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Harnessing the Power of Artificial Intelligence with Mathematics

Artificial intelligence (AI)—and the mathematics that support it—is developing at an extraordinary pace. Given the transformative power of AI and its potential impact on all sectors of the US economy, we urge Congress to pass legislation to **A) drive AI innovation, B) support AI education and workforce training, and C) ensure that AI is used responsibly.**

A. We urge Congress to drive AI innovation by supporting robust and sustained appropriations to the National Science Foundation (NSF).

Math Advances AI. The theoretical bases for AI lie in mathematics, and the NSF is the largest single source of federal funding for mathematical sciences research on college and university campuses.

“AI is not magic; it’s just
mathematics”

— *Towards Data Science*

Throughout history, mathematics has improved “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.

As just one illustration of mathematics advancing AI, consider an AI trained to recognize digits. This AI might have trouble with the numbers on 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 and can refine *how* it works.



AI Also Advances Math. New results in mathematics have been discovered with the assistance of machine learning. This subfield of AI demonstrates that machines and humans can be genuine collaborators. It’s becoming clear that AI, rather than replacing human ingenuity, has the potential to enhance it in ways we are only beginning to understand.^{1,2}

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 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.

B. We urge Congress to support AI education and workforce training by

- **creating incentives for AI experts to teach;**
- **creating incentives for universities to offer effective AI curricula with strong foundations in the mathematical sciences;**
- **cosponsoring the bipartisan Mathematical and Statistical Modeling Education Act** (H.R. 1735, S. 2739), to improve science, technology, engineering, and math (STEM) education by supporting mathematical modeling in K–12 education.

Challenges to the AI Innovation Ecosystem. There is 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 US universities has received relatively little attention from policymakers and analysts.” The last decade has seen a brain-drain of AI researchers from universities into industry; with this, there is a shift away from essential exploratory science that is federally funded and noncommercial.⁴

C. 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.

- Bias in AI used by the transportation and logistics industry to improve cargo flow and supply chain management could mean segments of the population receive higher or lower priority when shipping important items like prescription drugs.
- 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 algorithms that permit the inclusion of ethical constraints, rather than trying to account for and mitigate ethical problems—including algorithmic bias—after the fact.

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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