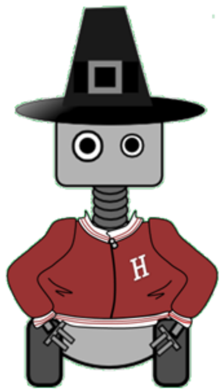


2nd Annual Northeast Robotics Colloquium

Northwest Science Building
Harvard University
Cambridge, Massachusetts

October 6th, 2013

JAYBRIDGE ROBOTICS

WYSS INSTITUTE

Welcome

Robotics is poised for rapid and dramatic growth in the coming decade as technical advances, the growing availability of talented and highly-trained roboticists, and falling hardware costs combine to render many real-world applications feasible. The northeastern united states have become a prominent area for robotics practitioners with numerous universities doing research, and a number of startups and companies bringing the latest developments to the real world.

The Northeast Robotics Colloquium (NERC) aims to bring together all the robotics practitioners in an event that is simultaneously a research meeting, a networking and job-fair event, and a showcase for established and up-and-coming robotics companies. Ultimately, we hope to promote the kind of healthy and well-connected robotics community that will be essential in fueling the field's rapid growth in the coming decade.

Last year, the first edition of NERC was held at MIT to great reception with about 150 people from 21 universities and 15 companies. We hope to continue the tradition, and have assembled an exciting program with invited speakers from both academia and industry, and an eclectic collection of posters and demos. The popularity of NERC is growing as evidenced by the participation - 200 participants from 20 universities and 18 companies, and the event being sold out in advance. Please make the most of the event learning about the latest technological developments, and making new friends.

We hope you enjoy it as much as we have in bringing it to you!

Karthik Dantu, University of Buffalo
Richard Moore, Harvard University
Yigit Menguc, Harvard University
Kirstin Petersen, Harvard University
Daniel Vogt, Harvard University

Schedule

9:00am–9:45am	Registration
9:45am–10:00am	Welcoming Remarks
10:00am–11:00am	Invited Talk: John Leonard - *A Long-term View of SLAM*
11:00am–11:15am	Sponsor Spotlight: Jaybridge Robotics
11:15am–12:15pm	Interactive Session: Posters and Industry Exhibits (tea, coffee, and snacks provided)
12:15pm–1:15pm	Invited Talk: Conor Walsh - *Next Generation Soft Wearable Robots*
1:15pm–2:15pm	Lunch (Provided)
2:15pm–3:15pm	Invited Talk: Marc Raibert - *Dynamic Robots: Mobility, Speed, and Dexterity*
3:15pm–3:30pm	Sponsor Spotlight: Wyss Institute
3:30pm–4:30pm	Interactive Sessions: Posters and Industry Exhibits (tea, coffee, and snacks provided)
4:30pm–5:30pm	Invited Talk: Rob Howe - *Robot Hands for the Real World*
5:30pm–5:45pm	Concluding Remarks

Invited Talks

A Long-term View of SLAM

John Leonard
Professor of Mechanical and Ocean Engineering
Massachusetts Institute of Technology

Abstract: This talk will provide a long-term view on the Simultaneous Localization and Mapping (SLAM) problem in Robotics. The first part of the talk will review the history of SLAM research and define some of the major challenges in SLAM, including choosing a map representation, developing algorithms for efficient state estimation, and solving for data association and loop closure. Next, we will give a snapshot of current state-of-the-art research in SLAM based on joint work between MIT and the National University of Ireland, Maynooth. We will describe a new technique for visual SLAM that uses a reduced pose graph representation to achieve temporally scalable performance. Unlike previous visual SLAM approaches that maintain static keyframes, our approach uses new measurements to continually improve the map, yet achieves efficiency by avoiding adding redundant frames and not using marginalization to reduce the graph. We demonstrate long-term mapping in a large multi-floor building, the MIT Stata Center, using approximately nine hours of data collected over the course of six months.

A major new innovation in SLAM is the development of real-time dense mapping system using RGB-D cameras. We will describe Kintinuous, a new SLAM system capable of producing high quality globally consistent surface reconstructions over hundreds of meters in real-time with only a cheap commodity RGB-D sensor. By using a fused volumetric surface reconstruction we achieve a much higher quality map over what would be achieved using raw RGB-D point clouds. The approach is based on three key innovations in volumetric fusion-based SLAM: (1) using a GPU-based 3D cyclical buffer trick to extend dense volumetric fusion of depth maps to an unbounded spatial region; (2) combining both dense geometric and photometric camera pose constraints, and (3) efficiently applying loop closure constraints by the use of an as-rigid-as-possible space deformation. Experimental results will be presented for a wide variety of data sets to demonstrate the system's performance for trajectory estimation, map quality and computational performance.

We will conclude the talk with a discussion of current and future research topics, including object-based and semantic mapping, lifelong learning, and advanced physical interaction with the world.

Joint work with Hordur Johannsson, Tom Whelan, Michael Kaess, Maurice Fallon, John McDonald, David Rosen, Mark Van Middlesworth, Ross Finman and Paul Huang.

Bio: John J. Leonard is Professor of Mechanical and Ocean Engineering in the MIT Department of Mechanical Engineering. He is also a member of the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL). His research addresses the problems of navigation, mapping, and persistent autonomy for autonomous mobile robots. He holds the degrees of B.S. in Electrical Engineering and Science from the University of Pennsylvania (1987) and D.Phil. in Engineering Science from the University of Oxford (1994). He is the recipient of a Thouron Award (1987), an NSF Career Award (1998), a Science Foundation Ireland E.T.S. Walton Visitor Award (2004), the Best Paper Award at ACM SenSys in 2004 (shared with D. Moore, D. Rus, and S. Teller), the Best Student Paper Award at IEEE ICRA 2005 (with R. Eustice and H. Singh) and the King-Sun Fu Memorial Best Transactions on Robotics Paper Award in 2006 (shared with R. Eustice and H. Singh).

Next Generation Soft Wearable Robots

Conor Walsh
Assistant Professor of Mechanical and Biomedical Engineering
Harvard University

Abstract: Next generation wearable robots will use soft materials such as textiles and elastomers to provide a more conformal, unobtrusive and compliant means to interface to the human body. These robots will augment the capabilities of healthy individuals (e.g. improved walking efficiency, increased grip strength) in addition to assisting with patients who suffer from physical or neurological disorders. This talk will focus on two different projects that demonstrate the design, fabrication and control principles required to realize these systems. The first is a soft exosuit that that can apply assistive joint torques to synergistically propel the wearer forward and provide support to minimize loading on the musculoskeletal system. Unlike traditional exoskeletons which contain rigid framing elements, the soft exosuit is worn like clothing, yet can generate significant moments at the ankle and hip to assist with walking. Future versions of the exosuit will monitors the 3D kinematics and kinetics of the wearer using soft stretchable sensors that do not interfere with the natural mechanics of motion. The suit has the advantages over a traditional exoskeleton in that the wearer's joints are unconstrained by external rigid structures, and the worn part of the suit is extremely light, which minimizes the suit's unintentional interference with the body's natural biomechanics. The second part of the talk will focus on the preliminary development of a soft robotic glove for hand rehabilitation that consists of a wearable textile with attached elastomeric fluid-powered actuators specially designed to match the natural movements of the fingers and thumb. A component of the research is to develop the knowledge

and techniques required to design soft multi-material fluid-powered actuators. These actuators, powered by pneumatic or hydraulic means, are of particular interest to the robotics community because they are lightweight, inexpensive, easily fabricated with emerging digital fabrication techniques and capable of producing complex three-dimensional outputs with simple control inputs. These soft actuators are fabricated via a multi-step molding process where some combination of fillers (e.g. cloth, paper, particles and fibers) are integrated into a soft elastomeric matrix to create anisotropy in the bulk material properties. Upon pressurization, embedded channels or chambers in the soft actuator then expand in directions with the lowest stiffness and give rise to linear, bending, and twisting motions. In addition some related work on applying emerging meso-scale manufacturing approaches to the design of smart medical tools for the minimally invasive diagnosis and treatment of disease will be presented.

Bio: Prof. Walsh is an Assistant Professor of Mechanical and Biomedical Engineering at the Harvard School of Engineering and Applied Sciences. He is also the founder of the Harvard Biodesign Lab, which brings together researchers from the engineering, industrial design, medical and business communities to develop smart medical devices and translate them to industrial partners in collaboration with the Wyss Institute's Advanced Technology Team. Dr. Walsh received his B.A.I and B.A. degrees in Mechanical and Manufacturing engineering from Trinity College in Dublin, Ireland, in 2003, and M.S. and Ph.D. degrees in Mechanical Engineering from the Massachusetts Institute of Technology in 2006 and 2010.

Dynamic Robots: Mobility, Speed, and Dexterity

Marc Raibert
CTO and Founder
Boston Dynamics

Abstract: Advanced robots with dynamic control systems and high-performance mechanical designs are leaving the laboratory and entering the world. They are particularly useful operating in rough terrain, where existing wheeled and tracked vehicles cannot go. In this talk I will give a status report on the robots we are developing at Boston Dynamics, such as AlphaDog, the follow-on to BigDog, WildCat, a fast-running quadruped, and Atlas, an anthropomorphic robot designed to explore real-world tasks.

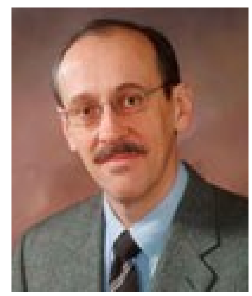
Bio: Marc Raibert is CTO and Founder of Boston Dynamics, a company that develops some of the worlds most advanced dynamic robots, such as BigDog, Petman, Atlas, Cheetah, Urban Hopper and the AlphaDog. Before starting Boston Dynamics, Raibert was Professor of Electrical Engineering and Computer Science at MIT from 1986 to 1995 and Associate Professor of Computer Science and Robotics

Institute at Carnegie Mellon from 1980 to 1986. While at MIT and Carnegie Mellon Raibert helped establish the scientific basis for dynamic legged robots. Raibert got a PhD from MIT in 1977. He is a member of the National Academy of Engineering.

Robot Hands for the Real World

Rob Howe
Abbott and James Lawrence Professor of Engineering
Harvard University

Abstract: Manipulating objects in unstructured environments like homes and workplaces is challenging because object properties are not known a priori and sensing is prone to error. Research in this area has largely focused on anthropomorphic hands that are complex, fragile, and difficult to control. We are pursuing an alternate approach that focuses on the passive mechanical behavior of the hand. By integrating carefully-selected joint compliance and adaptive transmissions, we have developed a simple and inexpensive hand that can grasp objects spanning a wide range of size, shape, weight, and position, while using only one motor. The hand is constructed using polymer-based Shape Deposition Manufacturing (SDM), resulting in a robust design that can withstand large impacts. Experimental testing demonstrates that the SDM Hand can autonomously grasp objects while keeping contact forces low. A new manipulator, the i-HY Hand combines optimized passive mechanics with five motors that can use precision fingertip grasps. We have also developed low-cost tactile sensors that report the location of contact between the object and hand. The resulting system can grasp and manipulate a wide range of objects despite large errors in sensed object size, shape, and location.



Bio: Prof. Robert Howe is Abbott and James Lawrence Professor of Engineering in the school of Engineering and Applied Sciences at Harvard University. He founded the BioRobotics Laboratory in 1990, which investigates the roles of sensing and mechanical design in motor control, both in humans and in robots. His research interests focus on robot and human manipulation and the sense of touch. Biomedical applications of this work include the development of robotic and image-guided approaches to minimally invasive surgical procedures. Dr. Howe earned a bachelors degree in physics from Reed College, then worked as a design engineer in the electronics industry in Silicon Valley. He received a doctoral degree in mechanical engineering from Stanford University in 1990, and then joined the faculty at Harvard.

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Exhibitors and Sponsors

Demonstrations

Visual motion control in flies and fly-sized robots
Sawyer B. Fuller, *Harvard University*

Exploring Underwater Environments with Curiosity
Yogesh Girdhar and Gregory Dudek, *McGill University*

Sensing and Compliance in Grasping and Manipulation
Leif Jentoft, Qian Wan, Yaroslav Tenzer, and Robert Howe, *Harvard University*

Wearable Soft Sensing Suit for Human Gait Measurement
Yigit Menguc, Robert Wood, and Conor Walsh, *Harvard University*

NarwhalEdu
Nancy Ouyang, Cappie Pomeroy, Hanna Lin

Posters

Embeddable Power Sources for Autonomous Systems
S. Adam, Y. Takagi, K. Kerman and S. Ramanathan, *Harvard University*

Visual Simultaneous Localization and Mapping for a Tree Climbing Robot
Benzun Pious Wisely Babu and Michael A. Gennerty, *Worcester Polytechnic Institute*

A robot avatar for remote participation in laboratory courses
Jean-Luc Bergeron, Andre Brueckner, and Matthew Stein, *Roger Williams University*

Control of Noisy Differential-Drive Vehicles from Time-Bounded Temporal Logic Specifications
Igor Cizelj and Calin Belta, *Boston University*

Reinforcement Learning with Multi-Fidelity Simulators
Mark Cutler, Thomas J. Walsh, and Jonathan P. How, *MIT*

Development of Virtually Interfaced Robotic Ankle and Balance Trainer (vi-RABT)
Amir B. Farjadian, Mohsen Nabian, Paul Douot, Maureen Holden, and Constantinos Mavroidis, *Northeastern University*

Bingham Procrustean Alignment for Object Detection in Clutter
Jared Glover, *MIT*, and Sanja Popovic, *Google*

NanoDoc: Crowdsourcing the design of swarming nanobots for cancer treatment
Sabine Hauert, Justin H. Lo, Ofir Nachum, Andrew D. Warren, and Sangeeta N. Bhatia, *Harvard-MIT Division of Health Sciences and Technology*

Learning Spatial-Semantic Representations from Natural Language Descriptions and Scene Classification
Sachithra Hemachandra, Matthew R. Walter, Stefanie Tellex, and Seth Teller, *MIT*

Robust, Low Cost Force-Torque Sensors
Leif Jentoft, Jacob Guggenheim, Yaroslav Tenzer and Robert Howe, *Harvard University*

Optimal information gathering under temporal logic constraints
Austin Jones, Mac Schwager, and Calin Belta, *Boston University*

Surface Patches for Rough Terrain Perception
Dimitrios Kanoulas, *Northeastern University*

An Efficient Quadratic Programming Approach to Stabilizing Dynamic Locomotion
Scott Kuindersma, Frank Permenter, and Russ Tedrake, *MIT*

A Variational Approach to Trajectory Planning for Persistent Monitoring of Spatiotemporal Fields
Xiaodong Lan and Mac Schwager, *Boston University*

Automated Pointing of Cardiac Imaging Catheters
Paul M. Loschak, Laura J. Brattain, and Robert Howe, *Harvard University*

A passive knee exoskeleton to assist in independent Sit-Stand transitions
Gaurav Mukherjee, Grant Schaffner, *U. Cincinnati*, and Manish Kumar, *U. Toledo*

The TERMES Project: Collective Construction by Autonomous Mobile Robots
Kirstin Petersen, Justin Werfel, Radhika Nagpal, *Harvard University*

Adaptive Trust in Multi-Robot Coverage Control
Alyssa Pierson and Mac Schwager, *Boston University*

Restraining Objects with Curved Effectors
Jun Seo, Mark Yim, and Vijay Kumar, *University of Pennsylvania*

Localizing Grasp Affordances in 3-D Points Clouds Using Taubin Quadric Fitting
Andreas ten Pas and Robert Platt, *Northeastern University*

Data Assocation for Semantic World Modeling from Partial Views
Lawson L.S. Wong, Leslie Pack Kaelbling, and Tomas Lozano-Perez, *MIT*

Event Map