Artificial Intelligence Exploration

All next campaign

DARPA

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Sciences & technologies

Advances in technology have shifted the roles of humans and machines in conflict from direct human-to-human confrontations to machine-mediated engagements. Humans originally engaged in primitive forms of combat.

With the advent of the industrial age, however, humans recognized that machines could greatly improve their fighting abilities. Networks then enabled teleoperation, which eventually proved vulnerable to electronic attacks and subject to constraints due to long distances and signal propagation times. The next stage of warfare will involve more capable autonomous systems, but before we can allow such machines to complement human combatants, they must achieve much higher levels of intelligence.

Traditionally, we have designed machines to handle well-defined tasks at high volume or high speed, freeing humans to focus on increasingly complex problems. In the 1950s and 1960s, early computers automated tedious or laborious tasks. It was at this time that scientists realized that it was possible to simulate human intelligence and the field of artificial intelligence (AI) was born. AI would enable computers to solve problems and perform functions that would normally require a human intellect.

Early AI work focused on craft knowledge, and computer scientists developed so-called expert systems that capture the specialized knowledge of experts in rules that the system could then apply to interesting situations. These "first wave" AI technologies have been very successful - the tax preparation software is a good example of an expert system.These "first wave" AI technologies have been very successful - tax preparation software is a good example of an expert system - but the need to develop home-made rules is costly and time-consuming and therefore limits the applicability of rules-based AI.

In recent years, there has been an explosion of interest in a sub-area of AI machine learning that applies rules-based metadata.statistical and probabilistic methods to large datasets to create generalized representations that can be applied to future samples. At

the forefront of these approaches are deep learning (artificial) neural networks that can be trained to perform a variety of classification and prediction tasks when adequate historical data are available. But herein lies the problem, as the collection, labeling and control of the data on which to train these "second wave" AI techniques is prohibitively expensive and time-consuming.

DARPA envisions a future in which machines are not just tools that execute human-programmed rules or generalize from human-processed datasets. Rather, the machines envisioned by DARPA will function more like colleagues than tools. To this end, DARPA's research and development in the field of human-machine symbiosis has set itself the goal of associating itself with machines. Enabling computer systems in this way is of crucial importance because sensor, information and communication systems generate data at speeds beyond which humans can assimilate, understand and act. The integration of these technologies into military systems that work with combatants will facilitate better decision-making in complex, time-critical battlefield environments and will allow for a more complete understanding of the situation.hension of massive, incomplete and contradictory information and will enable unmanned systems to accomplish critical missions safely and with a high degree of autonomy. DARPA is focusing its investments on a third wave of artificial intelligence that produces machines that understand and reason in context.

Next campaign

For more than five decades, DARPA has been a leader in groundbreaking research and development (R&D) that has facilitated the advancement and application of rules-based AI and statistical learning technologies. Today, DARPA continues to lead the way in AI research innovation by funding a wide range of R&D programs, from basic research to advanced technology development. DARPA believes that this future, where systems are able to acquire new knowledge through generative contextual and explanatory models, will be realized through the development and application of "third wave" AI technologies.

In September 2018, DARPA announced a multi-year investment of more than $2 billion in new and existing programs called "AI Next". Key areas of the campaign include automating critical DoD business processes, such as security clearance screening or accreditation of software systems for operational deployment, improving the robustness and reliability of AI systems, and improving the quality of AI systems.The campaign includes automating critical DoD business processes such as security clearance control or accreditation of software systems for operational deployment, improving the robustness and reliability of AI systems, improving the security and resilience of machine learning and AI technologies, reducing inefficiencies in power, data and performance, and developing next-generation AI algorithms and applications, such as "understandability" and common sense reasoning.

AI Next builds on DARPA's five decades of building AI technology to define and shape the future, always keeping in mind the Department's most challenging problems. As a result, DARPA will create powerful capabilities for the DoD by specifically addressing the following areas:

New **capabilities**: AI technologies are routinely applied to enable DARPA's R&D projects, including over 60 existing programs such as the Electronic Resurgence Initiative and other programs related to real-time analysis.These include the Electronic Resurgence Initiative and other programs related to real-time analysis of complex cyber attacks, fraudulent image detection, building dynamic chains of destruction for all-field warfare, human language technologies, multi-modal automatic target recognition, biomedical

advances and prosthetic limb control. DARPA will advance AI technologies to enable the automation of the Department's critical business processes. One such process is the extended accreditation of software systems prior to their operational deployment. Automation of this accreditation process using known AIs and other technologies now appears feasible.

Robust AI: AI **technologies** have demonstrated great value for missions as diverse as space imagery analysis, cyber attack warning, supply chain logistics and microbiological systems analysis. At the same time, the failure modes of AI technologies are poorly understood. DARPA strives to bridge this gap through targeted R&D, both analytical and empirical. The success of DARPA is critical to the Department's ability to deploy AI technologies, particularly for tactical advantage, where reliable performance is required.

Adversarial AI: The most powerful **AI tool** today is machine learning (ML). ML systems can easily be fooled by input changes that would never fool a human. The data used to train such systems can be corrupted. In addition, the software itself is vulnerable to cyber attacks. These and other areas need to be addressed at scale as more AI-based systems are deployed operationally.

High-performance AI: The increase in computer performance over the past decade has enabled the success of machine learning in combination with large datasets and software libraries. Improving low-power performance is essential to enable data center and tactical deployments. DARPA has demonstrated analog processing of AI algorithms with 1000x acceleration and 1000x power efficiency over advanced digital processors, and is currently investigating AI-specific hardware designs. DARPA is also addressing current inefficiencies in machine learning by investigating methods to significantly reduce the requirements for labeled training data.

Next-generation AI: The machine learning **algorithms** that enable facial recognition and automatic vehicle driving were invented more than 20 years ago. DARPA has taken the lead in cutting-edge research to develop the next generation of AI algorithms, which will transform computers from tools to problem-solving partners. DARPA's research is aimed at enabling AI systems to explain their actions, acquire and reason with common sense. DARPA R&D has produced early AI successes, such as expert systems and research, and more recently has advanced machine learning tools and equipment. DARPA is creating the next wave of AI technologies that will enable the United States to maintain its technological lead in this critical area.

In addition to DARPA's new and existing research, a key component of the campaign will be DARPA's Artificial Intelligence Exploration Program (AIE), which was announced in July 2018. The AIE is a series of high-risk, high-return projects where researchers will work to establish the feasibility of new AI concepts within 18 months of the award. The use of streamlined procurement procedures and funding mechanisms will improve the efficiency of the contracting process and funding mechanisms.

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