

## MIT IBM Watson AI Lab

The [MIT-IBM Watson AI Lab](#) aims to advance artificial intelligence (AI) science and discovery with hardware, software, and algorithms related to deep learning and reasoning; amplify AI's impact in industries like healthcare and cybersecurity; and explore the economic and ethical implications of AI on society. The lab is co-led by Aude Oliva, senior research scientist and director of MIT Quest Corporate in the MIT Schwarzman College of Computing, and David Cox of IBM Research. It is co-chaired by Anantha Chandrakasan, dean of the MIT School of Engineering, and Dario Gil, vice president of AI at IBM Research.

The lab represents an investment of \$240 million from IBM Research in AI research and education over 10 years. We have raised an additional \$30 million by signing seven IBM corporate members to the lab to date.

The lab joined the MIT Schwarzman College of Computing in spring 2019 as one of its six independent research units. Despite the rise of the Covid-19 pandemic and subsequent period of confinement, lab operations were kept running smoothly while the whole team worked remotely for an entire academic year.

### Goals and Priorities

In fall 2021, the IBM lab team will be moving to a newly finished space in Kendall Square. This new space is adjacent to the MIT campus and the MIT lab team. This will greatly enhance collaboration between MIT and IBM researchers and will allow for closer involvement with the MIT student community. We will focus on community building activities and will expand our corporate membership program in order to connect with students from the MIT Schwarzman College of Computing.

In four years, the lab has solicited more than 330 research proposals and awarded a total of 125 grants to 24 departments, labs, and centers (DLCs) across campus. Our review process includes reviews for each proposal from experts of the MIT and IBM teams, an advisory discussion with the MIT-IBM steering committee, a ranking of the proposals, and final awards decisions by the chairs.

In academic year 2021 the lab launched 41 new projects, including two large-scale signature projects that represent long-term bets on new concepts for transformative technologies. More than 100 principal investigators from MIT and 60 researchers from IBM are actively engaged in single-year and multiyear projects. Our MIT and IBM researchers have co-authored more than 130 peer-reviewed papers since the lab's founding.

The pandemic had minimal impact on the research operations and outputs of the lab. Thirty joint peer-reviewed papers were produced remotely, for a total of 130 papers since the lab's inception four years ago. Our seminars and outreach events shifted to virtual activities, with a total of 21 events produced remotely. A highlight was our April 2021 virtual poster session and open house for research collaboration, which brought in more than 300 MIT and IBM researchers for virtual discussions.

Over the past year the lab has identified opportunities to collaborate with MIT departments, labs, and centers to support diversity, equity, and inclusion efforts at MIT. These include the MIT Summer Research Program, MIT's Graduate Application Assistance Program, Masters of Engineering Research Assistantships, and the Undergraduate Research Opportunities Program.

## Industry Research Collaborations

In addition to 10 years of basic research funding provided by IBM, the lab has built a multitier industry engagement program offering companies a multitude of ways to advance their strategic goals. In AY2021, the lab had seven members in the corporate program. Member benefits include state-of-the-art research output, between one and five active sponsored-research projects (approximately 100 sponsored-research projects are active each year), access to tools and technologies tailored to their business (via IBM's software engineering team), exposure to a broad range of faculty and AI projects through participation in MIT events, and opportunities to access MIT talent, including networking with Electrical Engineering and Computer Science and Schwarzman College of Computing students.

In AY2021, the lab had a total spend volume of \$9.4 million (\$8.1 million of which was research volume administered in the home DLCs).

Our corporate members include:

- Nexlore, which aims to take the guesswork out of construction monitoring
- Woodside, which aims to develop “plant auto-pilot” for efficient liquefied natural gas production
- Wells Fargo, which aims to leverage data more efficiently in finance
- Samsung, which aims to increase capabilities on the edge
- Boston Scientific, which aims to improve operational efficiency through AI
- London Stock Exchange Group, which aims to translate data into a first-in-class customer experience
- Evonik, which aims to drive digitalization in chemistry research and development

## Selected Research Overview

Below are some highlights from the approximately 100 active MIT-IBM Watson AI Lab-funded projects:

- *Signature Project: Incorporating linguistic structure into deep learning models.* Nearly 7,000 languages are spoken in the world, but a dozen have the massive training data that machine learning needs. Researchers are developing models that can transfer linguistic structures across languages, weaving linguistic rules into AI models.
- *Signature Project: Bootstrapping fluid intelligence by merging deep learning with symbolic programs.* AI systems are given little opportunity to learn cumulatively from their experiences. Researchers are designing an open-ended learning environment that

combines the pattern-matching ability of deep learning with the power to use built-in knowledge, leading to artificial agents with more fluid intelligence.

- *Robust approaches for making use of privacy-preserving data.* How does private, aggregated data influence decisions? Despite the sudden increase in differential privacy methods, relatively little is known about the downstream effects and whether resulting decisions and medical interventions are fair. Researchers are exploring what can be learned about the effects of interventions to develop more robust approaches for making use of privacy-preserving data.
- *Cutting the cost of drug discovery by identifying the most promising molecules for testing.* Before testing a new drug candidate, chemists run millions of simulations of how possible molecules might interact with a protein. To expedite the discovery process, researchers are using these simulations plus machine learning algorithms to guide them to the molecules and pathways most likely to have therapeutic potential.
- *The formation of silica materials.* Industrial silica is found in toothpaste, semiconductors, and telescopes. Though silica is everywhere, the structural changes responsible for creating its properties are poorly understood. Researchers replace expensive quantum simulations with surrogate machine-learning models that can optimize chemical reactions to produce atom-by-atom structures of desired materials.
- *Bringing more video applications to smartphones.* The limited battery life of smartphones has limited the spread of AI to mobile devices. Researchers are developing methods to design efficient model architectures for video analysis in order to reduce computation by an order of magnitude for faster, greener, and more accessible AI.

To date, the lab has submitted 30 patents originating from original research performed by our team. Fourteen of these patents were submitted during AY2021.

## Student Engagement

The lab is focused on identifying opportunities to collaborate with MIT at large in order to support student engagement, including diversity, equity, and inclusion efforts.

- In September 2020, the lab covered the registration fee for 12 students from MIT Electrical Engineering and Computer Science to virtually attend the 2020 Association for Computing Machinery Richard Tapia Celebration of Diversity in Computing Conference.
- In October 2020, the lab contributed to the Electrical Engineering and Computer Science Graduate Application Assistance Program, a student-run graduate mentorship program that assists underrepresented students in their applications to doctoral graduate programs.
- For both the fall and spring semesters, the lab sponsored the AI@MIT undergraduate club. This club is a community of undergraduates that promotes and fosters the growing interest around machine intelligence on campus.

## Undergraduate Research Opportunities

Since its creation, the lab has funded 91 students (48% women) in the MIT Undergraduate Research Opportunities Program (UROP) and the Super UROP program to support the research skills of MIT undergraduates. In AY2021, the lab sponsored 30 UROP and five Super UROP projects. These research projects aimed to push the frontiers of artificial intelligence and its applications. The students performed all research remotely. A few undergraduate student projects are highlighted below:

- *Squeezing more energy from the sun.* In a project with MIT's Institute for Soldier Nanotechnologies, a student is developing a solar cell simulator that would allow deep learning algorithms to systematically find better solar cell designs.
- *Putting language comprehension under a microscope.* In a project with a faculty member in the Brain and Cognitive Sciences Department, a student is studying how longer reading times can indicate when a word has been improperly used, offering insight into how the brain incrementally finds meaning in a string of words.
- *Defending code-processing AI models against adversarial attacks.* In a project with a Computer Science and Artificial Intelligence Laboratory researcher, a student is focused on finding and fixing the weaknesses in code-processing models that can cause them to misbehave.
- *Reconstructing real-world scenes from sensor data.* In a project with an Electrical Engineering and Computer Science professor, a student uses computer-drawn scenes to train a model of navigation.

## Master and Graduate Student Opportunities

- In fall 2020 and spring 2021, the lab funded original research from six graduate students who were mentored by MIT faculty of the lab. Research topics included new algorithms for lifelong reinforcement learning, neuro-symbolic model of language, and business case development of AI.
- In spring 2021, the lab selected four master of engineering students from the Electrical Engineering and Computer Science 6A program to conduct remote internships at IBM Cambridge to be completed during AY2022. The 6A program allows students to pursue a leading-edge industry project while simultaneously working towards the completion of their thesis.
- In June 2021, the lab awarded a full academic year of research assistantships AY2022 to six master of engineering students who will work under the co-mentorship of an MIT faculty and IBM researcher to develop a master's thesis on a lab-funded project.

## Community Outreach and Events

Below are highlights of the 21 virtual events we produced in the past year:

- Virtual Roundtable: "The path to building more flexible AI." Experts from MIT and IBM gathered to discuss some of the challenges of developing AI systems that perform optimally in the real world. (July 2020)

- What's next in AI? "AI We Can Trust; AI We Can Scale; AI We Can Reason With." AI offers a competitive advantage, but only a fraction of companies use it to its full potential. In this three-part series, we convened scientists and business leaders to explain how to overcome three key barriers to implementing AI successfully — trust, scalability, and reasoning. The series had approximately 350,000 total viewers on our YouTube channel. (November 2020)
- Quest AI Roundtable Virtual Series: a five-part series on the current state of AI with MIT experts. The MIT Quest AI Roundtable is a forum to get up to speed on the advances in AI and its real-world applications. Created and moderated by Aude Oliva, the series hosts experts for discussions on topics ranging from novel AI hardware technologies to natural language processing models and AI for Good. (Spring 2021)
- MIT-IBM Technical Seminar "Repurposing Drugs for Covid-19 through Causal Inference." An AI framework for integrating interventional data could be a boon for drug discovery. In this talk, MIT researchers discussed how their research on causal inference is helping identify existing drugs that might be repurposed to fight Covid-19. (March 2021)
- MIT-IBM Watson AI Lab Open House, Virtual Poster Session and Networking. A behind-the-scenes look at current and upcoming research projects with member companies and MIT and IBM researchers. Opening remarks were given by lab directors Aude Oliva and David Cox. (April 2021)
- IBM Think 2021: "Three Principles for Innovation: An MIT-IBM Watson AI Lab Case Study with Boston Scientific." In collaboration with Boston Scientific, a global leader in medical devices and one of our corporate members, the lab showcased the development of transfer learning for AI inspections in a manufacturing setting. (May 2021)

The lab sponsored conferences and student activities at MIT and beyond. Our efforts included a virtual course, 6.S191 Introduction to Deep Learning, that ran in January 2021, and a Computer Vision and Pattern Recognition Workshop on Dynamic Neural Networks, held in June 2021.

## Communications

The lab produced 13 research and education stories for MIT News in the last year. Highlights include the following:

- [Shrinking deep learning's carbon footprint](#). To reduce the energy needed to train modern AI, researchers are experimenting with ways of making software and hardware more energy efficient and in some cases, more like the human brain.
- [Toward a machine learning model that can reason about everyday actions](#). In a study at the European Conference on Computer Vision, researchers show that a deep learning model can compare dynamic events on video to tease out the high-level concepts connecting them, as people naturally do.
- [Shrinking massive neural networks used to model language](#). Modern language models are not only massive but computationally expensive. A new approach

- based on the Lottery Ticket Hypothesis could make them leaner and more efficient, bringing natural language processing models to smartphones.
- [Vibrations of coronavirus proteins may play a role in infection](#). Vibrations of the coronavirus spike protein allow it to invade cells the way jiggling a key in a sticky lock can help open a door.
  - [Training Robots to manipulate soft and deformable objects](#): PlasticineLab, a new simulation environment, is designed to make robot learning more intuitive.
  - [Q&A: Vivienne Sze on crossing the hardware-software divide for efficient artificial intelligence](#). A review of Professor Sze's research on more efficient deep neural networks to process video and more efficient hardware to run applications.

The lab was cited or featured by media outlets 63 times, including multiple mentions in the *Academic Times*, *Forbes*, *Gizmodo*, *Medium*, *Morning Brew*, *Venture Beat*, and *Wired*.

With our original content and AI-related press coverage, we continued to amass followers on Twitter. We now have an audience of 3,547. We are continuing to build out our website to feature news, staff, investigator profiles, newsletters, research projects, and messaging for prospective corporations. In AY2021 we produced eight lab newsletters (three general newsletters sent to 865 people and five corporate-tailored event newsletters reaching 550 people).

## Administration and Governance

The lab has a new steering committee that is composed of equal numbers of MIT and IBM researchers. The members are:

- Antonio Torralba, professor, MIT Department of Electrical Engineering and Computer Science; head, Artificial Intelligence and Decision-making Faculty
- Daniel Huttenlocher, dean, MIT Schwarzman College of Computing
- Lisa Amini, director, IBM Research Cambridge
- Jeffrey Welser, internal vice president and Exploratory Science Lab director, IBM Research – Almaden; vice president, IBM Australia, China, and Japan Labs

We hired the following new staff:

- Gil Cordova, part-time Administrative Officer (MIT)
- Emily Goldman, program manager (MIT)
- Austin Little, AI strategy associate (IBM)

**Aude Oliva**

**MIT Director, Schwarzman College of Computing**

**Anantha Chandrakasan**

**Chair, MIT School of Engineering**