ONR helps undersea robots get the big picture

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The Office of Naval Research conducts Autonomous Underwater Vehicleoperations aboard the USNS Sioux off of San Clemente Island in the Pacific Ocean in September 2010. Recently ONR-sponsored scientists completed sea tests of new control software that makes underwater robotic vehicles smarter at autonomously surveying large swaths of ocean. Credit: US Navy photo by John F. Williams/Released

Scientists have successfully transitioned fundamental research in autonomy to undersea gliders, demonstrating in recent sea tests how the new software, sponsored by the Office of Naval Research (ONR), can help robots become smarter at surveying large swaths of ocean.

"Using the new algorithms, the vehicle has a greater ability to make its own decisions without requiring a human in the loop," said Marc Steinberg, program officer for ONR's Adaptive Networks for Threat and

Intrusion Detection or Termination (ANTIDOTE), a multi-disciplinary university research program.

With plans to deploy squadrons of air, surface and undersea robotic vehicles later this decade, the Department of the Navy is investing in basic research programs to improve autonomous system capabilities.

"Advancing autonomy for unmanned systems allows you the ability to do things that wouldn't be practical otherwise because we don't have enough warfighters or communication today," said Steinberg, who works in ONR's Naval Air Warfare and Weapons Department. "If you incorporate some intelligence on the vehicles that can solve complex mission problems, then we can enable wholly new capabilities that can be achieved with limited numbers of people and communications in complicated, dynamic environments."

ONR provided funding to researchers at the Massachusetts Institute of Technology (MIT) and University of Southern California (USC) to advance the intelligence of autonomous vehicles under both ANTIDOTE and a related university program called Smart Adaptive Reliable Teams for Persistent Surveillance. They developed a persistent surveillance theory that provides a framework for decision-making software that maximizes a robot's collection of information over a given area. It gives some guarantees on performance in dynamic environments.

"The ability to do surveillance that takes into account the actual conditions of the environment brings a whole new level of automation and capability," said Dr. Daniela Rus, co-director of MIT's Computer Science and Artificial Intelligence Laboratory Center for Robotics. "We have come up with a solution that lets the robot do local reasoning to make decisions and adjust the path autonomously without having to come up to the surface to interact with humans."

The scientists produced an algorithm that incorporates both the user's sensing priorities and environmental factors, such as ocean currents, into a computer model to help undersea robots conduct surveys and mapping missions more efficiently.

Tests proved the benefits of using the new algorithm. The scientists conducted two separate experiments using underwater robots called gliders, operated by oceanographers. They used two gliders, one with the algorithm and one without, to measure whether the experimental technology yielded better maps of algae blooms and other underwater phenomena in the Pacific Ocean.

"In areas where the oceanographers wanted more information, the persistent surveillance algorithm actually produces more detail," said Dr. Gaurav S. Sukhatme, ANTIDOTE's principal investigator and director of USC's Robotic Embedded Systems Lab. "The system can automatically figure out how to divide its time between areas that are more interesting and areas that are less interesting."

The algorithm helps the gliders decide when to spend more time looking at regions that have changes in activity or environmental factors. Without the control algorithm, gliders paid equal attention to all areas and acquired less information during the experiments in Monterey Bay, Calif., and along the southern coastal waters near Los Angeles in October and November 2010. The first experiment lasted a period of three weeks; the second ran for two weeks. A third experiment in August 2011 took place in the Southern California Bight for 10 days. Results of the single-glider test are being analyzed.

Though the gliders were an ideal first test of the persistent surveillance theory and algorithm, the software is applicable to many different machines and robots, the scientists said.

Provided by Office of Naval Research