

1st SUMMER SCHOOL ON COGNITIVE ROBOTICS

June 12 - 16, 2017
MIT, Stata Center
Cambridge, MA, USA

MERS
Model-based Embedded
& Robotic Systems group
CSAIL@MIT



Contents

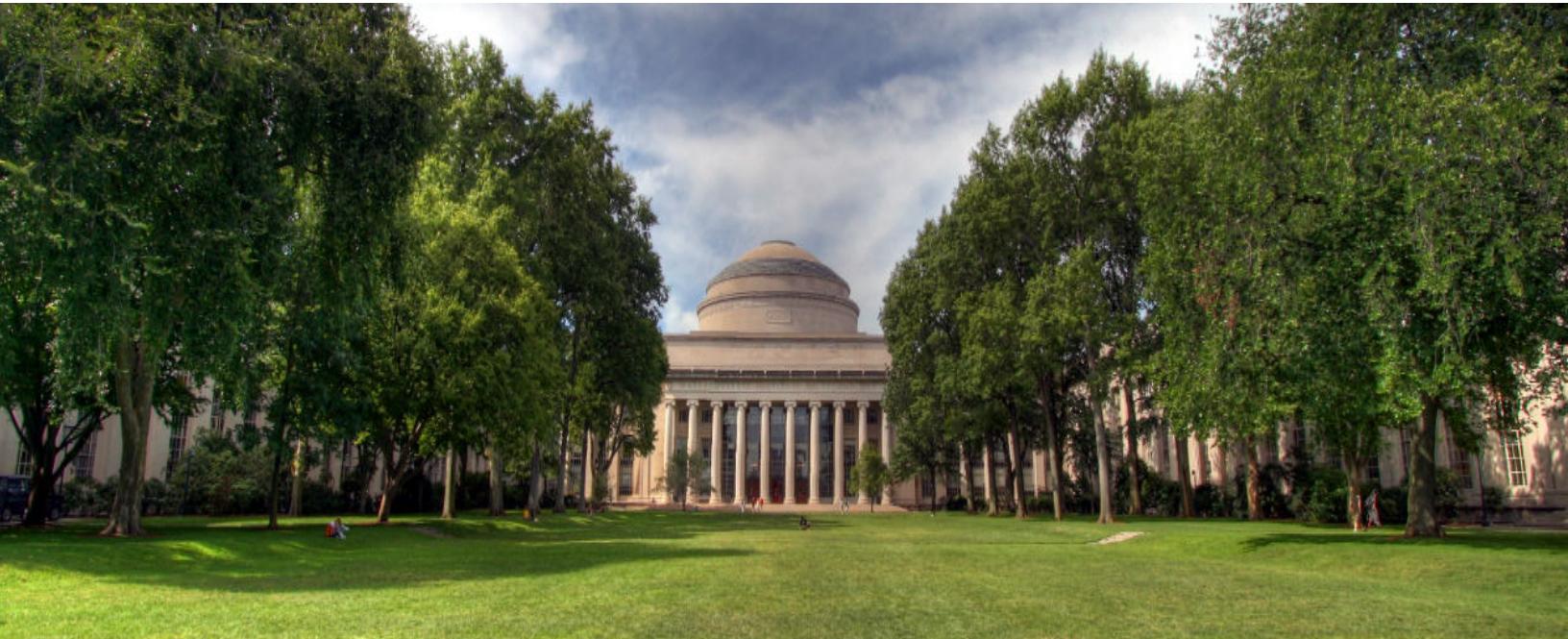
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Organizing Committee

- [Brian Williams](#), MIT
- [Tiago Vaquero](#), MIT

Local Organizers

The Summer School on Cognitive Robotics is planned and run by the [Model-based Embedded and Robotic Systems](#) (MERS) group at MIT.



General Information

Registration Desk

Each day the registration desk is located outside the room where tutorials are presented.

June 12, 13, 14 and 16:

The registration desk is located in front of the room D463 (Star) on the 4th floor of the State Center, MIT Building 32.

June 12: 8:30am - 9:30am

June 13, 14 and 16: 8:00am - 8:30am

June 15:

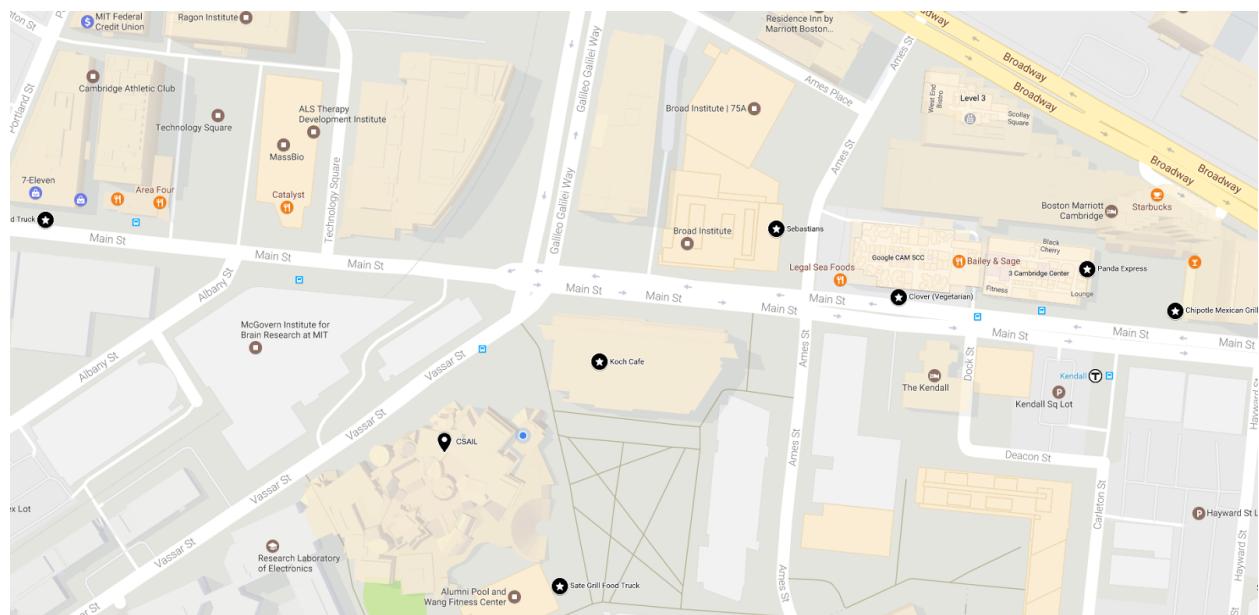
The registration desk is located in front of the room G449 (Kiva) on the 4th floor of the State Center, MIT Building 32.

June 15: 8:00am - 8:30am

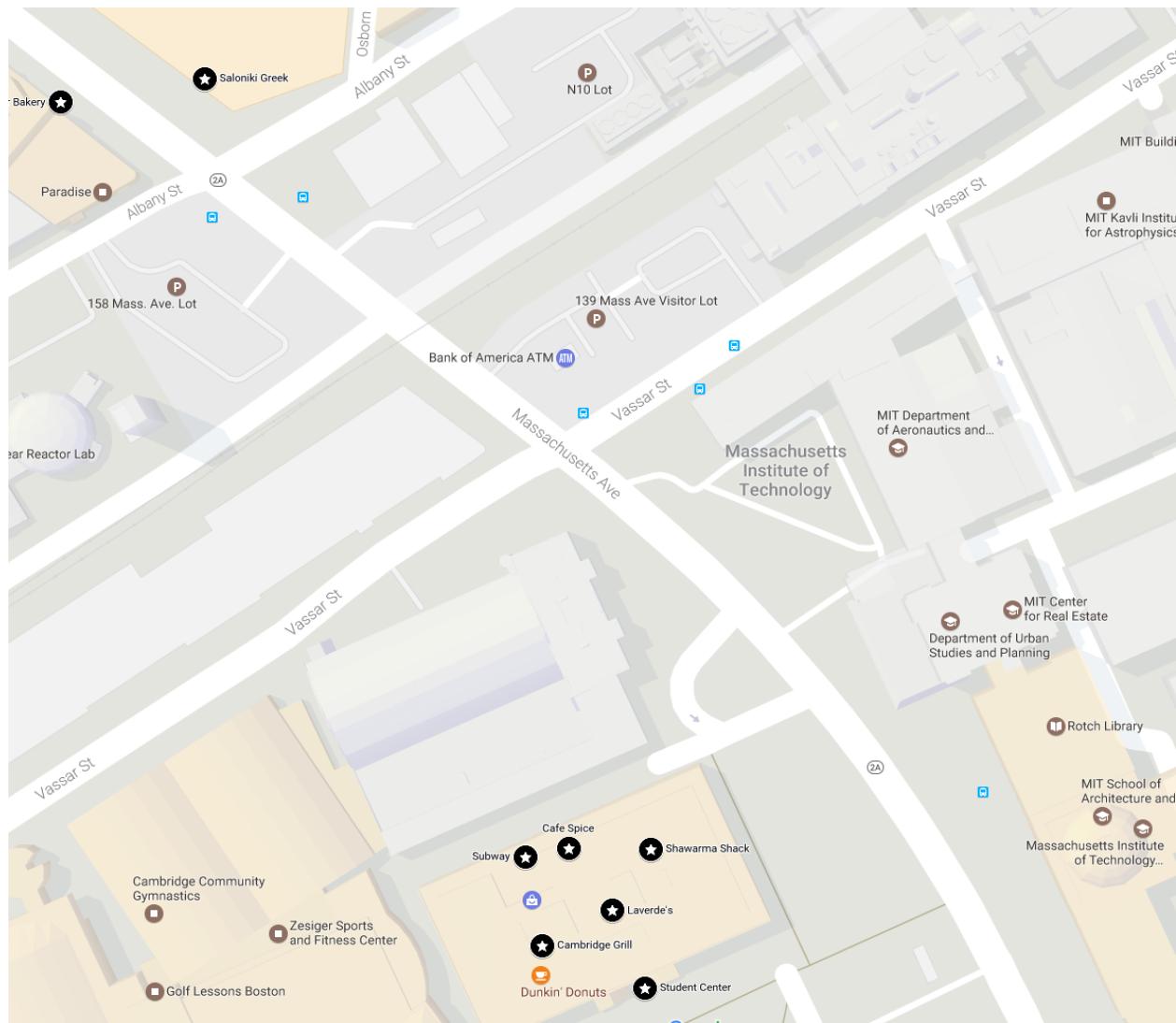
Lunch Break

Lunch is not provided during the summer school, but there is a wealth of options in Kendall Square, right outside the door. Please take this as a time to explore, together with new colleagues. Options near campus include food trucks, sub shops, take out, brew pubs and gourmet restaurants. Examples near Kendall square include (see maps for locations):

Clover (Vegetarian), Flour Bakery, Koch Cafe, Sebastians, Sata Grill Food Truck, Chinese Food Truck, Chipotle Mexican Grill, and Panda Express.



Options at the MIT Student Center include Cambridge Grill, Shawarma Shack (Middle Eastern Food), Cafe Spice, Laverde's, and Subway.



Internet Access

Wireless internet access is available in the Stata Center Building.

Participants from eduroam institutions can use their usual authentication process to connect.

Other participants can connect to one of the following guest networks:

- StataCenter
- MIT Guest
- MIT



Schedule

Day 1 - June 12. Theme: Robust Execution: Estimation, Monitoring and Scheduling	
8:30am - 9:30am	Registration
9:30am - 10:00am	Introduction 1: Architectures for Autonomy <i>Speaker: Brian Williams, Massachusetts Institute of Technology</i>
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 2: Self-Monitoring, Self-Diagnosing Systems <i>Speaker: Brian Williams, Massachusetts Institute of Technology</i>
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 3: Temporal Networks for Dynamic Scheduling <i>Speaker: Luke Hunsberger, Vassar College</i>
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab
6:00pm - 7:00pm	Open lab hours
Day 2 - June 13. Theme: Motion Planning	
8:30am - 10:00am	Tutorial 4: Sampling-based Motion Planning <i>Speakers: Mark Moll and Lydia Kavraki, Rice University</i>
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 5: Single-Robot and Multi-Robot Path Planning with Quality Guarantees <i>Speaker: Sven Koenig, University of Southern California</i>
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 6: Trajectory Optimization for Underactuated Robots <i>Speaker: Scott Kuindersma, Harvard University</i>
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab
6:00pm - 7:00pm	Open lab hours
7:00pm	Social Dinner
Day 3 - June 14. Theme: Activity Planning (AI)	
8:30am - 10:00am	Tutorial 7: Classical Planning@Robotics: Methods and Challenges <i>Speaker: Joerg Hoffmann, Saarland University</i>
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 8: Planning in Hybrid Domains <i>Speaker: Andrew Coles, King's College London</i>
12:00pm - 1:00pm	Lunch

1:00pm - 2:30pm	Tutorial 9: Planning of Concurrent Timelines <i>Speaker: David Wang, NuVu</i>
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab
6:00pm - 7:00pm	Open lab hours
Day 4 - June 15. Theme: Perception and Manipulation	
8:30am - 10:00am	Tutorial 10: Multi-vehicle Routing with Time Windows <i>Speaker: Philip Kilby, CSIRO Data61 / Australian National University</i>
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 11: Generative Models for Perception <i>Speaker: John W. Fisher, Massachusetts Institute of Technology</i>
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 12: Fundamentals of Robotic Manipulation and Grasping <i>Speaker: Alberto Rodriguez, Massachusetts Institute of Technology</i>
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab
6:00pm - 7:00pm	Open lab hours
Day 5 - June 16. Theme: Planning with Uncertainty and Risk	
8:30am - 10:00am	Tutorial 13: Probabilistic Planning <i>Speaker: Shlomo Zilberstein, University of Massachusetts Amherst</i>
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 14: Localization and Mapping <i>Speaker: Nicholas Roy, Massachusetts Institute of Technology</i>
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 15: Risk-bounded Planning and Scheduling <i>Speaker: Brian Williams, Massachusetts Institute of Technology</i>
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Demonstration/Competition



Tutorials and Talks

Introduction 1: Architectures for Autonomy

Date: Monday, June 12, 2017

Time: 9:30am - 10:00am

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Brian Williams, Massachusetts Institute of Technology

Abstract:

In this introduction we kick off the cognitive robotics summer school, by discussing some of the architecture and language principles that enable robotic systems to be commanded simply, to be fluid and to be robust. This includes architectural principles for goal-directed commanding, closed loop monitoring of goals, flexible execution, and managing the coupling between state and time. Language principles include non-deterministic, decision-theoretic, state-based and risk-bounded programming. Intro includes demonstrations of systems and architectures that embody these concepts.

Tutorial 2: Self-Monitoring, Self-Diagnosing Systems

Date: Monday, June 12, 2017

Time: 10:30am - 12:00pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Brian Williams, Massachusetts Institute of Technology

Abstract:

Goal-directed systems improve robustness by monitoring and diagnosing failures that influence goal achievement, so that these failures can be repaired before they become catastrophic. In this tutorial we will first discuss closing the loop on goal-directed systems, through causal link monitoring. Second, we will introduce conflict-directed search algorithms that generate likely diagnoses to component failures. Finally, we will illustrate how variants of these algorithms can be used to navigate large spaces of candidate plans, and can be used to help users to collaboratively diagnose and repair inconsistent goal specifications. Applications include self-diagnosing space explorers, robotic task planning, human-robot collaboration and network management.

Tutorial 3: Temporal Networks for Dynamic Scheduling

Date: Monday, June 12, 2017

Time: 1:00pm - 2:30pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Luke Hunsberger, Vassar College

Abstract:

This tutorial surveys a variety of temporal networks, including Simple Temporal Networks (STNs), STNs with Uncertainty (STNUs), Conditional STNs (CSTNs), and Conditional STNs with Uncertainty (CSTNUs), as well as algorithms for checking their dynamic consistency and controllability, many of which have appeared only very recently in the literature. The networks differ in their expressivity and the complexity of the algorithms used to process them. These

methods can be used to provide a means of representing and reasoning about temporal constraints, and thus can serve as the foundation for dynamic scheduling systems.

Tutorial 4: Sampling-based Motion Planning

Date: Tuesday, June 13, 2017

Time: 8:30pm - 10:00am

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Mark Moll and Lydia Kavraki, Rice University

Abstract:

In robot motion planning, the central problem is to find feasible motions that take a given robotic system from some initial state to a desired goal state. This involves searching a high-dimensional continuous space for feasible paths, where the dimensions correspond to the degrees of freedom of the robot. Although even a basic version of the motion planning problem is already PSPACE-hard, in practice so-called sampling-based planning algorithms have been demonstrated to solve motion planning problems very effectively, even for systems with many degrees of freedom and subject to complex constraints. This tutorial will cover the basic building blocks of sampling-based planning, will describe their theoretical properties, and will demonstrate how motion planning and task planning can be combined.

Tutorial 5: Single-Robot and Multi-Robot Path Planning with Quality Guarantees

Date: Tuesday, June 13, 2017

Time: 10:30am - 12:00pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Sven Koenig, University of Southern California

Abstract:

Path planning is an important technology for a large number of robotics applications, and most computer scientists and roboticists are familiar with a number of path-planning algorithms, from Dijkstra's algorithm to A*. This tutorial will discuss recent progress on single-agent and multi-agent path planning in the context of A*-based heuristic search algorithms. Many of these path-planning algorithms provide quality guarantees on the resulting paths for the chosen granularity of discretization, such as their optimality or bounded suboptimality. The following techniques will be discussed: 1) A*-based incremental search (that is, heuristic search algorithms that reuse information from previous searches to search faster than repeated A* searches); 2) A*-based any-angle search (that is, heuristic search algorithms that propagate information on graphs, but do not restrict the resulting paths to the edges of the graphs), and 3) A*-based multi-agent pathfinding (that is, heuristic search algorithms that plan collision-free paths for multiple robots to their destinations).

Tutorial 6: Trajectory Optimization for Underactuated Robots

Date: Tuesday, June 13, 2017

Time: 1:00pm - 2:30pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Scott Kuindersma, Harvard University

Abstract:

Underactuated systems encompass a wide range of walking, flying, and manipulating robots. Algorithms for planning and controlling behaviors in these systems must capture, exploit, and reshape the robot's dynamics to achieve motion goals while obeying task-specific constraints. This tutorial provides an overview of popular trajectory optimization algorithms for generating locally-optimal dynamic motions for constrained dynamical systems. Topics include: a brief overview of dynamics and underactuation, trajectory optimization formulations, direct transcription, differential dynamic programming, contact-implicit planning, and LQR tracking.

Tutorial 7: Classical Planning@Robotics: Methods and Challenges

Date: Wednesday, June 14, 2017

Time: 8:30am - 10:00am

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Joerg Hoffmann, Saarland University

Abstract:

The generative planning sub-area of AI tackles the creation of general purpose algorithms for solving sequential decision making problems, involving the optimal choice of actions towards a goal, given specifications for allowed primitive actions. These planners take as input a world model that is specified in a generic logic-based language, and employ algorithms that should work correctly for any input of this kind. Generative planning thus employs a model-based framework for highly adaptive decision-making, inspired by capabilities that humans have, and that are an asset to long-term autonomy in highly dynamic environments. Generative planning was originally conceived in the late 1960s and early 1970s for decision-making in autonomous systems -- yet has developed largely separate from robotics for several decades. Given the vast increased capabilities and robustness of both robotic systems and planning systems, there is now an opportunity to close this gap.

This tutorial provides an overview of relevant algorithms, developments, and research questions in the so-called area of classical planning, which examines the planning problem in its purest form, by making a significant number of simplifying assumptions, such as fully observable world state, deterministic atomic actions, and sole agent of change. Classical planning has a long history as a source of algorithmic ideas that are fruitfully employed within more expressive planning models. This tutorial focuses on recent advances, while assuming a basic knowledge of generative planning. I begin with a brief introduction, and then present the basic techniques employed in delete-relaxation heuristics, a technique that has been employed for almost 20 years, but remains a paramount source of performance in modern planning algorithms and systems. I will cover partial delete relaxation heuristics, a more recent technique that avoids some of the pitfalls of delete relaxation. These techniques are employed within greedy algorithms that attempt

to find plans quickly, but without formal guarantees of optimality or completeness. Next I will highlight recent influential ideas at proving properties about the entire space of plans. This includes the derivation of lower bounds on plan length, and methods for learning nogoods through an analysis of the conflicts (dead-end states) that are encountered during search. The final part of this tutorial devotes 15-20 minutes to the discussion of open questions that I consider particularly relevant in the context of planning for robotics.

Tutorial 8: Planning in Hybrid Domains

Date: Wednesday, June 14, 2017

Time: 10:30am - 12:00pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Andrew Coles, King's College London

Abstract:

In classical activity planning, the task is to find a plan that progresses through a series of discrete state transitions to reach the goals. For this to work well, the model used by the activity planner needs to abstract the underlying continuous dynamics of the world, into a discrete model that still allows reasonable plans to be found, while leaving the resolution of any issues arising due to the continuous nature of the world to execution time. In some cases, this is not practical, and hence we turn to hybrid activity planning. Here, the planner is given an enriched problem definition that additionally contains a model of the continuous dynamics: for instance, numeric values (such as battery charge) change during the execution of actions. In addition, background processes act independent of the planned activities, thus influencing what is feasible. In this tutorial, I'll discuss techniques for planning in hybrid domains. Building upon techniques used in the classical setting, I will discuss how planners can search for plans that dictate what to do, and when to do it, by explicitly reasoning with the specified continuous dynamics. This will be motivated by examples taken by recent and ongoing work in the area.

Tutorial 9: Planning of Concurrent Timelines

Date: Wednesday, June 14, 2017

Time: 1:00pm - 2:30pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: David Wang, NuVu

Abstract:

A common feature of timeline planners is that they organize state information along timelines. Other areas of planning research, such as those based on heuristics, hierarchical task networks, or planning as constraint satisfaction, are related due to algorithmic similarities. In contrast, timeline planners are related by how their plans are represented, by the use of relevant features of a planning problem, and by the way state evolution is tracked over time.

In this tutorial we explore the topic of planning with timelines. What constitutes those features we wish to track? How can we handle the complex network of dependencies shared by those features? We survey the field of early timeline planners, such as HSTS and NASA's Europa, talk about some approaches to planning along timelines, and then take a deeper dive into

temporal Burton (tBurton), a recent timeline planner that combines timeline planning with techniques popular within the planning as heuristic forward search community.

Tutorial 10: Multi-vehicle Routing with Time Window

Date: Thursday, June 15, 2017

Time: 8:30am - 10:00am

Room: G449 (Kiva), 4th floor of Stata Center (Building 32)

Speaker: Phil Kilby, CSIRO Data61 / Australian National University

Abstract:

In vehicle routing, we seek to visit a given set of locations with a fleet of vehicles at minimum cost. A variety of constraints may apply, including time window, capacity and a host of others. The problem arises in a variety of contexts – goods or service delivery, FedEx style parcel pickup and delivery, ridesharing, and circuit board drilling, to name a few. In this tutorial we look at practical ways to solve this problem. In particular, we look at methods that combine to produce a powerful framework: Constraint Programming aided by Large Neighbourhood Search. We introduce Constraint Programming, by using and playing with the MiniZinc language and IDE. Through the Vehicle Routing Problem, we see that these methods are able to solve a large number of combinatorial optimization problems effectively.

Tutorial 11: Generative Models for Perception

Date: Thursday, June 15, 2017

Time: 10:30am - 12:00pm

Room: G449 (Kiva), 4th floor of Stata Center (Building 32)

Speaker: John W. Fisher, Massachusetts Institute of Technology

Abstract:

This tutorial focuses on the analysis of complex, high-dimensional perceptual data, based on generative models. I will describe methods for analysis that combine elements of Bayesian inference, information theory, optimization, and physical sensor models, thus providing scalable algorithms with theoretical performance guarantees. Applications will be drawn from multi-modal data fusion, distributed inference under resource constraints, structural inference, resource management in sensor networks, and analysis of video, seismic volumes, and radar images.

Tutorial 12: Fundamentals of Robotic Manipulation and Grasping

Date: Thursday, June 15, 2017

Time: 1:00pm - 2:30pm

Room: G449 (Kiva), 4th floor of Stata Center (Building 32)

Speaker: Alberto Rodriguez, Massachusetts Institute of Technology

Abstract:

Manipulation is the process by which we rearrange the world around us using our hands, our bodies, or tools. It is a very wide and unstructured problem, from throwing a rock to unbuttoning one's shirt. Like many other human skills, it sits right between art and science. The story of robotic manipulation is one of finding snippets of the manipulation problem that are sufficiently structured

to be modeled and replicated. As a consequence, there is no one unified robotic manipulation problem, but rather a collection of manipulation problems, each with different tools for analysis and synthesis. In this tutorial I'll start by discussing the path of robotic manipulation research, from wide and hopeless to narrow and solvable, and will describe a "taxonomy" of some manipulation problems that robotics has tackled.

Tutorial 13: Probabilistic Planning

Date: Friday, June 16, 2017

Time: 8:30am - 10:00am

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Shlomo Zilberstein, University of Massachusetts Amherst

Abstract:

The tutorial covers models and algorithms for sequential decision making under uncertainty. Topics include planning with Markov decision processes (MDPs); solving MDPs using dynamic programming and heuristic search methods, such as LAO*; using determinization and other reduced models, and real time continual planning techniques. Extensions of MDPs to handle partial observability and multi-agent coordination will be briefly discussed.

Tutorial 14: Localization and Mapping

Date: Friday, June 16, 2017

Time: 10:30am - 12:00pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Nicholas Roy, Massachusetts Institute of Technology

Abstract:

The ability for robots to understand and operate in the world around them has advanced considerably. Examples include various self-driving car systems, the proliferation of drone-enabled services and the growing interest in home and service robots. A crucial component of all autonomous systems is the ability to estimate where they are and what is around them. In particular, the Simultaneous Localization and Mapping, or SLAM, problem has received considerable attention in recent years. I will give a description of the fundamental problem and a survey of recent solution techniques across a variety of platforms and sensing modalities.

Tutorial 15: Risk-bounded Planning and Scheduling

Date: Friday, June 16, 2017

Time: 1:00pm - 2:30pm

Room: D463 (Star), 4th floor of Stata Center (Building 32)

Speaker: Brian Williams, Massachusetts Institute of Technology

Abstract:

A barrier to the adoption of systems that perform online planning and decision-making is the risk that their decisions will be dangerous, coupled with the lack of methods for ensuring that this risk is bounded *a priori*. In this tutorial I focus on risk-bounded motion planning, scheduling and activity planning for problems with unbounded uncertainty. In particular, we explore an emerging

family of solution methods centered on the metaphor of risk allocation. In these methods a global risk bound is viewed as a resource that can be “spent,” in order to decide how much risk to take of violating each individual constraint. Given a risk allocation, the stochastic problem can be reformulated to a deterministic problem that often introduces only a small amount of conservatism. The optimal risk allocation is then one that maximizes expected utility, while satisfying the global risk bound. In this tutorial I explore the solution to convex and non-convex problems using closed form and iterative approaches to risk allocation. Applications include underwater observing systems, transportation and energy management.



Speakers

Andrew Coles



Andrew Coles is a Lecturer in Computer Science at King's College London, where he is a member of the Planning research group. His research is in the area of planning with expressive world models, finding ways to effectively reason with hybrid domains containing continuous resources. He is the principal investigator at King's on the H2020-funded [ERGO project](#), looking at ways of managing temporal constraints to allow on-board planning for autonomous space robotics.

John Fisher



John Fisher is Principal Research Scientist at the MIT Computer Science and Artificial Intelligence Laboratory. His research focuses on information-theoretic approaches to machine learning, computer vision, and signal processing. Application areas include signal-level approaches to multi-modal data fusion, signal and image processing in sensor networks, distributed inference under resource constraints, resource management in sensor networks, and analysis of seismic and radar images. In collaboration with the Surgical Planning Lab at Brigham and Women's Hospital, he is developing nonparametric approaches to image registration and functional imaging. He received a BS and MS in Electrical Engineering at the University of Florida in 1987 and 1989, respectively. He earned a PhD in Electrical and Computer Engineering in 1997.

Joerg Hoffmann



Joerg Hoffmann obtained a PhD from the University of Freiburg, Germany, with a thesis that won the ECCAI Dissertation award 2002 (the award for the best European dissertation in AI). After positions at Max Planck Institute for Computer Science (Saarbruecken, Germany), the University of Innsbruck (Austria), SAP Research (Karlsruhe, Germany), and INRIA (Nancy, France), he is now a Professor of CS at Saarland University, Saarbruecken, Germany. He has published more than 100 scientific papers, has been Program Co-Chair of the AAAI'12 Conference on AI, and has received 4 Best Paper Awards from the International Conference on Automated Planning and Scheduling, as well as the IJCAI-JAIR Best Paper Prize 2005. His core research area is AI automated planning, but he has performed research also in related areas including model checking, semantic web services and business process management, Markov decision processes, natural language generation, and network security testing.

Luke Hunsberger



Luke Hunsberger is a professor of Computer Science at Vassar College, where he has worked since earning his Ph.D. in Computer Science from Harvard University in 2002. His primary teaching duties include courses on declarative models of programming and artificial intelligence. He also served three years as Chair of the CS department at Vassar (2012-2014). His research focuses on the use of temporal networks to represent and reason about time, and formal models of intention in multi-agent systems. Most recently, he has developed algorithms for processing temporal networks in collaboration with Carlo Combi and Roberto Posenato from the University of Verona; and he worked with Alessandro Cimatti, Andrea Micheli, and Marco Roveri from Fondazione Bruno Kessler (FBK) in Trento to demonstrate important relationships between temporal networks and Timed Game Automata (TGAs). In addition, he has collaborated with Charles Ortiz of Nuance Communications on formal representations of intentions in multi-agent systems. Luke has an M.A. in Mathematics from the University of Oregon; and he is a musician with a long-standing love of the music of the Beatles.

Lydia E. Kavraki



Dr. Lydia E. Kavraki is the Noah Harding Professor of Computer Science and Bioengineering at Rice University. She received her B.A. in Computer Science from the University of Crete in Greece and her Ph.D. in Computer Science from Stanford University. Her research contributions are in physical algorithms and their applications in robotics (robot motion planning, hybrid systems, formal methods in robotics, assembly planning, micromanipulation, and flexible object manipulation), as well as in computational structural biology, translational bioinformatics, and biomedical informatics. Dr. Kavraki has authored more than 200 peer-reviewed journal and conference publications and is one of the authors of the robotics textbook titled "Principles of Robot Motion" published by MIT Press. She is the recipient of the 2000 Association for Computing Machinery (ACM) Grace Murray Hopper Award, a Fellow of ACM, IEEE, AAAS, AAAI, and AIMBE.

Philip Kilby



Dr Philip Kilby is a Principal Research Scientist at CSIRO's Data61. His research in discrete optimisation problems - particularly problems in transportation - has focused on providing solutions for real-world problems. After receiving a Ph.D. from The University of Queensland, Philip worked in private industry, at the optimisation consultancy OPCOM. Philip spent 12 years with CSIRO, finishing as leader of the Operations Research Group. He joined the Australian National University as a Fellow in 2002, and moved across to NICTA in 2004. NICTA was merged into Data61 in 2016.

Sven Koenig



Sven Koenig is a professor in computer science at the University of Southern California. Most of his research centers around techniques for decision making (planning and learning) that enable single situated agents (such as robots or decision-support systems) and teams of agents to act intelligently in their environments and exhibit goal-directed behavior in real-time, even if they have only incomplete knowledge of their environment, imperfect abilities to manipulate it, limited or noisy perception or insufficient reasoning speed. Additional information about Sven can be found on his website: idm-lab.org.

Scott Kuindersma



Scott Kuindersma is an Assistant Professor of Engineering and Computer Science at Harvard University and the director of the Harvard Agile Robotics Laboratory. Previously, he was a postdoc in the Robot Locomotion Group at MIT CSAIL and the Control Lead for MIT's DARPA Robotics Challenge team. He received his PhD in Computer Science from the University of Massachusetts Amherst in 2012. His current work is focused on developing algorithms for robust locomotion and manipulation, contact-implicit motion planning, and model-predictive control with applications to legged robots, fixed-wing UAVs, and human assistive devices.

Mark Moll



Dr. Mark Moll is a senior research scientist in the Computer Science Department at Rice University. His research contributions are in applied algorithms for problems in robotics (robot motion planning, integrated task and motion planning, self-reconfigurable robots, tactile sensing, parts orienting), computational structural biology (conformational search), and biomedical informatics (large-scale functional annotation of proteins). He is also leading the development of the Open Motion Planning Library, which is widely used in industry and academic research. He received an M.S. in Computer Science from the University of Twente in the Netherlands and a Ph.D. in Computer Science from Carnegie Mellon University.

Alberto Rodriguez



Alberto Rodriguez is the Walter Henry Gale (1929) Career Development Professor at the Mechanical Engineering Department at MIT. Alberto graduated in Mathematics ('05) and Telecommunication Engineering ('06) from the Universitat Politècnica de Catalunya (UPC) in Barcelona, and earned his PhD in Robotics ('13) from the Robotics Institute at Carnegie Mellon University. He spent a year in the Locomotion group at MIT, and joined the faculty at MIT in 2014, where he leads the Manipulation and Mechanisms Lab (MCube). Alberto is the recipient of the Best Student Paper Awards at conferences RSS 2011 and ICRA 2013 and Best Paper finalist at IROS 2016. His main research interests are in robotic manipulation, mechanical design, and automation.

Nicholas Roy



Nicholas Roy is the Bisplinghoff Professor of Aeronautics & Astronautics at the Massachusetts Institute of Technology, and a member of the Computer Science and Artificial Intelligence Laboratory (CSAIL) at MIT. He received his Ph. D. in Robotics from Carnegie Mellon University in 2003. His research interests include unmanned aerial vehicles, autonomous systems, human-computer interaction, decision-making under uncertainty and machine learning. He spent two years at Google [x] as the founder of Project Wing.

David Wang



David Wang is currently a research associate with the MERS group at MIT, where he received his Ph.D. in 2015 working on the combination of planning and scheduling. Other research interests include temporal consistency checking, execution monitoring, and plan representations. David also co-founded NuVu, an innovation school for middle and high-school age students, and enjoys entrepreneurial pursuits.

Brian Williams



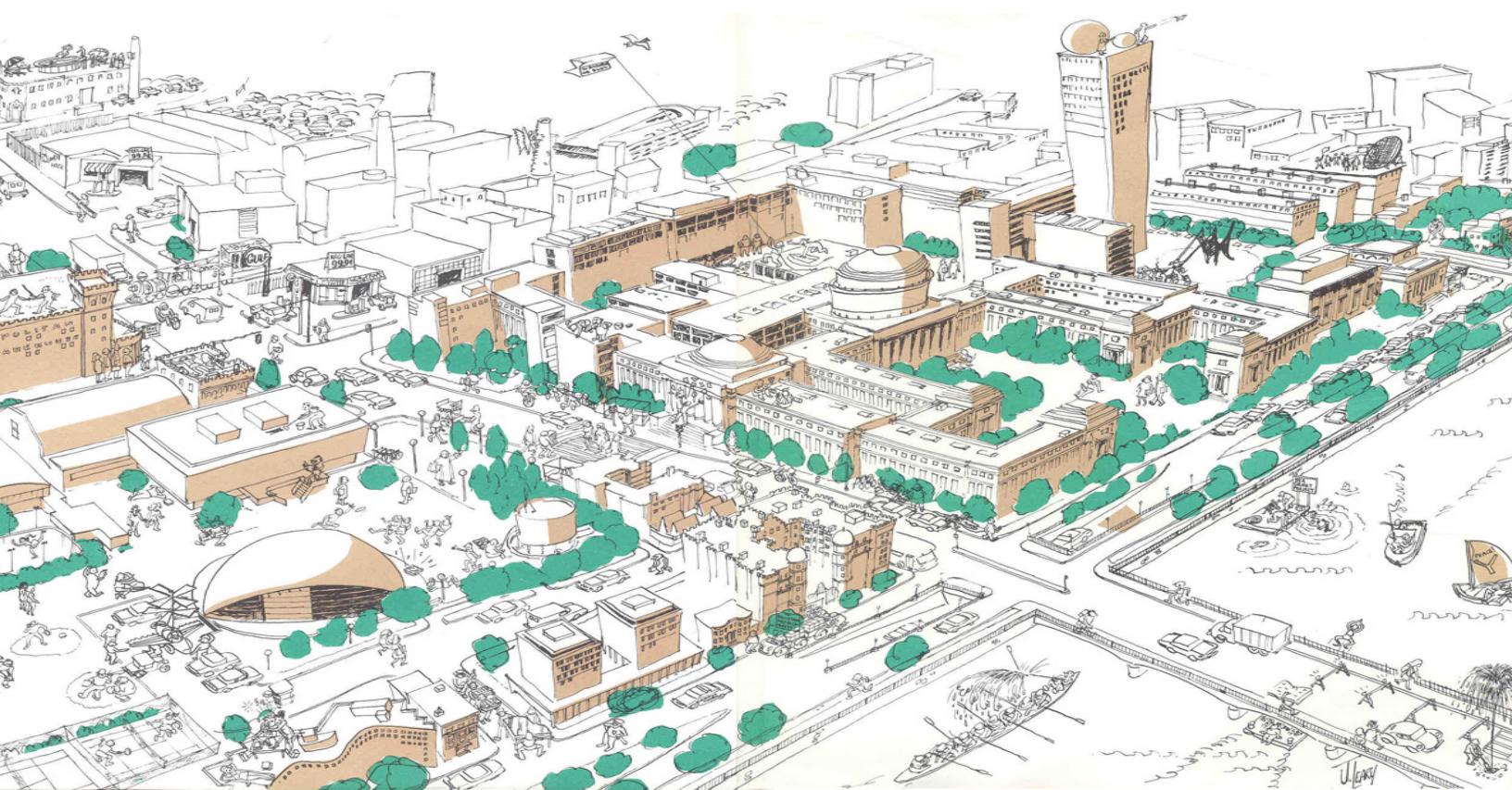
Prof. Williams' research concentrates on model-based autonomy -- the creation of long-lived autonomous systems that are able to explore, command, diagnose and repair themselves using fast, symbolic reasoning algorithms. Current research focuses on model-based programming and cooperative robotics: Model-based programming embeds commonsense within robotic explorers and everyday devices by incorporating model-based deductive capabilities within traditional embedded programming languages. Cooperative robotics extends model-based autonomy to robotic networks of cooperating space, air,

land and under sea vehicles, on Earth and other planets. Prof. Williams received his S.B., S.M and Ph.D. from MIT in Computer Science and Electrical Engineering in 1989. He pioneered multiple fault, model-based diagnosis in the 80's, and co-invented the NASA Remote Agent model-based autonomous control system, flown on the NASA Deep Space One probe. He was a member of the Tom Young Blue Ribbon Team in 2000, assessing future Mars missions in light of past failures, and a member of the Advisory Council of the NASA Jet Propulsion Laboratory. He is the current President of the Executive Council of the International Conference on Automated Planning and Scheduling.

Shlomo Zilberstein



Shlomo Zilberstein is Professor of Computer Science and Associate Dean for Research and Engagement at UMass Amherst. He received his Ph.D. in Computer Science from UC Berkeley. His research focuses on the foundations and applications of automated planning, particularly resource-bounded reasoning methods that allow complex systems to optimize their decisions while coping with uncertainty, missing information, and limited computational resources. Zilberstein is a Fellow of AAAI and a recipient of Best Paper Awards from ECAI, AAMAS, IAT, MSDM, ICAPS, and AAAI. He is a former Editor-in-Chief of JAIR, Associate Editor of AIJ, JAAMAS, and AMAI, and former Conference Chair of AAAI and ICAPS. He served on the Executive Council of AAAI and as President of ICAPS.



Venue and Directions

Venue

MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)

The Stata Center, Building 32 , 32 Vassar Street Cambridge, MA 02139 USA



Directions

The MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) is at the northeastern edge of the MIT campus, on Vassar Street near the intersection with Main Street. The building that houses CSAIL is known as the Stata Center, or MIT building number 32.

By Public Transportation (commonly called "The T"):

Subway: Take the Red Line to the Kendall/MIT Station (cost is \$2.00 with a CharlieTicket and \$1.70 with a CharlieCard. No cost from the airport). When you exit the T, walk Northwest, up Main Street (you will pass the MIT Coop and Legal Seafoods). This is away from the river. When you come to the second intersection (Vassar St.), the Computer Science and Artificial Intelligence Lab will be at the intersection, in the very unique "crumpled" building to your left.

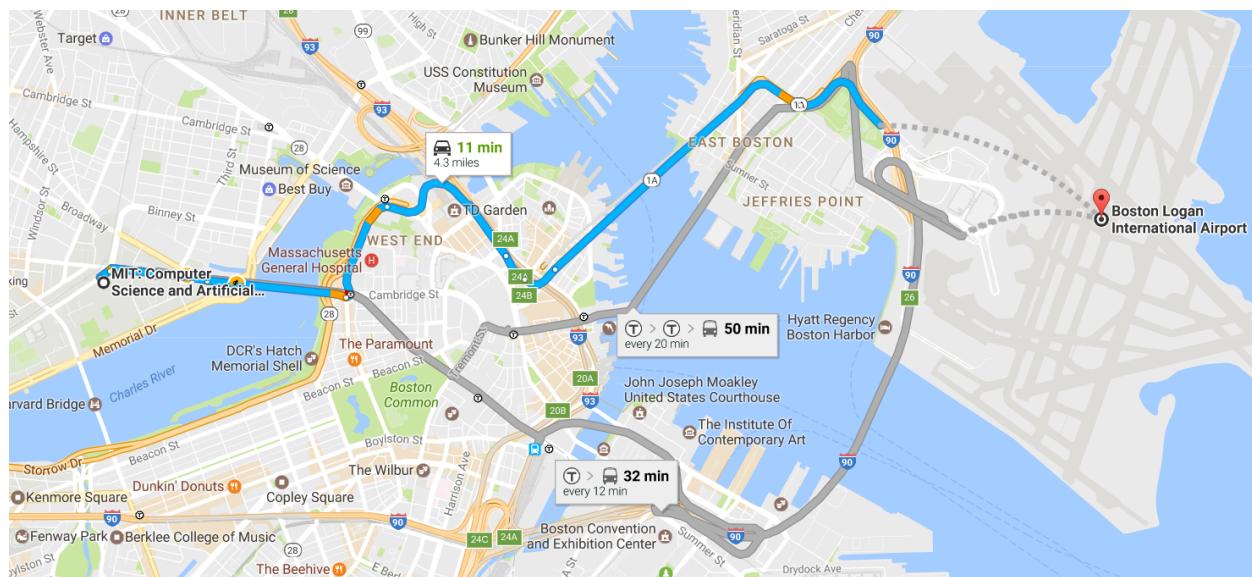
Bus: The #1 ("Dudley" bus) stops at MIT on Massachusetts Avenue. The MIT stop is at a large crosswalk with a stop light. On one side of the street are steps leading up to large Ionic columns and the Small Dome of MIT, on the other side of the street is the Stratton Student Center (Building W20) and Kresge Oval (an open, grass-covered area). To get to CSAIL, walk North on Mass. Ave., away from the river (so that the steps are on your right). Take a right at the first intersection (Vassar St.). Walk until you see the very unique "crumpled" building on your right, at the corner of the next major intersection (Main St.). More detailed public transportation maps and schedules are available from the [MBTA](#).

From Logan International Airport:

Taxi: Taxi fare from the airport is about \$25-\$30. Under normal traffic conditions the taxi ride will take about 25 minutes.

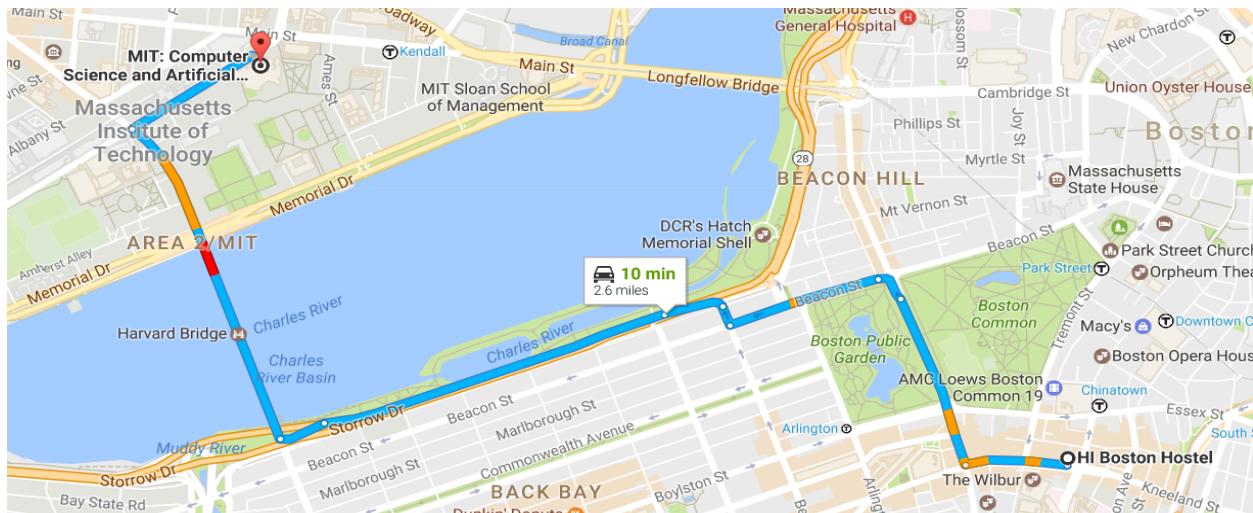
Subway: From the front of any terminal at Logan airport, take the Silver Line bus to South Station. There is no fee. Go downstairs and take the Red Line to Kendall/MIT (take the outbound train toward Alewife), again no fee. Under normal conditions, the ride will take about 30 minutes. From the T stop at Kendall, follow the directions illustrated on the map above.

Car: Be aware that the drive from Logan Airport can be rather nasty, depending on traffic conditions. Take the Sumner Tunnel exit from the airport (not the Ted Williams Tunnel) and follow the signs toward Boston via the Sumner Tunnel. The tunnel toll is \$3. As you exit the tunnel, take the ramp onto the expressway (I-93 North). Take the second exit, marked 'Storrow Drive West'. Immediately take the right fork of the road to a stoplight. Turn left, then immediately turn right and drive over the Charles River on the Longfellow Bridge. At the second traffic light after the river, take a left onto Ames Street and then a right onto Main Street. CSAIL will be on your left in the very unique "crumpled" building at the corner of Main and Vassar Street. We recommend a mobile navigation, to help you recover from frequent errors, and as an introduction to the summer school's focus on continuous planning and execution.

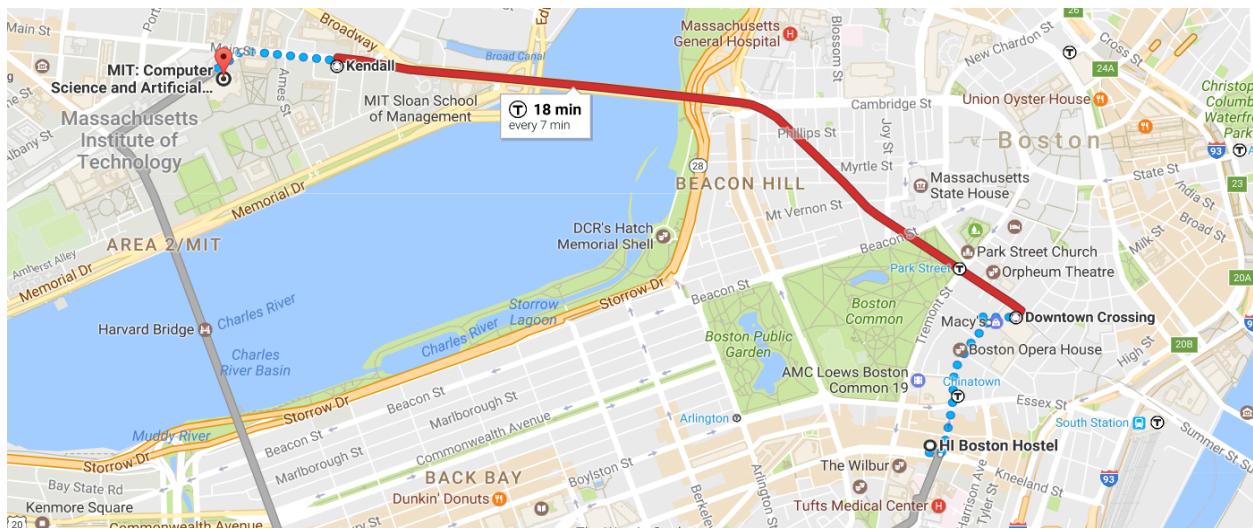


From Hostelling International Boston Hostel:

Taxi: Taxi fare from HI Boston Hostel, is \$12 - \$20. Under normal traffic conditions the taxi ride will take about 10 minutes.



Subway: There is 0.3 mile walk to Downtown Crossing Station. From Downtown Crossing, take the Red Line to Kendall/MIT (take the outbound train toward Alewife). Under normal conditions, the ride will take about 18 minutes.



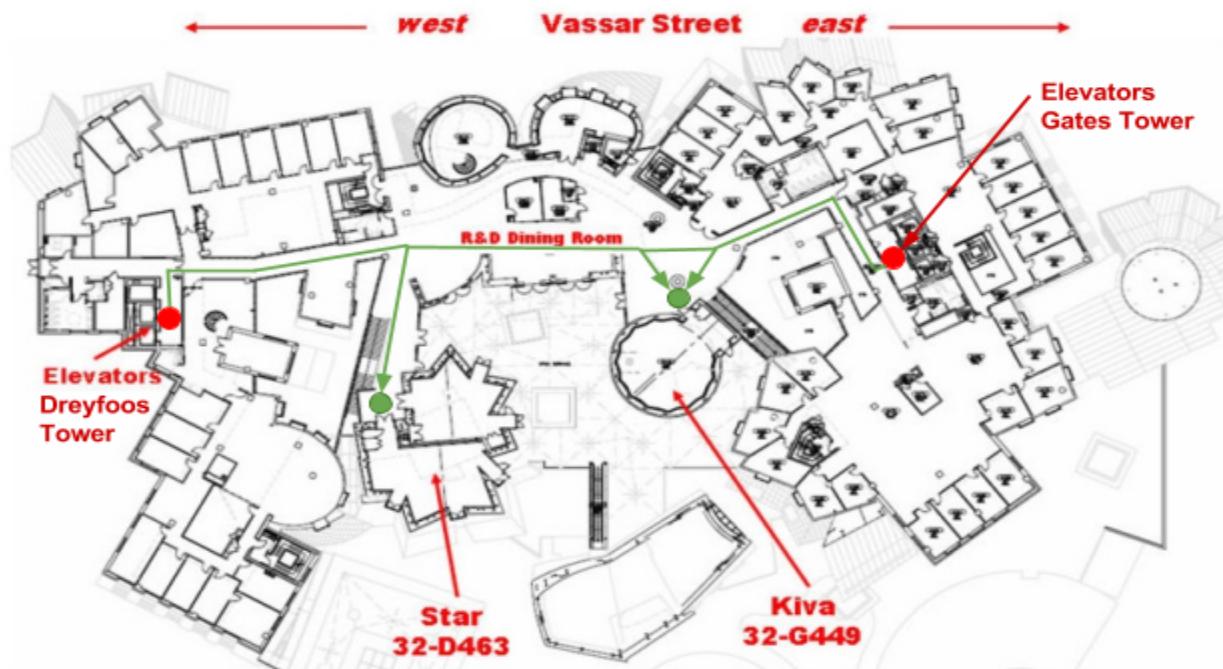
Seminar Rooms

Room D463 (Star) and Room G449 (Kiva) - 4th Floor

The Stata Center, 4th Floor, Building 32, 32 Vassar Street Cambridge, MA 02139 USA

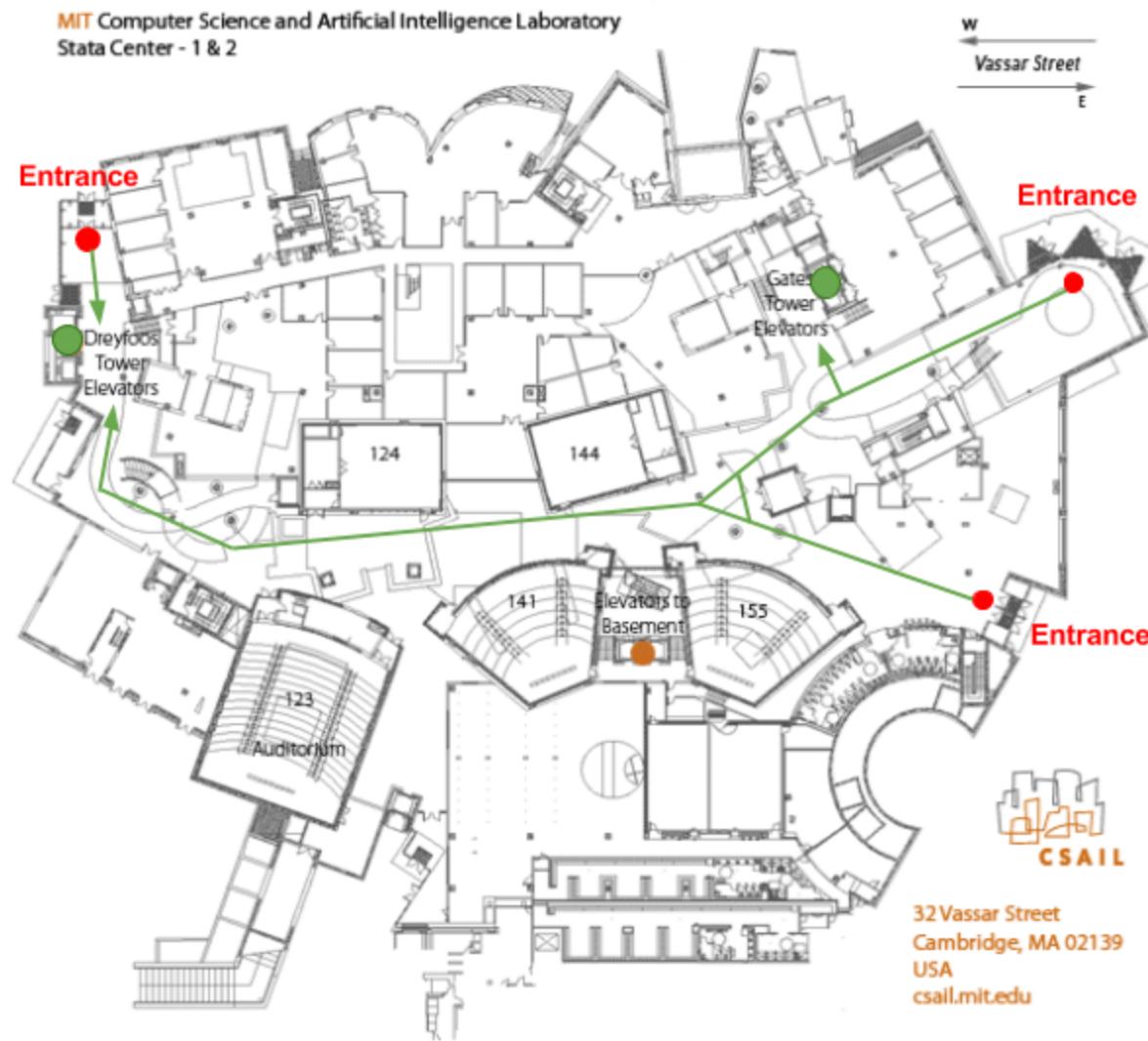


The summer school talks will be given in two seminar rooms, D463 (Star) and G449 (Kiva), on the 4th floor of the MIT Stata Center, Building 32. Please access the 4th floor by using the *Gates Tower elevators* on the east side of the building, or by using the *Dreyfoos Tower elevators* on the west side of the building.



Map of the State Center 4th floor with directions to access rooms Star and Kiva.

The Gates Tower elevators and Dreyfoos Tower elevators are both accessible from the 1st floor. The map below shows how to find them from the main entrances of the MIT Stata Center, where CSAIL resides.

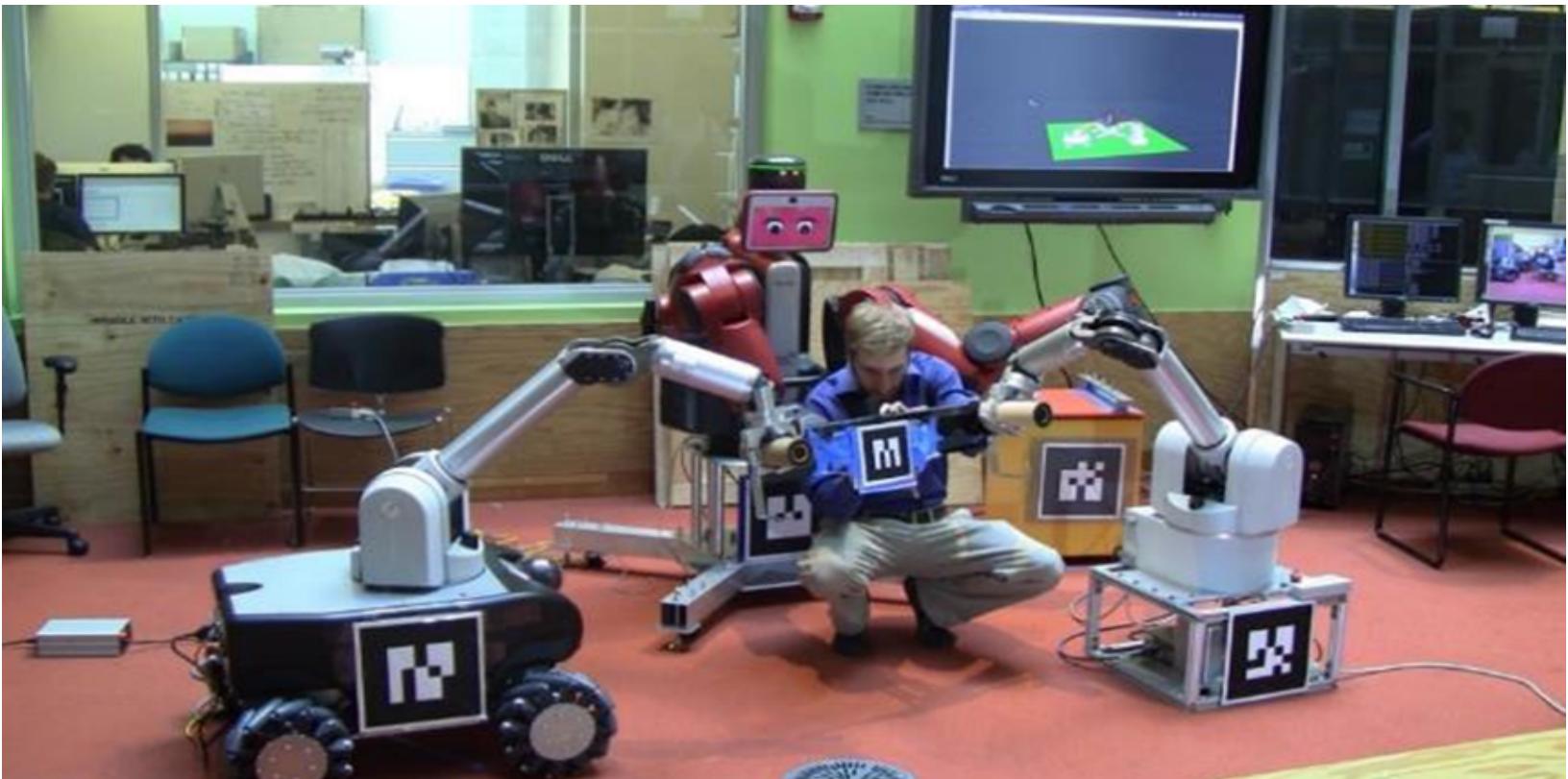


Map of the State Center 1 and 2 floors with directions to access Dreyfoos Tower Elevators to access rooms Star and Kiva on the 4th floor.

Laboratory

Model-based Embedded and Robotic Systems Group (MERS)

Room 226, The Stata Center, 2nd Floor, Building 32
32 Vassar Street, Cambridge, MA 02139 USA



The map below shows how to get from the Stata Center building main entrances, on the 1st floor, to the MERS lab, where the supervised lab sessions will take place. While the lab is on the second floor, this is only a very short set of stairs up from the first floor.



Map of the 1st and 2nd floors of the Stata Center. MERS is on the 2nd floor. No need to use elevators to access the 2nd floor.

Hostel

Hostelling International Boston

19 Stuart Street, Boston, MA 02116 USA



HI Boston Hostel

19 Stuart Street, Boston, Massachusetts 02116

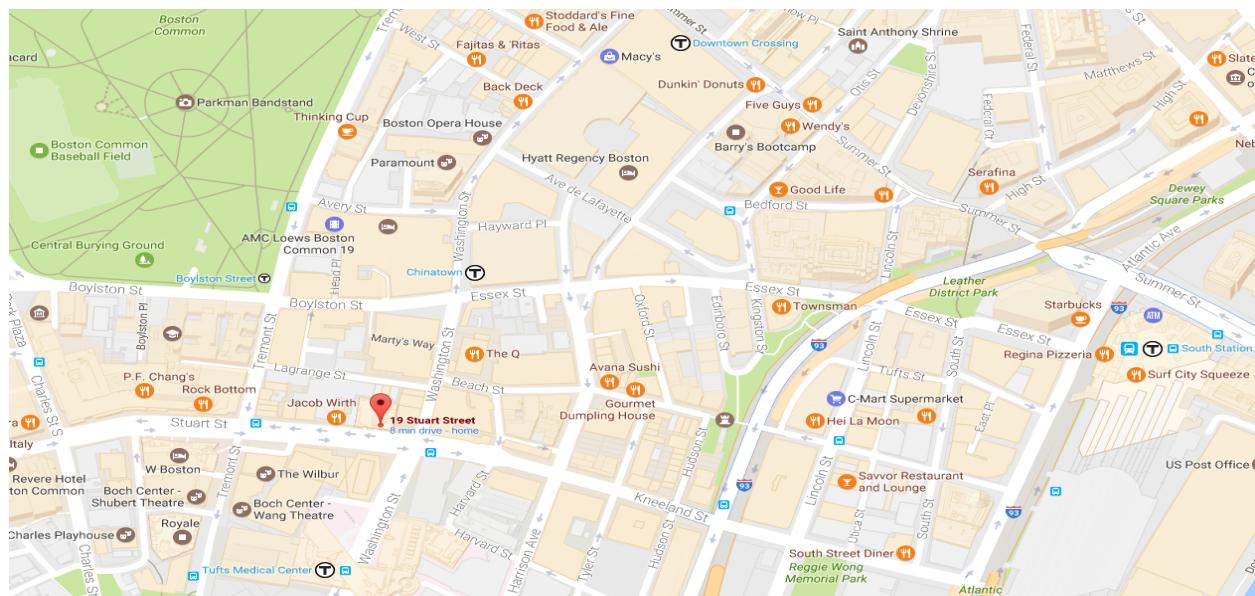
Call 1 (617) 536-9455 | reserve.boston@hiusa.org

Directions

HI Boston is steps from Boston Common and the Freedom trail, a metro ride to MIT, and a short walk from the famed Boston Public Library, Fenway Park, and Faneuil Hall.

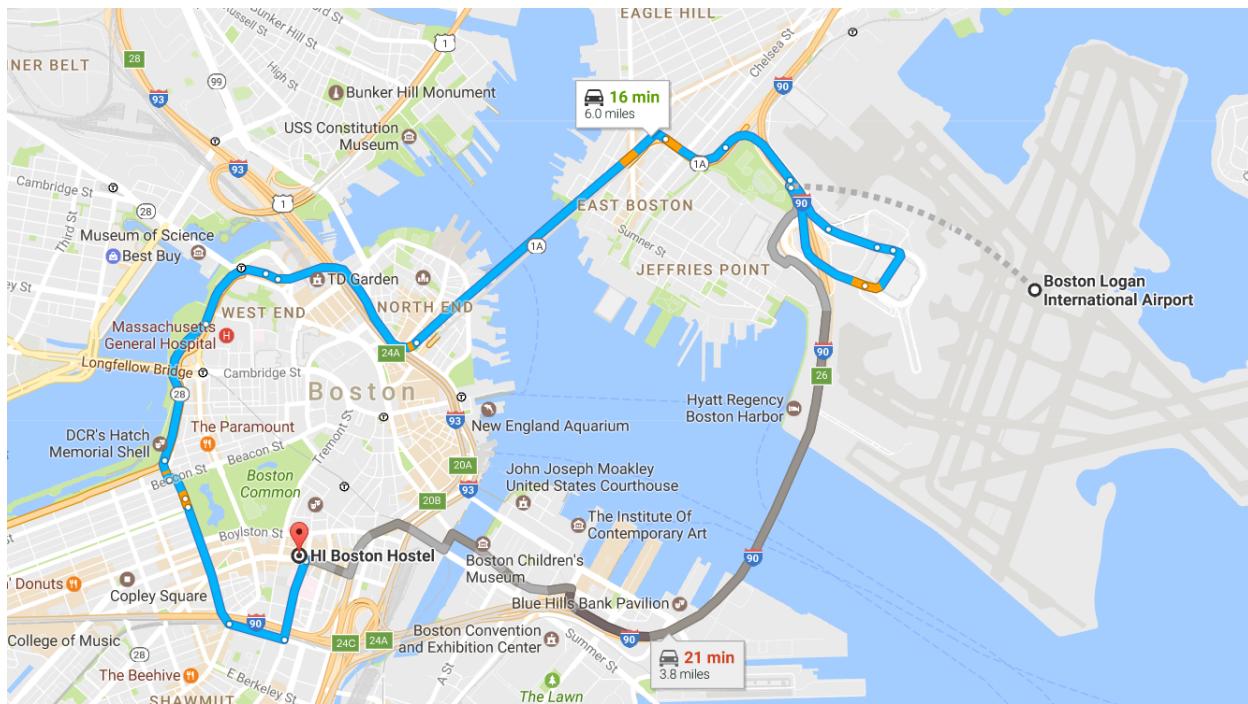
By Public Transportation (commonly called "The T"):

Subway: The hostel is close to several stations: 0.1 mile from Chinatown stop (Orange Line); 0.1 mile from Tufts Medical Center stop (Orange and Silver Lines); 0.2 mile from Boylston stop (Green Line); 0.4 mile from Downtown Crossing stop (Red and Orange Lines); and 0.5 mile from South Station (Red and Silver Lines; Greyhound; PeterPan; Amtrak).

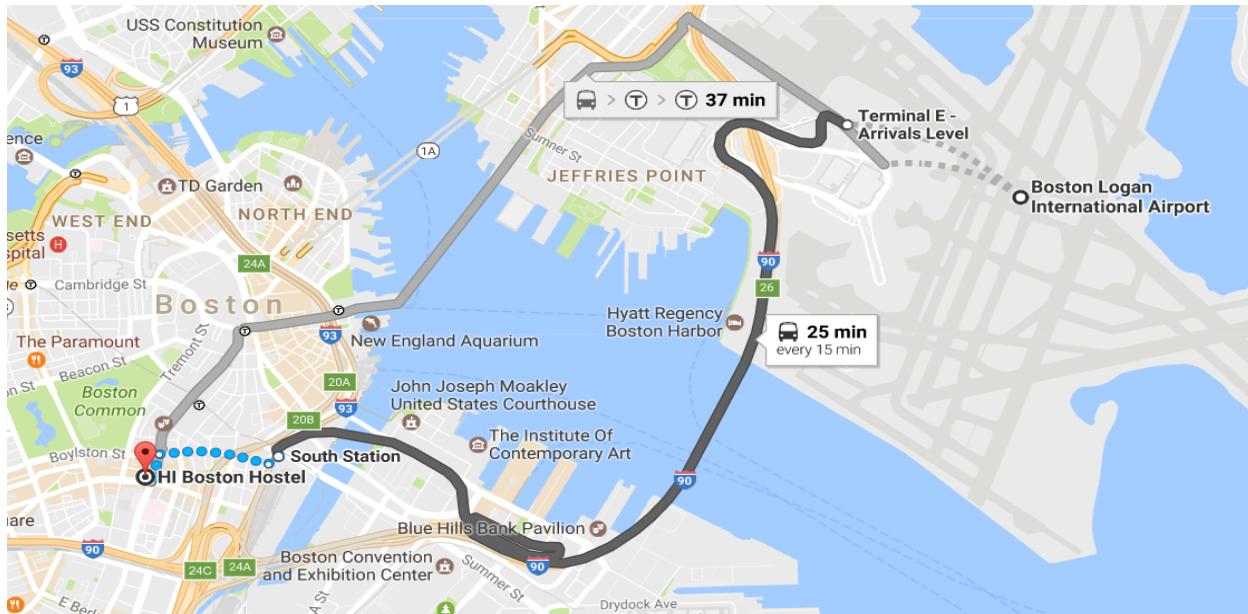


From Logan International Airport:

Taxi: Taxi fare from the airport is about \$25-\$30. Under normal traffic conditions the taxi ride will take about 20 minutes.



Subway: From the front of any terminal at Logan airport, take the Silver Line to South Station. Exit South Station for a 10 minute walk. Head southwest on Atlantic Avenue towards Kneeland Street. Turn right on Kneeland Street - Kneeland Street turns into Stuart Street. Hostelling International Boston is on the right.



Social Dinner



Tuesday, June 13, 7:00pm

Summer Shack

149 Alewife Brook Parkway
Cambridge, MA, 02140
Tel: 617-520-9500

Directions by Public Transport:

From MIT Stata Center, go to Kendall station, and take the outbound train to Alewife station. Get off at Alewife, and exit the station. You are just 2 minutes from Summer Shack. Walk south along Steel Place street, crossing Cambridge Park Drive. At the end of that street you will see Summer Shack, located in the building on your left.

