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NETWORKS

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Making Waves: Research Explores Uses for Robotic Fish

Robots were once the stuff of science fiction, but now sci-fi and advanced technology meet as robots have many applications in the 21st century. So, what about robotic fish? That's not sci-fi. That's the work of Xiaobo Tan, ECE assistant professor and director of the Smart Microsystems Laboratory.

Tan recently received funding from the Office of Naval Research (ONR) to develop highly maneuverable robotic fish, based on biological principles and incorporating biomimetic electroactive polymers. The current research project builds on the work Tan did with a National Science Foundation (NSF) CAREER project, "Dexterous Biomimetic Micromanipulation Using Artificial Muscles: Modeling, Sensing, and Control." The CAREER project provided a sound knowledge base in electroactive polymers. As part of another NSF grant, Tan's research lab will expand to house a large water tank (about 15 x 10 x 4 feet) to study schools of robotic fish and for a number of outreach activities. The water tank will also be used as part of a project with other MSU researchers to evolve adaptive and cooperative behavior among autonomous systems.

The robotic fish that Tan and his research team have been developing are propelled and maneuvered by soft actuation materials, called electroactive polymers. These materials, also known as artificial muscles, generate large deformations upon application of a voltage. Therefore, these robotic fish have no mechanical noise, unlike other robotic fish that use motors. The robotic fish are currently propelled by a tail fin and contain wireless communication and sensing components. Tan's group is also exploring the use of artificial pectoral fins for maneuvering and assistive propulsion. The latest funding will be used to gain a greater understanding of how fish move and behave in the water. "Real fish have interesting motions in three-dimensional water space, and can navigate through turbulent conditions with ease," says Tan. "We need to understand how this works so our robotic fish can be stable in different flow conditions." For example, Tan wants his robotic fish to be able to handle waves and currents.

The materials used for actuating the robotic fish are as important as the sensors. "We are pursuing fundamental studies on the development of novel

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Inspiring Future Engineers

Robotic fish have become an important avenue for recruitment and K-12 outreach. Through collaboration with Drew Kim, assistant to the dean for recruitment and K-12 outreach, Xiaobo Tan's research group developed a robotic fish–based educational kit for middle and high school students to inspire their interest in science and engineering. With the kit students can learn how to build a robotic fish and in the process gain a basic knowledge of robotics, artificial muscles, and circuits. The kit is used in local schools, and student teams came to the fall 2007 and spring 2008 College of Engineering Design Days to present and race their robotic fish prototypes.

With a proven track record in outreach, Tan, along with Kim and other engineering faculty, is launching a teacher training initiative by engaging middle and high school science teachers in university lab research on bio-inspired technology and systems.

The robotic fish were attention getters during Michigan State's Grandparents University.

from the Chair

TIMOTHY GROTJOHN

Greetings to alumni and friends of the MSU Department of Electrical and Computer Engineering. This newsletter shares several highlights of our undergraduate, graduate, and research programs.

Our department offers BS degrees in electrical engineering and computer engineering to over 500 undergraduate students. The computer engineering degree is offered jointly with the Department of Computer Science and Engineering. Our students acquire a solid foundation in electrical and computer engineering theory, gain experience in critical thinking, and explore innovative ways to address advanced engineering problems. Design and hands-on labs and courses are offered in all years of the curriculum. This starts in the freshman year when students take the cornerstone engineering design course their first semester and concludes with the senior design challenge in the last year that engages students in multidisciplinary teaming and open-ended problem solving. As a result, our students learn how to work with people from other science or engineering fields and are prepared for true-to-life work environments. Additionally, over the past few years the department has put a strong emphasis on all the undergraduate students having opportunities for engineering experience outside the classroom by participating in cooperative education, internships, study abroad, and/or undergraduate research. In a recent survey of graduating seniors, more than 90 percent have had some type of engineering experience outside the classroom.

The ECE graduate program is built on the quality of our 40 faculty and their research. This year 190 students are enrolled in our MS and PhD graduate programs. Our research activities have witnessed strong growth in recent years with annual research expenditures now over $10 million. Our faculty members are leaders in their chosen fields and are highly respected by their peers. The ECE faculty are continually investigating new areas of research. However, we retain our focus on computer engineering (computer architecture, computer networks, and VLSI/microelectronics), electro sciences (electromagnetics, electronic materials and devices, and nondestructive evaluation), and systems (biomedical engineering, control and robotics, power electronics and systems, and signal processing and communications). During this academic year we have four new faculty members joining our department in the areas of electrical power systems, Terahertz technology, nanomanipulation, and MEMS (micro-electro-mechanical systems.)

I want to invite you to stay in touch with us. These are exciting times, and we want to share our enthusiasm with you as we continue to grow our research-centered, student-oriented department.

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electroactive polymer hairs as artificial lateral lines for flow sensing," says Tan. This should give the robotic fish better balance. In addition, Tan and his research team want to develop fins capable of complex three-dimensional movements, as real fish fins are. The research is expected to advance the performance of robotic fish toward that of their biological counterparts. In the process, the research will potentially provide a way to investigate the locomotor and sensory mechanisms of real fish.

Tan wants to develop teacher training by engaging middle and high school science teachers in university lab research. John Thon, a Holt Junior High School teacher (wearing black shirt), works with Tan (top of photo), PhD student Dawn Hedgepeth, and Mart Anton, a post doctoral researcher (foreground).

Ultimately, Tan wants to be able to launch schools of the robotic fish in ponds, lakes, or an ocean and use them for tasks such as detecting pollution and harmful algal blooms, monitoring aqua-farms, and safeguarding drinking water reservoirs. That challenge has graduate students enthused. "There are many serious research issues, especially related to energy efficiency and energy harvesting," says Tan.

– Jane L. DePriest

Getting Legislative Attention

Robotic fish are definitely attention getters. That's part of the reason MSU selected Xiaobo Tan to be part of the 14th Annual Coalition for National Science Funding (CNSF) Exhibition and Reception in Washington D. C. this past summer. MSU is part of the CNSF, an alliance of more than 100 institutions and professional societies that supports the goal of increasing the national investment in the NSF's research and education programs.

During the exhibit, researchers had an opportunity to meet legislators and explain their research and the importance of scientific funding. Tan and ECE PhD student, Dawn Hedgepeth, presented a poster, "Electroactive Polymers as Artificial Muscles and Sensors; Investigation from a Systems Perspective," that described Tan's NSF CAREER project and its potential for societal, educational, and outreach impacts. The highlight was a live demonstration of artificial muscle-enabled robotic fish, which made their conversations with congressmen and their staffers much easier.

Dawn Hedgepeth (left), ECE PHD student, and Xiaobo Tan (center) visit with Arden Bement, director of the National Science Foundation during the CNSF Exhibit on Capitol Hill.