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Updated October 24, 2017

Overview of Artificial Intelligence

The use of artificial intelligence (AI) is growing across a wide range of sectors. Stakeholders and policymakers have called for careful consideration of strategies to influence its growth, reap predicted benefits, and mitigate potential risks. This document provides an overview of AI technologies and applications, recent private and public sector activities, and selected issues of interest to Congress.

AI Technologies and Applications

Though definitions vary, AI can generally be thought of as computerized systems that work and react in ways commonly thought to require intelligence, such as solving complex problems in real-world situations. According to the Association for the Advancement of Artificial Intelligence (AAAI), researchers broadly seek to understand "the mechanisms underlying thought and intelligent behavior and their embodiment in machines."

The field of AI encompasses many methodologies and areas of emphasis, such as machine learning (ML), deep learning, neural networks, robotics, machine/computer vision (image processing), and natural language processing. Advances in these areas, in information processing and hardware technology generally, and in the availability of large-scale data sets, have all contributed to recent progress in AI.

Applications of AI are found in everyday technologies, such as video games, web searching, spam filtering, and voice recognition (e.g., Apple's Siri). Notable AI systems have beaten human champions of games like chess, Go, and *Jeopardy!*. More broadly, AI has applications across a variety of sectors, including the following examples:

- Transportation—self-driving cars, adaptive traffic management to reduce wait times and emissions;
- Health care—diagnostics and targeted treatments;
- Education—digital tutors;
- Agriculture—soil moisture monitoring and targeted crop watering;
- Finance—early detection of unusual market manipulation and anomalous trading;
- Law—machine analysis of law case history;
- Manufacturing—automated delivery, improved worker safety and productivity via machine-human teaming;
- Cybersecurity—autonomous detection and decisionmaking to improve reaction times to threats;
- Defense—autonomous and semi-autonomous weapons systems;
- Space exploration—spacecraft and rover autonomy; and
- "AI for the social good"—using AI to address widespread societal challenges, e.g., to monitor wildlife populations, target anti-poaching efforts, and identify intervention zones for poverty reduction efforts.

Currently, AI technologies are highly tailored to particular applications or tasks, known as narrow (or weak) AI. In contrast, general (or strong) AI refers to intelligent behavior across a range of cognitive tasks, a capability which is unlikely to occur for decades, according to most analysts. Some researchers also use the term "augmented intelligence" to capture AI's various applications in physical and connected systems, such as robotics and the Internet of Things, and to focus on using AI technologies to enhance human activities rather than to replace them.

In describing the course of AI development, the Defense Advanced Research Projects Agency (DARPA) has identified three "waves." The first wave focused on handcrafted knowledge that allowed for system-enabled reasoning in limited situations, though lacking the ability to learn or address uncertainty, as with many rule-based systems from the 1980s. The second wave, from approximately the 2000s to the present, has focused on advances in neural networks and machine learning (e.g., image recognition, language translation) using statistical models and big data sets. The third wave will focus on contextual adaptation—learning and reasoning as the system encounters new tasks—moving towards general AI.

Among researchers and developers, the outlook on AI development and application across sectors is widely optimistic, though challenges exist. Such challenges are both technical (e.g., availability of datasets to train AI systems, and understanding and removing biases from AI-based decisions) and societal (e.g., addressing potential workforce shifts, privacy, security, and ethical use).

Private Sector Activity

In recent years, the private sector has been increasing research and development (R&D) investments and hiring in AI, particularly at large technology companies such as Amazon, Facebook, Google, IBM, and Microsoft. Large companies are also acquiring AI startups and launching venture funds to support startups. These and other technology companies, along with the AAAI—a nonprofit scientific society—have formed the Partnership on AI, which aims to create best practices, educate the public, and serve as a platform for discussing AI technologies and societal impacts.

Automotive and ride-sharing companies, such as Toyota and Uber, have also announced large investments in AI research, as well as partnerships with university scientists and engineers. For example, the Toyota Research Institute includes experts from Stanford's AI Laboratory and Massachusetts Institute of Technology's Computer Science and AI Laboratory.

Federal Activity

In 2016, the National Science and Technology Council (NSTC) formed the Subcommittee on Machine Learning and Artificial Intelligence (MLAI) to help coordinate federal efforts and the development of federal R&D priorities in AI. The MLAI and Networking and Information Technology Research and Development (NITRD) subcommittees, and a team from the Executive Office of the President, released three reports on AI:

- *Preparing for the Future of Artificial Intelligence*
- *National Artificial Intelligence R&D Strategic Plan*
- *Artificial Intelligence, Automation, and the Economy*

These reports built on four workshops held across the country by the Office of Science and Technology Policy. The workshops focused on aspects of AI including social good; safety and control; legal and governance implications; and near-term social and economic implications of related technologies.

According to the *National AI R&D Strategic Plan* report, U.S. government investments in unclassified R&D in AI-related technologies in 2015 totaled approximately $1.1 billion. Some federal agencies have long-standing programs conducting and supporting AI-related R&D, such as DARPA, the National Science Foundation, and U.S. Navy.

The Senate Subcommittee on Space, Science, and Competitiveness held a broad overview hearing on the state of AI, entitled "The Dawn of Artificial Intelligence," on November 30, 2016. Additional Senate and House committee hearings have included aspects or applications of AI, including the following examples:

- "The Promises and Perils of Emerging Technologies for Cybersecurity," Senate Committee on Commerce, Science, and Transportation, March 22, 2017
- "Self-Driving Cars: Levels of Automation," House Committee on Energy and Commerce, March 21, 2017
- "The Transformative Impact of Robots and Automation," Joint Economic Committee, May 25, 2016
- "Worldwide Threat Assessment of the US Intelligence Community," Senate Select Committee on Intelligence, February 9, 2016.

Additionally, the Congressional Artificial Intelligence Caucus, founded in 2015, has been active in the 115th Congress, including organizing congressional briefings.

Legislation from the 115th Congress has mentioned AI or ML as part of a focus on multiple topics, such as computer science education, workforce training, data sharing between public and private sectors, defense and national security.

Issues and Policy Considerations

Though debates over AI may vary by sector, overarching considerations for ongoing federal engagement include crafting a balance in policies and regulations that mitigate social and ethical risks of new technologies while providing an environment that allows for, and potentially actively supports, AI without hindering innovation.

Those who support wider development and use of AI technologies assert that increased federal and private sector research, investments, and collaboration can provide economic and societal benefits widely if well considered. Concerns about AI advances include questions of reliability and accountability for autonomous decisionmaking; ethical use (particularly in defense and law enforcement settings); privacy; and equitable sharing of AI benefits.

Research and Development. Should Congress wish to augment federal AI R&D support, options could include direct funding for basic research at federal agencies and in the private sector, especially for research unlikely to be supported by industry; increased sharing of federal datasets to private sector developers for AI training and development; and prize competitions or tax incentives for commercial R&D efforts. For example, grand challenges—such as those held by DARPA to build autonomous vehicles capable of navigating complex courses—could help set ambitious goals for R&D teams to advance foundational technologies.

Public-private partnerships could also help leverage private sector data and funds to support R&D of AI technologies. To cite one example, the Smart Manufacturing Innovation Institute—a partnership between the nonprofit Smart Manufacturing Leadership Coalition and the Department of Energy—plans to invest over $140 million to develop advanced manufacturing technologies such as smart sensors and to support workforce and education activities.

Workforce and the Economy. Federal access to expertise has been a concern in AI and related fields such as cybersecurity. Public and private stakeholders have noted a need for more technical expertise in government. Should Congress wish to expand an AI-knowledgeable federal workforce, options could include direct hiring authorities or contractual agreements with the private sector. Further, Congress may consider efforts to grow the talent pool in AI through education programs focused on AI, or the expansion of scholarship-for-service programs to both support education and bring new talent into federal service.

In the private sector, some analysts have predicted that AI advances may have disproportionate impacts on low-wage workers, causing job losses from AI-enhanced automation. On the other hand, AI is predicted to create new types of jobs. One way to help address workforce shifts could be through retraining displaced workers, either through private sector initiatives or federal programs or incentives.

Coordination. Given the range of applications across sectors, interagency coordination will likely be an important mechanism for ongoing federal efforts in AI, including consideration of adaptive regulatory approaches to allow for rapid technology advancements. Coordination could be assigned to the NITRD and MLAI subcommittees, or Congress or the Administration could create a new interagency mechanism, possibly with nonfederal members.

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IF10608

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