The MIT Quest for Intelligence

Mission

The MIT Quest for Intelligence, a research unit of the MIT Stephen A. Schwarzman College of Computing, is a campus-wide initiative aimed at one of the most central challenges in human history: understanding intelligence.

MIT Quest is a search to understand how brains produce intelligence and how intelligence can be replicated in artificial systems. The Quest approaches this as a single grand challenge requiring the organized, collaborative efforts of science, engineering, the humanities, and beyond.

To achieve this vision, new scientific theories of natural intelligence must be developed, computational models must be created, and implementations must be compared against the capabilities of natural intelligence and tested on real-world problems and applications. MIT Quest sees the engineering of artificial intelligence (AI) and the scientific understanding of natural intelligence as interlocking aspects of this challenge.

Working across the whole of MIT and with the world at large, the Quest capitalizes on MIT's long history of leadership at the boundary of natural and machine intelligence. It is uniquely positioned to advance the development of novel intelligent systems and associated tools and technologies that will have a wide spectrum of societal benefits and applications in numerous fields. MIT Quest's approach does not require merely a crossing of boundaries but a true integration across disciplines. While recent progress illustrates the mutual benefit of studying natural intelligence and intelligent engineered systems, we believe transformative advances in intelligence will require a new approach that more closely integrates the science of natural intelligence with the engineering and applications of AI.

Leadership

In January, leadership was restructured to provide more clearly defined roles:

James DiCarlo

Having previously served as scientific lead, Peter de Florez Professor of Neuroscience James DiCarlo was named director of MIT Quest. He stepped down as department head of Brain and Cognitive Sciences in April.

Aude Oliva

Having previously served as application lead, senior research scientist at the Computer Science and Artificial Intelligence Laboratory and director of the MIT-IBM Watson AI Lab, Aude Oliva was named director of MIT Quest Corporate.

Nick Roy

Having previously served as engineering lead, Nicholas Roy, professor of Aeronautics and Astronautics, was named the director of MIT Quest Systems Engineering.

Strategy, Values, and Impact

The Quest for Intelligence is a bet on how to advance our understanding of intelligence and on the practical impacts of those advances. This vision represents a substantial repositioning of MIT Quest to align with and benefit from the mission and structure of the MIT Schwarzman College of Computing, enabling a more ambitious undertaking. The Quest draws on and contributes to all three pillars of the College: advancing computer science and AI, driving computing across disciplines, and attention on social and ethical responsibilities.

To execute on this vision, MIT Quest research is organizing around long-term collaborative projects we call missions, which are rooted in a foundational question in intelligence—animal, human, or collective. Each Quest mission will support research organized around a domain of natural intelligence. The new models of intelligence proposed along the way will be integrated into a theoretical or computational platform designed to both test the models within a coherent system of intelligence by assessing the system's ability to explain and account for phenomena of natural intelligence in the domain (and thus gauge our overall progress) and to demonstrate the utility of the system in solving real problems of perception, reasoning, or decision-making on campus or in the world at large. This approach ensures that we can aim for long-term success while also producing steps along the way that will be packaged and applied to one or more of those real-world problems.

MIT Quest's Values

- Fundamental research: We are committed to progressing a fundamental understanding of intelligence. We choose problems that require advances from both science and engineering.
- Real applications: We are committed to solving real-world problems for MIT and the world at large. We validate our work on problems that people care about.
- Social responsibility: We recognize that our work will affect society in ways that are hard to predict. We are thoughtful about those effects and are transparent and accountable.

Who Is Served?

- The MIT community: MIT is served in two ways—first by advancing our understanding of intelligence and developing new models, algorithms, and techniques; and second by building a set of engineered systems designed to address technical, on-campus issues encountered by faculty, students, and researchers.

- Our country and the world: By developing a new science of natural intelligence and new systems that implement that science, we will ensure that the U.S. maintains its preeminent position as the leader of intelligent and learning systems. At the same time, we take seriously our responsibility to educate the world and create substantial economic growth for all.
- Humanity: Advances in our understanding of natural intelligence and its implementation in artificial systems will expose new ways to ameliorate brain disorders and better ways to educate children and adults; these advances will also revolutionize how people live and work globally. Communication, transportation, and manufacturing systems are already being transformed by progress in AI. New forms of intelligent systems that are on par with human intelligence in terms of capability, generalization, and efficient energetics are essential for continuing to create such transformations in all areas of human life.

Research Affiliates and Industry Collaborations

MIT Quest maintains a three-tier industry engagement program that offers companies a variety of ways to advance their strategic goals. As part of our program, we host two research affiliates—the MIT-Liberty Mutual Insurance Collaboration and the Center for Deployable Machine Learning—and collaborate with units such as the MIT-IBM Watson AI Lab and the MIT Energy Initiative.

The Discovery level ($275,000/year, three-year commitment) provides exposure to a broad range of faculty and AI projects via participation in MIT events, opportunities to access MIT talent, and previews of Quest research and tools in emerging fields of AI and machine learning. We have two Quest Discovery members, seven Discovery members affiliated with the MIT-IBM Watson AI Lab, and one Discovery member affiliated with the MIT Energy Initiative.

The Exploratory level ($1 million/year, three-year commitment) multiplies the impact of Discovery membership with targeted research, providing the opportunity to develop a set of research projects with MIT Quest researchers and engineers. Shell, as part of its affiliation with the MIT Energy Initiative, signed on at the Exploratory level in 2020.

The Visionary level ($5 million/year, five-year commitment) provides broad access to faculty, students, and state-of-the-art research via joint projects, early access to research results, platforms and tools, and options for corporate researchers to join MIT.

In fiscal year 2021, MIT Quest had a total spent fund volume of $3.3 million, and the MIT-Liberty Mutual Insurance Collaboration had $2.1 million in total spent secondary research volume.

Collaboration with Liberty Mutual

Liberty Mutual Insurance signed on as a Visionary member in April 2019. This collaboration focuses on AI research in computer vision, natural language processing, machine learning fairness, data privacy and security, and risk-aware decision-making,

among other topics. In FY2021, Liberty Mutual awarded 10 grants totaling $4.5 million to researchers in the MIT School of Engineering, MIT School of Science, MIT Sloan School of Management, and MIT Schwarzman College of Computing (SCC). Funded projects include developing natural language processing systems to analyze policy language and legal outcomes; developing tools to optimize internal job opportunities for employee retention; and analyzing data sharing between manufacturers and suppliers to improve business relationships and opportunities.

Center for Deployable Machine Learning

The MIT Center for Deployable Machine Learning works toward creating AI systems that are robust, reliable, and safe for real-world deployment. Led by Aleksander Madry, the Cadence Design Systems Professor of Computing at MIT's Department of Electrical Engineering and Computer Science (EECS), the center brings together faculty experts in interpretability, security, computer vision, and applied machine learning.

The MIT-IBM Watson AI Lab and the MIT Energy Initiative have issued their own reports that include more details concerning their membership programs and research volume.

Resource Development

MIT Quest works closely with SCC to provide philanthropic partnership opportunities to help advance our mutual vision. Current philanthropic support for MIT Quest includes a $5 million gift from Eric Schmidt to fund a range of AI-education projects; a $10 million gift from David Siegel to fund research missions (which was transferred from MIT's Department of Brain and Cognitive Sciences to SCC in April), a $3 million gift from Tang Xiao'ou to fund diversity, equity, and inclusion graduate fellowships, research missions, and the MIT Quest Covid-19 mission; and a $750,000 gift from Neil Webber to support Quest engineering activities.

MIT Quest Response to the Covid-19 Pandemic

As MIT closed its campus in March 2020, senior administrators asked MIT Quest's engineering team to build a part of the MIT Covid Response System (MCRS) to model campus operation during the pandemic, help with decision-making for campus operations, and help plan for an eventual reopening. A collaboration of MIT Quest and MIT Lincoln Laboratory, MCRS required redirecting Quest engineers to build infrastructure that ingested a variety of data from across campus and fused them into a daily model showing how Covid-19 might impact campus. The resulting models were integrated into a dashboard developed by MIT Lincoln Laboratory to assist senior administrators in making daily campus operations decisions. Five research groups also received funding on a variety of Covid-related projects, including building models of Covid-19 prevalence at the ZIP code level, Covid-19 transmission across Boston public transit, and aerobic Covid-19 transmission across MIT buildings.

Selected Research

MIT Quest launched a request for proposals in February, with the goal of funding concept projects that align with the vision of solving foundational questions of intelligence in engineering terms. MIT Quest received 31 proposals from across the

Institute and committed $2.6 million in funding for 10 concepts at a range of funding levels (four at the mission level, and six at the seedling level). Funding was initially committed for a 12-month incubation period (from September 2021 to August 2022), with an opportunity to renew at amplified funding levels for multiple years, depending on excitement generated within the MIT community and beyond. Looking beyond this call, MIT Quest anticipates that each concept could be expanded into a long-term, multiyear mission. As part of the incubation period, MIT Quest is providing institutional support, guidance, and protocols.

Missions

Engineering Embodied Intelligence

Lead Principal Investigators (PIs): Leslie Kaelbling, Panasonic Professor of Computer Science and Engineering; Nancy Kanwisher, Walter A Rosenblith Professor of Cognitive Neuroscience

Collaborators: Professor Ila Fiete; Professor Joshua Tenenbaum; Russ Tedrake, Toyota Professor of Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Mechanical Engineering at MIT; Associate Professor Mehrdad Jazayeri; Professor Tomás Lozano-Pérez

This research mission broadly addresses how we perceive the world around us and integrate this information to plan and complete tasks. Scientific goals include research into how perception, planning, and action interface, how we learn efficiently from small data sets, and the creation of behavioral benchmark tasks. Engineering goals include task-based benchmarks derived from natural intelligence and methods for composing artificial systems to achieve those tasks.

Developing Intelligence: Scaling AI the Human Way

Lead PI: Joshua Tenenbaum

Collaborators: Professor Laura Schulz; Professor Rebecca Saxe; Principal Research Scientist Vikash Mansinghka; Leslie Kaelbling; Russ Tedrake

This research mission broadly aims to understand how children grasp new concepts from few examples, and how children build upon layers of concepts to reach an understanding of the world and have the flexibility to solve an unbounded range of problems. Can we build AI that starts like a baby and learns like a child? Goals include defining common sense core knowledge and replicating learning algorithms used by babies up to 18 months to eventually build robots that can flexibly adapt to new situations.

Collective Intelligence

Lead PIs: Thomas Malone, Patrick J. McGovern (1959) Professor of Management at the MIT Sloan School of Management; Cadence Design Systems Professor of Computing Aleksander Madry

Collaborators: Daniela Rus, Andrew and Erna Viterbi Professor in the Department of Electrical Engineering and Computer Science; Abdullah Almaatouq, Douglas Drane Career Professor in Information Technology; Daron Acemoglu, Elizabeth and James Killian Professor of Economics; Adam Berinsky, Mitsui Professor of Political Science; Asuman Ozaglar, MathWorks Professor of Electrical Engineering and Computer Science; David Rand, Erwin H. Schell Professor and Professor of Management Science and Brain and Cognitive Sciences

This mission approaches how we can optimize human–AI group decision-making. How can we create superintelligent groups that operate effectively in dynamic environments? How can highly polarized groups make decisions the whole group will implement? Goals include defining benchmarks to determine what superintelligence is, the character types of tasks and groups, and how to evaluate performance of different types of groups and tasks. Engineering goals include developing modeling and computer-aided design tools for group design, creating a library of group configurations, and establishing predictive models to evaluate performance.

Brain-Inspired Hardware

Lead PIs: Professor Bilge Yildez; Donner Professor Jesús del Alamo

Collaborators: Glenn V. and Phyllis F. Dorflinger Professor of Neuroscience Michale Fee; Battelle Energy Alliance Professor in Nuclear Engineering Ju Li, Associate Professor Vivienne Sze, Advanced Television and Signal Processing Professor of Electrical Engineering Hae-Seung "Harry" Lee, Professor of the Practice Joel Emer

This research mission looks at electrochemical synapses as building blocks to emulate and advance learning models. What can we learn from biological synapses to build better, more energy-efficient engineered hardware? Science research goals include modeling the circuits that both underlie complex learned behaviors and begin to emulate and advance state-of-the-art learning rules. Engineering goals include building bio-inspired energy efficient hardware, new computing architectures, neural networks, and integrated high-density circuits.

Seed funding

In addition to these mission projects, MIT Quest provided seed funding to the following, with the understanding that these early-stage projects may evolve into new missions or dovetail with existing ones:

- Assistant Professor Jacob Andreas: Deriving meaning from language in minds and humans
- Assistant Professor Robert Yang: Building and evaluating multisystem functional brain models
- Assistant Professor Philip Isola: Bootstrapping emergent intelligence
- Assistant Professor Pulkit Agrawal: Reimagining reinforcement learning via memory-based biological learning

- Eugene McDermott Professor in Brain and Cognitive Sciences Tomaso Poggio: Neural circuits underlying the computation of the 3 1/2-D sketch
- Professor Cynthia Breazeal: Quest mission on understanding social mechanisms of learning in humans and machines with application to early childhood education

Community Outreach and Activities

Education

MIT Quest trains and provides mentorship to undergraduates interested in neuroscience, psychology, and software engineering through the Undergraduate Research Opportunities Program (UROP). We sponsored 12 fall and 12 spring UROP projects. We sponsored 10 Super UROP projects and eight projects over winter Independent Activities Period.

Events

MIT Quest helped sponsor events, conferences, and student activities for the benefit of the AI community at MIT and beyond:

Frontiers of AI/ML (June 14–16)

Quest Sponsored/Industrial Liaisons Program

From research into privacy-preserving machine learning, to creating robust and deployable AI, to improving human-AI collaboration, MIT faculty shared their insights on the path to the AI and machine learning (ML) frontier. This event was co-sponsored with MIT Corporate Relations and the MIT Industrial Liaison Program.

Artificial Intelligence @ MIT Research Blitz (December 1)

Student Event

Assistant Professor Pulkit Agrawal, Associate Professor Justin Solomon, and graduate students Sarah Cen and Genevieve Flaspohler gave AI-related lightning talks as part of the student-led MIT Machine Intelligence Community's third annual AI@MIT Research Blitz.

Extending Deep Nets to New, Unexpected Situations (February 11)

MIT Quest Roundtable Event, Webinar

Speakers: Pulkit Agrawal, Phillip Isola, Alyosha Efros (University of California at Berkeley)
Moderator: Director of the MIT-IBM Watson AI Lab Aude Oliva

Deep neural networks could very well memorize their training data, but instead they find generalizable rules. This event focused on various ideas about why this happens and how we can build deep learning systems that generalize even better to new and unexpected scenarios.

Toward Brain-Inspired, Energy-Efficient Chips (March 26)

MIT Quest Roundtable Event, Webinar

Speakers: Professor Bilge Yildiz, Michale Fee
Panelists: Donner Professor Jesús del Alamo, Ju Li
Moderator: Aude Oliva

Traditional computer chips waste time and energy shuttling data between separate memory and computational units. By contrast, neural circuits in the brain achieve enormous efficiencies by storing and processing information at the same place, and researchers are designing computing elements that mimic neural circuits and consume massively less energy.

Crossing the Hardware-Software Divide for Faster AI (April 29)

MIT Quest Roundtable Event, Webinar

Speakers: Vivienne Sze, Associate Professor Song Han
Moderator: Aude Oliva.

AI applications are moving quickly to smartphones and low-power handheld devices. To make the shift, both hardware and software will need to be redesigned for speed and efficiency. This event discussed leading strategies for achieving efficient AI by co-designing hardware and software for deep learning.

AI for Social Good (May 10)

MIT Quest Roundtable Event, Webinar

Speakers: Ford International Professor of the Social Sciences Fotini Christia, Stacy Hobson (IBM)
Moderator: Aude Oliva

AI has the potential to address longstanding societal problems ranging from economic inequality to unequal access to health care, but it could also widen these divisions without deliberate steps to mitigate its potential negative effects. This event discussed ideas for harnessing AI for the benefit of all.

Frontiers of Artificial Intelligence and Machine Learning (May 25 and 27)

Quest Sponsored/Industrial Liaisons Program

Businesses are integrating AI and ML into every facet of their work, but we're far from realizing their potential. An understanding of what's possible, and what's still over the horizon, is essential to understanding how businesses can maximize the value of AI and ML.

Natural Language Processing for All (June 4)

MIT Quest Roundtable Event, Webinar

Nearly 7,000 languages are spoken in the world today, but fewer than two dozen have the massive training data required to build AI applications like language and speech-to-text translation. The problem is compounded by a shortage of computing resources in much of the world. This panel explored ways of making natural language processing more efficient, interpretable, and linguistically informed to better reach speakers of all languages.

Additional community-building activities included the following:

- Provided funding for conference registration fees for EECS students to virtually attend the 2020 Association for Computing Machinery/Richard Tapia Celebration of Diversity in Computing Conference held September 16–19
- Contributed to the EECS Graduate Application Assistance Program, a student-run graduate mentorship program to assist underrepresented students with their applications to doctoral graduate programs
- Provided funding for conference registration expenses and poster presenter fees for MIT students at the Shared Visual Representations in Human and Machine Intelligence workshop at the 2020 Conference on Neural Information Processing Systems in December
- Provided funding for the 2021 academic year to AI@MIT, a community of undergraduates who look to promote and foster the growing interest around machine intelligence on campus.

Website Project

The website redesign and implementation began in January 2020 with the creation of the Quest Knowledge Base, a Drupal database of all Quest-funded PIs for use by corporate members. Website development, in collaboration with Wing Ngan of Inkd Design and Rafael Caldeira da Silva, a contractor with Toptal Design, began in March 2021 with a soft launch in May, and expected launch of all elements, including a new events landing page, in the fall.

James DiCarlo, MD, PhD
Director
Peter de Florez Professor of Neuroscience