Biomimetic Technologies Project Will Create First Soft-Bodied Robots

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While robots have moved from the realm of science fiction to a myriad of real-life uses, the potential of the “hard-bodied” robots of the 21st century remains limited by their stiff construction and lack of flexibility.

A group of researchers at Tufts University has launched a multidisciplinary initiative focused on the science and engineering of a new class of robots that are completely soft-bodied. These devices will make possible advances in such far flung arenas as medicine and space exploration.

Barry Trimmer, professor of biology, and David Kaplan, professor of biomedical engineering, are co-directors of the Biomimetic Technologies for Soft-bodied Robots project, which represents a consortium of seven Tufts faculty members from five departments in the School of Engineering and the School of Arts and Sciences. The project has just been awarded a grant of $730,000 from the W.M. Keck Foundation.

According to Kaplan, the project will bring together biology, bioengineering and micro/nano fabrication. “Our overall goal is to develop systems and devices--soft-bodied robots--based on biological materials and on the adaptive mechanisms found in living cells, tissues and whole organisms,” he explains. These devices, he notes, will have direct applications in robotics, such as manufacturing, emergency search and retrieval, and repair and maintenance of equipment in space; in medical diagnosis and treatment, including endoscopy, remote surgery, and prostheses design; and in novel electronics such as soft circuits and power supplies.

“A major characteristic that distinguishes man-made structures from biological ones is the preponderance of stiff materials,” explains Trimmer. “In contrast, living systems may contain stiff materials such as bone and cuticle but their fundamental building blocks are soft and elastic. This distinction between biological and man-made objects is so pervasive that our evaluation of artificial or living structures is often made on the basis of the materials alone. Many machines incorporate flexible materials at their joints and can be tremendously fast, strong and powerful, but there is no current technology that can match the performance of an animal moving through natural terrain.”

First “Molecules to Robots” Effort

The Tufts team represents the first major effort to design a truly soft-bodied locomoting robot with the workspace capabilities similar to those of a living animal. While other groups around the world are applying biomimetic approaches to engineering design, most focus on narrow areas within this field.

"This represents a wonderfully rich and novel collaboration that takes a comprehensive 'molecules to robots' approach to the use of soft materials," notes Linda M. Abriola, dean of the Tufts School of Engineering.

Work will focus on four primary areas: Control systems for soft-bodied robots, biomimetic and bionic materials, robot design and construction, and development and application of research-based platform technologies.

Caterpillars and Silkworms

The Keck grant will provide the team with specialized equipment for use with soft materials and biomechanics experiments, according to Trimmer, whose work with caterpillars provides insights on how to build the world's first soft-bodied robot. Trimmer, a neurobiologist, has been studying the nervous system and biology since 1990 through grants from the National Institutes of Health and the National Science Foundation. His goal has been to better understand how the creatures can control their fluid movements using a simple brain and how they can move so flexibly without any joints. He hopes to adapt his caterpillar research to this new project using the expertise of Tufts engineers.

Kaplan, whose laboratory focuses on biopolymer engineering, has already uncovered the secret of how spiders and silkworms are able to spin webs and cocoons made of incredibly strong yet flexible fibers. More recently, his team applied genetic engineering and nanotechnology to create a "fusion protein" that for the first time combined the toughness of spider silk with the intricate structure of silica. Kaplan notes that there has been tremendous progress in the development and use of soft materials in devices ranging from keyboards to toys. "However, it is very hard to make soft devices that move around and can be precisely controlled," he says. "This is the fundamental reason why robots currently move like robots instead of lifelike animals."

The new robots developed at Tufts will be continuously deformable and capable of collapsing and crumpling into small volumes. They will have capabilities that are not currently available in single machines including climbing textured surfaces and irregular objects, crawling along ropes and wires, or burrowing into complex confined spaces. "Soft-bodied robots could make many dangerous surgeries much safer and less painful," Trimmer adds. "They could also be used by NASA to repair space stations by reaching places that astronauts can't, perform more complicated tasks in industry that require flexibility of movement, help in hazardous environments like nuclear reactors and landmine detection, and squeeze more efficiently into tight spaces."

In addition to Trimmer and Kaplan, Assistant Professors Robert White, mechanical engineering, and Sameer Sonkusale, electrical and computer engineering, will supervise projects in the Tufts Microfabrication Laboratory. Associate Professor Luis Dorfmann, civil and environmental engineering, and Visiting Assistant Professor Gary Leisk, mechanical engineering, will supervise the material testing and modeling parts of the project, and Assistant Professor Valencia Joyner, electrical and computer engineering and Sonkusale will direct the design and production of sensors and soft material integrated circuits.

Source: Tufts University

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