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11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

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13. ABSTRACT (Maximum 200 words)

Under this seedling effort, Metron has developed and demonstrated “function-driven design” technology for complex distributed systems, and applied it to a UAV ground target surveillance scenario. We considered three types of UAV interaction mechanisms (auction/bidding methods, swapping-based methods and local optimization methods) and two different target motion models (stationary and mobile, random walkers).

There are two primary breakthroughs. The first is a value potential approach to optimizing search paths based on approximating an infinite-horizon search plan. Using this value potential to dictate UAV motion improves the search performance, especially for disjoint, multimodal (“patchy”) probability distributions on target position.

The second innovation introduces dynamic area sectoring, which allows UAVs to partition the search area dynamically and to balance the search workload across UAVs. Sectoring also eliminates the need to deconflict search paths and simplifies collision avoidance because each UAV stays inside its sector.

Combining the value potential-based UAV motion and dynamic sectoring reduces the median time to target detection by up to forty percent in our experimental testing. Based in part on the improved multi-sensor search capability developed under this seedling effort, Metron has been awarded a NAVAIR Phase II SBIR contract to accelerate transition of this distributed search technology.

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Top-Down Mechanism Design Study for Multi-UAV Search and Surveillance

Contract W911NF-04-C-0041
Seedling Period of Performance: 1 June 2004 to 31 May 2005

Final Progress Report Submitted to
Defense Advanced Research Projects Agency and Army Research Office

by

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Statement of the Problem Studied

Under this seedling effort, Metron has developed and demonstrated "function-driven design" technology for complex distributed systems, and applied it to a UAV ground target surveillance scenario. Our approach leverages an existing multi-agent test environment that we built for the purpose of evaluating UAV interaction design in the context of a ground target surveillance scenario.

The current state-of-the-art for the design of complex distributed systems is to postulate individual entity behavior and the overall system topology, see what happens by simulating the system, and then iteratively changing the entity behavior or topology as necessary until the desired system behavior is achieved. In contrast, our approach starts with the desirable system characteristics and uses design guidelines to specify the types of entity interactions that lead to the desired behavior.

For this UAV study, we considered three types of UAV interaction mechanisms (auction/bidding methods, swapping-based methods and local optimization methods) and two different target motion models (stationary and mobile, random walkers).

Results

There were two primary breakthroughs in our "function-driven design" technology as applied to the UAV ground target surveillance scenario. The first is a value potential approach to optimizing search paths based on approximating an infinite-horizon search plan. Using this value potential to dictate UAV motion improves the search performance, especially for disjoint, multimodal ("patchy") probability distributions on target position.

The second innovation introduces dynamic area sectoring, which allows UAVs to partition the search area dynamically and to balance the search workload across UAVs. Sectoring also eliminates the need to deconflict search paths and simplifies collision avoidance because each UAV stays inside its sector.

Combining the value potential-based UAV motion and dynamic sectoring reduces the median time to target detection by up to forty percent in our experimental testing. Based in part on the improved multi-sensor search capability developed under this seedling effort, Metron has been awarded a NAVAIR Phase II SBIR contract to accelerate transition of this distributed search technology.

Reports Supported Under this Contract

(a) Peer reviewed publications

i. None

(b) Non-peer reviewed publications

i. None

(c) Presentations:

i. Greg Godfrey, *Interim Review Presentation to DARPA Program Manager*. 27 May 2004

ii. Greg Godfrey, "Dynamic Sector Negotiation for UAV Surveillance", *Guaranteed Many Body Behavior Surveillance, UCLA Workshop*. 1 November 2004

iii. Greg Godfrey, *Program Review Presentation to DARPA Program Manager.* 14 March 2005

(d) Manuscripts

i. None

(e) Technical reports:

i. Greg Godfrey, "Top-Down Mechanism Design Study for Multi-UAV Search and Surveillance". *Final Technical Report,* 31 October 2005

Advanced Degrees Earned

None

Report of Inventions

None

Bibliography

None

Appendices

None