member profile

redefining robotics

Yosi Bar-Cohen brings biomimetics within arm's reach.

By Erin M. Schadt

Imagine sitting down to an arm-wrestling match. You place your elbow on the table and reach across to grab your opponent's hand. You grasp a hand, but it's not human. Instead, the arm is powered by artificial muscles.

This scene may not be too far off due to efforts by SPIE Fellow Yoseph Bar-Cohen, a senior research scientist and group leader at the Jet Propulsion Laboratory (JPL; Pasadena, CA) responsible for Nondestructive Evaluation and Advanced Actuators (NDEAA) Technologies.

EAP in action

Bar-Cohen first pitched the idea to develop artificial muscles to NASA's TeleRobotic Intercenter Working Group in 1995. From this sprang a four-year project called LoMMAs (Low Mass Muscle Actuators) involving a team of scientists from NASA, the Langley Research Center (Hampton, VA), and the University of New Mexico (Albuquerque, NM).

This project was supported by the NDEAA lab, which Bar-Cohen formed in 1991. This lab not only focuses on actuators and robotics, but also on NDE methods, transducers, and sensors. In 1999, NASA spotlighted Bar-Cohen and his team's creation of a four-fingered gripping device and a dust-wiper EAP actuator for space applications.

Yoseph and Denny Bar-Cohen with their Shih-Tzu, Bamba.

Also that year, Bar-Cohen initiated the first SPIE conference "Electroactive Polymer Actuators and Devices (EAPAD)" as a part of the Smart Structures and Materials Symposium, and has chaired the conference each year ever since. "To make this field more exciting, I came up with a challenge to the world science and engineering community to develop a robotic arm that would arm wrestle a human opponent and win," he says. "Furthermore, I initiated a session called 'EAP-in-Action' at the EAPAD conference where developed materials and devices are presented, and my hope is to have the arm-wrestling match as part of this session."

But his passion for EAP doesn't stop there. He edited the book *Electroactive Polymer (EAP) Actuators as Artificial Muscles—Reality, Potential, and Challenges*, published in 2001 by SPIE Press. In addition, he and co-editor Cynthia Breazeal took the field of artificial muscles to the next level—biomimetic robots—in their book *Biologically Inspired Intelligent Robots*, out soon from SPIE Press.

more than muscle

Bar-Cohen isn't just about muscle, though. During childhood, he says, "I enjoyed reading books about chemistry tricks, and, of course, liked to impress the neighborhood kids with the expertise that I gained."

During high school, Bar-Cohen was drawn to physics, finding that it provides the foundation to understanding nature and chemistry. He went on to earn his undergraduate degree in physics from the Hebrew University (Jerusalem, Israel). "Right around the time that I finished my undergraduate studies, the university opened a new master's program in applied science and technology. It had what I sought—a materials science department—and I was the first student to graduate from this program," he says.

In 1971, while a co-op student at the Israel Aircraft Industry,

he discovered the interdisciplinary field of nondestructive evaluation (NDE), and earned a PhD at the Hebrew University with the thesis topic of ultrasonic visualization of defects using the analogy to optics.

Shortly thereafter, Bar-Cohen moved to the United States with his wife, Denny, and young fraternal twins, Limor and Yaniv, to work at the NDE branch of the Air Force Materials Laboratory, Wright Patterson Air Force Base (Dayton, OH). During his first year there, he discovered the polarization backscattering (PBS) phenomenon, and later discovered the leaky lamb waves (LLW) in composite materials.

"Actually, I was looking through a Schlieren system to see if I could detect leaky surface waves, which was a phenomenon that was widely studied in metals in the early '80s," Bar-Cohen explains. "To my surprise, I was getting similar patterns even though I was using a relatively low-precision system, and the phenomenon appeared in many angles as opposed to the case of the surface waves. Out of concern that this was an artifact, I conducted many experiments over a period of three months before mentioning it to anyone."

Thankfully, he did share his work on PBS and LLW; the resulting studies by NDE engineers are used around the world to detect defects in composite structures. Because of this innovation in the field of NDE, Bar-Cohen was awarded SPIE's NDE Lifetime Achievement Award in 2001. He is also a fellow of the American Society for Nondestructive Testing.

Since forming the NDEAA in 1991, "most of my time is dedicated to research and development related to harnessing the capabilities of electroactive materials for planetary and other applications," he says. Mechanisms resulting from work at JPL include the ultrasonic/sonic driller/corer (which won the 2000 *R&D Magazine* award as one of the 100 most innovative instruments of that year), piezopumps, the haptic interface MEMICA, multi-radiation ferrosource, medical treatment tools, biomimetics, and robotics. These innovations and initiatives earned him the 2001 NASA Honor Award: NASA Exceptional Engineering Achievement Medal.

"I attribute my success to my imagination, creativity, and hard work; but above all, it comes from good collaboration with top experts worldwide," Bar-Cohen says. "My idea of cooperative research with interdisciplinary experts was adapted from the world of the ants who collectively are capable of performing impressive tasks that are far beyond what they are expected to be able to do as individuals."

beyond robotics

"My daughter, Limor, lives in Los Angeles," Bar-Cohen says, "and is a social-science researcher at UCLA's Center for Healthier Children, Families, and Communities. My son, Yaniv, lives with his wife Dorin in Boston, and he is a Fellow at the Harvard children's hospital, specializing in pediatric cardiology." Denny is just as busy. She went back to school, earned an MS in psychology, and is nearing completion on a PhD in organizational psychology at the California School of Professional Psychology, part of Alliant University.

Bar-Cohen and Denny find time to ride their tandem bicycle on weekends, with their Shih-Tzu dog, Bamba, along for the ride in the front basket. Bar-Cohen says one of his favorite hobbies is telling jokes; he has even drafted a manuscript for a joke book. And perhaps, sometime soon, he will be able to add robotic arm-wrestling to his list of hobbies.

member news and announcements

members put their stamp on new SPIE products

Many members are involved in creating new SPIE products. Featured below is information on new and upcoming products offered by SPIE members.

Two short courses presented at Photonics West will soon be transformed into 3-in-1 distance education tools. The following courses will show up as video, CD-ROM, and Webcast products. SPIE Fellow James R. Leger's *Microlens Arrays: Properties and Applications* provides an introduction for engineers, technical managers, and students to the types of microlens arrays currently available and their optical characteristics. Topics include optical properties of arrays, fabrication techniques, and applications to coherent and incoherent imaging systems.

William J. Cassarly's *Design of Efficient Illumination Systems* also will be a 3-in-1 distance education tool. Cassarly addresses balancing uniformity, maximizing the collection efficiency from the source, and minimizing the size of the optical package when designing optical systems through a combination of computer simulations, hardware demonstrations, and discussions.

Computed Tomography: Principles, Design, Artifacts, and Recent Advances by Jiang Hsieh is just out from SPIE Press. Hsieh's book provides an overview of the evolution of x-ray computed tomography, the mathematical and physical aspects of the technology, and the fundamentals of image reconstruction using algorithms. Hsieh examines image display from traditional methods through the most recent advancements, and discusses key performance indices, theories behind the measurement methodologies, and different measurement phantoms in image quality.

Kenneth Compton's new tutorial text *Image Performance in CRT Displays* fully explains CRT-based displays in a single, easy-to-understand narrative. Detailed explanations and insights into performance properties and safety limits of the various glass melts follow a discussion of the fundamentals. For more information on these products, see the Education and Publications portions of www.spie.org.

homeland security group to conduct inaugural meeting

A new homeland security technical group has been formed in part because of the enthusiastic response to SPIE's Optics and Photonics for Homeland Security workshop in December 2002 and also because of the focus on defense. The recent development of commercially available, low-cost photonic devices, components, and systems suggests that these technologies have significant potential for defense applications. The inaugural meeting will take place during SPIE's AeroSense meeting on 22 April (Orlando, FL). Ted Saito (Lawrence Livermore National Labs, Livermore, CA) is chair pro-tem.

The new technical group will bring together leading international experts from industry, government, and academia to discuss the field of photonic systems and devices for security, verification, and anticounterfeiting. The group will develop strategies and plans to bring key people together to focus technical resources and integrate with government efforts. The group will discuss research needs and current technology, major research, development goals for research in the field, including strategies for achieving those goals, and more.

For more information, contact Ted Saito at ted.saito@osd.mil.

in memoriam: Werner Weiglhofer

By Akhlesh Lakhtakia

Werner Siegfried Weiglhofer, professor of applied mathematics at the University of Glasgow (UK), died 12 January. While snowshoeing on the slopes of Bispen, Norway, he was struck by an avalanche.

Born in 1962 in Austria, Weiglhofer obtained a doctorate in technical sciences from the Technical University of Graz in 1986. Weiglhofer's research interests lay in magnetohydrodynamics and theoretical electromagnetics of complex materials. Author or co-author of more than 120 journal papers, he created work marked by an elegance that was spartan in style and extensive in scope.

Among his many notable contributions were the delineation of magnetic instabilities in rotating plasmas; the development of scalar Hertz potentials and Green functions for bianisotropic materials; wave propagation in structurally chiral materials such as certain sculptured thin films; and homogenization of linear and nonlinear, particulate composite materials. Weiglhofer was a prolific reviewer for more than 30

different international journals, and served on the editorial boards of two journals: *Electromagnetics* and *Archiv für Elektronik und Uebertrangungstechnik.*

He was the chair of two SPIE conferences ("Complex Mediums" in 2000 and "Complex Mediums II" in 2001), and served as a session chair at several other SPIE conferences. In September 2002 he began co-editing a pedagogical volume on electromagnetic fields in complex materials, which will be published by SPIE Press this year.

But the preeminent love of his life was the mountains. He enjoyed hiking, skiing, and snowshoeing. The peaks of Romsdal, Norway, held him in complete thrall; he surveyed Romsdal and published two guidebooks to its peaks. He was never happier than when in high country, above the clouds, which is where he left his parents, comrades-in-arms, friends, students, and admirers.

Akhlesh Lakhtakia, a friend of Werner Weiglhofer, is a professor of engineering sciences and mechanics at Pennsylvania State University.

Luxel Corp. receives Tibbetts Award

SPIE Corporate Member Luxel Corp. (Friday Harbor, WA) received a Tibbetts award from the U.S. Small Business Administration's Small Business Innovation Research (SBIR) program on 2 October 2002, in Washington, D.C.

Since 1973, Luxel has produced ultrathin foil filters for use as bandpass filters in the extreme UV and soft x-ray portion of the electromagnetic spectrum, for both laboratory and space research applications. Luxel supplies the filters to such programs as NASA's Chandra X-ray Observatory and Lawrence Livermore National Laboratory's National Ignition Facility (Livermore, CA).

Building on the success of Luxel's first SBIR contract in 1992, the company has grown from seven employees to 20 and sales have tripled to more than $2.2 million per year. Luxel has been awarded a total of 11 SBIR contracts, including five Phase II contracts.

Improved filters for solar astronomy and for use with cryogenic detectors have been made possible as a direct result of the work accomplished under these SBIR contracts.

The Tibbetts awards are presented annually to small firms, projects, organizations, and individuals judged to exemplify the very best small business practices in research and development, and to recognize them as models of excellence in high technology.

"Luxel owes much of its success to the SBIR program," says Forbes Powell, president and owner of Luxel. "Through SBIR investments, Luxel has developed new filter materials and processes for plasma research and space astronomy. For example, NASA's Chandra X-ray Observatory utilized Luxel filters based on SBIR-funded technology."

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