2ND SUMMER SCHOOL ON COGNITIVE ROBOTICS

JULY 23 - 27
MIT, Stata Center
Cambridge, MA USA

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

NSF · Artificial Intelligence · BOEING · JOANNEUM RESEARCH ROBOTICS · MIT AEROASTRO · CSAIL · MIT

Contents

Organizing Committee

Professor Brian Williams
MERS Lab PI
bwilliams@mit.edu

Ashkan Jasour
Postdoc
jasour@mit.edu
(814) 441-7422

Marlyse Reeves
PhD Student
mreeves@mit.edu
(818)748-7371

Michael Lewy
Administrator
mlewy@mit.edu
(617)715-5836

Local Organizers

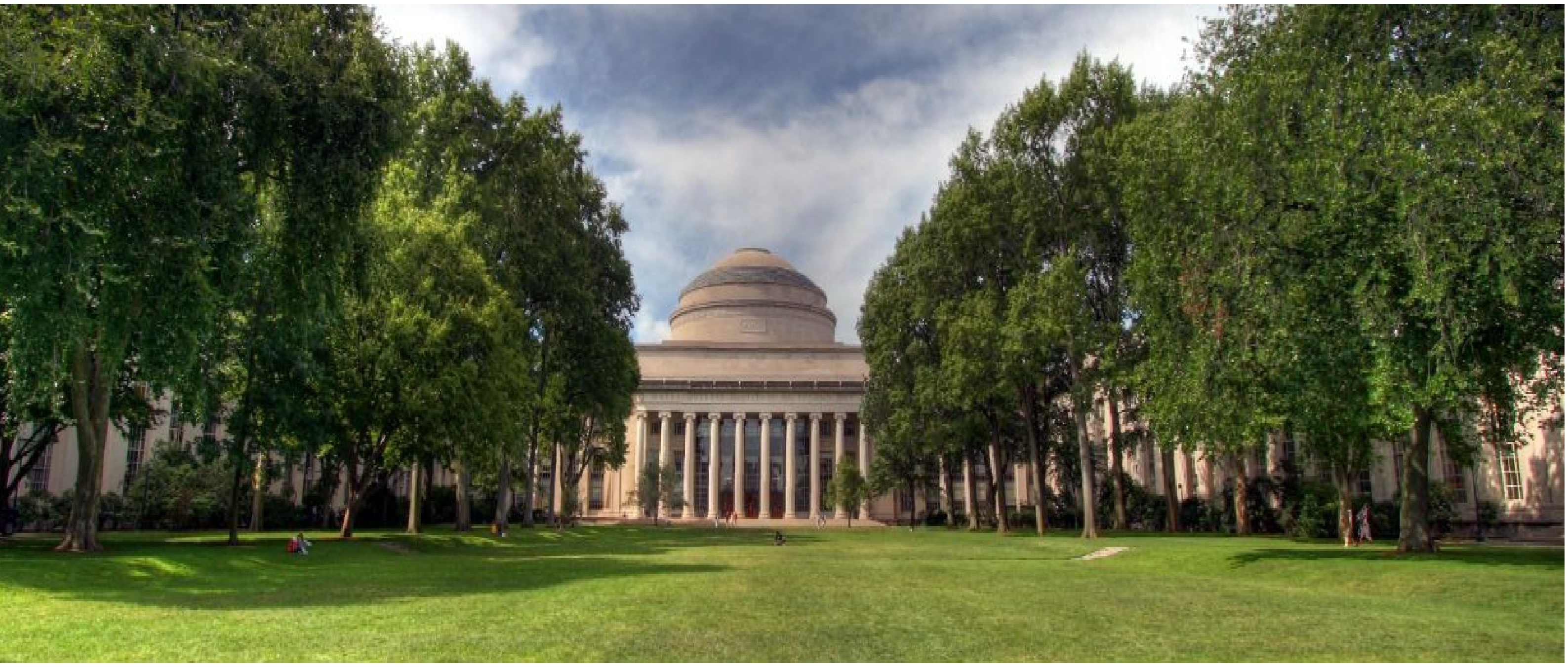
The Summer School on Cognitive Robotics is planned and run by the Model-based Embedded and Robotic Systems (MERS) group at MIT.

Additional Contact Information

For general questions or concerns, please email mers.cognitive.robotics@gmail.com.

If you ever get locked out of the building and are unable to contact any peers or summer school staff, please call MIT Facilities at 617-253-4948.

For emergencies, call the MIT Police at (617) 253-1212.



General Information

Program Registration

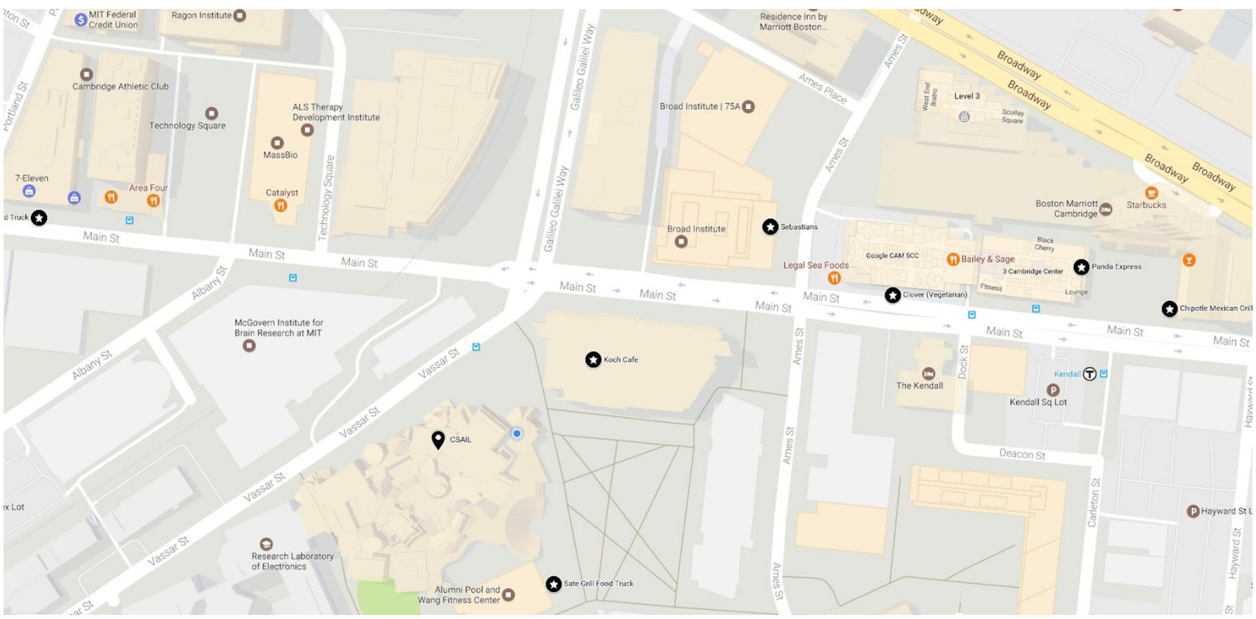
Program registration will take place between 8:00 am - 8:45 am on Monday, July 23, 2018. The registration desk will be located in the Stata center, MIT Building 32 on the 4th floor outside of the Star Conference (Room D463). There will be signage posted around the building to help direct you to the program registration. Please arrive on time as the program will start promptly at 8:45 am in the Star Conference Room.

Please see the Venue and Directions section for maps and more detailed directions.

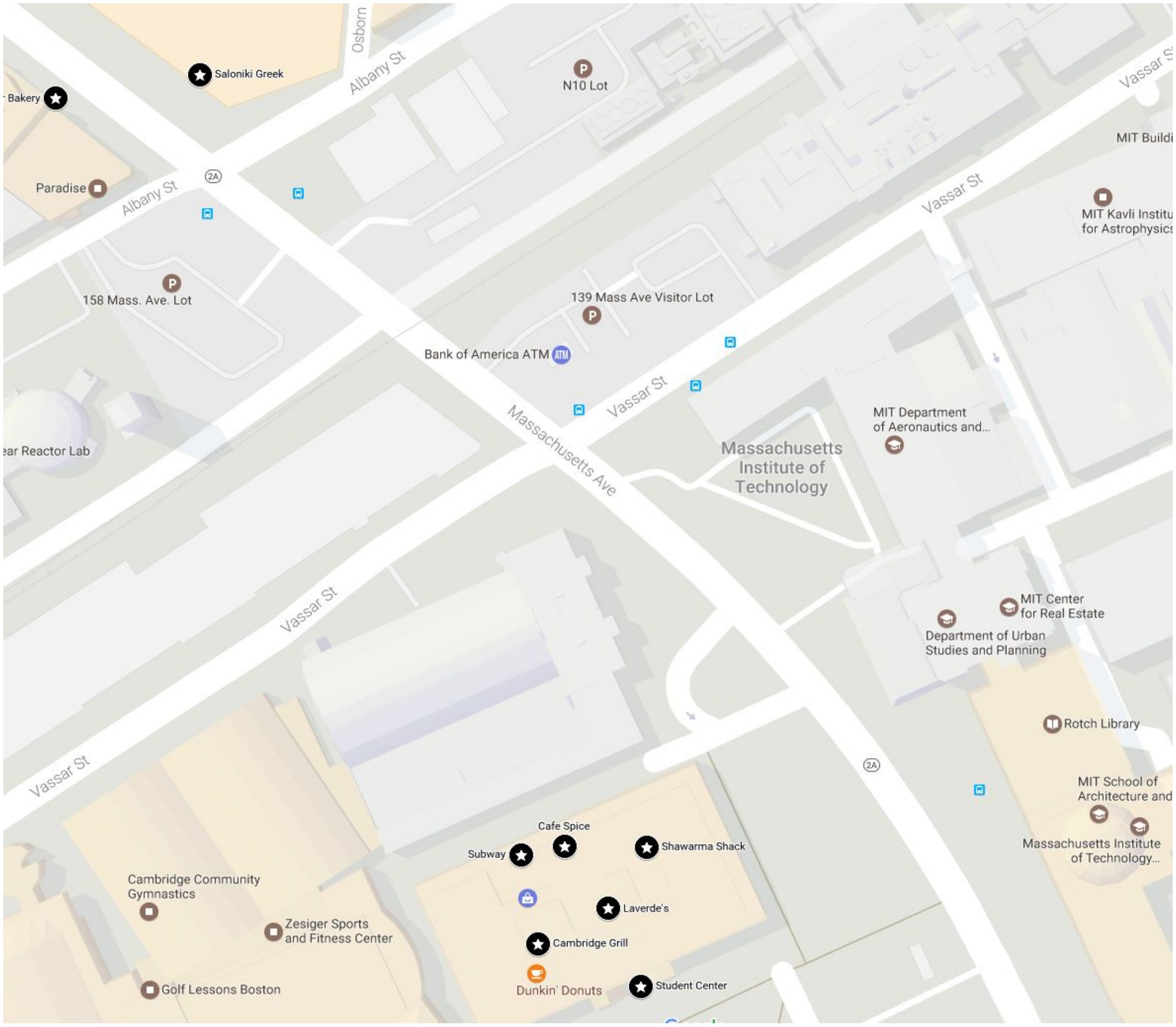
Lunch Break

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), Al's Sandwiches, Koch Cafe, Sebastians, Sata Grill Food Truck, Chinese Food Truck, Chipotle Mexican Grill, Legal Fish Bowl, and more!



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


Sunday 2
Thursday 6
Monday 10
Friday
Friday 14
Tuesday 11
17
18
Saturday 15
Saturday 22
Wednesday 19

Schedule

Day 1 - July 23. Theme: Robust Execution: Estimation, Monitoring and Scheduling	
Location: Star Conference Room (Stata Center, Building 32 Room D463)	
8:00am - 8:45am	Registration
8:45 am - 9:00 am	Program Welcome *Speakers: Marlyse Reeves and Ashkan Jasour, MIT*
9:00am - 10:00am	Introduction: Architectures and Languages for Cognitive Robotics *Speaker: Brian Williams, Massachusetts Institute of Technology*
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 1: *Spatial Perception for Robotics* *Speaker: Luca Carlone, Massachusetts Institute of Technology*
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 2: Self-Monitoring, Self-Diagnosing Systems *Speaker: Brian Williams, Massachusetts Institute of Technology*
2:30pm - 3:00pm	Coffee Break
3:00pm - 4:30pm	Tutorial 3: Dynamic Scheduling and Uncertainty *Speaker: Robert Morris, NASA Ames Research Center*
4:30pm - 7:00pm	Supervised lab - Robust Execution (RMPL)
7:00pm - 8:00pm	Open lab hours
Day 2 - July 24. Theme: Motion Planning	
Location: Star Conference Room (Stata Center, Building 32 Room D463)	
8:30am - 10:00am	Tutorial 4: Sampling-based Motion Planning *Speakers: David Hsu, National University of Singapore*
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 5: Single-Robot and Multi-Robot Path Planning with Quality Guarantees *Speaker: Sven Koenig, University of Southern California*
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 6: Trajectory Optimization for Underactuated Robots *Speaker: Scott Kuindersma, Harvard University*
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab - Trajectory Planning
6:00pm - 7:00pm	Open lab hours
7:00pm	Social Dinner - Summer Shack

Day 3 - July 25. Theme: Activity Planning (AI)	
Location: Star Conference Room (Stata Center, Building 32 Room D463)	
8:30am - 10:00am	Tutorial 7: Classical Activity Planning *Speaker: Joerg Hoffmann, Saarland University*
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 8: Hybrid Activity and Motion Planning *Speaker: Enrique Fernandez and Brian Williams, MIT*
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 9: Planning of Concurrent Timelines *Speaker: David Wang, NuVu*
2:30pm - 4:00pm	Tutorial 10: Planning and Verification *Speaker: Daniele Magazzeni, King's College London*
4:00pm - 7:00pm	Supervised lab - Activity Planning
7:00pm - 8:00pm	Open lab hours
Day 4 - July 26. Theme: Perception and Manipulation	
Location: Kiva Conference Room (Stata Center, Building 32 Room G449)	
8:30am - 10:00am	Tutorial 11: Visual Perception for Dynamic Environments *Speaker: Oscar Pizzaro, Australian Centre for Field Robotics*
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 12: Fundamentals of Robotic Manipulation and Grasping *Speaker: Alberto Rodriguez, Massachusetts Institute of Technology*
12:00pm - 1:00pm	Lunch
1:00pm - 2:30pm	Tutorial 13: Multi-vehicle Routing with Time Windows *Speaker: Philip Kilby, CSIRO Data61 / Australian National University*
2:30pm - 3:00pm	Coffee Break
3:00pm - 6:00pm	Supervised lab - Manipulation
6:00pm - 7:00pm	Open lab hours
Day 5 - July 27. Theme: Planning with Uncertainty and Risk	
Location: Star Conference Room (Stata Center, Building 32 Room D463)	
8:30am - 10:00am	Tutorial 14: Probabilistic Planning *Speaker: Shlomo Zilberstein, University of Massachusetts Amherst*
10:00am - 10:30am	Coffee Break
10:30am - 12:00pm	Tutorial 15: Risk-bounded Motion Planning *Speaker: Ashkan Jasour, Massachusetts Institute of Technology*
12:00pm - 1:00pm	Lunch
1:00pm	Grand Challenge

Tutorials and Talks

Introduction 1: Architectures for Autonomy

Date: Monday, July 23, 2018
Time: 9:00am - 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 1: Spatial Perception for Robotics

Date: Monday, July 23, 2018
Time: 10:30am - 12:00pm
Room: D463 (Star), 4th floor of Stata Center (Building 32)
Speaker : Luca Carlone, Massachusetts Institute of Technology
Abstract:

Modern applications of robotics, including self-driving cars, humanoids and autonomous drones, require the robot to sense and understand the external environment (obstacles, location of objects or actors of interest, …) to support effective and high-level decision making. This tutorial covers fundamental algorithms and state-of-the-art implementations for spatial perception, including Simultaneous Localization and Mapping (SLAM) and visual-inertial navigation (VIN). I will provide an overview of the fundamental algorithms and give a broad perspective on the state of the art and the open problems in spatial perception for autonomous robots.

Tutorial 2: Self-Monitoring, Self-Diagnosing Systems

Date: Monday, July 23, 2018
Time: 1:00pm - 2:30pm
Room: D463 (Star), 4th floor of Stata Center (Building 32)
Speaker: Brian Williams, Massachusetts Institute of Technology
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 3: Dynamic Scheduling and Uncertainty

Date: Monday, July 23, 2018

3:00pm - 4:30pm

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

Speaker: Robert Morris, NASA Ames Research Center

Abstract:

Often, autonomous agents that operate in real-world environments must be able to schedule and execute actions to accomplish mission goals while being robust to uncertainty and disturbances that arise during operations. This tutorial will focus on classes of models and algorithms that have been used to enable effective, robust strategies for dynamically dispatching plans in real time. The tutorial will begin with a survey of past and current research in modeling uncertainty in planning and scheduling, as well as research in different classes of approaches to dynamic scheduling. We then focus on a general class of approaches based on executing temporal plans using graphical models of events and their temporal ordering. These approaches allow for ensuring temporal flexibility in scheduling, as well as for developing strategies for executing partially controllable plans.

Tutorial 4: Sampling-based Motion Planning

Date: Tuesday, July 24, 2018

Time: 8:30am - 10:00am

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

Speakers: David Hsu, National University of Singapore

Abstract:

Motion planning is a central question of robotics. The objective is to find the optimal or near-optimal motion for the robot to move from an initial state to a desired goal state. While many instances of motion planning are computationally intractable in the worst case, probabilistic sampling algorithms have made motion planning practical for robotics. This tutorial will cover the models and sampling algorithms to address the main challenges of motion planning: geometry, dynamics, and uncertainty (if time allows) and demonstrate the power of probabilistic sampling in tackling these challenges.

Tutorial 5: Single-Robot and Multi-Robot Path Planning

Date: Tuesday, July 24, 2018
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 in addition to techniques for determining good heuristic values: 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 path finding (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, July 23, 2018
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 Activity Planning

Date: Wednesday, July 25, 2018
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 being 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, July 25, 2018
Time: 10:30am - 12:00pm
Room: D463 (Star), 4th floor of Stata Center (Building 32)
Speaker: Brian Williams, MIT

Abstract: *Coming Soon*

Tutorial 9: Planning Concurrent Timelines

Date: Wednesday, July 25
Time: 1:00pm - 2:30pm
Room: G449 (Kiva), 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: Planning and Verification

Date: Wednesday, July 25
Time: 2:30pm - 4:00pm
Room: G449 (Kiva), 4th floor of Stata Center (Building 32)
Speaker: Daniele Magazzeni, King's College London
Abstract:

Despite the growing application of AI in autonomous systems, serious concerns remain about the safety and trustworthiness of current AI technologies. We consider a system to be safe when we can provide strong guarantees about the correctness of its behaviour; we say a system is trusted if the average user has confidence in the system and its decision making. AI Planning is very well placed to be able to address the challenges of safety and trustworthiness, also thanks to the synergy between planning and model checking. This tutorial will focus on how the model-based reasoning used in AI planning can be leveraged to provide safety and explanations in order to build trust.

Tutorial 11: Visual Perception for Dynamic Environments

Date: Thursday, July 26
Time: 8:30am - 10:00am
Room: G449 (Patil/Kiva), 4th floor of Stata Center (Building 32)
Speaker: Oscar Pizarro, University of Sydney's Australian Centre for Field Robotics
Abstract:

This lecture provides and overview of two key uses of visual perception in enabling effective robotics in the real-world: 1) estimating scene geometry and robot motion, and 2) scene understanding. We present some motivating applications, discuss fundamental challenges, cover major approaches to thinking and solving problems in this area and touch on successful implementations and key references.

Tutorial 12: Fundamentals of Robotic Manipulation and Grasping

Date: Thursday, July 26
Time: 10:30am - 12:00pm
Room: G449 (Patil/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: Multi-Vehicle Routing with Time Windows

Date: Thursday, July 26

Time: 1:00pm - 2:30pm

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

Speaker: Phil Kilby, 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 14: Probabilistic Planning

Date: Friday, Friday, July 27

Time: 8:30am - 10:00am

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

Speaker: Shlomo Zilberstein, UMass 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 15: Risk-bounded Motion Planning

Date: Friday, Friday, July 27

Time: 10:30am - 12:00pm

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

Speaker: Ashkan Jasour, Massachusetts Institute of Technology

Abstract:

Probabilistic control and analysis of robotic systems play a key role in generating safe motion plans in the presence of uncertainties. In this tutorial, I focus on risk-bounded motion planning for uncertain robotic systems where we look for control inputs and trajectories to bound the probability of violation of safety constraints. This problem is hard and challenging because of two reasons. First, it requires computation of the probability distribution of states of robotic systems over time. Second, it requires evaluation of multivariate integrals over safety constraints to calculate the risk. We explore a family of methods to solve risk bounded motion planning problems in the presence of different probabilistic uncertainties. Applications include control and obstacle avoidance for self-driving vehicles, quadcopters, mobile, and manipulator robots in the presence of uncertainties.

Speakers

Luca Carlone

Luca Carlone is the Charles Stark Draper Assistant Professor in the MIT Department of Aeronautics and Astronautics, and a Principal Investigator in the MIT Laboratory for Information & Decision Systems (LIDS). Prof. Carlone received his PhD from the Polytechnic University of Turin in 2012. He joined LIDS as a postdoctoral associate (2015) and later as a Research Scientist (2016), after spending two years as a postdoctoral fellow at the Georgia Institute of Technology (2013-2015). His research interests include nonlinear estimation, numerical and distributed optimization, and probabilistic inference, applied to sensing, perception, and decision-making in single and multi-robot systems. His work includes seminal results on certifiably-correct algorithms for localization and mapping, as well as practical approaches for visual-inertial navigation and distributed mapping. Prof. Carlone published more than 70 papers on international journals and conferences, including a Transactions on Robotics King-Sun Fu Memorial Best Paper Award, a best paper award finalist at RSS 2015, and a best paper award winner at WAFR 2016.

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.

David Hsu

David Hsu is a professor of computer science at the National University of Singapore (NUS) and a member of NUS Graduate School for Integrative Sciences & Engineering. He received PhD in computer science from Stanford University. At NUS, he co-founded NUS Advanced Robotics Center and has since been serving as the Deputy Director. His research spans robotics, AI, and computational structural biology. In recent years, he has been working on robot planning and learning under uncertainty for human-centered robots. He, together with colleagues and students, won the Humanitarian Robotics and Automation Technology Challenge Award at International Conference on Robotics & Automation (ICRA) 2015, the RoboCup Best Paper Award at International Conference on Intelligent Robots & Systems (IROS) 2015, and the Best Systems Paper Award at Robotics: Science & Systems (RSS), 2017. He is an IEEE Fellow.

Ashkan Jasour

Ashkan Jasour is a postdoctoral associate with the MERS group at MIT's Computer Science and Artificial Intelligence Laboratory. In 2016 he received his Ph.D. in electrical engineering and Ph.D. minor in mathematics from Pennsylvania State University. His Ph.D. research focuses on convex relaxations of chance constrained problems in systems and control. His research interests include optimization, control and analysis of dynamical systems, robotics, artificial intelligence, and data processing.

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. The tools Philip brings to bare include methods from Operations Research and Artificial Intelligence, such as (integer) linear programming, constraint programming, and metaheuristic search. He has worked in private industry as a consultant mathematician, at the Australian National University, and now at the Australian government's largest scientific research organisation.

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.

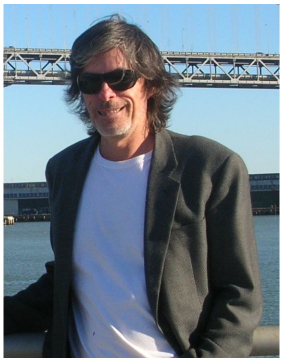
Scott Kuindersma

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.

Daniele Magazzeni

Daniele Magazzeni is Senior Lecturer in AI at King's College London, where he leads the Trusted Autonomous Systems Hub. His research is in AI planning, with a special focus on planning for robotics and autonomous systems, explainable AI and human-autonomy teaming. He is co-chair of the first Workshop on Explainable Planning at ICAPS-18, and co-chair of the second Workshop on Explainable AI at IJCAI-18. He is the current President-Elect of the Executive Council of the International Conference on Automated Planning and Scheduling.

Robert Morris



Robert Morris is a senior researcher in the Exploration Technology Directorate, Intelligent Systems Division at NASA Ames Research Center. His major research focus has been on designing automated planning and scheduling systems for NASA's exploration systems and mission operations. Dr. Morris has published numerous articles on constraint-based approaches to planning and scheduling, and has co-authored a book on methods for temporal reasoning in AI planning and scheduling systems. More recently his focus has been on designing architectures for autonomous aeronautical systems.

Oscar Pizarro

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.

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 Politecnica 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 in the Mechanical Engineering Department 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. He has lead Team MIT-Princeton in the Amazon Robotics Challenge between 2015 and 2017, and is recipient of the Amazon Research Award. His main research interests are in autonomous robotic manipulation, robot dexterity and end-effector design.

David Wang

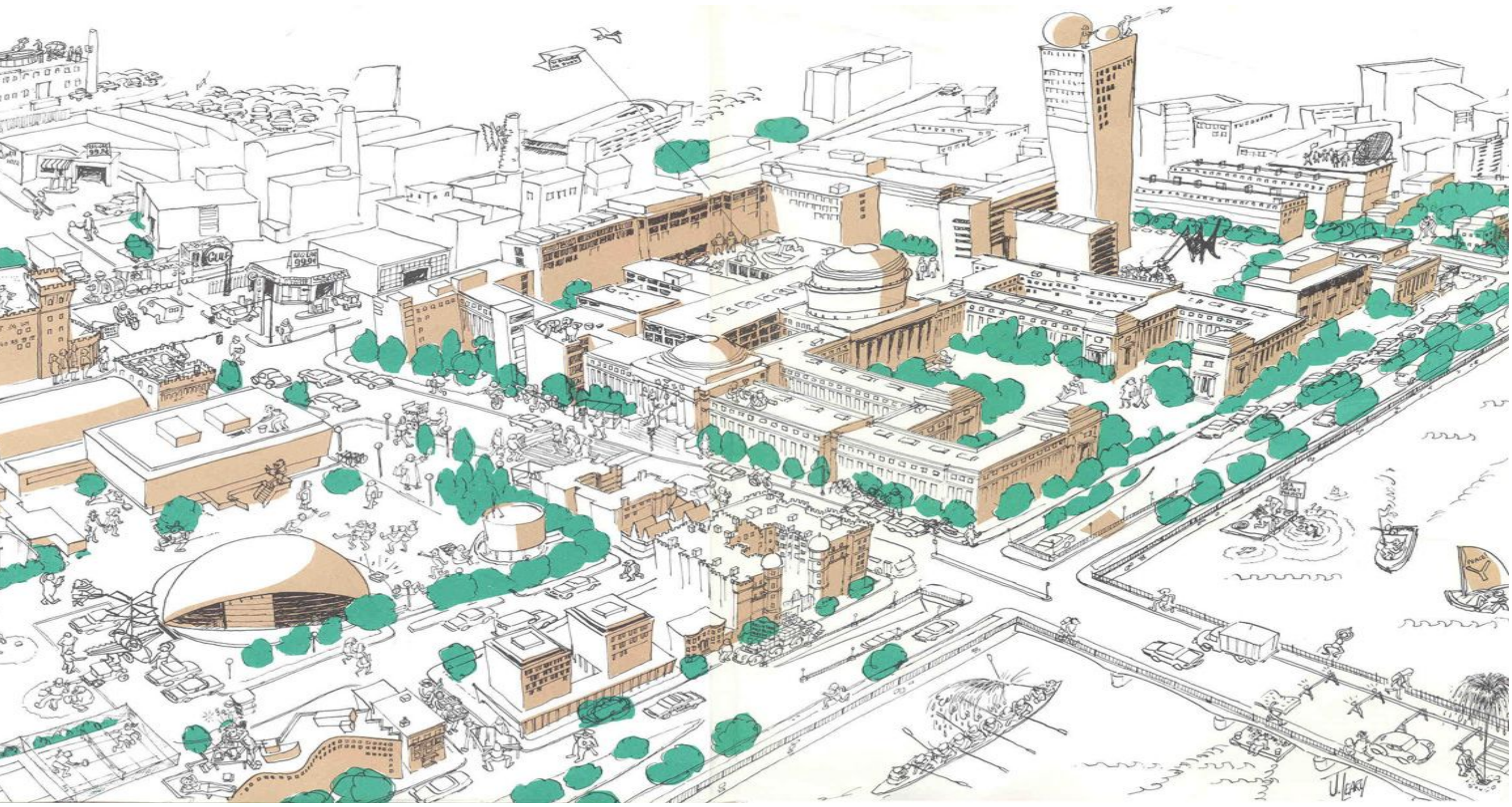
David Wang is currently a research associate with the MERS group at MIT, where he received his Ph.D. in 2015 working on the combination of planning and scheduling. Other research interests include temporal consistency checking, execution monitoring, and plan representations. David also co-founded NuVu, 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)

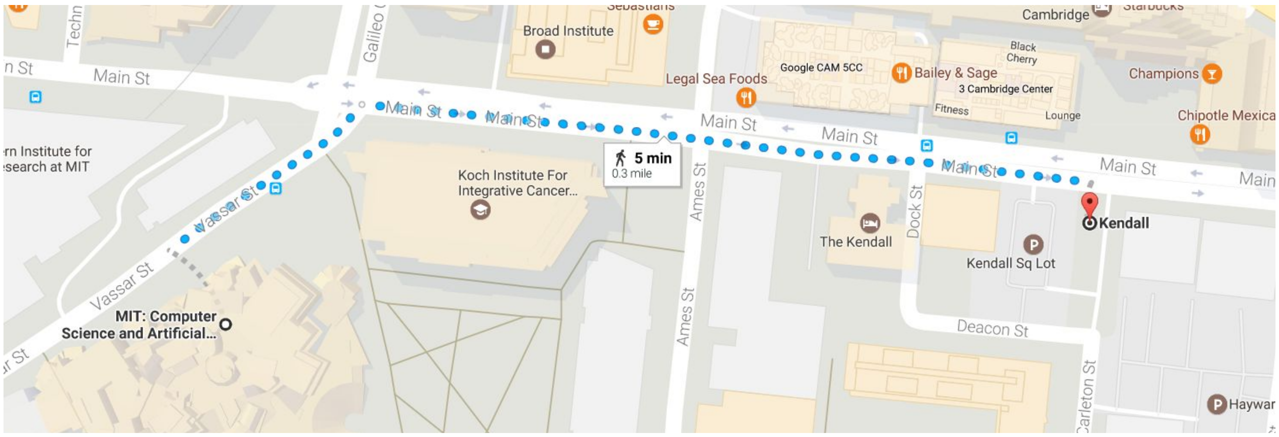
The Stata Center, Building 32 , 32 Vassar Street Cambridge, MA 02139 USA

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 $2.50 with a CharlieTicket. 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.



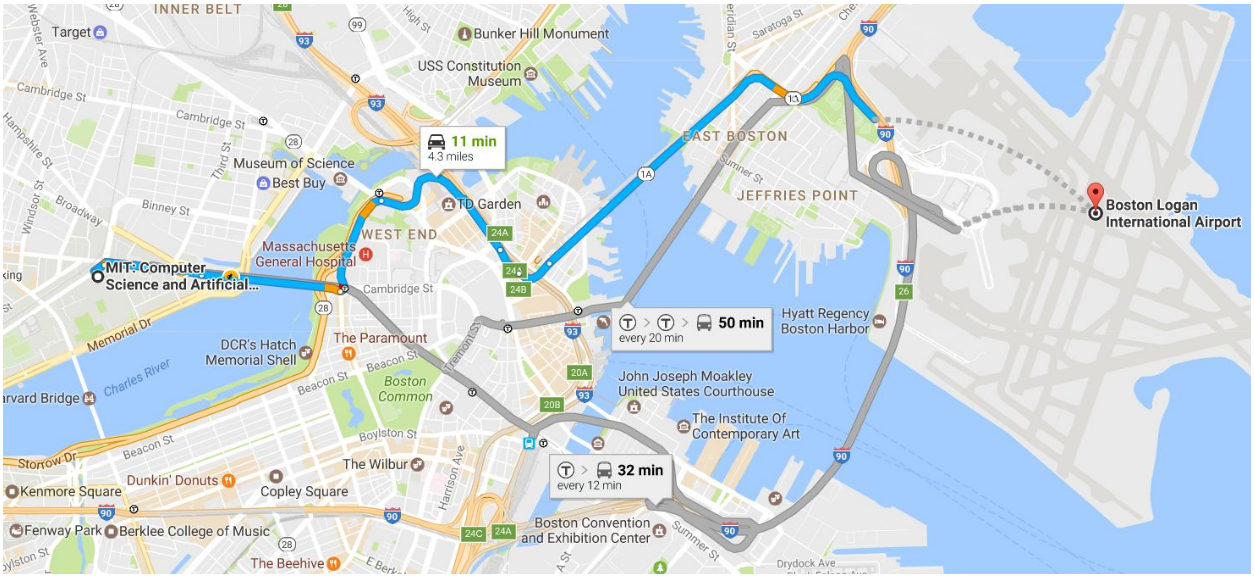
Bus: The #1 ("Dudley" bus) stops at MIT on Massachusetts Avenue. The MIT stop is at a large crosswalk with a stop light. On one side of the street are steps leading up to large Ionic columns and the Small Dome of MIT, on the other side of the street is the Stratton Student Center (Building W20) and Kresge 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/Uber: Taxi fare from the airport is about $25-$30. Under normal traffic conditions the ride will take about 20-25 minutes.

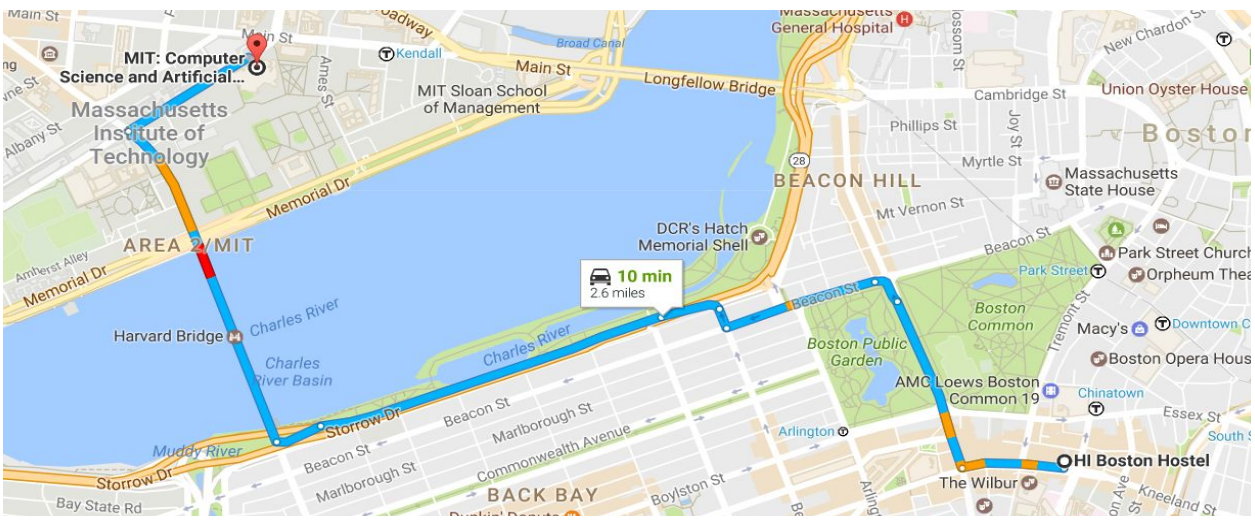
Subway: From the front of any terminal at Logan airport, take the Silver Line bus to South Station. There is no fee. Go downstairs and take the Red Line to Kendall/MIT (take the outbound train toward Alewife), again no fee. Under normal conditions, the ride will take about 30 minutes. From the T stop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

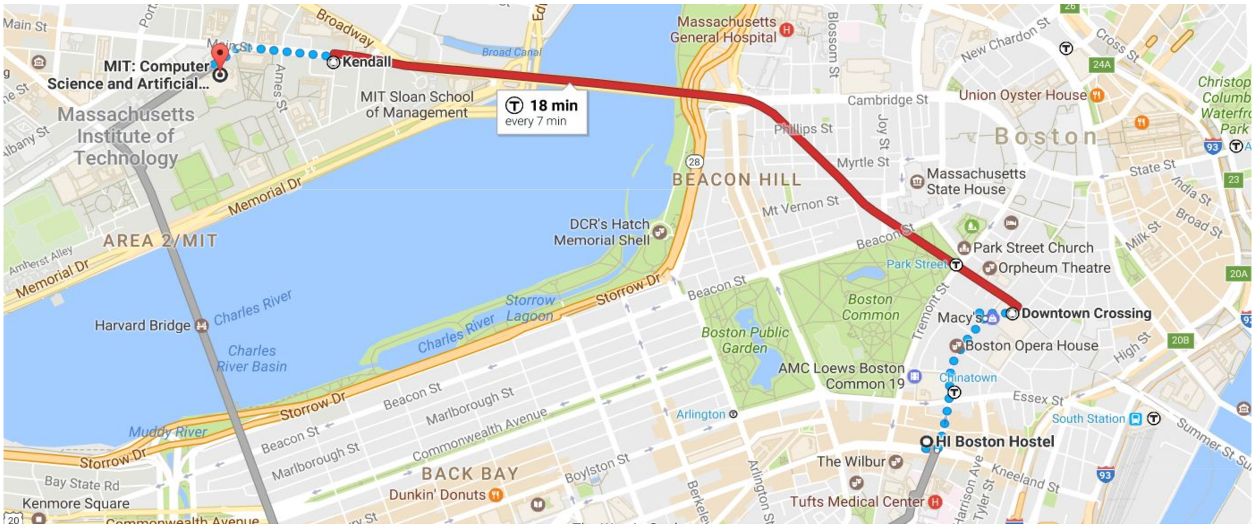


From Hostelling International Boston Hostel:

Rideshare: Uber/Lyft rides from HI Boston Hostel are ~$12 - $15. Under normal traffic conditions the ride will take about 10 minutes.

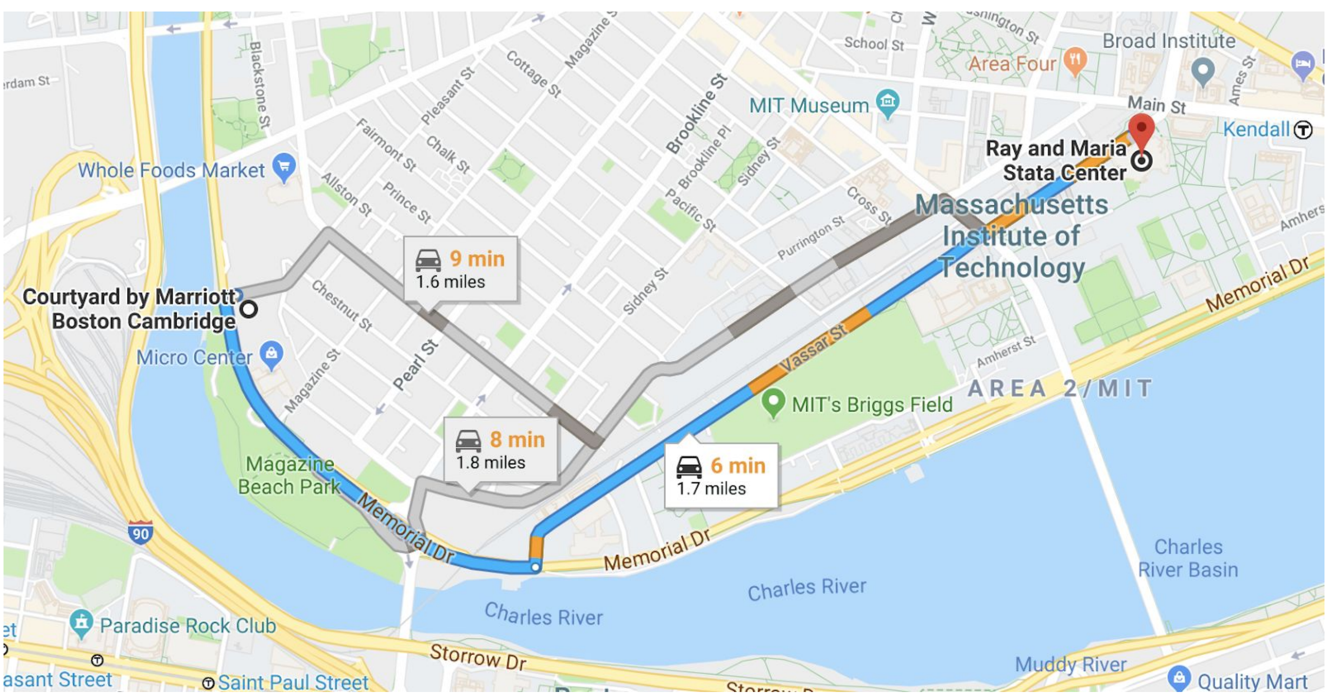


Subway: There is 0.3 mile walk to Downtown Crossing Station. From Downtown Crossing, take the Red Line to Kendall/MIT (take the outbound train toward Alewife). Under normal conditions, the ride will take about 18 minutes.

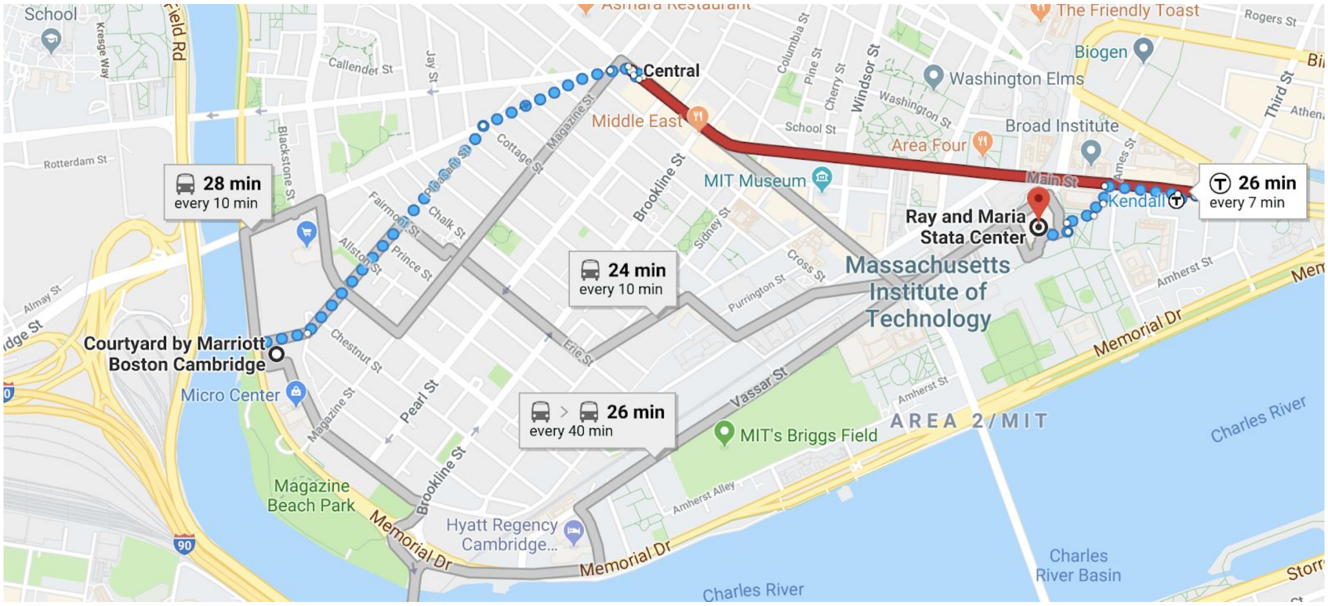


From Courtyard Marriott Cambridge:

Rideshare: Uber/Lyft rides from the Courtyard Marriott in Cambridge are ~$8 and the ride will take, depending on the traffic, approximately 10 minutes.



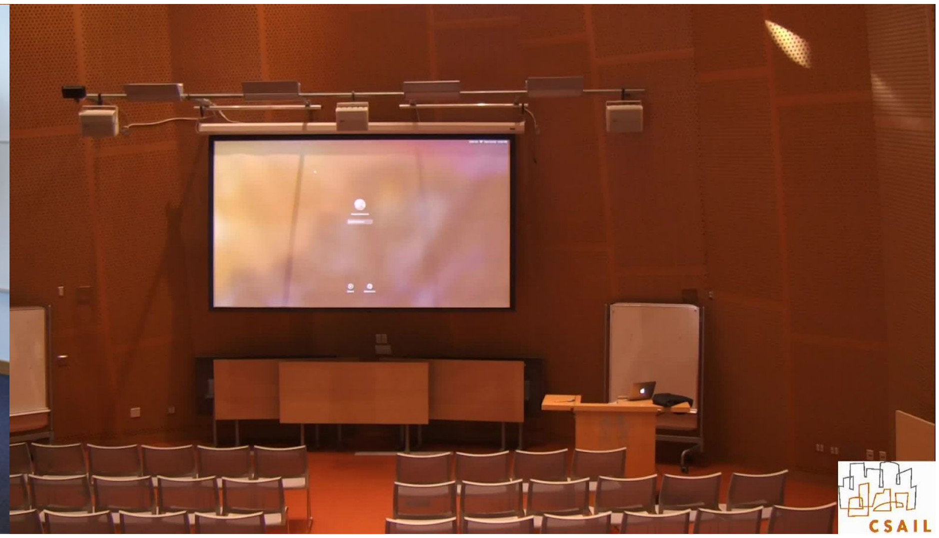
Walking/Subway: You can take a 15 minute walk to Central square and hope on the Red Line subway (take the inbound train toward Ashmont/Braintree). The first stop will be Kendall/MIT. From there, is a 5 minute walk to the Stata Center. Additionally you can walk directly to the MIT Stata Center which is about a 30 minute walk along Memorial Drive and Vassar St.



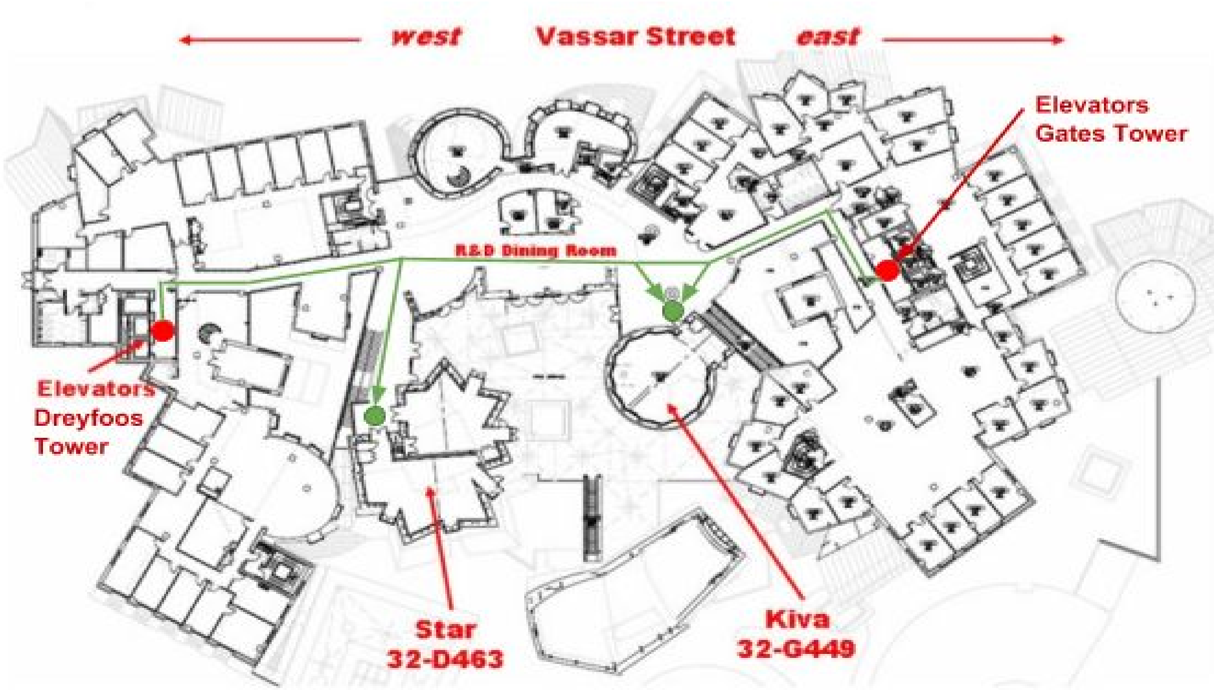
Tutorial Rooms

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

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

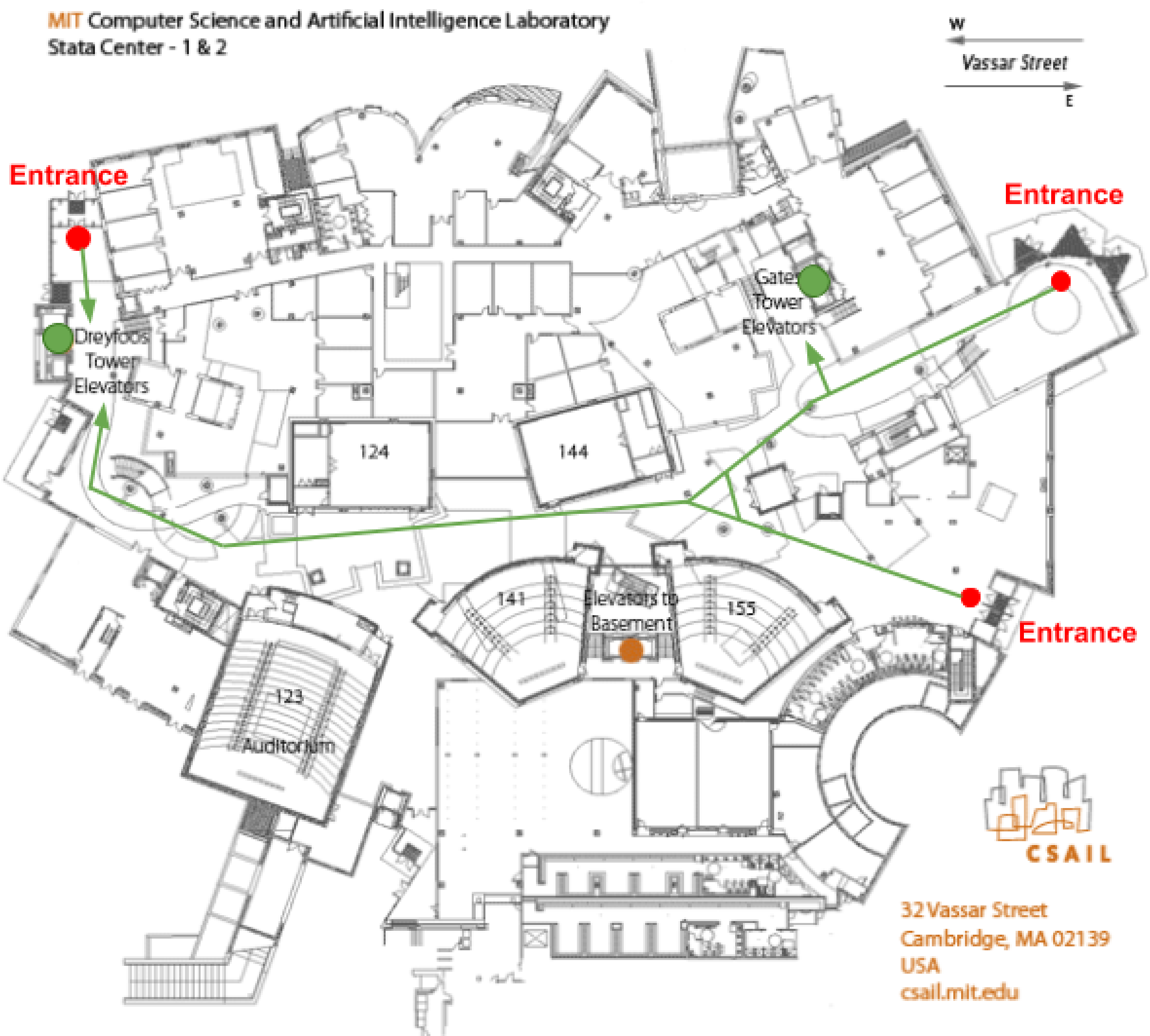


The summer school talks will be given in two seminar rooms, D463 (Star) and G449 (Kiva), on the 4th floor of the MIT Stata Center, Building 32. Please access the 4th floor by using the *Gates Tower elevators* on the east side of the building, or by using the *Dreyfoos Tower elevators* on the west side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



Map of the Stata 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.

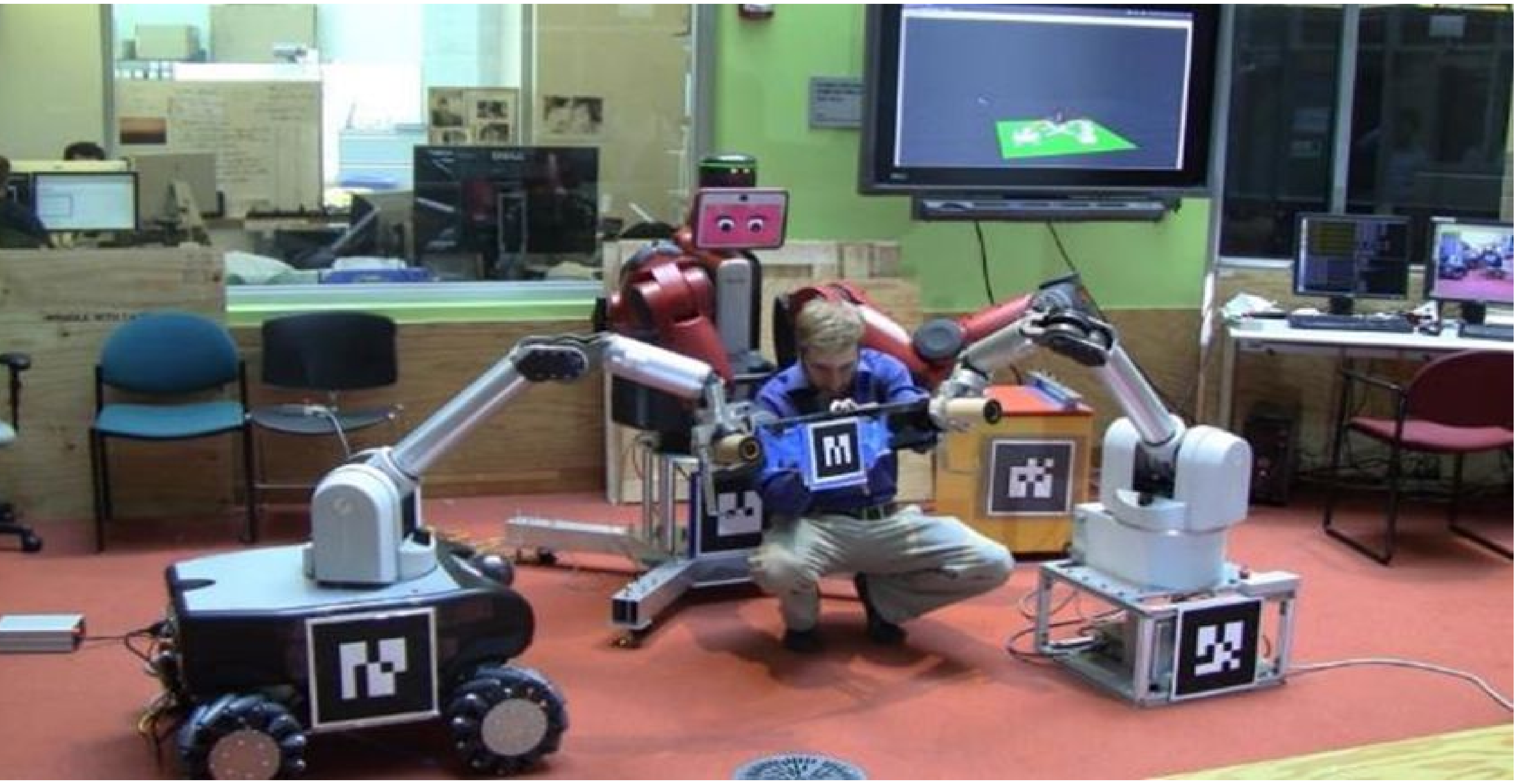


Map of the Stata Center 1 and 2 floors with directions to access Dreyfoos Tower Elevators to access rooms Star and Kiva on the 4th floor.

Laboratory

Model-based Embedded and Robotic Systems Group (MERS)

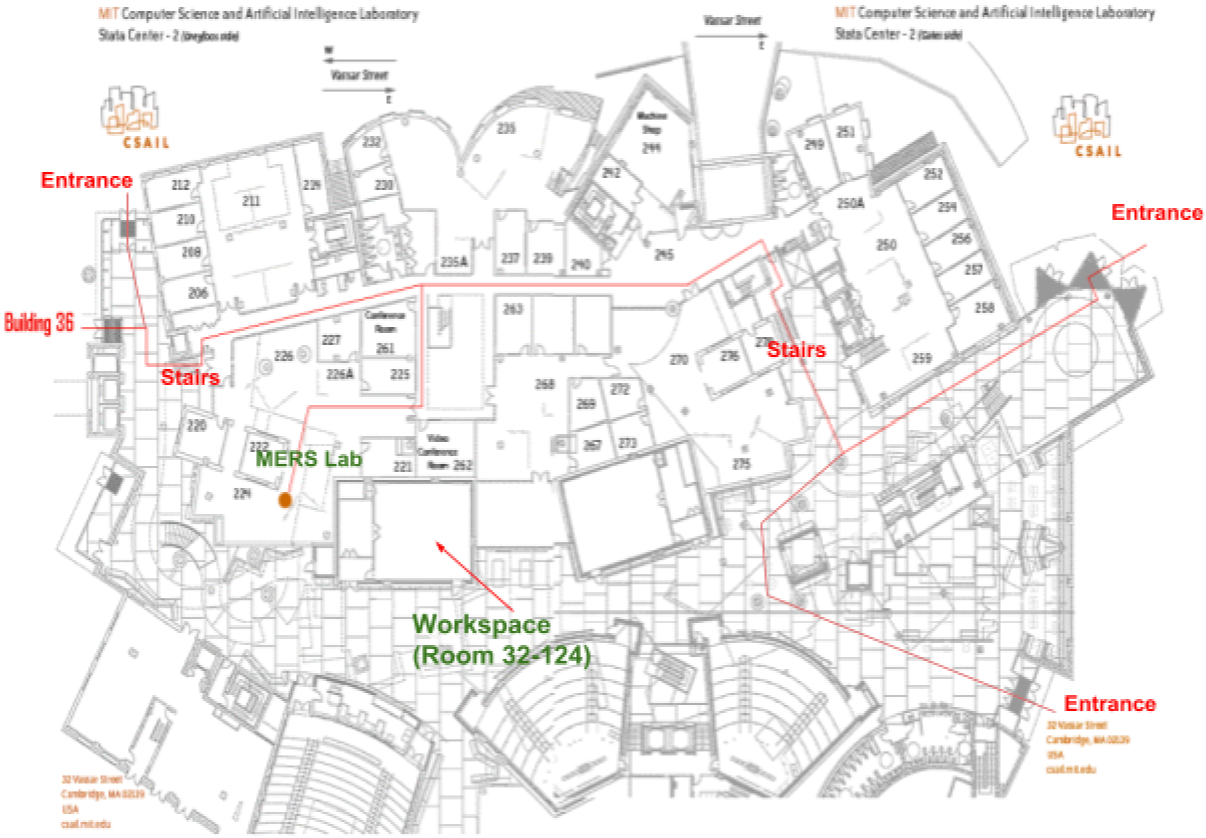
Room 226 and 277, The Stata Center, 2nd Floor, Building 32
32 Vassar Street, Cambridge, MA 02139 USA



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.

Student Workspace

Because our lab is space-limited, we have reserved another classroom nearby for you to work on the lab exercises. The participant workspace is located right around the corner from the MERS lab and is in room 32-124. Its location is also indicated on the map below.



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

Hostel

Hostelling International Boston

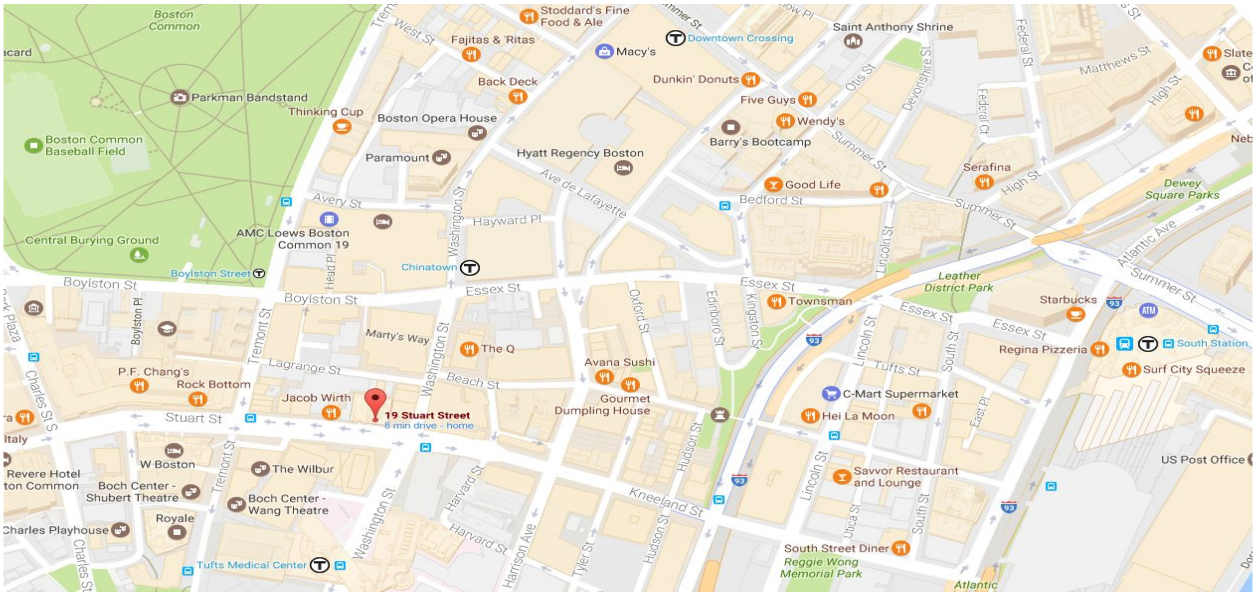
19 Stuart Street, Boston, MA 02116 USA

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.

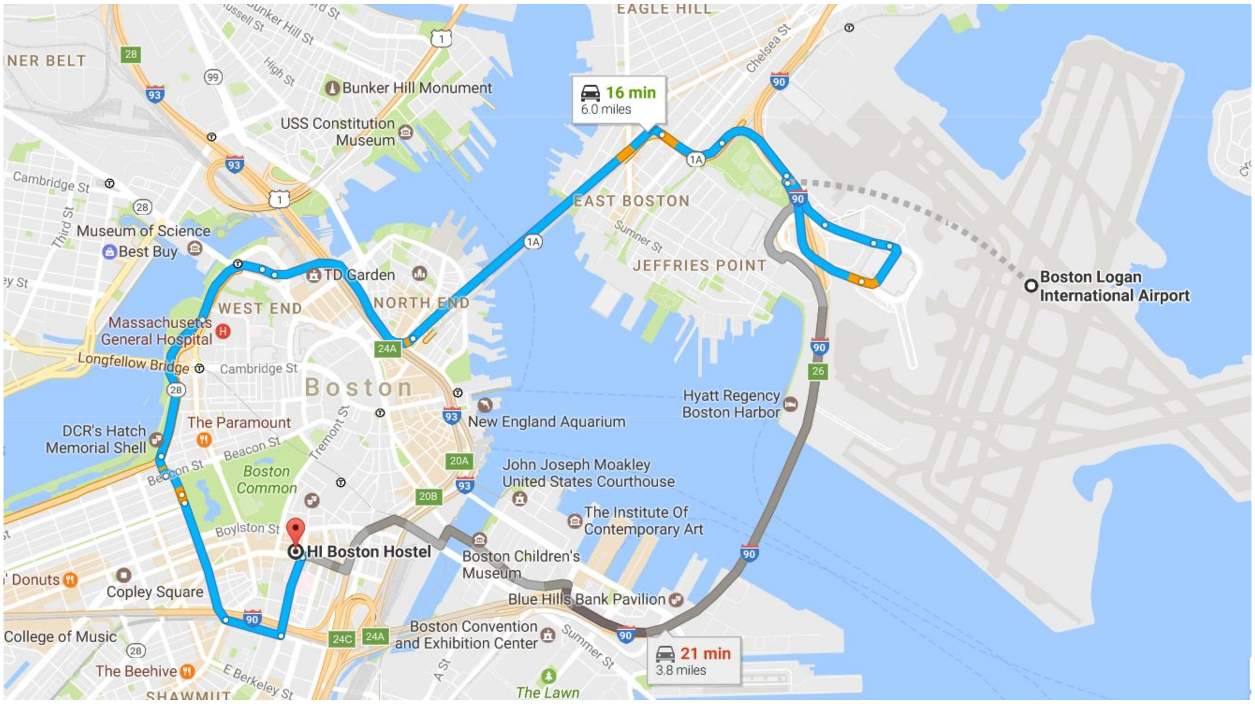
<u>By Public Transportation (commonly called "The T"):</u>

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).

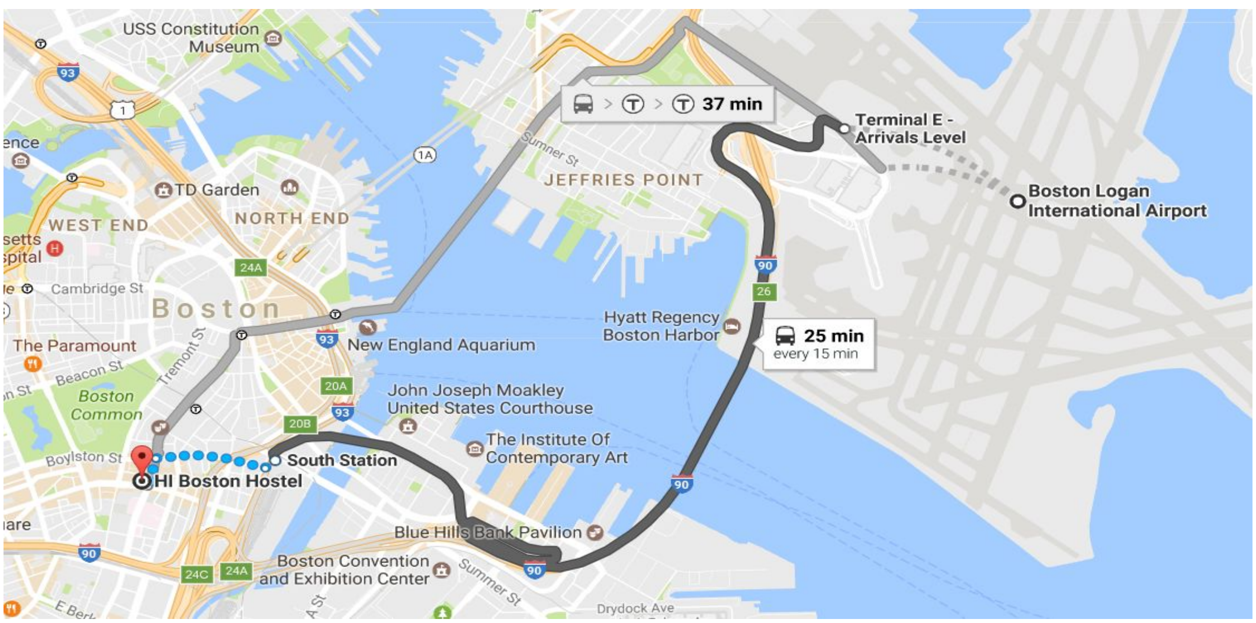


From Logan International Airport:

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, July 24, 7:00pm

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

Directions by Publication 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.