Northeast Robotics Colloquium

Stata Center
Massachusetts Institute of Technology
Cambridge MA, October 20th 2012

JAYBRIDGE ROBOTICS

CSAIL

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.

Robotics is also an unusual field in that its progress depends directly on sustained technology and skill transfer between academia and industry, and between different industry sectors. The northeastern United States is dense with world-leading universities, cutting edge robotics research laboratories, and robotics companies—yet there are very few events where roboticists from all of these institutions can mix freely and forge productive local collaborations.

Today's colloquium aims to bring together all of the many varieties of robotics practitioners in the northeast, in an event that is simultaneously a research meeting, a networking and job-fair event, and a showcase for established and up-and-coming robot companies. A well-connected robotics community will be essential in fueling the field's rapid growth in the coming decade—so please use the opportunity to get to know each other, and make new friends!

— George Konidaris, Brian Scassellati, Stefanie Tellex and Matt Walter.

Schedule

09:00am–09:45am	Registration	32-123
09:45am–10:00am	Welcoming Remarks	32-123
10:00am–11:00am	Invited Talk: Dave Barrett	32-123
11:00am–11:15am	Sponsor Spotlight: Jaybridge Robotics	32-123
11:15am–12:15pm	Interactive Session & Coffee Break	Fourth floor
12:15pm–01:15pm	Invited Talk: Tomás Lozano-Pérez	32-123
01:15pm–03:00pm	Lunch (catered)	Fourth floor
03:00pm–04:00pm	Invited Talk: Rodney Brooks	32-123
04:00pm–05:00pm	Interactive Session & Coffee Break	Fourth floor
05:00pm–06:00pm	Invited Talk: Dana Yoerger	32-123
06:00pm–06:15pm	Closing Remarks	32-123

Invited Talks

Robotics as an Engine of Global Disruptive Change?

David Barrett
Associate Professor of Mechanical Engineering
Olin College

Abstract: The growth of civilization is driven by disruptive technological events that fundamentally change how we live from one generation to the next. Technologies like computing, the Internet and social media have transformed how we communicate, fight wars and conduct business. The world we currently face is dramatically different from the one our parents inherited. The world our children inherit will be heavily shaped by robotic systems moving into virtually all walks of life. How we produce food, promote health, fight wars and conduct commerce will all be transformed by "machine intelligence" in ways that are hard to imagine or control. This transformation is already well underway and this talk will give both give video examples of robotics transforming all sectors of the economy as well as pose the critical questions of how the up-and-coming generation of robotics engineers will be able to steer this globally transformative process.

Biography: With over 30 years of experience in the robotics industry, Dr. Barrett has built a host of robotic systems that walk, swim, drive and fly for a wide variety of government, commercial and industrial customers. Dr. Barrett received his Ph.D. and M.S. in ocean engineering and M.S. in mechanical engineering from MIT. He currently teaches mechanical engineering and robotics at Olin College and serves as a technological adviser to major corporations and the federal government. Prior to joining the Olin faculty, Dr. Barrett was vice president of Engineering at the iRobot Corporation. Before iRobot, he held positions as a director of the Walt Disney Imagineering Corporation, as a research engineer at MIT's Artificial Intelligence Laboratory, and as a technical director at Draper Laboratory.

Hierarchical Task and Motion Planning for Uncertain Robot Domains

Tomás Lozano-Pérez
Professor of Computer Science and Engineering
Massachusetts Institute of Technology

Abstract: As robots become more physically robust and capable of sophisticated sensing, navigation, and manipulation, we want them to carry out increasingly complex tasks. A robot that helps in a household must plan over the scale of hours or days, considering abstract features such as the desires of the occupants of the house, as well as detailed geometric models that support locating and manipulating objects. The complexity of such tasks derives from very long time horizons, large numbers of objects to be considered and manipulated, and fundamental uncertainty about properties and locations of those objects.

We have developed an approach to integrated task and motion planning that integrates geometric and symbolic representations in an aggressively hierarchical planning architecture, called HPN. The hierarchical decomposition allows efficient solution of problems with very long horizons and the symbolic representations support abstraction in complex domains with large numbers of objects and are integrated effectively with the detailed geometric models that support motion planning. We have also extended the HPN approach to handle two types of uncertainty: future-state uncertainty about what the outcome of an action will be, and current-state uncertainty about what the current state actually is. Future-state uncertainty is handled by planning in approximate deterministic models, performing careful execution monitoring, and replanning when necessary. Current-state uncertainty is handled by planning in belief space: the space of probability

distributions over possible underlying world states.

This is joint work with Leslie Pack Kaelbling.

Biography: Tomás Lozano-Pérez is the School of Engineering Professor of Teaching Excellence at MIT, where he is a member of the Computer Science and Artificial Intelligence Laboratory. Professor Lozano-Pérez has all his degrees (SB '73, SM '76, Ph.D. '80) from MIT in Computer Science. He has been Associate Director of the Artificial Intelligence Laboratory and Associate Head for Computer Science of MIT's Department of Electrical Engineering and Computer Science. Professor Lozano-Pérez's research has been in robotics (configuration-space approach to motion planning), computer vision (interpretation-tree approach to object recognition), machine learning (multiple-instance learning), medical imaging (computer-assisted surgery) and computational chemistry (drug activity prediction and protein structure determination from NMR and X-ray data).

A New Class of Industrial Robot

Rodney Brooks
Chairman, Chief Technology Officer
Rethink Robotics

Panasonic Professor of Robotics (emeritus)
Massachusetts Institute of Technology

Abstract: At Rethink Robotics we have been developing a new class of industrial robot. The transition from mainframes to PCs completely transformed office work, and then transformed how we access information in our daily lives. With mainframes only specialists had direct access to computation. With the PC ordinary people were empowered to control computation and to use if for their own purposes. The Baxter robot is aimed at an analogous transformation from current industrial robots which are installed, integrated, and controlled by specialists, to a situation where anybody who can work on a factory floor can install a robot and have it doing useful work within an hour. The important metrics for this new class of robot are adaptability, flexibility, and ease of use. And low cost. This talk will show how we defined and drove the design of the robot and its own manufacture to these metrics.

Biography: Rodney Brooks is the emeritus Panasonic Professor of Robotics at MIT, and the former director of MIT CSAIL. He was a co-founder of iRobot and CTO there until 2008. He is the founder, chairman and CTO of Rethink Robotics.

Collaborative Human/Robotic Exploration of the Deep Sea

Dana Yoerger
Senior Scientist
Department of Applied Ocean Physics and Engineering
Woods Hole Oceanographic Institution

Abstract: In the past two decades, engineers and scientists have used robots to study basic processes in the deep ocean including the Mid Ocean Ridge, coral habitats, volcanoes, and the deepest trenches. In this talk, the basic types of robotic vehicle systems we have used will be reviewed, including towed vehicles, remotely operated vehicles (ROVs), and autonomous vehicles (AUVs). Their underlying technologies will also be reviewed, including navigation and control systems, mapping sensors, and in-situ sensors. In recent years, the remotely-operated/autonomous dichotomy has dissolved as advances in acoustic and optical telemetry has improved our ability to communicate with untethered platforms. The talk will present results from the first autonomous vehicle surveys of the Mid-Ocean Ridge, our use of autonomous vehicles to make the first discoveries of hydrothermal vents on the Southern Mid-Atlantic and Southwest Indian Ridges, and our recent surveys of unique asphalt volcanoes off the coast of Southern California and the Galapagos Rift Spreading Center. In June 2010, we used the Sentry autonomous underwater vehicle and the TETHYS in-situ mass spectrometer to map a deep hydrocarbon plume emerging from the BP oil spill in the Gulf of Mexico. We also used Sentry to locate sensitive deep-sea coral habitats that may have been effected by the spill. Finally field results from our Nereus vehicle, which reached the bottom of the Challenger Deep in 2009, will be discussed. The talk will conclude with speculation about how these systems will evolve in the future.

Biography: Dr. Dana Yoerger is a Senior Scientist at the Woods Hole Oceanographic Institution and a researcher in robotics and unmanned vehicles. He supervises the research and academic programs of graduate students studying oceanographic engineering through the MIT/WHOI Joint Program in the areas of control, robotics, and design. Dr. Yoerger has been a key contributor to the remotely-operated vehicle JASON; to the Autonomous Benthic Explorer known as ABE; most recently, to the autonomous underwater vehicle, SENTRY; and the hybrid remotely operated vehicle NEREUS which reached the bottom of the Mariana Trench in 2009. Dr. Yoerger has gone to sea on over 70 oceanographic expeditions exploring the Mid-Ocean Ridge, mapping underwater seamounts and volcanoes, surveying ancient and modern shipwrecks, and studying the environmental effects of the BP/Deepwater Horizon oil spill. He was the 2009 recipient of the Lockheed Award for Ocean Science and Engineering and serves of the Research Board for BP's Gulf of Mexico Research Initiative.

Industry Exhibits

The industry exhibits will be located in the Kiva conference room, which is located adjacent to the R&D Commons area on the fourth floor of the Stata Center.

Representatives from the following companies will be on hand during both interactive sessions:

- Barrett Technology, Inc.
- Draper Laboratory
- Harvest Automation
- Jaybridge Robotics
- Kinova Robotics
- MIT Lincoln Laboratory
- Scientific Systems Company, Inc.
- Special Projects Initiative Team, LLC
- Vecna Technologies

Poster Exhibits

The poster exhibits will be in the R&D Commons area on the fourth floor of the Stata Center.

Multi-Robot Field Repair and Maintenance in Inaccessible Environments
Mahdi Agheli, Worcester Polytechnic Institute

Decentralized Multirobot Control in Partially Known Environments
Nora Ayanian, Massachusetts Institute of Technology

Manipulation with Diverse Actions
Jenny Barry, Massachusetts Institute of Technology

Active Sound Localization in Asymmetric Environments
Jordan Brindza and Ashleigh Thomas, University of Pennsylvania

Vision-Based Shared Control in Human-Mobile Manipulator Teams
Velin Dimitrov, Worcester Polytechnic Institute

Reducing the Memory Requirements for Sparse Roadmap Spanners
Andrew Dobson, Rutgers University

Robust Real-Time Underwater Digital Video Streaming using Optical Communication
Marek Doniec, Massachusetts Institute of Technology

Homeomorphic Manifold Analysis for Multi-Modal RGBD Object Recognition
Tarek El-Gaaly, Rutgers University

Towards Humanoid-Human Music Ensembles
David Grunberg, Drexel University

Swarming Nanorobots for Cancer Treatment
Sabine Hauert, Massachusetts Institute of Technology

Acquiring Maps from Natural Language Descriptions
Sachithra Hemachandra, Massachusetts Institute of Technology

Object Placement as Inverse Motion Planning
Anne Holladay, Massachusetts Institute of Technology

Towards Extended Virtual Presence of the Therapist in Stroke Rehabilitation
Hee-Tae Jung, University of Massachusetts Amherst

Powering Autonomous Systems with Micro-solid Oxide Fuel Cells
Kian Kerman, Harvard University

Decentralized Reciprocal Path Selection
Andrew Kimmel, Rutgers University

Pedestrian-Inspired Sampling-Based Multi-Robot Collision Avoidance
Ross Knepper, Massachusetts Institute of Technology

Towards Using Discrete Multiagent Pathfinding to Address Continuous Problem
Athanasios Krontiris, Rutgers University

Planning Periodic Persistent Monitoring Trajectories in GRF
Xiaodong Lan, Boston University

Lazy Roadmap with Gaps: Are Gaps Beneficial?
Zakary Littlefield, Rutgers University

Amorphous Robotic Construction
Nils Napp, Harvard University

Correct Control for High-Level Behaviors with Arbitrary Action Durations
Vasumathi Raman, Columbia University

Kilobot: A low Cost Scalable Robot System For Collective Behaviors
Michael Rubenstein, Harvard University

Satellite Image Based Precise Robot Localization on Sidewalks
Turgay Senlet, Rutgers University

Controlling a Robot Arm with Cultured Mouse Neurons
Abraham Shultz, University of Massachusetts Lowell

Shared Human-Robot Autonomy for a Modular Wheelchair-Manipulator System
Dmitry Sinyukov, Worcester Polytechnic Institute

Teleoperation System for MRI-Guided Needle Insertion with Haptic Feedback
Hao Su, Worcester Polytechnic Institute

Comparison of Three Learning from Demonstration Algorithms
Halit Suay, Worcester Polytechnic Institute

Toward a Probabilistic Approach to Acquiring Information from Human Partners Using Language
Pratiksha Thaker, Massachusetts Institute of Technology

A Cable-Driven Robotic Arm for Use on a Cyber-Physical Wheelchair
Ty Tremblay, Worcester Polytechnic Institute

A Tree Climbing Robot for Insect Detection
Benzun Wisley Babu, Worcester Polytechnic Institute

Manipulation-based Active Search for Occluded Objects
Lawson Wong, Massachusetts Institute of Technology

Poster Abstracts

Mahdi Agheli

Worcester Polytechnic Institute

Title: "Multi-Robot Field Repair and Maintenance in Inaccessible Environments"

Abstract: The main goal of the proposed research is to develop a team of micro-machines for in-situ repair and maintenance within constrained and hazardous environments. The use of micro-machines removes human workers from having to crawl within highly cluttered and constrained spaces, breathing in stale air mixed with fumes from welding or particulates from repair work, and provides higher reliability and consistency in the repair work. The micro-machines will need to traverse over highly irregular terrain while maintaining the multiple degrees-of-freedom necessary for the repair work. Therefore, one outstanding solution could be using hexapod walking robots capable of both walking and manipulating. Since micro-machines should be capable of actively maintaining stability within the tool workspace while in motion, both workspace and stability become most important parameters to be considered for design and control purposes. To enhance the workspace and stability, a scalable hexapod robot is designed by adding prismatic joints into the hexapod articulated legs which provide the robot a flexible workspace. The closed-loop solution to the reachable workspace of the robot is presented. For stability purposes, a Foot Force Stability Margin is presented and shown to be accurate, simple, sensitive, and efficient enough making it practical for use in on-line and real-time controllers. Finally, proper control strategies are needed to be developed in order to integrate stability and reachable workspace of the robot while machining and traversing over highly irregular terrain. Coordination amongst multiple micro machining hexapod robots will also be studied to provide speed up through parallelization.

Nora Ayanian

Massachusetts Institute of Technology

Title: "Decentralized Multirobot Control in Partially Known Environments"

Abstract: This work provides a decentralized solution to multirobot coordination in partially-known environments where the problems of task assignment, trajectory planning and safe control are concurrently solved in the presence of communication constraints.We assume that the robots are homogeneous, can localize themselves and have access to a known map of the environment, except for obstacles and hazards that cannot be circumvented and must be detected through local sensing. Second, we assume that only robots that are within a specified, known communication range can communicate. A group of communicating robots is able to reassign tasks within the group to refine and improve the resulting solution in terms of total time or energy required for traversal. The key contribution of this paper is an approach that concurrently solves the three typically separated problems of task assignment, path planning, and control under constraints with proofs of completeness and convergence. We illustrate the application of these ideas through simulations and experiments with applications to surveillance of multiple destinations.

** This work was previously published at the 2012 IFAC NecSys.

Jenny Barry

Massachusetts Institute of Technology

Title: "Manipulation with Diverse Actions"

Abstract: We consider problems with multiple types of manipulation. Given a robot, a set of movable objects, and a set of actions for manipulating the objects, we are looking for a sequence of manipulation actions that move the robot and objects from an initial configuration to a final configuration. The manipulation actions may be non-prehensile, meaning that the object is not rigidly attached to the robot, such as push, tilt, or pull. We first describe a simple extension to the RRT and RRTConnect algorithms to search the combined space of robot and objects. We then show that the space has natural sub-goals corresponding to the manipulation actions available to the robot in different parts of the domain and give a hierarchical algorithm that automatically finds these sub-goals. We implemented these algorithms on the PR2 robot and showed that we can solve interesting problems in a difficult manipulation domain.

Jordan Brindza & Ashleigh Thomas

University of Pennsylvania

Title: "Active Sound Localization in Asymmetric Environments"

Abstract: Localization for humanoid robots becomes difficult when events that disrupt robot position information occur. This holds especially true in symmetric environments since landmark data is not sufficient to determine orientation. We propose a technique for lo-

calizing a multi-robot team in a known, symmetric environment using auditory localization to disambiguate direction. We complement a Rao-Blackwellized particle filter, which cannot break the symmetry of the environment, with a disambiguation system that uses auditory signals from a beacon robot. This system was used in the RoboCup Standard Platform League to localize on a symmetric soccer field environment and has been shown to regain and maintain accurate localization, even after total loss of localization information..

Velin Dimitrov

Worcester Polytechnic Institute

Title: "Vision-Based Shared Control in Human-Mobile Manipulator Teams"

Abstract: This work presents initial results from using a three-camera vision system to provide loop-closure for a mobile manipulator performing manipulation tasks in a human-robot(s) team. In particular, the design/development framework for a system to be implemented with heterogeneous bomb-disposal robot teams is evaluated. Results of a simple manipulation task are presented along with future directions and specifications for a complete system.

Andrew Dobson

Rutgers University

Title: "Reducing the Memory Requirements for Sparse Roadmap Spanners"

Abstract: This work focuses on constructing sparse representations of continuous configuration spaces with near-optimal solutions to the path planning problem. The poster will highlight high-level concepts and introduce the algorithms SPARS and SPARS2 and show experimental results which verify the theoretical bounds drawn, and show the methods' practicality.

Marek Doniec

Massachusetts Institute of Technology

Title: "Robust Real-Time Underwater Digital Video Streaming using Optical Communication"

Abstract: Our demo presents a real-time video delivery solution based on free-space optical communication for underwater applications. This system comprises of AquaOptical II, a high-bandwidth wireless optical communication device, and a two-layer digital encoding scheme designed for error-resistant communication of high resolution images. Our system can transmit digital video reliably through a unidirectional underwater channel, with minimal infrastructural overhead. It can deliver high quality video at up to 15 Hz, with near-negligible communication latencies of 100 ms. The corresponding end-to- end latencies, i.e. from time of image acquisition until time of display, are below 200 ms, which facilitates a wide range of applications such as underwater robot tele-operation and interactive remote seabed monitoring.

Tarek El-Gaaly

Rutgers University

Title: "Homeomorphic Manifold Analysis for Multi-Modal RGBD Object Recognition"

Abstract: Object recognition and pose estimation are key pre-cursing challenges in the field of robotic object manipulation. Recognizing object categories, particular instances of objects and viewpoints/poses of objects are three critical subproblems robots must face in order to accurately grasp and manipulate objects. Multi-view images of the same object lie on intrinsic low-dimensional manifolds in descriptor spaces (e.g., visual/depth descriptor spaces). This manifold can be thought of as a deformed version of a conceptual manifold representing the actual geometric viewpoints (e.g., a unit circle representing viewpoints of an object on a turn-table). Each object manifold can be represented as a deformed version of this unified conceptual manifold. These two manifolds share the same topology despite being geometrically different. The object manifolds can thus be parametrized by its homeomorphic mapping/reconstruction from the conceptual manifold. In this work, we construct a manifold descriptor from this mapping between homeomorphic manifolds and use it to solve the three challenging recognition sub-problems. We extensively experiment on a challenging multi-modal (i.e., RGBD) dataset and achieve state-of-the-art results. We also present a close to real-time method of table-top object detection and recognition using this approach.

David Grunberg

Drexel University

Title: "Towards Humanoid-Human Music Ensembles"

Abstract: We seek to enable Hubo, our adult-sized humanoid, to participate alongside humans in musical ensembles and performances. We have thus developed specific motions and communications algorithms for the robot, allowing it to dance and play instruments. Demonstrations of this work include a dance performance alongside the Drexel Dance Ensemble in which

the robot utilized motion-captured data to move in a fluid manner similar to the dancers, and a rendition of the Beatles song Come Together performed on pitched and unhitched percussive instruments. In order to allow the robot to adjust its performances based on the music that it hears, we have also developed several algorithms that analyze acoustic music and extract important high-level features, such as beat locations, tempo, pitch, and mood. We are currently implementing these algorithms in conjunction with the Hubo's performances so that the robot can perform while reacting to live music.

Sabine Hauert

Massachusetts Institute of Technology

Title: "Swarming Nanorobots for Cancer Treatment"

Abstract: Nanorobots are increasingly being designed for the intelligent treatment of cancer. Biological-building blocks and properties of nanomaterials allow nanorobots to move, sense and act on their environment in a controlled fashion. Leveraging these capabilities, the next step is to design nanorobots that cooperate to synergistically improve their behavior. Designing such swarm strategies is challenging because there typically exists no relation between the design of each individual and their collective behavior. Building on the power of the crowd and their desire to learn about nanomedicine and help in the fight against cancer, we aim to crowd-source the design of swarm treatments through an online game and simulation framework. Novel solutions will be evaluated in reality using a simplified in vitro model of cancer.

Sachithra Hemachandra

Massachusetts Institute of Technology

Title: "Acquiring Maps from Natural Language Descriptions"

Abstract: We proposes a novel algorithm that enables robots to learn models of their environment by fusing information from natural language descriptions of the environment with low- level metric information obtained through range sensors. Traditional mapping work focuses on building maps that are metrically accurate but do not model semantic attributes of the environment. More recent semantic mapping approaches augment metric maps with higher-level properties of the robots surroundings such as appearance information and object locations, but do not use this information to improve or change the metric map. Our approach, in contrast, maintains a probability distribution over a hybrid metric/topological/semantic representation of an environment. Information obtained through language augments the semantic map and also enables the robot to improve its metric map of the environment. We evaluate the algorithms performance on experiments involving guided tours of an environment and demonstrate its ability to use information from language to update the semantic map as well as accurately close loops in the lower-level metric map.

Anne Holladay

Massachusetts Institute of Technology

Title: "Object Placement as Inverse Motion Planning"

Abstract: We present an approach to robust placing that uses movable surfaces in the environment to guide a badly grasped object into a goal pose. We model the physics of placing as a mixture model of simple object motions, and show that this easily computed model allows us to do useful planning for placing. We give an algorithm that searches over the possible configurations of the object and environment and chooses the configuration most likely to lead to a successful place according to the transition model. We show that this algorithm coupled with a very simple model allows the PR2 robot to execute places that fail with traditional placing implementations.

Hee-Tae Jung

University of Massachusetts Amherst

Title: "Towards Extended Virtual Presence of the Therapist in Stroke Rehabilitation"

Abstract: This paper considers the use of robots in residential eldercare to facilitate both direct and indirect communication between clients and medical professionals. Direct interaction is realized through a humanoid-mediated teletherapy where a therapist assesses the motor function of a patient and provides therapy. During the teletherapy sessions, the therapist uses a simple speech interface to program therapeutic behavior and activity, which is re-used in autonomous therapy in the absence of the therapist. We propose that such an approach can amplify the outcome per hour of therapist time. Based on the study, we argue that the proposed approach can successfully provide customized therapy to individuals in residential settings.

Kian Kerman

Harvard University

Title: "Powering Autonomous Systems with Micro-solid Oxide Fuel Cells"

Abstract: We highlight our recent results on the design, fabrication and experimental demonstration of thin film solid oxide fuel cells as potential embeddable power sources and power skins for autonomous systems.

Andrew Kimmel

Rutgers University

Title: "Decentralized Reciprocal Path Selection"

Abstract: This poster will focus on describing an algorithm which allows multiple robots to navigate through an environment in a collision free manner, while avoiding deadlock and livelock situations that can arise from densely crowded environments. This algorithm builds upon methods from reactionary collision avoidance, such as the Velocity Obstacle method, and also game-theoretic notions, as each robot maintains a matrix of pair-wise costs for a discrete set of paths. This poster will also provide comparisons to similar existing techniques, which were run in simulation, along with quantitative data to support the algorithm.

Ross Knepper

Massachusetts Institute of Technology

Title: "Pedestrian-Inspired Sampling-Based Multi-Robot Collision Avoidance"

Abstract: We present a distributed collision avoidance algorithm for multiple mobile robots that is model-predictive, sampling-based, and intuitive for operation around humans. Unlike purely reactive approaches, the proposed algorithm incorporates arbitrary trajectories as generated by a motion planner running on each navigating robot as well as predicted human trajectories. Our approach, inspired by human navigation in crowded pedestrian environments, draws from the sociology literature on pedestrian interaction. We propose a simple two-phase algorithm in which agents initially cooperate to avoid each other and then initiate civil inattention, thus lessening reactivity and committing to a trajectory. This process entails a pedestrian bargain in which all agents act competently to avoid each other and, once resolution is achieved, to avoid interfering with others' planned trajectories. This approach, being human-inspired, fluidly permits navigational interaction between humans and robots. We report experimental results for the algorithm running on real robots with and without human presence and in simulation.

Athanasios Krontiris

Rutgers University

Title: "Towards Using Discrete Multiagent Pathfinding to Address Continuous Problem"

Abstract: Motivated by efficient algorithms for solving combinatorial and discrete instances of the multi-agent pathfinding problem, this work investigates ways to utilize such solutions to solve similar problems in the continuous domain. While a simple discretization of the space which allows the direct application of combinatorial algorithms seems like a straightforward solution, there are additional constraints that such a discretization needs to satisfy in order to be able to provide some form of completeness guarantees in general configuration spaces. This poster reviews ideas on how to utilize combinatorial algorithms to solve continuous multi-agent pathfinding problems efficiently, while still providing probabilistic completeness. It also presents preliminary results towards this direction.

Xiaodong Lan

Boston University

Title: "Planning Periodic Persistent Monitoring Trajectories in GRF"

Abstract: This paper considers the problem of planning a trajectory for a sensing robot to best estimate a time-changing Gaussian Random Field in its environment. The robot uses a Kalman filter to maintain an estimate of the field value, and to compute the error covariance matrix of the estimate. A new randomized path planning algorithm is proposed to find a periodic trajectory for the sensing robot that tries to minimize the largest eigenvalue of the error covariance matrix over an infinite horizon. The algorithm is proven to find the minimum infinite horizon cost cycle in a graph, which grows by successively adding random points. The algorithm leverages recently developed methods for periodic Riccati recursions to efficiently compute the infinite horizon cost of the cycles, and it uses the monotonicity property of the Riccati recursion to efficiently compare the cost of different cycles without explicitly computing their costs. The performance of the algorithm is demonstrated in numerical simulations and in experiments with an m3pi robot in a motion capture room.

Zakary Littlefield

Rutgers University

Title: “Lazy Roadmap with Gaps: Are Gaps Beneficial?”

Abstract: Recently, sampling-based motion planners have created that can provide asymptotic optimality. These algorithms however require a method to connect any two states exactly. The purpose of this work is to determine if this requirement is needed, i.e., can we relax the connection requirement so that “gaps” appear in the data structure and still provide asymptotic optimality. This could be useful for systems where dynamics are not known or noisy.

Nils Napp

Harvard University

Title: “Amorphous Robotic Construction”

Abstract: We present a model of construction using iterative amorphous depositions and give a distributed algorithm to reliably build ramps in unstructured environments. The relatively simple local strategy for interacting with irregularly shaped, partially built structures gives rise robust adaptive global properties.

Vasumathi Raman

Columbia University

Title: “Correct Control for High-Level Behaviors with Arbitrary Action Durations”

Abstract: This poster describes a controller-synthesis framework that ensures provably correct continuous behavior given an automatically-synthesized hybrid controller, even when relaxing the assumption of instantaneous controller execution.

Michael Rubenstein

Harvard University

Title: “Kilobot: A low Cost Scalable Robot System For Collective Behaviors”

Abstract: A large group of decentralized closely cooperating robots, commonly called a collective or swarm, can work together to complete a task that is beyond the capabilities of any of its individual robots. In current robotics research there is a vast body of work on algorithms and control for these robotic collectives. While these algorithms are generally meant to control collectives of hundreds or even millions of robots, for reasons of cost, time, or complexity, they are generally validated in simulation only, or on a group of a few 10's of robots. This poster describes a robot called Kilobot, which is designed to operate in collectives with an order of magnitude more robots than the largest that exist today. We will describe the design and operation of this robot system that allows it to easily operate in such large collectives, which would be difficult or impossible to do with existing robotic systems.

Turgay Senlet

Rutgers University

Title: “Satellite Image Based Precise Robot Localization on Sidewalks”

Abstract: We present a novel computer vision framework for precise localization of a mobile robot on sidewalks. In our framework, we combine stereo camera images, visual odometry, satellite map matching, and a sidewalk probability transfer function obtained from street maps in order to attain globally corrected localization results. The framework is capable of precisely localizing a mobile robot platform that navigates on sidewalks, without the use of traditional wheel odometry, GPS or INS inputs. On a complex 570-meter sidewalk route, we show that we obtain superior localization results compared to visual odometry and GPS.

Abraham Shultz

University of Massachusetts Lowell

Title: “Controlling a Robot Arm with Cultured Mouse Neurons”

Abstract: In collaboration with Thomas Shea's lab in the Umass Lowell biology department, we are developing a system to allow cultured mouse neurons to move a robot arm and receive information about the environment around the arm. This poster covers the work so far, and future directions for this research.

Dmitry Sinyukov

Worcester Polytechnic Institute

Title: “Shared Human-Robot Autonomy for a Modular Wheelchair-Manipulator System”

Abstract: The aim of this research is to develop a control framework for shared human-robot autonomy for a

wheelchair-manipulator system which will allow locked-in individuals, who are unable to interact with the physical world through movement and speech, to perform activities of daily living (ADL). Our current focus is on designing a modular, semi-autonomous robotic wheelchair platform with a 7-DOF robotic arm, controlled through a Body/Brain Computer Interface (BBCI). One of the key questions of the research is how to optimally use limited human input available through BBCI. Our approach to identify human intent is based on classic information theory and probabilistic filtering which, according to our preliminary experiment results, allowed to significantly decrease time required for semi-autonomous indoor navigation. As part of our effort to design a system which would safely operate in the close proximity to a human we have developed a high-performance algorithm for simulating a tactile sensor system which will enable development of effective and safe control algorithms for grasping. We also address the requirement for system modularity by designing modular sensor units for range detection, optometry measurements and mapping.

Hao Su

Worcester Polytechnic Institute

Title: "Teleoperation System for MRI-Guided Needle Insertion with Haptic Feedback"

Abstract: This work presents a surgical master-slave teleoperation system for percutaneous interventional procedures under continuous magnetic resonance imaging (MRI) guidance. This system consists of a piezoelectrically actuated slave robot for needle placement with integrated fiber optic force sensor utilizing Fabry-Perot interferometry (FPI) sensing principle. The sensor flexure is optimized and embedded to the slave robot. A novel opto-mechanical FPI interface that is compact and portable is integrated into the robot controller to generate the sensor light pathway. By leveraging the complementary feature of pneumatic and piezoelectric actuation, a pneumatically actuated haptic master robot is also developed to render proprioception associated with needle placement interventions. An aluminum load cell is designed and calibrated to close the impedance control loop of the master robot. Force-position control algorithm is developed to control the hybrid actuated system. Force and position tracking results of master-slave robots are demonstrated to validate the tracking performance of the integrated system.

Halit Suay

Worcester Polytechnic Institute

Title: "Comparison of Three Learning from Demonstration Algorithms"

Abstract: We compare and evaluate three different learning from demonstration algorithms in a real-world domain using a small humanoid robot. The algorithms we present are 1) Interactive Reinforcement Learning, 2) Behavior Networks, and 3) Confidence-Based Autonomy. For each algorithm, we show sample policies, give implementation specific details and talk about practical issues.

Pratiksha Thaker

Massachusetts Institute of Technology

Title: "Toward a Probabilistic Approach to Acquiring Information from Human Partners Using Language"

Abstract: Our goal is to build robots that can robustly interact with humans using natural language. This problem is challenging because human language is filled with ambiguity, and furthermore, due to limitations in sensing, the robots perception of its environment might be much more limited than that of its human partner. To enable a robot to recover from a failure to understand a natural language utterance, we describe an information-theoretic strategy for asking targeted clarifying questions and using information from the answer to disambiguate the language. To identify good questions, we derive an estimate of the robots uncertainty about the mapping between specific phrases in the language and aspects of the external world. This metric enables the robot to ask a targeted question about the parts of the language for which it is most uncertain. After receiving an answer, the robot fuses information from the command, the question, and the answer in a joint probabilistic graphical model in the G3 framework. When using answers to questions, we show the robot is able to infer mappings between parts of the language and concrete object groundings in the external world with higher accuracy than by using information from the command alone. Furthermore, we demonstrate that by effectively selecting which questions to ask, the robot is able to achieve significant performance gains while asking many fewer questions than baseline metrics.

Ty Tremblay

Worcester Polytechnic Institute

Title: "A Cable-Driven Robotic Arm for Use on a Cyber-Physical Wheelchair"

Abstract: This work presents the initial results from the development of a robotic arm for use on a robotic wheelchair using the igus robolink system. Improvements to the power plant of the arm are presented and

an initial hardware architecture is described. Applications for the arm are presented as well as plans for the future.

Benzun Wisley Babu

Worcester Polytechnic Institute

Title: "A Tree Climbing Robot for Insect Detection"

Abstract: This poster reviews progress in the development of a scansorial robot for invasive insect detection. It discusses the motivation for our approach, provides design considerations and implementation details, and presents progress to date. One notable feature of the robot is its use of vSLAM to map the tree under study. The robot is currently under development at WPI and this poster provides a summary of its status and future plans.

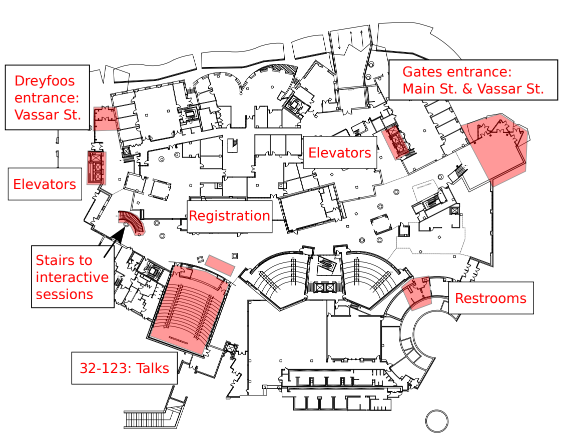
Lawson Wong

Massachusetts Institute of Technology

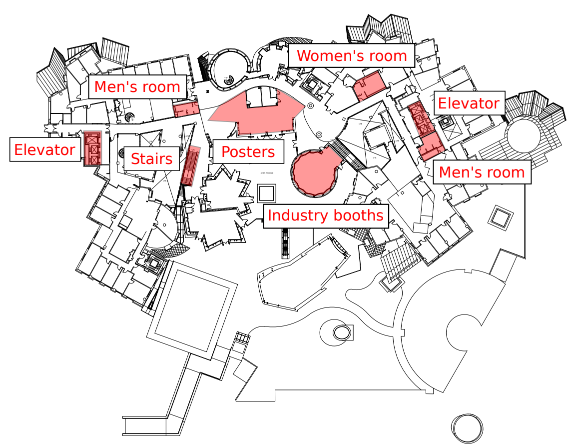
Title: "Manipulation-based Active Search for Occluded Objects"

Abstract: Object search is an integral part of daily life, and in the quest for competent mobile manipulation robots it is an unavoidable problem. Previous approaches focus on cases where objects are in unknown rooms but lying out in the open, which transforms object search into active visual search. However, in real life, objects may be occluded in the back of cupboards behind other objects, instead of conveniently on a table by themselves. Extending search to occluded objects requires a more precise model and tighter integration with manipulation. We present a novel generative model for representing container contents by using object co-occurrence information and spatial constraints. Given a target object, a planner uses the model to guide an agent to explore containers where the target is likely, potentially needing to move occluding objects to enable further perception. We demonstrate the model on simulated domains and a detailed simulation involving a PR2 robot.

Maps



Stata Ground Floor Map



Stata 4th Floor Map

Where to Eat

A catered lunch will be served in the R&D Commons on the 4th floor of the Stata Center from 1:15pm to 3:00pm. Alternatively, there are several places within a short walking distance from the Stata Center where you can get a bite to eat. These include, in order of increasing distance: Legal Sea Foods (lunch, dinner, bar), Starbucks, Mead Hall (lunch, dinner, bar), Catalyst (dinner, bar), Area Four (coffee, lunch, dinner), Chipotle Mexican Grill (take-out), Au Bon Pain (take-out), Cosi (take-out), Emma's Pizza (lunch, dinner), Cambridge Brewing Company (lunch, dinner, bar), Lord Hobo (dinner, bar), and Miracle of Science (lunch, dinner, bar).