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General Comment

This response reflects Duke University's strategic insights and experiences in advancing cutting-edge AI research, particularly in AI hardware and infrastructure, interdisciplinary science, and education. The goal is to offer actionable recommendations that can guide national investments and policy development in AI research and innovation for the public good.

Attachments

Duke_AI_RFI_Response_2025

Response to the Request for Information on the Development of the 2025 National Artificial Intelligence (AI) Research and Development Strategic Plan

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Date: May 28, 2025

Introduction

This response reflects Duke University's strategic insights and experiences in advancing cutting-edge AI research, particularly in AI hardware and infrastructure, interdisciplinary science, and education. The goal is to offer actionable recommendations that can guide national investments and policy development in AI research and innovation for the public good.

1. Advancing Next-Generation AI Hardware and Infrastructure

Recent breakthroughs in AI, particularly those driven by large models and generative AI (GenAI) technologies, have been enabled by massive increases in computing resources—a trend commonly referred to as the "scaling law." Dominant models, such as deep neural networks (DNNs), which rely on hierarchical feature representations and dense interconnections, are primarily trained and deployed on GPUs and other specialized AI accelerators. However, it is increasingly acknowledged that this scaling-driven approach is reaching its limits, and a fundamental transformation of the AI computing paradigm is both necessary and imminent.

The continued advancement in the performance and versatility of AI systems will depend on transformative innovations in both model architectures and computing hardware. For instance, the long-standing criticism of deep neural networks (DNNs) for their lack of interpretability may be addressed through progress in neurosymbolic approaches. These modern techniques integrate the flexibility and performance of DNNs and other mainstream models with the inherent explainability of symbolic AI, offering a promising path toward compact, interpretable AI designs that could eventually replace today's expensive foundational models.

The innovations in next-generation AI models will be closely mirrored in the design of AI computing hardware, which aims to execute these models both effectively and efficiently. For instance, the shift toward symbolic representations in AI will introduce the concept of "primitives" in hardware design: minimal, interpretable components aligned with interpretable algorithmic functions. Correspondingly, hardware design methodologies will evolve into interpretable workflows that automate the construction of complex systems using these primitives. Each intermediate component will also carry neurosymbolic meaning.

Future AI systems will encompass not only advanced computing capabilities but also the ability to sense, interact with, and adapt to the physical world. These systems, collectively referred to as *Embodied AI*, will shape the future of autonomy across various domains, including robotics, manufacturing, healthcare, defense, and space exploration. To operate effectively and safely, they will require novel approaches to continual learning, real-time perception, and adaptive control, all of which must be inherently interpretable to meet safety, transparency, and regulatory requirements.

Federal investments should prioritize end-to-end co-design of the interpretable AI algorithms and hardware, alongside shared infrastructure for benchmarking and validation. Since such design methodologies are not a primary focus in industrial practice and are not immediately aligned with the priorities of commercial products (e.g., computing throughput), relevant research has long been underexplored in industry. We also recommend expanding support for simulation environments to accelerate the design and testing of embodied AI systems. Additionally, resources such as cloud computing credits and managed services should be made available to under-resourced institutions. Mechanisms to strengthen industry-academic collaborations are essential to enabling efficient research, real-world validation, and scalable deployment. These efforts will drive innovation in collaborative robotics and intelligent infrastructure from an underexplored angle that complements the existing industrial practices, thereby significantly enhancing U.S. competitiveness and economic resilience in the long run.

2. AI for Scientific Discovery and Technological Breakthroughs

AI has emerged as a powerful enabler for accelerating discoveries across diverse fields, spanning genomics, drug development, quantum mechanics, materials discovery, and materials synthesis. Foundational models trained on scientific data automate hypothesis generation, uncover previously unknown phenomena, and optimize complex experimental processes. More recently, AI agent technologies, which refer to autonomous systems capable of learning, adapting, and taking goal-directed actions, have begun to play an increasingly active role in scientific research. These agents can learn very efficiently from millions of technical papers and provide insightful suggestions, functioning as research assistants or even collaborative partners in the research discussions.

We recommend that the U.S. invest in foundational AI models designed to serve as proactive assistants or collaborative partners in scientific research. These models should be tailored to specific scientific domains, with the capacity to continually learn from a broad and evolving body of scientific knowledge and to generate creative, constructive contributions, or even autonomously conduct and guide research processes. Such capabilities will significantly enhance research productivity, help address the declining number of domestic students entering STEM fields, and improve the quality of researcher training and development.

We also recommend investing in the development of self-improving scientific AI agents and autonomous laboratories. These efforts will enhance researchers' access to advanced research facilities and enable the generation of high-quality, interoperable datasets that benefit the broader scientific community. In particular, establishing pilot AI-automated research laboratories in academia will provide essential experience in developing relevant technologies and translating them into scalable industrial applications. Moreover, the operation of such intelligent, autonomous labs will yield valuable insights to further refine and upgrade the AI agents—an essential step for maintaining U.S. leadership in global innovation.

3. AI Systems and Education to Empower American Workers

AI is reshaping the labor market, making strategic investments in education and systems that augment human capabilities more essential than ever. With rapid advances in foundational models and AI agents, workforce education must shift from a focus on acquiring static skills to fostering lifelong learning and adaptive problem-solving. We recommend federally funded initiatives to integrate AI into undergraduate and graduate curricula across all disciplines from the outset. These efforts should include the development of tailored curricula, AI-powered education tools (e.g., AI copilots for coding training), and robust technical support to empower faculty and students to engage with AI effectively and responsibly. Additionally, reskilling programs in partnership with community colleges and technical institutions will broaden access to high-growth AI-related careers and promote economic mobility.

Conclusion

Through strategic investment in advanced AI computing systems, scientific AI agents, and AI-driven workforce development, the United States can lead the way in building an inclusive, secure, and future-oriented AI innovation ecosystem. Duke University is committed to partnering with national stakeholders to help realize this vision and accelerate AI research and innovation for the benefit of society.

Statement of Submission

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