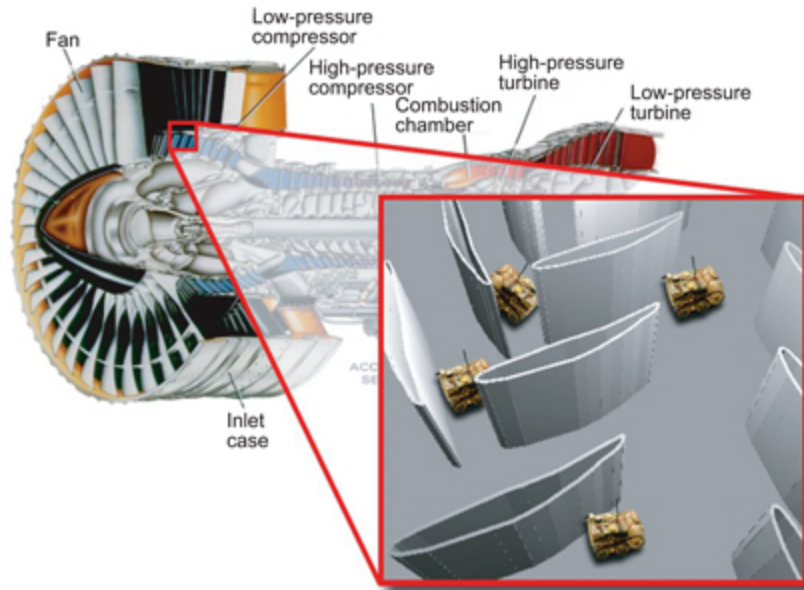


Control Algorithms and Simulated Environment Developed and Tested for Multiagent Robotics for Autonomous Inspection of Propulsion Systems

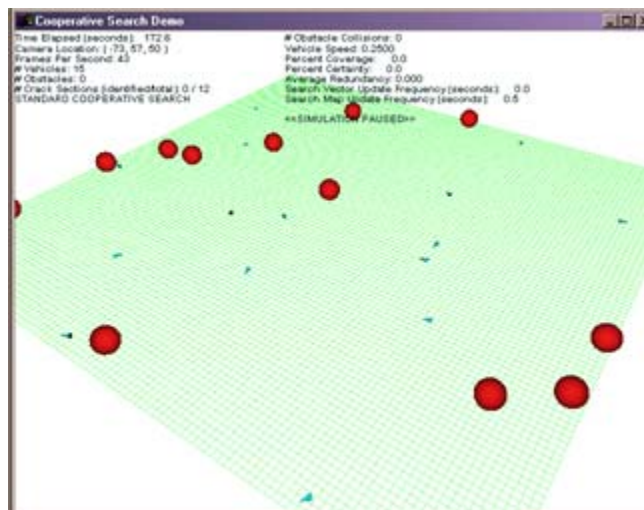
The NASA Glenn Research Center and academic partners are developing advanced multiagent robotic control algorithms that will enable the autonomous inspection and repair of future propulsion systems. In this application, on-wing engine inspections will be performed autonomously by large groups of cooperative miniature robots that will traverse the surfaces of engine components to search for damage. The eventual goal is to replace manual engine inspections that require expensive and time-consuming full engine teardowns and allow the early detection of problems that would otherwise result in catastrophic component failures. As a preliminary step toward the long-term realization of a practical working system, researchers are developing the technology to implement a proof-of-concept testbed demonstration.

In a multiagent system, the individual agents are generally programmed with relatively simple controllers that define a limited set of behaviors. However, these behaviors are designed in such a way that, through the localized interaction among individual agents and between the agents and the environment, they result in self-organized, emergent group behavior that can solve a given complex problem, such as cooperative inspection. One advantage to the multiagent approach is that it allows for robustness and fault tolerance through redundancy in task handling. In addition, the relatively simple agent controllers demand minimal computational capability, which in turn allows for greater miniaturization of the robotic agents.



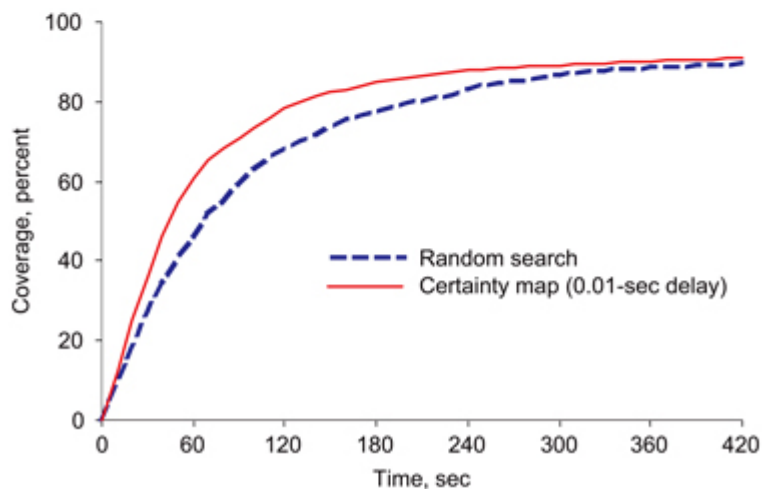
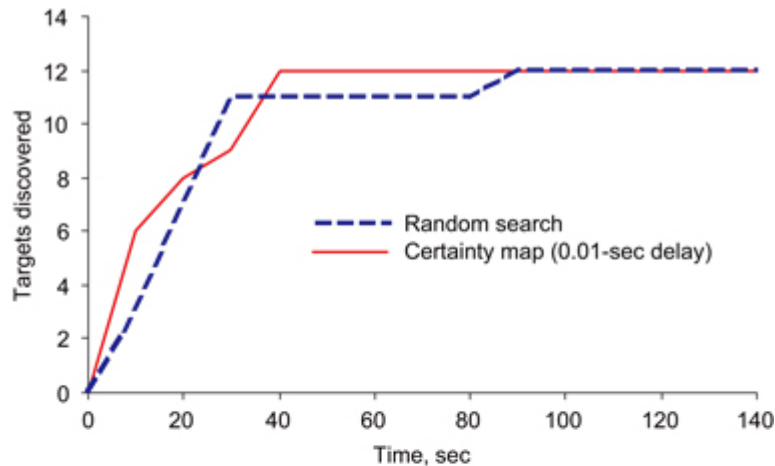
Conceptual drawing showing a cooperative team of miniature mobile robots autonomously inspecting the interior of an engine for damage.

Under this effort, researchers have developed and tested a range of algorithms to address pertinent control objectives such as cooperative search, coverage completeness, and obstacle avoidance. Algorithms range from those that require centralized coordination and communication to those that take a more distributed approach and rely only on indirect interactions. Each approach has strengths and weaknesses. Research is underway to refine these algorithms and to investigate how elements of each approach can be combined to exploit their respective strengths in a practical implementation that best addresses the specific inspection application.



Screen capture of three-dimensional simulation software developed at Glenn to facilitate the testing of multiagent control algorithms.

The researchers developed an interactive, three-dimensional graphical simulation environment to facilitate the design and testing of the control algorithms. This virtual testbed software can model a three-dimensional environment that represents the interior of a turbine system, replete with obstacles and barriers. Agents representing inspection robots within this environment are capable of full 6-degree-of-freedom steering. The cooperative actions of the agents are controlled with plug-in control logic modules that allow developers to quickly implement and test various algorithms and to demonstrate the resulting multiagent behavior in real-time, three-dimensional motion graphics.



Simulation results showing how search agents can find targets more quickly and cover the environment more efficiently when they use a certainty map-based cooperative search algorithm instead of a random search.

The final validation of these multiagent algorithms will be performed in a proof-of-concept demonstration in which a team of real demonstration robots will cooperatively search for "damage" targets in a hardware robotic testbed facility that is being constructed at Glenn. This demonstration will validate the feasibility of using cooperative multiagent robotics to perform efficient and effective inspections in applications such as on-wing turbine engine maintenance.

Bibliography

Wong, E.; and Litt, J.: Autonomous Multi-Agent Robotics for Inspection and Repair of Propulsion Systems. AIAA-2004-6364, 2004.

Find out more from the Controls and Dynamics Technology Branch at
<http://www.grc.nasa.gov/WWW/cdtb/>

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