

Funding Opportunity Title: Human-Guided Machine Learning

Funding Instrument Type: Cooperative Agreement

Funding Opportunity Number in Grants.gov: W911NF-17-S-0003-SN-MACHINE-LEARNING

Description:

The aim of this Special Notice under the Army Research Laboratory (ARL) Broad Agency Announcement (BAA) (W911NF-17-S-0003), under Grants.gov Opportunity W911NF-17-S-0003-SN-MACHINE-LEARNING, is to solicit research proposals related to the ARL BAA Topics, “KCI-HS-1: Robust Human and Machine Hybridization” and “CCE-HS-4: Humans in Multi-Agent Systems.” The Army is interested in collaborating on research efforts to further develop the field of human-guided machine learning in the following areas: novel forms of human-intelligent technology decision making; cybernetics; hybridized thinking between man and intelligent technology; human technological savvy, and human-intelligent technology teaming assessment tools.

Research Goals:

The research goals in human-guided machine learning are to integrate empirical and theoretical efforts and generating novel concepts and approaches for humans to influence and guide the evolving behavior of intelligent technologies with the goal of effectively solving complex problems under variable resource and time constraints. We generally characterize the complex problems as more ambiguously structured by having uncertain boundaries (if any) across time and space, requiring massive and perhaps unattainable amounts of data in order to obtain complete certainty, and thus are computationally intractable for common analytic solutions. These problems may not have singularly optimal solutions, because problems will often have multiple, competing criteria and all solutions will ultimately reflect trade-offs and reduction of optimality in meeting other criteria in the set. Contextualized within the concept of enhancing adaptive human-autonomy teamwork, the human-guided machine learning research effort has five thrust areas, each with specific goals:

1) Novel forms of human-intelligent technology decision making: discover a novel suite of mechanisms to extract human intelligence that ensures Soldiers *in the field* can efficiently train and adapt intelligent technologies. Example thrust area goals include: to develop novel human-guided machine learning training mechanisms that rely on non-technically trained humans for domain knowledge; actively use human-machine knowledge transfer to develop models of Soldiers; and/or develop a mathematical framework for combining multiple forms of knowledge transfer from humans to infer intent.

2) Cybernetics: elucidate principles of effective, stable mutual adaptation between humans and intelligent systems that improve performance in complex, dynamic environments. Example challenges in this thrust area include: distilling critical information from groups of people to train an AI (i.e., how do you provide information to the AI?); mathematically incorporating and prioritizing information from groups of people when influencing AI (i.e., how do you resolve conflict?); and balancing long-term stability and adaptability when allowing *groups of people* to train intelligent technologies (i.e., how do you achieve local and global mission requirements?).

3) Hybridized thinking between man and intelligent technology: optimize how humans could think within complex human-technology ecosystems to maximize human potential to adapt the Army on the battlefield. This thrust area focuses on merging scientific advancements from human-guided machine learning (e.g., instantaneous crowdsourcing; interactive machine learning) with advancements from neuroscience (e.g., neuroprosthetics; neurostimulation) and/or team science and training (e.g.,

technology-enhanced human teaming; training for rapid human adaptation) to reconceive human brain processes and optimize human-machine thinking. Example research questions include: can agents (i.e., intelligent technologies) integrated with human teams generate novel ideas faster and more effectively than agents or teams alone? Can hybrid teams converge information into more effective decisions? Can neurostimulation paired with agents rapidly promote shared understanding and divergent thinking? Can humans' innate ability to adapt be made faster and extended to radically different forms of thinking (merged human-agent thinking)?

4) Human technological savvy: Create models, methods, measures, and techniques to assess and develop the "technological fluency" (i.e., "TF" = the ability of humans to use new and/or rapidly adapt existing intelligent technologies without formal training on these technologies) of Soldiers and units across a career. Example goals of this thrust area include: developing experimental environments with prototype human-guided machine learning systems sufficient to create and validate models of individual's TF; develop potential behavior-based measures of TF that can be opportunistically extracted from humans using human-guided machine learning systems without addition burden on operators (e.g., intelligent technologies to 'observe' and 'interpret' human adaptation to technological change); and creating initial training methodologies to improve TF in individual's working with human-guided machine learning systems.

5) Human-intelligent technology teaming assessment tools: create a stand-alone real-time assessment tool capable of adapting to evolving missions independently to support SME assessments of human-agent teaming. Critical elements of this thrust include: developing approaches to leverage and expand upon typical SME approaches to assess Army prototype technology experimentation (low numbers of subjects and limited experimental trials); embracing observational approaches to the complex and uncontrollable nature of Army prototype technology experimentation; and teaming experimental SMEs (i.e., in areas of human factors or autonomy) with adaptive data collection tools (e.g., human-guided machine adaptation) to maximize the interpretability of data in fixed experimental trials/time.

The Army is pursuing a perspective that research breakthroughs in human-guided machine learning technologies will emerge from individuals with significant scientific understanding of the mechanisms and unique capabilities/limitations of **both** human intelligence (individual and team) and machine intelligence (Metcalf, Perelman, Boothe, & McDowell, 2021, Systemic oversimplification limits the potential for human-AI partnership, IEEE Access, 70242-260.) To this end, this special notice focuses on ensuring students working on the research are developing a graduate-level understanding both human and machine intelligence and are embracing collaborative communities that bridge human-centric and machine-centric research. The research proposed should identify student research projects on issues critical to advancing the five research thrusts described above, leveraging sharable experimental platforms to enable a collaborative community capability to advance the field, and to provide collaborative research opportunities between academia and the Army. The Army is interested in ensuring several specific approaches are addressed in this research to include the development of graduate students and post-doctoral students with both an intelligent technology-centric and a human-centric mentor and a range of collaborative mechanisms and shared research opportunities between academia and the Army are pursued.

Proposal submission:

Proposal must be submitted in response to this Special Notice in grants.gov (W911NF-17-S-0003-SN-MACHINE-LEARNING) in accordance with the preparation and submissions instructions under BAA

W911NF-17-S-0003. In order to be considered for award associated with this Special Notice, proposals must be received by 25 June 2021. The proposal content information is as specified under BAA W911NF-17-S-0003, except the Project Description (Technical Proposal) content should also describe: 1) graduate/post-doctoral student mentoring and 2) collaborative mechanisms between academia and the Army detailing how research projects will be developed and evolved. As described in the BAA W911NF-17-S-0003, the proposal must also include a budget for each year of support requested.

Evaluation Criteria:

Proposals submitted in response to this Special Notice will be evaluated using the factors listed below (in descending order of importance):

- a. The overall scientific and/or technical merits of the proposal.
- b. The potential contributions of the effort to the Army mission and the extent to which the research effort will contribute to balancing the overall ARL research program.
- c. The potential effectiveness of proposed mechanisms to enable academia and the Army to collaboratively develop and evolve research projects.
- d. The potential effectiveness of graduate/post-doctoral student mentoring.
- e. The applicant's capabilities, related experience, facilities, techniques, or unique combinations of these, which are integral factors for achieving the proposed objectives.
- f. The qualifications, capabilities, and experience of the proposed PI, team leader, or other key personnel who are critical to achievement of the proposed objectives.
- g. The applicant's record of past performance.

****NOTE:** Cost sharing will not be considered in the evaluation.

Proposal evaluation is expected to be complete and any award selections are expected to be made by 30 September 2021. An offeror whose proposal is selected for award will be contacted by a Grants Specialist or Grants Officer. The Government will not provide feedback on proposals not selected for award.

Questions on this Special Notice:

Clarifying questions regarding this special notice may be submitted to the TECHNICAL Point of Contact.

Awards:

The Government reserves the right to make multiple awards, or no award, as a result of this Special Notice. The Army expects, but is not limited, to funding 2-3 awards. The expected award range is from \$200,000 to \$400,000 per year for 3-5 years. Awards will be yearly with options.

Points of Contact:

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