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Harnessing the Power of Artificial Intelligence with Mathematics

Artificial intelligence (AI)—and the mathematics that supports it—are developing at an extraordinary pace. Given the transformative power of AI and potential impact on all sectors of the U.S. economy, we urge Congress to pass legislation to **harness the power of AI fully** and **ensure that AI is used responsibly. Effective legislation will increase research investments and build a stronger AI workforce.**

We urge Congress to advance fundamental research that will drive AI innovation by supporting robust and sustained appropriations to the National Science Foundation.

Math Advances AI. The theoretical bases for AI lie in mathematics, and the National Science Foundation (NSF) is the source of more than 70% of federal funding for fundamental research in the mathematical sciences.

> "AI is not magic; it's just mathematics."
> — *Towards Data Science*

As just one illustration of "Math Advancing AI," consider an AI trained to recognize digits. This AI might have trouble with the numbers in a speed-limit sign, reading "35" as "85" with potentially dangerous results. Understanding when an AI trained in one context can reliably function in a new context is a fundamentally mathematical problem. This requires not only that we make an AI work but that we understand something about *how* it works.

Throughout history, mathematics has provided methods of improving "brute force" solutions, enabling technology to work smarter instead of harder. At the moment, many challenges in AI are addressed by deploying huge amounts of computational resources at a problem, trying many different approaches until an effective one is found. Mathematics enables optimal data architectures, more efficient algorithms, improved performance and reliability, and explainable decisions. In short, deeper mathematical understanding will enable AI development of the future to make the most effective choice first instead of eventually by chance.

AI Also Advances Math. New fundamental results in mathematics have been discovered with the assistance of machine learning. This subfield of AI is the process by which a machine learns from examples and thereby develops its intelligence, demonstrating that AI can help mathematicians discover new conjectures and theorems, and more generally, that machines and humans can be genuine collaborators. It's becoming clear that AI, rather than replacing human scientific ingenuity, has the potential to enhance it in ways we are only beginning to understand.[1,2]

For example, AI has contributed to solving important mathematical problems of imaging, such as denoising, edge detection, and inpainting. AI-driven systems already help mathematicians analyze the behavior of partial differential equations, which can model physical processes from ocean currents to nuclear explosions. In addition to discoveries with immediate real-world applications, AI has been used successfully to solve theoretical mathematical problems. As history has shown, this kind of development can be tremendously impactful in science and engineering, not just now but 10 or 100 years from now.

Congress can support AI education and workforce training by

- creating incentives for AI experts to teach and for universities to offer effective AI curricula with strong foundations in the mathematical sciences;
- co-sponsoring the bipartisan Mathematical and Statistical Modeling Education Act (H.R. 3588, S. 1839), which would improve STEM education by supporting mathematical modeling in K–12 education;
- becoming an original co-sponsor of the Data Science and Literacy Act, which would ensure access to data science, data literacy, and statistics education for K–16 students and professional development for their teachers.

The AI Workforce and Challenges to the AI Innovation Ecosystem. There is a significant need for AI experts to teach at the university level and for the inclusion of foundational AI concepts in K–12 education. According to a report recently released by the Center for Security and Emerging Technologies,[3] "Despite its wide-ranging repercussions, the lack of AI-teaching capacity at U.S. universities has received relatively little attention from policymakers and analysts." The last decade has seen a brain-drain of AI researchers from universities and into industry; with this, we see a shift away from cutting-edge science that is federally funded and non-commercial.[4]

We urge Congress to pass legislation ensuring that AI systems be transparent, traceable, and designed to improve fairness and accountability.

Responsible AI. The prospect of irresponsible uses of AI extends across policy areas:

- AI is used by the transportation and logistics industry to improve cargo flow and supply chain management. In an age where customers expect fast deliveries, segments of the population can be given higher or lower priority for receiving important items like prescription drugs.

> "Artificial intelligence is currently leading to one breakthrough after the other, both in public life with, for instance, autonomous driving and speech recognition, and in the sciences in areas such as medical diagnostics or molecular dynamics."
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> —Gitta Kutyniok, *International Congress of Mathematicians, 2022*

- Many employers use algorithmic screening to hire quality candidates more efficiently and address human biases, but AI tools can entrench biased traits of a "good employee."

Mathematicians can inform the development of algorithms that permit the inclusion of ethical constraints, rather than trying to account for and mitigate ethical problems—including algorithmic bias—after the fact.

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1 www.nature.com/articles/s41586-021-04086-x

2 An example is explained in this Nature article about how AI and humans worked together to solve a problem in mathematical "knot theory": www.nature.com/articles/d41586-021-03593-1

3 cset.georgetown.edu/publication/ai-faculty-shortages/

4 hai.stanford.edu/sites/default/files/2021-10/HAI_NRCR_2021_0.pdf

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