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Lobster-Sniffing Study May Spawn Underwater Robots

BOULDER, Colo., Nov. 29 (AScribe Newswire) -- Scientists are unraveling the mystery of how lobsters "untangle" underwater odors in their search for prey, predators and mates, findings that may have applications for robots to someday follow chemical trails to locate explosives or dangerous chemicals underwater or on land.

Led by the University of California, Berkeley's Mimi Koehl, the study focused on the Caribbean spiny lobster, which has antennae with arrays of sensitive hairs to sniff out odors. The research team used a robotic lobster, high-speed video and fluorescent dye to model the flow of odors past the lobster's antennae -- each about two inches long -- which flick rapidly up and down when sniffing for odors.

A paper on the subject is being published in the Nov. 30 issue of Science. In addition to Koehl, other authors included Jeffrey Kosseff from Stanford University, John Crimaldi from the University of Colorado at Boulder, Michael McCay and Tim Cooper from the University of California, Berkeley, Megan Wiley from Stanford and Paul Moore from Bowling Green State University in Ohio.

The process lobsters use to find or avoid other marine animals is known as plume tracking. The researchers believe the antenna's lightning fast downstroke may allow it to capture high-resolution information about the plume's structure, while the slightly slower upstroke may give the lobster's odor-sensitive cells and neural circuitry time to analyze the structure, wrote the authors.

As a plume of fluorescent dye flowed downstream to the robotic lobster, the antennae used in the study -- real lobster antennae slipped onto tiny wires where the lobsters' antennae are located -- were flicked in the water electronically in time scales similar to those used by live lobsters. In this case, it was roughly 100 milliseconds for the downstroke and 300 milliseconds for the upstroke.

CU-Boulder civil and environmental engineering Assistant Professor Crimaldi, who continues to work on the project, said many objects on Earth emit odors that are transported by chemical plumes downstream or downwind. The project is funded by the Defense Advanced Research Agency and the Office of Naval Research.

"It is intriguing that lobsters evolved to use chemical odors to determine an object's location, especially since they do this under hydrodynamic conditions that are highly chaotic," Crimaldi said. "They have developed an efficient method to perceive extraordinarily complex patterns of odors and follow them."

In both air and water, turbulence can cause odors to become patchy and intermittent, he said. But the lobster antenna apparently can provide highly detailed information about the structure of odor plumes, allowing the crustaceans to track down the source despite the plume's ever-changing flow, shape and direction.

The U.S. Navy would like to develop robots that can do what the lobsters do as far as identifying the source of specific odors both underwater and on land from the wealth of odors found in both places, said Crimaldi. "It would certainly be impractical to send humans searching for underwater explosives or the chemical odor of TNT in a land mine with little or no information on their whereabouts."

The bottom line, said Crimaldi, is the opportunity to learn from animals like lobsters, which are not considered intelligent but can do these tasks with efficiency. The team is using complicated mathematical analysis techniques to attempt to translate what causes lobsters to make behavioral decisions as they follow the chemical signatures.

If the research team can understand how the shape and motion of the antenna affects its function, it may be able to design similar artificial antennae on robots to work in turbulent water and air flows and hone in on single chemical signatures, said Crimaldi.

"We're trying to understand how living organisms use information -- in this case, olfactory information that they sense by smell -- to find either prey or a mate," said Koseff, a professor of civil and environmental engineering at Stanford. Koseff also is senior associate dean for faculty affairs in the school of engineering at Stanford.

"We ultimately want to replicate how lobsters -- which have a miniscule brain -- are able to carry out such extraordinary functions," said Crimaldi.

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