STTR Swarms

MDA23-T002 TITLE: AI-Informed Algorithms Combined with Differential Game Theory to Support Swarm-on-Swarm Engagements

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Hypersonics; Network Systems-of-Systems; Trusted AI and Autonomy

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR),
22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design and develop innovative solutions, methods, algorithms and concepts that leverage differential game theory and artificial intelligence to support anti-swarm operation in the hypersonic defense context. Demonstrate a working software prototype with example results. The algorithms should be narrow in focus, and verifiable in operation. The solutions should identify appropriate methods and technologies to minimize the time intensive processes, incorporate new technologies unearthed during the effort, and document key areas for further development.

DESCRIPTION: Unmanned vehicles operating in "swarms" are a growing concern for warfighters operating across all domains of the modern battlespace (air, sea, ground, and space). In particular, swarms operating in the exo-atmosphere and in the hypersonic regime may be encountered by missile defense systems. To enable defensive systems to counter these evolving threats, this program desires AI-informed algorithms combined with differential game theory to support swarm-on-swarm engagement where the adversary swarm is AI directed. In addition, the desire for algorithms that are executable post-launch on hardware with size, weight, and power suitable for carrying on each missile and have adequate on-board (and/or satellite-based) sensing and intra-missile-fleet communications. Ideally, entire system would be free of command and control after launch while utilizing centralized battle management control prior to launch; the entire system would be peer-to-peer, without a central fly-along "mother ship", in order to reduce single-point vulnerability. Hypersonic engagements may include multiple attacking hypersonic missiles (glide vehicles or powered, and either separately launched or multi-warhead launched) and multiple defensive missiles, presumably involving multiple launches with multiple KVs on each launch.
For both red and blue missiles fleets, consider the following factors:

* Significant missile-trajectory maneuverability
* Intra-vehicle communication
* Implementation of pursuit/evasion strategies
* Maneuvers informed by real-time observation of adversary action
* Distributed decision-making connecting (perhaps onboard) sensor information and directing maneuver response

* Decision making informed by artificial intelligence (AI), particularly of the machine learning/deep learning type (ML/DL)
* Maneuvering decisions based on differential game theory.
* Possible total autonomy from human control after launch.

Exploitation of AI algorithms being developed for offensive deployment of, or defense against, UAVborne weapons is encouraged. Development of sensing and communication technology would not be part
of research.

PHASE I: Develop preliminary system design(s) with anticipated performance. Perform modeling, simulation and analysis (MS&A) and/or limited bench level testing to demonstrate the concept and an understanding of the technology. The proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws and feasibility.

PHASE II: Complete a critical design and demonstrate the use of the technology in a table top/brass board prototype. Evaluate the effectiveness of the technology. Perform MS&A and characterization testing within the financial and schedule constraints of the program to show the level of performance achieved. If brass board achieved, government can provide independent test and characterization. Develop a plan for

Phase III product design, test and characterization.

PHASE III DUAL USE APPLICATIONS: Incorporate lessons-learned from the Phase II prototype into a product design and formulate how to Integrate into battle management. Work with government and/or government contractor to demonstrate product's performance improvement as compared to the state of the art. Work with government and/or government contractor to fully qualify the product for the intended application(s). Assist government and/or government contractor in integrating this product into a demonstrator system and assist with test and characterization.

REFERENCES:
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4. Laura Strickland, Michael A. Day, Kevin DeMarco, Eric Squires, and Charles Pippin "Responding to unmanned aerial swarm saturation attacks with autonomous counter-swarms", Proc. SPIE 10635, Ground/Air Multisensor Interoperability, Integration, and Networking for Persistent ISR IX, 106350Y (4 May 2018); https://doi.org/10.1117/12.2305086.

KEYWORDS: AI; artificial intelligence; game theory; differential game theory; swarm; hypersonic; hypersonic defense; distributed decision making; peer-to-peer; ML/DL; machine learning; deep learning

TPOC-1: Kurt McGuire
Phone: 505-846-3117
Email: Kurt.mcguire@mda.mil