doctoral research, I investigated several issues concerning how robots can learn and be taught increasingly complex, adaptive-optimal control programs. In [3], I addressed how a large amount of sophisticated behavior can be composed from set of domain-general control actions that allow a robot to optimize the use of its sensory and motor resources. In [4], I demonstrated an intrinsically motivated learning framework in which a robot can employ actions like those developed in [3] to acquire a hierarchy of manipulation skills. In [2,5], I showed how control programs learned in a simplified context can be generalized, adapted, and transferred to more complex situations or even to other robots. A forthcoming journal pubication is in preperation demonstrating how the ideas in [1-5] can lead to a unifiying perspective on intrinisic motivation in computational systems. This body of work provides a perspective on robot learning where increasingly dexterous and common sense behavior is acquired efficiently and accumulated over the long-term.

In the course of creating a sound and practical basis for developmental learning, I also constructed a programming specification for use with robot middleware (or robot operating systems) that are emerging in the robotics industry today. This specification is designed specifically to interface machine learning algorithms that depend on exploration to control-theoretic actions in distributed robot systems. It also provides convenient ways to allow human programmers to combine devices into feedback control applications. Although this work is still in progress, it has already been widely adopted in the Laboratory for Perceptual Robtics at UMass, and is has been published at an appropriate conference workshop, [8].

RESEARCH AREAS

robotics, manipulation, control, control architectures, developmental learning, skill acquisition, reinforcement learning, artificial intelligence, machine learning, developmental psychology, motor control.

EDUCATION

University of Massachusetts Amherst, Amherst, MA USA

Ph.D., Computer Science, September 2009
- Title: "The Development of Hierarchical Knowledge in Robot Systems"
- Advisor: Roderic A. Grupen

M.S., Computer Science, May 2005.
B.S., Computer Systems Engineering, February 2002. Magna Cum Laude.

HONORS & AWARDS

UMass NASA Space Grant, Spring/Summer 2008.
NASA Graduate Student Research Program (GSRP) Fellowship, 2004-2007.
Monopoli Award for Excellent Academic Record and Interest in Automatic Control, 2001.
University of Massachusetts Commonwealth Honors Scholarship, 1997-2001.

Professional Experience

iRobot, Somerville, MA USA

Extended Internship **January 2002—August 2002**

Software engineer. Developed infrastructure for the Packbot robot, including communications, design of the Operator Control Unit (OCU) interface, and low-level control programs. Performed various testing and diagnostics on the platform.

Raytheon, Marlborough, MA USA

Internship **June 2000—August 2000, January 2001**

Electronics engineer. Maintained, tested, and programmed the Solid State Amplifier (SSA) unit for a Navy radar system. Other duties included managerial oversight of construction and testing operations at various Raytheon plants.

University of Massachusetts Amherst, CIIR Lab, Amherst, MA USA

Programmer **September 2000—December 2001**

Software developer for the Nightingale music playback and notation program. Duties included porting existing code from Macintosh to Windows operating system.

SystemSoft, Needham, MA USA

Internship **June 1999—August 1999**

Software Engineer, QA Engineer. Developed and tested diagnostic software for Windows operating systems.

Affiliations

American Association for Artificial Intelligence (AAAI)
Institute of Electrical and Electronics Engineers (IEEE)
Tau Beta Pi Engineering Honor Society
Eta Kappa Nu Electrical & Computer Engineering Honor Society

Research Assistantships

Laboratory For Perceptual Robotics, Fall 2002—present
Autonomous Learning Laboratory, Spring 2004

Teaching Assistantships

Embedded Systems, Fall 2007
Computational Complexity, Spring 2004

Course Work

Robotics, Embedded Systems, Control Systems, Artificial Intelligence, Machine Learning, Reinforcement Learning, Computational Neuroscience, Reasoning and Acting Under Uncertainty, Intrinsic Motivation, Computational Complexity, Advanced Algorithms, Information Retrieval, Advanced Computer Architecture, Information Theory

Computer Skills

Languages: C++, C#, C, Matlab, HTML, Java, some use of Unix shell scripts.
Operating Systems: Unix/Linux, Mac OS X, Windows.

Service Activities

Session Chair: Biologically-Inspired Robots: Manipulation at IROS '07.
Reviewer: ICRA, RAS, IROS, EPIROB, ICML, RO-MAN, NESCAI.

Theses

A Relational Representation for Generalized Knowledge in Robotic Tasks. Masters Thesis. Department of Computer Science, University of Massachusetts Amherst. December, 2004.

A Class of Networked Control Systems Architecture, Design and Implementation. Undergraduate Honors Thesis. Department of Electrical and Computer Engineering, University of Massachusetts Amherst. December, 2001.

Refereed Publications

[1] S. Hart. An Intrinsic Reward for Affordance Exploration, In 8th IEEE International Conference on Development and Learning (ICDL09). Shanghai, China. June, 2009.

[2] S. Hart, S. Sen, and R. Grupen. Generalization and Transfer in Robot Control, In 8th International Conference on Epigenetic Robotics (Epirob08). University of Sussex, Brighton, UK. July, 2008.

[3] S. Hart, S. Sen, and R. Grupen. Intrinsically Motivated Hierarchical Manipulation, IEEE Conference on Robotics and Automation (ICRA) 2008. Pasadena, California. 2008.

[4] S. Hart and R. Grupen. Natural Task Decomposition with Intrinsic Potential Fields, International Conference on Intelligent Robots and Systems (IROS). San Diego, California. 2007.

[5] S. Hart, R. Grupen, and D. Jensen. A Relational Representation for Procedural Task Knowledge, American Association for Artificial Intelligence (AAAI) Conference. Pittsburgh, Pennsylvania. July, 2005.

[6] B. Thibodeau, S. Hart, D. Karuppiah, J. Sweeney, and O. Brock. Cascaded Filter Approach to Multi-Objective Control, IEEE International Conference on Robotics and Automation (ICRA), New Orleans, Louisiana. April, 2004.

[7] S. Hart, N. Vozdolsky, T. Djaferis, A Class of Networked Control Systems Architecture, Design and Implementation, IEEE Conference on Decision and Control, Las Vegas, Nevada. December, 2002.

Workshops & Presentations

[8] S. Hart, S. Sen, S. Ou, and R. Grupen. The Control Basis API - A Layered Software Architecture for Autonomous Robot Learning, The ICRA 2009 Workshop on Software Development and Integration in Robotics. Kobe, Japan. May, 2009.

[9] S. Hart and R. Grupen. Intrinsically Motivated Affordance Learning, The ICRA 2009 Workshop on Approaches to Sensorimotor Learning on Humanoid Robots. Kobe, Japan. May, 2009.

[10] S. Hart and R. Grupen. Natural Task Decomposition with Intrinsic Potential Fields, Northeast Student Colloquium on Artificial Intelligence (NESCAI). Ithaca, NY. April, 2007. Also New England Manipulation Symposium (NEMS). Rensselaer Polytechnic Institute. June, 2007.

[11] S. Hart. The Developmental Organization of Dexterous Robot Behavior. Presentation to the University of Massachusetts Amherst Kinesiology Department. February, 2007.

[12] S. Hart. The Developmental Organization of Dexterous Robot Behavior. Presentation to the University of Massachusetts Amherst Developmental Psychology Department. November, 2006.

[13] S. Hart, S. Ou, J. Sweeney, and R. Grupen. A Basic Level of Attentional Behavior for Manipulation, Interaction, and Learning. New England Manipulation Symposium (NEMS). University of Massachusetts Amherst. June, 2006.

[14] S. Hart, S. Ou, J. Sweeney, and R. Grupen. A Framework for Learning Declarative Structure, Workshop on Manipulation for Human Environments, Robotics: Science & Systems. Philadelphia, Pennsylvania. August, 2006.

[15] S. Hart, D. Jensen, and R. Grupen. Mining Feedback to Inform Manipulation Control. New England Manipulation Symposium (NEMS). Rensselaer Polytechnic Institute. May, 2005.

[16] S. Hart, R. Grupen, and D. Jensen. Mining Affordances for Grasping and Manipulation, Workshop on Humanoid Manipulation, Robotics: Science & Systems. Cambridge, Massachusetts. June, 2005.

Technical Reports

[17] S. Hart, R. Grupen, and D. Jensen. A Relational Representation for Generalized Knowledge in Robotic Tasks, Technical Report 04-101. Computer Science Department, University of Massachusetts Amherst. December, 2004.