

Special Notice

**Future Artificial Intelligence Exploration Opportunity: Tensors
for Reprogrammable Intelligent Array Demonstrations (TRIAD)**

DARPA-SN-21-19

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Defense Advanced Research Projects Agency

Strategic Technology Office

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SPECIAL NOTICE DARPA-SN-21-19

Tensors for Reconfigurable Intelligent Array Demonstrations (TRIAD)

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Background

The purpose of this Special Notice (SN) is to provide public notification of additional research areas of interest to the Defense Advanced Research Projects Agency (DARPA), specifically the Artificial Intelligence Exploration (AIE) program. The mission of the Defense Advanced Research Projects Agency (DARPA) is to make strategic, early investments in science and technology that will have long-term positive impact on our Nation's security. In support of this mission, DARPA has pioneered groundbreaking research and development (R&D) in Artificial Intelligence (AI) for more than five decades. Today, DARPA continues to lead innovation in AI research through a large, diverse portfolio of fundamental and applied R&D AI programs aimed at shaping a future for AI technology where machines may serve as trusted and collaborative partners in solving problems of importance to national security.

The AI Exploration (AIE) program is one key element of DARPA's broader AI investment strategy that will help ensure the U.S. maintains a technological advantage in this critical area. Past DARPA AI investments facilitated the advancement of "first wave" (rule based) and "second wave" (statistical learning based) AI technologies. DARPA-funded R&D enabled some of the first successes in AI, such as expert systems and search, and more recently has advanced machine learning algorithms and hardware. DARPA is now interested in researching and developing "third wave" AI theory and applications that address the limitations of first and second wave technologies.

The pace of discovery in AI science and technology is accelerating worldwide. AIE will enable DARPA to fund pioneering AI research to discover new areas where R&D programs awarded through this new approach may be able to advance the state of the art. AIE will enable DARPA to go from idea inception to exploration in 90 days.

To enable this approach, DARPA will issue AIE Opportunities. These AIE Opportunities will focus on technical domains important to DARPA's goals in pursuing disruptive third wave AI research concepts. More information about DARPA's current AI technical domains and research topics of interest may be found on <http://www.darpa.mil> under individual offices opportunities page.

AI Exploration (AIE) Opportunities

AIE Opportunities will be announced via Pre-solicitation Notices on beta.sam.gov issued under this Program Announcement (PA) DARPA-PA-20-02. These AIE Opportunities will solicit proposals and will be open for at least 30 days from publication at beta.sam.gov. AIE Opportunities will describe rapid projects comprising two phases as described in Section 2.3 of this PA. During the periods of performance, very high-risk, high-reward topics will be investigated with the goal of determining feasibility and clarifying whether the area is ready for increased investment. The ultimate goal of each AIE Opportunity is to invest in research that leads to prototype development that may result in new, game-changing AI technologies for U.S. national security. The prototype projects pursued under AIE may include, but are not limited to, proofs of concept; pilots; novel applications of commercial technologies for defense purposes; creation, design, development, demonstration of technical or operational utility; or combinations of the foregoing, related to a prototype.

Each AIE Opportunity will (1) identify specific details regarding the research topic of interest

and (2) provide proposal content and submission instructions in addition to those outlined in this PA, including the due date for proposal submissions. Proposals must only be submitted in response to an AIE Opportunity. Proposals submitted in response to this PA without an active, corresponding AIE Opportunity may be disregarded.

At this time, the DARPA Strategic Technology Office (STO) is interested in the following research area to be announced as a potential AIE topic under the Artificial Intelligence Exploration program:

- **Tensors for Reprogrammable Intelligent Array Demonstrations (TRIAD):**

Electromagnetic (EM) phased arrays contain many antenna elements that transmit and receive EM signals. These signals are combined in such a way as to manipulate the spatial directions of the signals into beams, such as to transmit a signal in a specific direction or receive only those signals of interest from a desired direction, while ignoring signals emanating from other directions. The fundamental math operation behind phased arrays is a complex multiplication of rows of coefficients, one per beam, by every array element. The beam forming operation is followed by information extraction and processing. In current digital phased arrays, every element is digitized, leading to an explosion of data requiring billions to trillions of complex operations per second. Currently, racks of high-powered processors are used in many stages of processing to handle the data processing challenge. TRIAD will create a streamlined processing approach to manage the beam forming and information processing directly within the array to significantly cut down on processing time and cost.

TRIAD takes a new look at phased array processing by formulating the coefficient multiplication into a linear algebra tensor operation, which is also the fundamental operation behind statistical machine learning (ML) (e.g., deep learning, including deep neural networks). TRIAD benefits from three advances in tensor processing: tensor algorithm development and execution on specialized processors, such as graphics processing units (GPUs), tensor abstractions into common programming frameworks, such as PyTorch to speed up application development, and ongoing reduction in the costs of constructing all-digital phased arrays. Combining EM array processing, new computational architectures, and tensor/ML-based programming environments, TRIAD will revolutionize array processing.

TRIAD will require performers to devise architectures that support array applications and computations through tensor operations. These architectures are to be drawn from commercially available GPUs, FPGAs, multi-core CPUs, etc. that will comprise the array computational backplane. Performers must also devise tensor libraries specifically oriented towards array operations, from fundamental beam forming support to more advanced operations involving machine learning and quasi-optical analyses. TRIAD will likewise require prototype array development demonstrating TRIAD capabilities.

Administrative

The Artificial Intelligence Exploration program announcement, DARPA-PA-20-02, has been posted at beta.SAM at <https://beta.sam.gov/opp/667875ba2f464ccfa38688ea1a718fe7/view>. Any future AIE topic Pre-solicitation notices will be posted on Beta.SAM.gov and darpa.mil under “Work With Us” opportunities.

All administrative questions regarding this notice must be emailed to DARPA-PA-20-02@darpa.mil. DARPA will post an FAQ on the DARPA/DSO Opportunities page at (<http://www.darpa.mil/work-with-us/opportunities>). The list will be updated on an ongoing basis until the close of the Artificial Intelligence Exploration program announcement.

This Special Notice is issued solely for information and potential new program planning purposes. The notice does not constitute a formal solicitation for proposals or proposal abstracts, any so sent will be disregarded. Respondents are advised that DARPA is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this Special Notice.