Tufts to develop morphing 'chemical robots'

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Tufts University has received federal funding to develop chemical robots that will be able to squeeze into spaces as tiny as 1 centimeter, then morph into something 10 times larger, and ultimately biodegrade. The "chembots" could access urban environments, tunnels, caves and debris fields, and carry out other risky operations in complex environments.

Scientists at Tufts University have received a $3.3 million contract from the U.S. Defense Advanced Research Projects Agency (DARPA) to develop chemical robots that will be so soft and squishy that they will be able to squeeze into spaces as tiny as 1 centimeter, then morph back into something 10 times larger, and ultimately biodegrade.

The advantages of using unmanned devices to conduct dangerous or difficult operations are clear, and the U.S. has invested in such devices for years. But today's rigid robots, constructed mostly of hard materials, are unable to navigate complex environments with openings of arbitrary size and shape. They are stymied by, say, a building whose only access points may be a crack under a door or a conduit for an electrical cable.

The Tufts team will design the "chembots" to be capable of performing feats no current machine can accomplish, according to Professor of Biology Barry Trimmer, the Henry Bromfield Pearson Professor of Natural Sciences and co-principal investigator on the project. Among these tasks will be the ability to enter confined or complex spaces; follow cables, ropes or wires; and climb trees or other branched structures.

According to Dr. Mitchell Zakin, Ph.D., DARPA program manager for the ChemBots program, "DARPA's ChemBots program represents the convergence of soft materials chemistry and robotics. It is an entirely new way of looking at robots and could someday yield great technological advantage for our armed forces."

Chembots could extend the capabilities of today's unmanned ground vehicles by accessing urban environments, tunnels, caves and debris fields. Once in place, the energy-efficient chembots could survey the area using little power and then morph to accomplish their task. For example, they might gain entry to an improvised explosive device to gather information or potentially disable the device. Other applications include landmine detection, search and rescue in hazardous conditions, and biomedical diagnosis. They will also be capable of carrying miniature or micro versions of themselves for access to areas on an even smaller scale.

Bionic Caterpillars

The robot design is inspired by the team's findings on both the remarkable neuromechanical system of the Manduca sexta caterpillar and the extraordinary material properties of biopolymers.

The Tufts chembots will copy some of the performance capability of Manduca, including its flexibility, climbing ability and scalability – from hatching to the end of its larval stage, the caterpillar grows 10,000 fold in mass using the same number of muscles and motor neurons. Trimmer has been studying the nervous system and behavior of this caterpillar for almost two decades.

Key to success will be the use of new biomaterials. While the Tufts team will build the initial chembots with existing synthetic soft materials and actuators, the next stage of the project will use novel soft bionic composites that will be biocompatible and biodegradable.

"Use of all-biodegradable biopolymer systems will allow use of the robots in a broad range of environmental applications, as well as medical scenarios, without requiring retrieval after completion of the designated tasks," noted co-principal investigator David Kaplan, Stern Family Professor of Biomedical Engineering and chair of biomedical engineering. "We expect that these devices will literally be able to disappear after completing their mission."

The biomaterials will be designed from bioengineered polymers, which the group has studied for many years.

Wireless Telemetry Saves Energy

The complete chembot is envisioned to have multiple hair-like sensors for temperature, pressure, chemical and audio/video and to use wireless communication. The Tufts team has been developing strategies for wireless telemetry, including technology that uses 60 per cent less electricity than conventional devices.

The project is based at the Advanced Technologies Laboratory at Tufts University and will include experts in bio/tissue engineering, soft animal neuromechanics, micromechanical engineering, soft material characterization and modeling, wireless transmission of data and power, mixed mode integrated circuit design, and mobile robot navigation and sensor fusion.

The team plans to build prototype chembots as small as 2 grams and as large as 200 grams. With access to appropriate manufacturing capabilities, researchers say that these devices could be built at low cost in large numbers and at micro (mg) or macro (kg) levels.

Source: Tufts University