Jameel Clinic for Machine Learning in Health

Jameel Clinic for Machine Learning in Health has a mission to develop artificial intelligence (AI) technologies that will change the landscape of healthcare. This includes early diagnostics, drug discovery, care personalization, and management. Building on MIT's pioneering history in AI and life sciences, we are working on novel algorithms suitable for modeling biological and clinical data across a range of modalities including imaging, text, and genomics. While achieving this goal, we strive to make new discoveries in machine learning, biology, chemistry, and clinical sciences. Our other defining trait: emphasis on translating our discoveries into technologies that can improve people's lives. To realize this mission, we support research and educational activities in the AI/healthcare space and establish collaborations with hospitals, industry partners, and foundations that share our vision.

Fiscal year 2021 began at the peak of the 2020 pandemic. When Covid-19 began to spread worldwide, Jameel Clinic's community of machine learning and life science researchers redirected their work and began exploring how they could collaborate on the search for solutions by tapping into their collective knowledge and expertise. This led to the launch of AI Cures, an initiative dedicated to developing machine learning methods for finding promising antiviral molecules for Covid-19 and other emerging pathogens; and to lower the barrier for people from varied backgrounds to get involved by inviting them to contribute to the effort.

AI Cures

AI Cures is a collection of domain expertise where experts can access datasets, frame machine learning problems, suggest tools to test, and discuss technical challenges. Specifically, AI Cures researchers have access to three SARS-CoV datasets, six datasets related to SARS-CoV-2, and four datasets of drug catalogues and literature. A group of 14 principal investigators (PIs) and 18 students, members of 25 interdisciplinary teams, collectively worked on four main tasks. Three of these are directly related to Covid-19: fighting secondary effects of Covid-19, predicting a target compound's property from its molecular structure, and predicting synergistic effects (properties) of drug combinations (cocktails). The goal of the fourth task was to augment regression models to estimate their own uncertainty or expected error, enabling researchers to identify individual predictions of which they are highly confident.

AI Cures also has an active blog along with a community forum and a list of open tasks that encourages outside participation and open collaboration. These were funded by an award from the Patrick J. McGovern Foundation and by an individual donor.

Several researchers within AI Cures made crucial strides in dealing with the many facets of the pandemic. Highlights include the following:

- Regina Barzilay, AI faculty lead, worked with Tommi Jaakkola—the Thomas Siebel Professor—and other researchers in developing machine-learning models to detect antiviral activity in existing drugs, and their latest paper was a novel neural network architecture that jointly learned drug-target interaction and drug-drug synergy.

- Collin Stultz has been developing a machine learning algorithm, aimed at predicting heart damage inpatients.

- Professor Dimitris Bertsimas, entrepreneurship lead, and his students have been working on several Clinical AI projects to better allocate ventilators and other resources more effectively; his work on pandemics was featured in the *New York Times*, and his mortality calculator was widely used by government agencies both internationally and within the United States.

- Professor Caroline Uhler and her team developed a machine learning–based approach to identify drugs already on the market that could potentially be repurposed to fight Covid-19, particularly in the elderly. The system accounted for changes in gene expression in lung cells caused by both the disease and aging. That combination could allow medical experts to more quickly seek drugs for clinical testing in elderly patients, who tend to experience more severe symptoms.

- Professor Bonnie Berger—the Simons Professor of Mathematics—and her team were able to identify viral protein sequences that could make better vaccine targets. Professor Berger had devised a new way to computationally model viral escape, based on models that were originally developed to analyze language.

- In an article published at *MIT Technology Review*, James Collins, life sciences faculty lead, and his team proved how superspreading events were more important than initially thought. By applying mathematical tools to use extreme events in certain industries, Collins and his team found that the distribution of coronavirus transmissions had a fat tail rather than a tapering one, implying that even though superspreading events were extreme, they were still likely to occur.

International Support

Some of this work could not be completed without the international support of friends and collaborators, especially Community Jameel and their connections alongside Jameel Clinic's international network, as there were a number of data sets from different countries. Among others, there was assistance from the Walter Reed Army Medical Center, where our researchers' in-silico models were tested in a biosafety level 3 (BSL-3). More recently, new member teams from academia, research, healthcare systems (both hospitals and medical schools), and private companies from Argentina, Brazil, Colombia, and Mexico have joined the effort in support of the initiative.

An example of this collaborative work can be found in thermal imaging using noninvasive equipment. This equipment was acquired in the United States and shipped to two hospitals in Monterrey, Mexico. The thermal imaging from these cameras was successfully analyzed to validate noninvasive screening to diagnose Covid-19. The project has been showing promising results and this approach could be used in the future to train models for other diseases.

Conferences

Jameel Clinic hosted two AI Cures conferences in the fall. The Data-driven Clinical Solutions for Covid-19 Conference took place on September 29 and focused on detection,

monitoring, and clinical management. More than 650 people from 50 countries and 70 organizations registered. Participants heard from 15 speakers from a variety of backgrounds, including from clinical, academic, government, and non-governmental organizations, as well as representatives of local and international hospitals and the Centers for Disease Control. The second conference took place on October 30 and focused on drug discovery. The speakers included faculty from MIT and other institutions, as well as representatives from The Defense Advanced Research Projects Agency, the pharmaceutical industry, and venture capital.

Seminar Series

Jameel Clinic programing has continued online in our joint seminar series with the Institute for Medical Engineering and Science. A moderated discussion with Professor Peter Szolovits on natural language processing for information extraction from clinical note was held on October 21; the next event, which featured Professor Rosalind Picard on mental health forecasting, took place on November 17 with collaboration from Professor David Sontag and MIT graduate students.

Collaborations

This fall, Jameel Clinic established a formal collaboration with Sanofi. The aiDM conference, which Sanofi helped sponsor, was a crucial turning point for their decision to join Jameel Clinic. The information from the conference motivated Sanofi to more seriously explore a collaboration with Jameel Clinic. Initial participation agreement funding was significantly increased for new research work with the head of biologic platforms at Sanofi's research and development division. While the initial grants were for one year, there are conversations with Maria Wendt, head of Sanofi biologic platforms, about plans to extend this funding for up to three years.

The Jameel Clinic is also in discussion with a number of other pharmaceutical companies. For example, discussions with Novartis continue following their engagement in a corporate program that launched in July 2020; the contract for the Jameel Clinic corporate program with Novartis is under negotiation, with a final decision pending. There are also discussions with Janssen Pharmaceuticals, and Jameel Clinic has established partnerships with Rethink in Switzerland and Protea in Brazil, with explorations occurring with TecSalud in Mexico, Praesens Foundation in Belgium, and operations in sub-Saharan Africa.

In March 2021, Wellcome Trust Foundation approved a three-year program and $5 million award to Professor Regina Barzilay and her team of collaborators under Jameel Clinic's Data for Science and Health program. Clinical AI technologies promise better clinical care, from risk assessment and diagnostics to personalized treatment and prediction of outcomes. In addition to saving lives, they improve the quality and efficiency of patient care while controlling its costs. To optimize Clinical AI technologies, these powerful tools must be tested in a variety of clinical settings that represent diverse demographics and clinical facilities and with close collaboration between technologists and clinicians. With support from Wellcome Trust, Jameel Clinic is embarking on a research program to implement MIT-developed machine learning tools into real-life clinical experiences within the hospital network.

Specific aims of this engagement are to develop procedures for safe and effective deployment of AI tools in specific clinical contexts, to broadly test AI tools in diverse patient populations to ensure equitable health outcomes, and to refine AI tool development to optimize clinical utility. Use of the technology by clinical collaborators will provide valuable feedback toward improvement of Jameel Clinic research tools, with collaboration between MIT and hospitals fostering that innovation.

Funded Projects

The 18 inaugural-funded teams produced more than 20 papers in different peer-reviewed journals and scientific publications. They presented their work at 24 conferences and other events, including 23 talks and lectures. Their work at Jameel Clinic was also highlighted through various media channels, including 19 videos and podcasts. One donor was so taken by a project that the team was granted an additional $250,000 to pursue its research.

A new request for proposals was announced on January 29, which included opportunities for funding based on lessons learned from the initial funding round. The aim was to continue producing excellent work in the areas of AI, life sciences, and medicine, to foster a strong community committed to growth and impact, and to create longstanding value at MIT and in the world. In this call for proposals, the funding was structured in three broad classes of research projects:

- Life Sciences AI: Development of machine learning algorithms for solving fundamental questions in disease biology

- Therapeutics AI: Development of machine learning algorithms for drug discovery, including molecular modeling, target discovery, and de novo design

- Clinical AI: Development of machine learning algorithms for diagnostics, modeling disease progression, and personalized medicine

Special consideration for projects with a focus on pancreatic, breast, lung, prostate, and liver cancer; cerebrovascular and cardiovascular diseases; and multimodal approaches to AI (electronic health records, genomics, computer vision, natural language processing [NLP]). Any hard-to-treat tropical diseases will be considered as well as projects that promote commercialization and entrepreneurship.

Proposals were submitted electronically by March 8, 2021, and decisions were announced by May 21, 2021. Funding ranged from $100,000 to $150,000, with $300,000 for exceptional cases.

PIs funded through this program are expected to contribute to the development of the Jameel Clinic initiative, including participation in Jameel Clinic events, working to shape the machine learning and health care initiative at MIT, and building the Jameel Clinic community.

Education and Engagement

While the challenges of Covid-19 have shifted our programming to take place online, there has been a continuation of a robust set of activities to further our education and engagement efforts.

Seminar Series

The first seminar in the series—"How to Incorporate Domain Expertise into ML Models in Healthcare"—was held on September 15 and featured John Guttag, David Sontag, students, and the MIT community. The second seminar—"NLP for Information Extraction from Clinical Notes"—was held on October 21 and featured Peter Szolovits. The third seminar—"Mental Health Forecasting"—was held on November 17 and featured Rosalind Picard. Several conferences, classes, partnerships, and community-building activities followed during the next weeks, which built upon what was discussed in the various seminars.

Bootcamps

Two bootcamps that were meant to be in person at the beginning of 2020 were moved online and took place in early summer 2020. These sessions usually involve considerable person-to-person communication, so it was meaningful to be able to offer it successfully on Zoom. There were over 40 attendees per session for the foundations of machine learning for big data and text processing. The next sessions on AI and machine learning foundations took place during the last week of January 2021.

Online Course

An online course organized by Jameel Clinic, Sloan Executive Education, and MGH clinicians on artificial intelligence in health care was launched in August 2020. More than 750 students enrolled in the initial three editions—more than for comparable programs. The goal is to offer four to five sessions per year where participants pay an enrollment fee.

Leadership

Entrepreneurship

Dimitris Bertsimas, the Boeing Leaders for Global Operations Professor of Management, joined Jameel Clinic as a faculty co-lead and is focusing on its entrepreneurship efforts. He will support one of Jameel Clinic's central goals of introducing AI and machine learning algorithms into direct application in clinical care or indirectly through their use in the development of diagnostics and therapeutics.

In this role, Bertsimas supervises Luis Soenksen, the first Jameel Clinic venture builder, who is focused on projects at the intersection of artificial intelligence and health care. A team led by Bertsimas—which includes Soenksen, Ignacio Fuentes, and a group of PhD students from the Operations Research Center—are exploring a new Clinical AI care paradigm with Hartford Hospital.

The Audacious Project

Housed at TED and supported by leading social impact advisor the Bridgespan Group, the Audacious Project is a collaborative funding initiative that catalyzes social impact on a grand scale by convening funders and social entrepreneurs with the goal of supporting bold solutions to the world's most urgent challenges. Jim Collins and a team at Jameel Clinic, including co-principal investigator Regina Barzilay, were selected as one of this year's change-makers. Their Antibiotics-AI Project seeks to produce the first new classes of antibiotics society has seen in three decades by calling in an interdisciplinary team of

world-class bioengineers, microbiologists, computer scientists, and chemists. Over the next seven years, the Audacious Project's commitment will support Collins and Barzilay as they continue to use the same process to rapidly explore over a billion molecules to identify and design novel antibiotics.

Squirrel AI Award for Artificial Intelligence for the Benefit of Humanity

The Association for the Advancement of Artificial Intelligence (AAAI), the world's largest AI society, announced Regina Barzilay as the award's first recipient for her work developing machine learning models to develop antibiotics and other drugs and to detect and diagnose breast cancer at early stages. In February, AAAI officially presented Barzilay with the award, which comes with an associated prize of one million dollars provided by the online education company Squirrel AI.

Inaugural School of Engineering Distinguished Professor for Artificial Intelligence and Health

In January 2021, Professor Barzilay was appointed the inaugural School of Engineering Distinguished Professor for Artificial Intelligence and Health. Recognizing an outstanding senior faculty member, the inaugural professorship honored Barzilay's exceptional leadership and accomplishments. She is a principal investigator at the Computer Science and Artificial Intelligence Laboratory, a member of the Institute for Medical Engineering and Science, a member of Koch Institute for Integrative Cancer Research, AI faculty lead for the Abdul Latif Jameel Clinic for Machine Learning in Health, and educational lead for the new MIT-Takeda Program.

Communications

There have been several rebranding and communications strategies implemented to better publicize and highlight the work of the Jameel Clinic. Highlights include the following:

- Launch of the AI Cures website

- Launch of the Jameel Clinic - AI & Health YouTube channel

- Increased presence on both LinkedIn (3,131 followers) and Twitter (1,707 followers)

- Publication of 20 blog posts and 34 videos on both AI Cures and the Jameel Clinic website; both sites counted more than 26,000 visitors in only three months

- Increased engagement around the new Jameel Clinic logo

- An article on the identification of Halicin, a powerful new antibiotic compound, made it into the 2020 top 10 list of most viewed articles on MIT News

Gratitude is offered to Community Jameel for extending their considerable reach and connections to these and other communication efforts. This includes leveraging conferences with senior leaders to secure media coverage and partnering with publications for larger, more in-depth articles, including coverage of the Jameel Clinic's two-year anniversary.

Ignacio Fuentes Ribas
Executive Director