June 26, 2017

AAAS interdisciplinary panel dives into underwater robotics

Xiaobo Tan, a Michigan State University Foundation Professor of electrical and computer engineering, was part of a recent presentation at the American Association for the Advancement of Science’s Washington, D.C., headquarters discussing the progress in marine and freshwater research, largely due to the use and ability of underwater robotics to collect data from some of the world’s least hospitable regions.

Scientific collaboration required for marine and freshwater research was on full display during the “Pathfinders of the Abyss” panel discussion on June 16 jointly sponsored by Science Robotics, a new journal published by the AAAS, and Halcyon. A nonprofit organization, Halcyon seeks and celebrates creativity and galvanizes creative individuals aspiring to promote social good through core programs focused on the arts, sciences and social entrepreneurship.

Bodies of water present challenging environments in which to conduct research. Many are characterized by remote depths and vast ranges that are inaccessible and, sometimes, too harsh for human exploration, said John P. Ryan, a senior research specialist at the Monterey Bay Aquarium Research Institute.

“The interdisciplinary crossroads of marine and freshwater science is where the fruit is,” said Ryan, adding later, “Everyone comes with a unique perspective that ultimately helps create a better way to understand, develop and deploy better underwater technologies.”

Underwater robots are highly mobile and “offer persistence, the ability to track fine changes in the environment, high-resolution observations, specialized sensors, targeted sampling and molecular methods,” said Ryan. Technological advancements are being integrated into underwater robots regularly to provide researchers more efficient and ultimately cost-effective ways to study marine habitats, he added.

The diverse nature of robotics requires expertise from engineers and scientists with a range of specialties. Ryan, for instance, is a biological oceanographer by training, yet regularly works with engineers and computer scientists for his research.
Ryan’s research focuses on algal blooms, the rapid and dense growths of plankton that can starve marine organisms of oxygen and cause hypothermia in seabirds. When the winds shift, these toxic blooms can sink meters below the sea’s surface, disappearing from the sight lines of both humans and some underwater robots.

“This presents a challenge and opportunity for robotic systems, particularly if they have the necessary onboard intelligence,” said Ryan, whose work depends on Autonomous Underwater Vehicles, the veteran aquatic bots programmed to navigate without human control. He also utilizes what he calls “a laboratory in a can” – the newer Environmental Sample Processor, which collects water samples and conducts on-site analyses.

The robots allow researchers to more readily detect deeper algal blooms, highlighting the necessity of the collaboration between biology and engineering.

**Michigan State University Foundation Professor of electrical and computer engineering Xiaobo Tan** attested to the importance of multidisciplinary cooperation. “Basically, as engineers, we are responsible for creating these robotic platforms first. Later, we get them ready to gather information about anything [other scientists] would like to know about water.”

Tan’s involvement in underwater robotics, like the activities of many engineers, began with an invention without a clear purpose: a flexible, artificial muscle-like material able to flap back and forth, like a fin. The application came after Tan’s team members suggested: “How about a fish?”

From there, Tan created the Gliding-Robot-ACE, or GRACE, a robotic fish that utilizes a flexible mechanized muscle to move through water and even sense hydrodynamics. Equipped with more advanced sensing systems, such as those that can chart the environment, GRACE tracks fish and can monitor invasive and native species. GRACE is also lightweight and operates at a fraction of the cost of classic marine gliders, making it an attractive robotic candidate to underwater researchers.

Video: Pathfinders of the Abyss (See Dr. Tan at 1:08:20)

In describing GRACE, Tan gave a nod to the work of Naomi Leonard, a Princeton University professor in the Department of Mechanical and Aerospace Engineering, whose research offers another example of interdisciplinary robotics in action.

Leonard uses autonomous robotic swarms to collect data and increase the reach of marine exploration. Programming the robotic clans to work as a group requires not just physics and mechanics, but also needs to leverage social concepts of group decision-making and uncertainty.
"I live and breathe it," said Leonard. "I absolutely believe that these intersections are vital to making advancements in these fields."

As is often the case with robotics, Leonard looked to nature – fish, birds and honeybees – for inspiration and information. "How do animals that on their own can't do very well, do amazing things as aggregations? Somehow, they're able to organize themselves, even without a leader or choreographer," Leonard noted.

She discovered that, when grouped, fish are able to estimate subtle nuances, such as changes in water temperature, salinity or concentration and use such metrics to decide, together, on the best path. She also noticed the prevalent role of uncertainty in collective behavior: "The choice between exploiting what they know versus exploring the unknown," she explained.

Learning from animal behavior, Leonard and her team were able to design an algorithm representing collective decision-making and uncertainty and load the system onto a pack of AUV robots. Currently testing the gliders in a large water tank and small field experiments, her team is closer to robotically mimicking the teamwork of a fish school.

It's very scary to be a fish on your own," said Leonard. "You're basically dead if you're not in a group." Perhaps the same could be said of the collaborative field of underwater research.

*Story courtesy of AAAS.org and author Juwon Song, American Association for the Advancement of Science (AAAS)*

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