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www.princetonpacket.com

08/01/2006

PU computers remotely guide under-water robots a continent away

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Photo by David Benet

Naomi Leonard, a Princeton University professor of mechanical and aerospace engineering, with some of the 10 glider robots that report their Pacific Ocean data to her Princeton lab.

Research project aims to record water characteristics of Monterey Bay in California

They work tirelessly and nonstop.

And, they will continue to do so throughout the entire month of August, gathering information about Monterey Bay on the California coast for a project co-led by Princeton University Professor of Mechanical and Aerospace Engineering Naomi Leonard.

"Every day, I'm looking out at the Pacific Ocean and I know these little guys were up all day and all night doing their thing, moving around and collecting data," Professor Leonard said Monday in a phone call from California. "It's really amazing."

Professor Leonard isn't talking about her human collaborators on the Adaptive Sampling and Prediction project supported by the Office of Naval Research under the Multi-disciplinary University Research Initiative. Rather, she's referring to a fleet of 10 bright-yellow glider robots controlled by computer systems based at Princeton.

The under-water gliders are provided by Russ Davis of the Scripps Institution of Oceanography and David Fratantoni of Woods Hole Oceanographic Institution, two principal investigators on the project. Each is equipped with sensors to detect salinity and temperature, and the means to send the collected data back to computers at Princeton.

Upon receipt, the computers use the information from the gliders to determine their next course of action, and then transmit directions back to the gliders — all without any human input.

"I don't know that anybody has pulled this off yet, with such a large fleet in a three-dimensional environment with a serious science mission," she said of the adaptive sampling project that aims to conduct scientific research without the need of human intervention. The possibilities abound for the types of ecosystems that may one day be studied in a similar fashion, she said.

Prior to the deployment of the autonomous gliders in Monterey Bay, researchers simulated the project using the Princeton Glider Coordinated Control System software. The glider simulator is still in use even though the real experiment has commenced, with researchers using forecasts each morning to predict what the gliders may encounter and troubleshoot any impending problems.

As the area being covered is large (with a footprint of about 300 square miles), Professor Leonard said the computers must pay careful attention to the distance between the gliders and the amount of time any one glider spends in a given location. The battery-powered gliders travel slowly underwater, covering less than five miles per hour, and surface around every three hours to report back to the Princeton computers and receive further instruction.

While humans may be totally "out of the loop" in the future, for now, some human intervention is still necessary, Professor Leonard said. Just as the yellow gliders come together remotely via computer, the projects' multiple researchers keep in touch at the virtual control room — accessible on the Internet at www.princeton.edu/~dcsl/asap. There, they can make comments and suggestions about changes to the computer algorithms, and even demonstrate their ideas using movies made with the Trajectory Viewer tool on the Web site.

As all conversations, suggestions and modifications are recorded, the data generated by the experiment goes far beyond the amount of salt in some portion of Monterey Bay.

"It's a really nice, systematic way to do things," Professor Leonard said. "Although it's not 100 percent automated, what we're doing is archiving everything we say, everything we propose, so that in future iterations we can even make more human-out-of-the-loop decisions. ... The goal, ultimately, is to have this thing be really smart so that it knows how to adjust the patterns as things happen."

For the time being, it's important for researchers to assess the information and respond appropriately to areas that need more investigation, she said, perhaps in response to uncertain or abnormal data collected by the gliders.

Regardless, the project is largely a virtual one and many of the principal investigators will not be traveling to Monterey Bay during the month-long investigation. Travel may be optional, but it's definitely desirable for Professor Leonard, who will continue to travel between Princeton and California for the duration of the sampling.

"For me, it's incredibly motivating and exciting since the main job of my research group is developing feedback control algorithms," she said. "I don't have everyday experience with a glider."