AI RFI Responses, October 26, 2018

Update to the 2016 National Artificial Intelligence Research and Development Strategic Plan RFI Responses

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Society for Industrial and Applied Mathematics Response to the National Artificial Intelligence Research and Development Strategic Plan

The Society for Industrial and Applied Mathematics (SIAM) offers the below response to the Request for Information from the Networking and Informational Technology Research and Development (NITRD) National Coordination Office (NCO) seeking input on potential updates to the *National Artificial Intelligence Research and Development Strategic Plan*. SIAM is an international community of over 14,000 members from academia, industry, and government. Members come from many different disciplines, but all have a common interest in applying mathematics and computational science towards solving real world problems.

SIAM is grateful for the opportunity to offer comments as NITRD NCO prepares to update the current strategic plan. Federal investment in applied mathematics and computational science is important to advancing research and development (R&D) in artificial intelligence (AI) as these fields underpin the mechanisms by which machines can independently learn and make decisions. Continued advancements in both fundamental mathematics, as well as research translating this into faster, more scalable, and more efficient algorithms, is crucial to: training machine learning models from large and heterogeneous data sets; and assessing and improving accuracy of predictions and data-driven decisions. These capabilities form the core characteristics of AI.

SIAM finds the overall strategies in the 2016 plan to be appropriate, and urges the next plan to continue its focus on long term research, collaboration, ethical and societal issues, safety and security, data sharing, evaluation, and workforce issues. Below are specific thoughts and recommendations on individual strategies.

SIAM appreciates that *Strategy 1: Make Long-Term Investments in AI Research* recognizes the importance of forward-looking research investments across topic areas such as data-focused methodologies, perceptual capabilities, theoretical guarantees and limitations, and scalability. *Strategy 1* rightly points out that "long-term sustained investments in high-risk research can lead to high-reward payoffs." SIAM strongly agrees, and in keeping with that premise, we contend that an updated plan should recognize that sustained federal investment in applied mathematics is required to overcome persistent challenges, such as interpretability of predictions and quantification of uncertainty (i.e., risk assessment), across all of the aforementioned topic areas. Research in numerical optimization, matrix computations, and numerical analysis is particularly crucial to meeting these objectives, as advances in these areas will lead to robust and efficient AI systems that: reveal patterns and exploitable low-dimensional structures in high-dimensional data; yield actionable insights into complex

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social and scientific systems; and produce accurate predictions with qualified uncertainty.

SIAM also agrees with *Strategy 1's* emphasis on data-driven discovery. We concur that, "Further progress is needed in the development of more advanced machine learning algorithms that can identify all the useful information hidden in big data." The explosion in data available to scientists from advances in experimental equipment, simulation techniques, and computer power is well known, but commercial big data solutions developed at companies like Google and Facebook cannot readily be applied to scientific data. The Department of Energy (DOE) Office of Advanced Scientific Computing Research (ASCR), in particular, has recognized and begun to address this challenge. In January 2018, ASCR hosted a workshop that convened experts from DOE and several other federal agencies to explore ways in which basic research can generate machine learning-based solutions for meeting science and energy research needs. While the aim of the workshop was specific to the DOE mission, the multiagency approach ASCR employed exemplifies the way in which the Administration can foster interagency and cross-sectoral collaborations in AI R&D. One interagency example that is indicative of the importance of mathematical approaches to biomedical data, specifically, is the joint effort between the National Science Foundation (NSF) Division of Mathematical Sciences (DMS) and the National Institutes of Health (NIH) National Library of Medicine (NLM). The DMS-NLM partnership encourages generalizable data science for biomedical research, offering another demonstration of how agencies can collaboratively focus on the underlying mathematical challenges in AI.

SIAM also appreciates the inclusion of *Strategy 2: Develop Effective Methods for Human-AI Collaboration*, which recognizes the need to overcome major research challenges in human awareness, visualization, AI-human interfaces, and language processing. Similar to *Strategy 1*, investment in applied mathematics and computational science can help mitigate these challenges through efficient and scalable algorithms, interpretable predictions, and theoretical guarantees and limitations. Additionally, it is important to note that advances in machine learning are contingent upon a multidisciplinary approach that also engages researchers in statistics and computer science, as well as the domain-specific disciplines that use AI systems. It will be necessary to build bridges across varying scientific fields in order to recognize and address common and disparate mathematical elements inherent to algorithmic and computer-aided decision-making.

Research in applied mathematics and computational science is also important to implementing *Strategy 4: Ensure the Safety and Security of AI Systems*. Assurances that AI based systems will operate safely, securely, and in a controlled manner are built on rigorous understanding of the underlying mathematics and provable properties of those systems. An AI-based computer vision algorithm used for assisted driving, for example, is more dependable when its ability to distinguish between cars and buildings is built on provable mathematics rather than the limited conditions encountered in its design. To

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provide for the safety and security of future AI systems, continued advancement in foundation and applied mathematics is necessary.

Finally, as an organization representing thousands of researchers and educators from hundreds of academic institutions, SIAM is well aware of the AI R&D workforce challenges facing the nation. The potential limitations posed by workforce shortages could significantly constrain our ability to maintain our leadership in AI amid an international environment that is growing increasingly competitive. Federal science agencies have a critical role to play in sustaining the vitality of AI R&D in the U.S. through their support of research and education programs. As the Administration considers ways in which to implement *Strategy 7: Better Understand the National AI R&D Workforce Needs*, SIAM recommends that the updated strategic plan build support for programs like NSF's *NSF Research Traineeships (NRT), Graduate Research Fellowships (GRF)*, and *CAREER* awards and DOE's *Computational Science Graduate Fellowship* program. These programs are crucial to the training and professional development of the next generation of the mathematical researchers and computational scientists who will underpin U.S. competitiveness in AI in future decades.

Undergraduate curricula are critically important to ensuring American preeminence in AI through education in the mathematical foundations of machine learning. SIAM recommends that the updated strategic plan commit to supporting the integration of data science and modeling, specifically, into other undergraduate STEM coursework in order to improve students' familiarity with these subjects as they seek to successfully enter the AI workforce and shape its future directions. Concrete suggestions for integrating mathematical education across subjects and grade levels, including undergraduate programs, can be found in two reports entitled *Modeling across the Curriculum*, which reflect workshops SIAM held in conjunction with NSF in 2012 and 2014.[1]

[1] https://www.siam.org/Publications/Reports/Detail/modeling-across-the-curriculum