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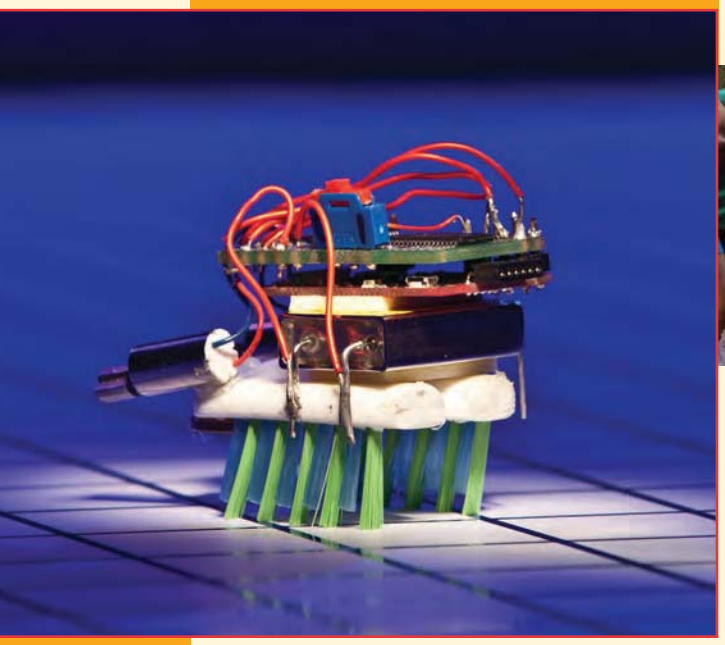
E@M

THE MAGAZINE OF THE A. JAMES CLARK SCHOOL *of* ENGINEERING

We, Robots

Building Collaborative Machines—and a Powerful Network of Researchers, Centers and Academic, Government and Corporate Partners

THE UNIVERSITY OF MARYLAND



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Dean

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Assistant Dean for Communications

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Jason Quick
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Please note that *Engineering @ Maryland* refers to the A. James Clark School of Engineering by that name in all cases, including stories that describe alumni who graduated before the name was established, in 1994, to honor Mr. Clark's outstanding philanthropy.

COVER PHOTO BY
PROF. DAVID AKIN.
PAGE 20 MAP BY
LAURA FIGLEWSKI

Dear Friends of the Clark School,

Have you ever swum with robots?

Heather Bradshaw has. She's the aerospace engineering graduate student pictured on this issue's cover, doing the sidestroke in our Neutral Buoyancy Research Facility while collaborative robotic mini-subs school around her.

If you didn't know that robotics is a key strength of the Clark School of Engineering and the University of Maryland, you're not alone. Only last year did we begin to assess the robotics research now underway on campus. Through that process we came to realize that, with some 30 faculty members participating, we have one of the nation's largest academic robotics groups.

Further, we are located in the federal region, where a significant number of organizations with a strong interest in robotics makes their home (see map, page 7). These include established and start-up corporations and a broad array of government agencies.

Many of our researchers have independently taken advantage of their proximity to these organizations to build their own research networks and secure funding for their work. But we know that we could capture even more significant grants and contracts, and make greater contributions to the field, if we could work together like the collaborative robots on the cover.

Have you ever swum with robots?

That's why we formed the Maryland Robotics Center. It helps researchers form partnerships across department boundaries, connect with funding opportunities in the federal region and beyond and launch new companies through the Maryland Technology Enterprise Institute. The Maryland Robotics Center is focused on modeling, designing and integrating robots of all scales that move in the air, sea or over land. These robots are autonomous, networked, and many can collaborate with one another.

The center also helps us connect with young people. At our first Maryland Robotics Day last fall, the many high school and middle school attendees participated in demonstrations, gained a new appreciation for engineering and the sciences and perhaps moved a step closer to pursuing these. If they do, we will find more Heather Bradshaws to help us not only in robotics but in our overall research enterprise. To gain insight into the quality and impact of our research, see the map on p. 20.

Our next Maryland Robotics Day is 9/9/11. I hope to see you there.

Sincerely,

Darryll Pines
Dean and Farvardin Professor of Engineering

Cybersecurity Center Taps Clark School Expertise

The Clark School will play a pivotal role in a new university initiative launched late last year to develop innovative ways to protect our nation from the growing threat of cyberattacks. Working in partnership with industry and federal agencies, the Maryland Cybersecurity Center (MC²) promotes education, research and technology development, and commercialization in this emerging field.

"Every day we hear more stories about cyberattacks to our businesses and government," said U.S. Senator Benjamin L. Cardin (D-Md.) at the launch event for MC² in December. "The work at the University of Maryland is critical for our national security and will create additional jobs for the people of Maryland." MC² builds on Gov. Martin O'Malley's CyberMaryland initiative, which calls for making the state the nation's center for cybersecurity.

"Cybersecurity is a complex and rapidly evolving field," says Center Co-Director Patrick O'Shea, chair, electrical and computer engineering. "MC² will provide comprehensive, interdisciplinary solutions drawing on the collective expertise of our faculty and the strength of our research programs."

Faculty members from diverse disciplines, including engineering, computer science, business, public policy, social sciences and economics will develop multidisciplinary solutions to complex cybersecurity concerns. MC² will tap into Clark School research expertise in areas such as wireless network security, software security, digital forensics and cryptography, and will draw on the technology-commercialization resources of the Clark School's Maryland Technology Enterprise Institute (Mtech).

Because of its proximity to the nation's capital and its close collaborations with key federal agencies, the university is uniquely poised to tackle the challenge of cybersecurity, notes O'Shea, who will lead the center with fellow Co-Director Larry S. Davis, computer science.

The center will play a key role in connecting organizations through partnerships and cooperative ventures in the public and private sectors. Current industry partners include Lockheed Martin and Science Applications International Corporation. ■

Workshop Focuses on Nuclear Power Industry

On May 4 and 5, the Clark School will host a professional workshop on cybersecurity that focuses on new regulatory and industry-led initiatives to protect nuclear power plants from cyber-based threats. For more information, visit www.cyber.umd.edu.

High-Tech Solution to "Dirty Bomb" Threat

Nearly seven million cargo containers arrive at U.S. seaports annually—each potentially compromised by terrorists. Thanks to the work of Clark School researchers, authorities may soon have a new tool in their fight against terrorism, allowing them to detect remotely a shipping container that is hiding radioactive materials that could be used to construct "dirty bombs."

Victor Granatstein, electrical and computer engineering and the Institute for Research in Electronics and Applied Physics (IREAP), and IREAP Senior Research Scientist Gregory Nusinovich have developed a technique for detecting concealed radioactive materials without individually searching shipping containers. The process, described in a recent article in the *Journal of Applied Physics*, is based on the concept that radioactive materials emit gamma rays, which ionize the surrounding air.

A device that points a high-power, short-wavelength electromagnetic source at shipping containers could detect this ionization, indicating radioactive material. The researchers predict that the system

could have a range of tens of meters—allowing remote detection of radioactive material from a helicopter flying overhead.

"It is not yet clear whether this approach to detection of nuclear material is practical," says Granatstein, "but it is worth pursuing, since it could impact an important need related to national security." A five-year grant from the Office of Naval Research supports their work. ■

PHOTO COURTESY OF THE WALTERS ART MUSEUM, BALTIMORE

This sculpture, whose detailed surface makes it difficult to protect from tarnish, would be a prime candidate to receive a new coating being developed by Clark School materials scientists and conservators at the Walters Art Museum in Baltimore.

Clark School Research Shines in Museum Collaboration

In an effort to keep irreplaceable silver artwork glistening for generations to come, Clark School researchers have teamed up with the Walters Art Museum in Baltimore to develop and test a new, high-tech preservation method. The technique is expected to shield detailed pieces that currently are difficult to protect from tarnish.

Atomic layer deposition (ALD) will create nanometer-thick, metal oxide films which, when applied to an artifact, are both transparent and optimized to reduce the rate of silver corrosion. The films are created when the object is exposed to two or more gases that react with its surface.

"ALD gives us an exquisite level of control, literally at the atomic level," says Ray Phaneuf, materials science and engineering, who is leading the research. "It is an effective, low-cost strategy to reduce corrosion and preserve artifact appearance and composition while complying with the rigorous standards of art conservation practice."

The three-year project is one of the first to be funded by the National Science Foundation's Chemistry and Materials Research at the Interface between Science and Art (SCIART). The program will be highlighted at the 2011 national meeting of the American Chemical Society, which has invited the Clark School team to present its work and describe how the new technique will be tested on silver samples. While the Walters does not plan to use the experimental treatment on any of its pieces during the course of the study, once it is proven effective and safe, the method may be critical to preserving the beauty of the museum's extensive silver collection. ■

E@M Update: Second Mtech Company Sold for More Than $1 Billion

The fall 2010 issue of *E@M* featured a profile of Martek Biosciences, a former Maryland Technology Enterprise Institute (Mtech) company. In early December, Martek entered an agreement to be acquired by the Dutch company Royal DSM NV for $1.1 billion, the companies jointly announced.

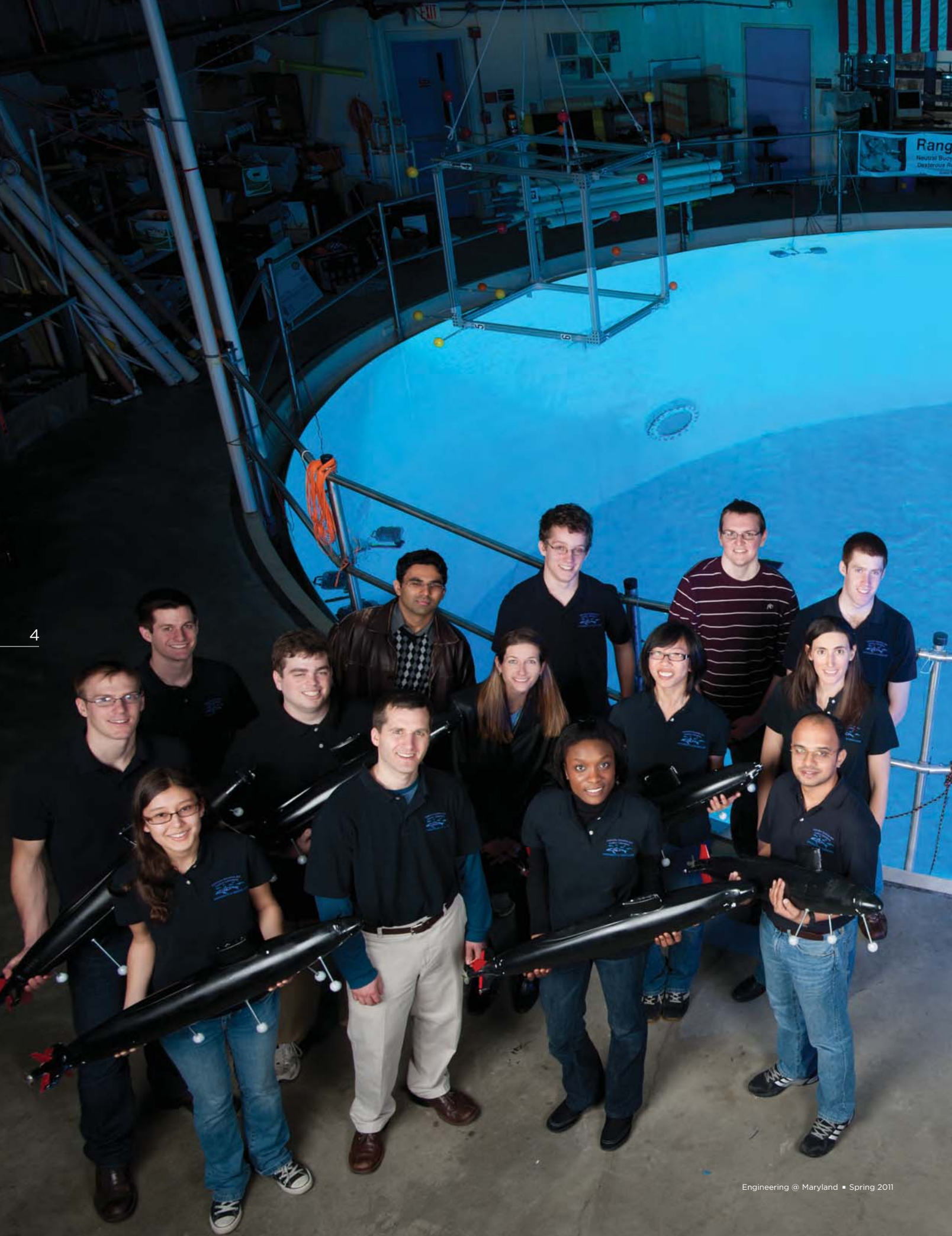
Martek is the second company sold for more than $1 billion in the past three years that made extensive use of Mtech's venture-building and biotechnology programs during its early stages. Digene Corporation was acquired by Qiagen NV for $1.6 billion in 2007.

Martek is a leader in the innovation, development, production and sale of high-value products from microbial sources that promote health and wellness through nutrition. The company's flagship product is a sustainable and vegetarian source of algal docosahexaenoic acid (DHA), which is important for brain, heart and eye health throughout life. The product is used in infant formula, pregnancy and nursing products, foods and beverages, dietary supplements and animal feeds. ■

PHOTO BY BILL GEIGER

Farvardin to Lead Stevens Institute of Technology

Nariman Farvardin, former university senior vice president for academic affairs and provost, and former Clark School dean, was named the seventh president of the Stevens Institute of Technology in January 2011, following a 27-year career at the University of Maryland. Farvardin's accomplishments as provost, beginning in 2007, include the development of a new General Education program, a new Honors College and new living-learning programs, and a host of initiatives resulting from the implementation of the university's ambitious strategic plan, *Transforming Maryland: Higher Expectations*. Farvardin served as dean of the Clark School from 2000 to 2007. Under his leadership, the school's research and fundraising activities reached new levels, the Keystone Professors and many other innovative programs were launched, and the school's rankings rose dramatically in a variety of surveys, with standings in the top 10 or 20, nationally and internationally. From 1994 to 2000, Farvardin served as chair of the Department of Electrical and Computer Engineering. The Clark School's faculty, staff, student body and Board of Visitors wish him nothing but the best in his new position. See the fall 2007 issue of *E@M* for an appreciation of Nariman Farvardin's contributions to the Clark School. ■



We, Robots

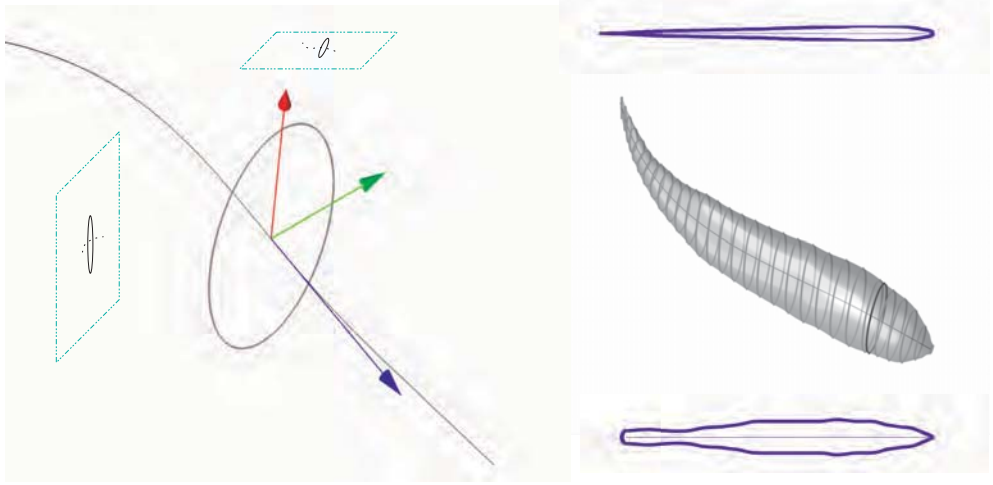
Building Collaborative Machines—and a Powerful Network of Researchers, Centers and Academic, Government and Corporate Partners

Six sleek, black, yard-long submarines move in unison, circling the 367,000-gallon cylindrical water tank in the Clark School's Neutral Buoyancy Research Facility (NBRF). Each sub is an inexpensive, off-the-shelf product, originally remote-controlled, that has been modified by students to operate as an autonomous, unmanned underwater vehicle (UUV), a robot able to function independently in the currents of this unique environment.

Autonomous—yet each is also linked to all the others. Golf-ball sized markers that sprout from the subs' walls enable an underwater motion-capture system to track their locations, orientations and speeds relative to each other. The system transmits that data to the subs, enabling their on-board controllers to guide them—together, against the currents—to a desired depth and moving formation.

Derek Paley, center front, stands tank-side with some of the undergraduate and graduate students on his Collective Dynamics and Control Lab team.

PHOTO BY MIKE MORGAN



Using silhouettes in multiple views, an automated process generates the fish shape as a series of elliptical cross sections along a flexible midline. The shape reconstruction allows researchers to determine more accurately how the fish interacts with its environment.

The similarity to a school of fish is unmistakable—and intentional. One day, when UUVs like these cooperatively explore the oceans in search and rescue, military or hurricane-forecasting missions, they will be modeling the behavior of organisms that have learned this technique over billions of years. Derek Paley, assistant professor of aerospace engineering (AE) and founding director of the Clark School's Collective Dynamics and Control Lab, is building the cooperative algorithms that will enable the UUVs to do so.

"My work studies natural systems to understand collective behavior," explains Paley, who last year won a Faculty Early Career Development Award (known as a CAREER award) from the National Science Foundation (NSF) to study the coordinated movement of fish and apply it to UUVs. "By studying a school as an information network, we can apply signal detection theory, which is used in biology and engineering, to begin to understand the movements of the group and how individuals respond in collaborative networks."

From Schooling Danio to Schooling UUVs...

Paley's work is on the cutting edge of the emerging field of biologically-inspired engineering, which explores and applies biological principles to create new technologies for mobility, sensing, communications and other functions in a wide variety of applications from health care to defense. Collaboration across disciplines, for which the Clark School is well known, is a key factor for success in the field.

Guided by Alison Flatau, interim Clark School associate dean for research and AE professor, Paley found an eager collaborator just a few buildings away. Art Popper, professor of biology, who has spent a large part of his career studying hearing in fish, welcomed Paley into his lab. There Paley set up a network of cameras in a large fish tank to track giant danio—hardy, blue and yellow freshwater minnows about three inches long. Amanda Chicoli, AE graduate research assistant, aided by neuroscience major Jennifer Lun, designed the experiments, in which they measure the response of a school of danio to a flashing light. Sachit Butail, Ph.D. '12, AE, refined the tracking system to collect vast amounts of data at unprecedented rates. (Some 22 graduate and undergraduate students work closely with Paley to construct his test beds and collect and analyze data.)

"We use mounted cameras on each side of the fish tank as sensors to track fish in the school," explains Butail. "We want to understand where the fish are looking and how fast they sense the threat of a predator and communicate it through the school. Using tools from projective geometry and Bayesian estimation, we reconstruct the three-dimensional position, orientation and shape of individual fish in the dense school and the shape of the school itself."

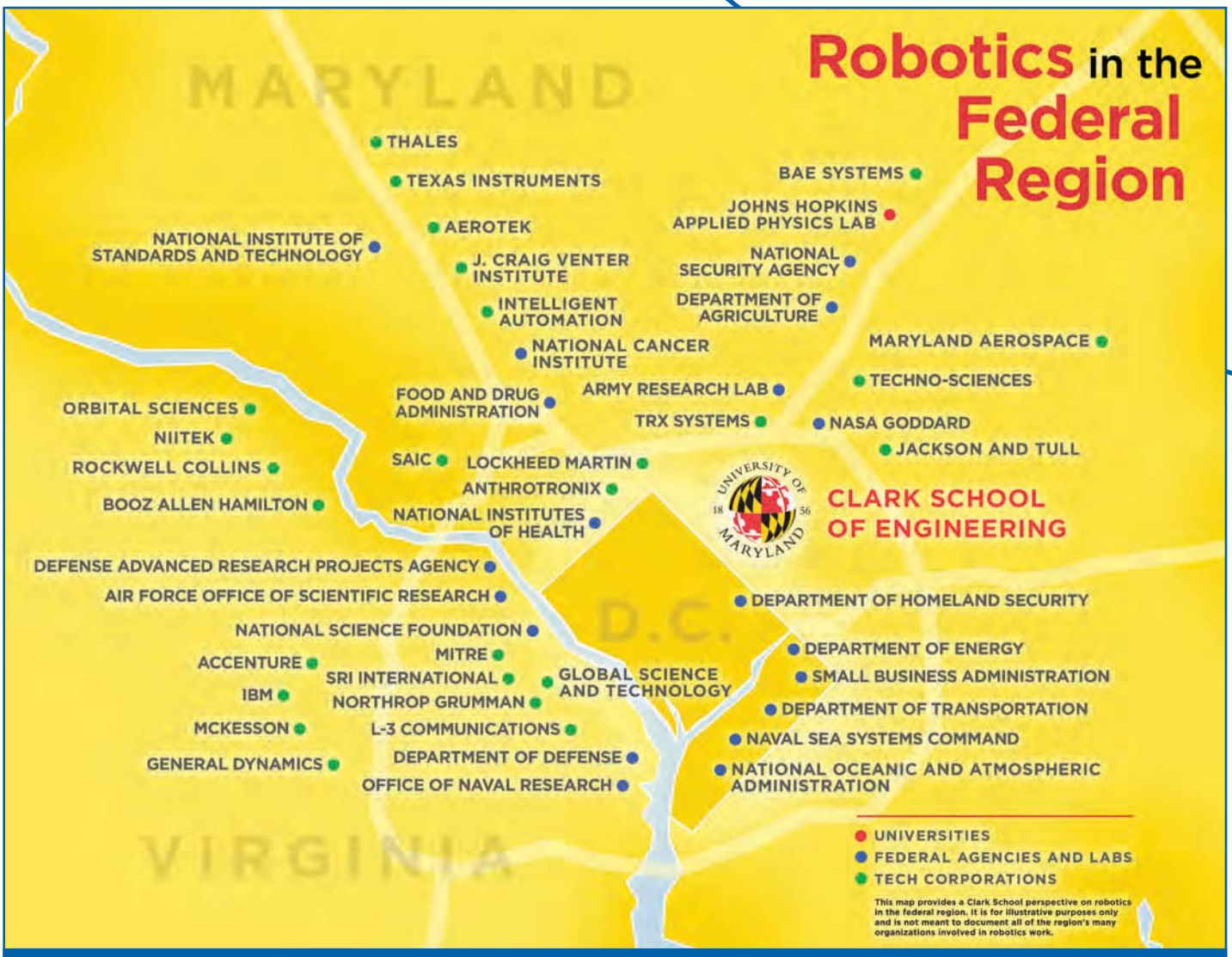
The team is particularly interested in learning the signaling methods among fish that coordinate school movements and the connection between school density and responsiveness. "The information will not only help us develop better sensing and communication technologies for collaborating UUVs, but also improve biologists' understanding of schooling behavior," Butail adds.

22 Number of students who work in the Collective Dynamics and Control Lab

...to Schooling Researchers

Back in the Neutral Buoyancy Research Facility, Paley makes the connection between the danio and his subs. "When our UUVs school in the NBRF today," he explains, "we give them information about currents in the tank, which they use to stay on course. The next step will be to sail them without that information." Like a real schooling fish, a UUV will have to detect a current, adapt to it and transmit the information to the other UUVs so they can

(continued on page 8)



The Advantages of Doing Research in the Federal Region

Derek Paley came to the Clark School by way of a bachelor's degree in applied physics from Yale, a stint at Massachusetts UUV firm Bluefin Robotics, and a doctoral degree in mechanical and aerospace engineering from Princeton. He joined the faculty of the Clark School's Department of Aerospace Engineering in 2006.

"The Clark School offers a highly collaborative research environment, which is critical to my work," says Paley. "And its location is ideal. I can drop my children off at school, drive into Washington, D.C., to participate in an NSF review panel or visit a program officer at a funding agency, and return home that evening rather than taking an overnight trip."

In addition to his recent NSF CAREER Award, Paley has received funding from the nearby Office of the Secretary of Defense and the Office of Naval Research (ONR). "From the dean on down, Clark School faculty and staff members help you learn how the system works. Many faculty members have worked closely with or held positions in agencies," Paley describes. "Their contacts and experience help you get involved in the peer review process and make the right connections." (See related story, p. 21)

"Derek's work in cooperative robotics is of great interest to us," says Marc Steinberg, an ONR project manager who cites the convenience of visiting the Clark School. The agency pursues robotics systems that can conduct minefield surveillance, carry military cargo and perform other tasks. "Derek's work may enable systems that can operate effectively in severe weather conditions with very strong winds and currents."

Paley maintains ties in the corporate sector as well, including his former employer. "Our experience is primarily single-vehicle control, but we need to monitor, control and fuse information for large numbers of vehicles as well," explains Jeff Smith, Bluefin director of programs. "Relationships with institutions like the Clark School are vital for staying on the cutting edge."

Closer to home, Paley is on the radar of TRX Systems, Inc., an Mtech incubator company that focuses on technology that tracks first responders in GPS-denied environments (see the fall 2010 issue of *E@M*). "We've concentrated on tracking personnel on foot," says Chief Technology Officer and Chairman Carole Teolis. "We are now expanding our architecture to accommodate tracking on land, sea and air. Derek has put together unique facilities for testing and validating navigation systems for submarines, swimmers and air vehicles, and we are interested in how his sensors and algorithms could be applied outside of the laboratory."

PHOTO BY MIKE MORGAN

From left, Sarah Bergbreiter, Pamela Abshire, Elisabeth Smela, and Nuno Martins review the components of their prototype antbots on a tracking system grid.

adapt as well. To accomplish this at low cost, without expensive and heavy inertial measurement units and global positioning components, Paley continues, will require "new mathematical models and motion-coordination algorithms, derived from our experiments in Professor Popper's lab. These will be of value not only for UUVs but for cooperative unmanned air vehicles as well."

Just as the danio depend on a schooling network that Paley hopes to define better than anyone previously, his research depends on a network that he and the Clark School have built. "You can't help but make the analogy," Paley says. "My 'school' consists of mentors, colleagues, students, federal agencies and tech corporations. We communicate with each other, alert each other to new opportunities and help each other navigate unexpected currents."

Antbots to the Rescue

In a futuristic disaster scenario, we might imagine tiny, nearly invisible, networked autonomous robots that swarm over the wreckage of a major earthquake. They penetrate through narrow gaps in massive, fallen slabs of concrete that larger robots—or people—would have to lift. The swarming micro-robots sense buried victims and send back information to enable highly targeted, life-saving rescue missions.

In a group of labs not far from the NBRF, a team of Clark School researchers from mechanical engineering (ME) and electrical and computer engineering (ECE) takes the ant, one of the world's tiniest and most collaborative insects, as inspiration for just such a scenario.

"Our goal is to develop the first network of autonomous robots that can cooperate in a specific task at an ultra-small size. This has never been accomplished before," says Nuno Martins, assistant professor of ECE and the Institute for Systems Research (ISR). Martins serves as the principal investigator for a $1.5 million grant awarded by the newly created NSF Cyber-Physical Systems Program to develop "antbots." "We are pushing the limits with new design principles and technologies for a distributed network of ant-sized mobile micro-robots at the sub-cm^3 scale that can self-organize into cooperative configurations."

Four Perspectives

Martins's role is to develop algorithms for distributed coordination and formation control of the wireless network of micro-robots. Their small size presents severe power, communication and mobility constraints. "The algorithms must be very simple. The more complex they are, the more computation that is required, the larger and more power-hungry the processor must be," he says.

Pamela Abshire, associate professor of ECE and ISR, is creating low-power, lightweight electronic hardware to support the antbots' computation and communication functions. "The robots must transmit information using as little energy as possible and activate communication only when necessary," she explains. She will explore hybrid computational approaches, such as a combination of analog, digital and mixed-signal formats.

Ant-size robots need ant-size legs. Elisabeth Smela, associate professor of ME, is building hardware for polymer-based legs that are electronically controlled and energy efficient. "The legs of these micro-fabricated systems need to be mechanically compliant to allow the robots to move in the real world," explains Smela.

Sub-cm^3 Scale of "antbots" for search and rescue

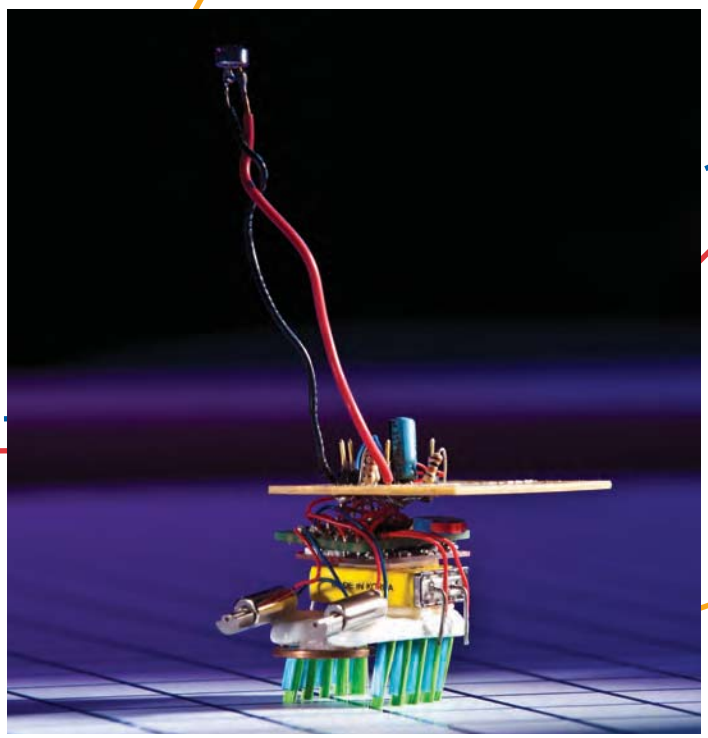


PHOTO BY MIKE MORGAN

A larger version of an antbot, used to test new control algorithms, includes an audio transducer to determine its location among other robots.

"These dielectric elastomer micro-actuators are a brand new technology. From the military to the medical community, there is a great interest in improving the capabilities of micro-actuators," she says, noting potential applications in micro-air vehicles that need to flap wings or change shape and micro-grippers to assist in surgical procedures.

Sarah Bergbreiter, assistant professor of ME and a winner this year of a NSF CAREER Award, is studying the form, or architecture, required for the robots and looking at methods of locomotion using the micro-actuators developed by Smela. "Nature is very good at moving across all sorts of terrain," she says. "Part of solving this problem for our robots is developing the actuators, but the legs and choice of locomotion methods, such as jumping or walking, are equally important. Locomotion will also have a big impact on both control and communication in robot networks."

The design of the antbot requires constant interaction among the researchers and an open-door policy at their respective laboratories. Formal biweekly meetings allow the ten or so graduate and undergraduate students working on the project to share their work and for the researchers to address pressing issues. "We are participating in the culture of collaboration for which the Clark School and especially the Institute for Systems Research are well known," says Martins. "It is a culture crucial to advanced robotics, but whose benefits impact all areas of research."

According to Martins, the antbots' applicability goes well beyond search and rescue. "These robots could be useful in conducting surveillance in high-risk military situations. They could help identify small amounts of toxic chemicals or assist with environmental monitoring. In medicine, they could play an important role in cell manipulation and micro-factories. I believe they will help us find applications we have not yet imagined."

Robotics Helps Develop a Cadre of Undergraduate Researchers

Robotics researchers often reap the benefits of hardworking undergraduate students who gain invaluable hands-on research experience in their labs—experience that can lead to career-shaping internship opportunities.

In his introductory aerospace engineering (AE) course, Patrick Mohl, B.S. '12, AE, rolled up his sleeves and set to work building the initial fleet of UUVs for Derek Paley (see related story, p. 5), installing radio-frequency transmitters and on-board automatic depth controllers to help make them autonomous. The project, led by Seth Napora, B.S. '09, M.S. '11, AE, ignited Mohl's interest in robotics. "Learning to apply concepts and theories to systems has made the whole area of robotics less daunting to me," says Mohl. "It's fun to work on the cutting edge of research."

"We installed equipment on the subs and conducted testing to be sure the subs were able to drive via remote control or autonomously," explains Patrick Nolan, B.S. '12, AE, whose experience in the lab helped him gain an internship with a defense contractor in systems engineering. "When you work on research projects, you know you are at the forefront of what is happening in the field and in industry."

Alexander Leishman, B.S. '12, AE, was a high school senior when he first visited the Clark School and met Paley. Leishman now develops formulas for a sophisticated wind estimator that can be used with motion-tracking systems to study movement of unmanned air vehicles. Last summer, Leishman worked for a company conducting geological surveys on the sea floor of the Gulf of Mexico using an autonomous vehicle.

Ethan Schaler

In the lab of Sarah Bergbreiter, (see related story, p. 19), Ethan Schaler, B.S. '11, mechanical engineering, is developing a technique for micro-robots to harvest and store energy. Schaler hopes to create networked micro-robots that can jump, crawl and climb, providing them access to remote and difficult-to-navigate areas to perform tasks such as planetary exploration and search and rescue.

Schaler is one of only 14 undergraduates nationwide to receive a prestigious Churchill Scholarship to study at the University of Cambridge in the United Kingdom. "My research experiences made a difference when applying for the Churchill Scholarship," notes Schaler, who previously won a Barry M. Goldwater Scholarship.

The Maryland Robotics Center

Helping Autonomous Researchers Work Collaboratively

Derek Paley and Nuno Martins are both developing cooperative, small-scale robots to perform search and rescue and related applications, Paley inspired by schooling fish, Martins by swarming ants. But Paley works in aerospace engineering and Martins in electrical and computer engineering, and despite the obvious similarities in their projects, traditional departmental boundaries might have kept the two from learning of, and benefiting from, each other's work.

But today they do work together, thanks to the new Maryland Robotics Center, administered within the Clark School's Institute for Systems Research (ISR). Paley and Martins, plus Nikhil Chopra, assistant professor of ME, are partners in a project to create a new testbed for cooperative robotics that will support projects by any faculty member within the center. Their project is funded by the center's new Seed Grant Program, started late last year.

The program is a competition that awards start-up funds to teams whose proposals are selected by an independent panel; it enables winning teams to take their work to the level at which external funding may be obtained. In the inaugural contest, "Panelists were quite impressed with the breadth and depth of the proposed projects," says Clark School Dean Darryll Pines. "We hope that the seed program incentivizes our researchers, increases the number of ideas that see the light of day and in the long run improves our ability to vie for and win agency grants."

The seed grant team of Martins, Paley and Chopra will develop enhanced robotics testing facilities, including the purchase of three ground robots and one aerial robot and the development of

Neutral Buoyancy Research Facility Attracts Researchers Across Disciplines

PHOTOS COURTESY OF NEUTRAL BUOYANCY RESEARCH FACILITY

The Clark School offers researchers many outstanding facilities, among them the Glenn L. Martin Wind Tunnel, the FabLab class 1000 cleanroom, the Center for Advanced Transportation Technology Lab, the Bioprocess Scale-Up Facility, the Keck Laboratory for Combinatorial Nanosynthesis and Multiscale Characterization, and the Nanoscale Imaging Spectroscopy and Properties Lab.

But of all our great research sites, it is perhaps the multi-part Space Systems Lab (SSL) that captures more people's imaginations than any other. Indeed, the SSL was recently voted one of the top five most "awesome college labs" by *Popular Science* magazine. And of SSL's several facilities, the Neutral Buoyancy Research Facility (NBRF) is, as described in a recent *Washington Post* article ("Gearhead Nirvana"), the *piece de resistance*. With its 50-foot diam-

new software. They will also create methods for the design and validation of algorithms for distributed control and coordination of collaborative robots.

The second team of Hugh Bruck, Elisabeth Smela and Miao Yu, all from ME, is using seed funding to explore multifunctional materials for robotic sensors, actuators and infrastructures. "We will be creating robotic structures that behave like biological systems, with the ability to sense pressure and temperature," explains Bruck. To devise those structures, "we are exploring an innovative concept using nanotechnology to create new, smart materials."

His team will investigate polymer systems to build robots at the nanoscale, milliscale and microscale. "We want to make the robots stronger and more damage-tolerant with materials that have integrity. This is a transformational technology that can facilitate enhanced interaction between robots and the environment and result in more versatile, robust robots," explains Bruck.

(continued on page 12)

The Source and Meaning of "Robot"

"Robot" was first used in *R.U.R. (Rossum's Universal Robots)*, written in 1920 by Czech playwright Karel Čapek. It is derived from a Czech word meaning "to work as a slave or a drudge."

Isaac Asimov introduced "robotics" in "Runaround," a short story in his *I, Robot* collection (1950).

Asked for a simple definition of "robot," three Clark School researchers provided these responses:

"A multifunctional machine that can move or manipulate parts, tools or specialized devices based on programmed instructions."

S.K. Gupta

"A machine that uses feedback control to respond automatically to its environment."

Derek Paley

"A device that can move and sense, with sensing and activation coupled in the same device. It should also have its own intelligence, ultimately making its own decisions."

Jaydev Desai

Top 5 Ranking of Space Systems Lab in the *Popular Science* "most awesome college labs" listing

eter, two-million pound water tank, it is the only facility of its type on a college campus and the only one in the U.S. dedicated to research. Tours by prospective students, and projects by current students and faculty members, regularly occupy the NBRF.

As part of the SSL, the facility's original focus was simulating the weightlessness that astronauts and robots experience in space. One major project was the Ranger series of robots, which were designed to repair satellites, prepare work sites and act as servicing systems for the Hubble Telescope and International Space Station. The NBRF has also developed the Maryland Advanced Research/Simulation (MARS) space suit, which is used to study human/robot interaction and simulate astronauts' working conditions.

While the NBRF remains a valuable asset for space-related research (see related sidebar, p. 14), the facility is now at the center of research that has implications much closer to home.

"Right now there is an explosion of research opportunities on the water's surface and with submersible, small-scale vehicles," says Dave

Akin, professor of AE and SSL director. "At the Clark School, you have faculty members with a wide variety of research domains and the desire to collaborate. The NBRF offers the instrumentation and equipment they need. The opportunities for collaboration just keep growing, and it has a snowball effect."

"We have an incredibly vibrant robotics community, and this lab can provide the framework for collaborative exchanges," says Akin. "Together, we can pursue research and proposals that could never be pursued on an individual basis."

One of the Nation's Largest Academic Robotics Research Groups

Helping faculty members from diverse areas form useful alliances is one of the primary purposes of the Maryland Robotics Center, which is directed by Satyandra K. Gupta, professor of ME and ISR. As Gupta explains it, the center is designed to increase awareness of campus robotics work among center members, encourage new cross-disciplinary interactions and lead to more innovative thinking and the sharing of resources. Ultimately the center aims to increase researchers' ability to vie for and win large research grants, create new products and—through the Clark School's Maryland Technology Enterprise Institute (Mtech)—launch companies to license, or build and market, those products. At the same time, the center will engage in outreach to increase external audiences' awareness of center work, serve as the point of contact to respond to inquiries and partnering requests and begin the process of establishing a full-fledged graduate education program and undergraduate minor.

"When we assessed robotics activities on campus," Gupta says, "we found that, in terms of the numbers of researchers engaged in robotics work, we had one of the largest academic groups in the nation." Good news—but many of the researchers worked in isolation. "We were pursuing interesting areas of work and winning some important grants. But there was clearly unrealized potential for more significant impact in the field, impact we would not achieve without making new connections among our own people internally and with academic, government and corporate partners externally. We decided to make those connections by establishing the center in spring 2010."

At present the center brings together 30 faculty members representing 18 different labs in eight different departments of the Clark School and the College of Computer, Mathematical and Natural Sciences: aerospace engineering, bioengineering, biology, civil and environmental engineering, computer science, electrical and computer engineering, kinesiology and mechanical engineering. Researchers explore sensors, actuators, structures and communication; novel robotic platforms; and robot intelligence and autonomy (see pp. 16-19 for a sampling of center work). Current research is supported by a host of major federal funding agencies, including the National Science Foundation, Army Research Lab, Office of Naval Research, Air Force Office

(continued on page 14)

30 Number of faculty members in the Maryland Robotics Center

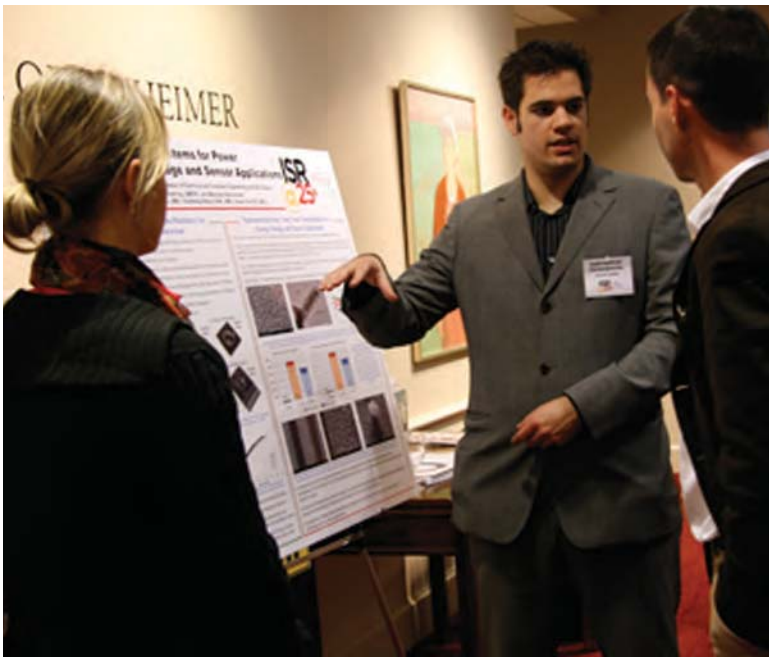
Robotics@Maryland Club Captures Third Place in International Competition

The Robotics@Maryland Club placed third among 22 other teams from across the United States, India, Canada, Iceland, Korea, China and Japan at the annual International Robosub competition in San Diego in 2010. Each team was challenged to design and build an autonomous underwater vehicle capable of navigating realistic underwater missions. The Robotics@Maryland Club is composed of more than 40 undergraduate and graduate students, including engineering, physics, math, computer science and business majors. Since its founding in fall 2006, the club has continued to expand and engage in novel projects, including a new Autonomous Robot Speedway land competition. To learn more about Robotics@Maryland, visit www.ram.umd.edu.

Mtech-Incubated Anthrotronix Cited by *Fast Company*

Anthrotronix, a graduate of the Mtech Technology Advancement Program, is developing advanced interface technologies, wearable computing and robotic control systems and simulation tools for training applications for both commercial and government clients. Its AcceleGlove is a low-cost gesture recognition system (based on patented technology) that detects the individual motions of the finger, hand, wrist and arm. As a robot controller, it uses the natural movements of the operator's hand/arm as the input device to control both the movement of the robot itself as well as the movement of ancillary devices, such as grasping and lifting arms. One application: bomb disposal. Co-founder Corinna Lathan was recently named one of *Fast Company* magazine's "100 Most Creative People."

ISR, at 25, is a National Leader in the Cross-Disciplinary Revolution



Left, Ph.D. student Konstantinos Gerasopoulos presents his work at the poster session held in conjunction with the ISR anniversary celebration. Right, Pam Abshire, associate professor, electrical and computer engineering (ECE) and ISR, right, works with Nicole Nelson, Ph.D. '10, ECE.

"At its core," states Reza Ghodssi, Herbert Rabin Distinguished Professor of ECE and director of the Institute for Systems Research (ISR), "robotics brings together multiple systems from multiple disciplines to work together as one. There could be no better home for the Maryland Robotics Center than ISR at the Clark School."

Bringing together historically separate disciplines to advance engineering is a methodology championed by ISR since its earliest days. In 1985, NSF established six Engineering Research Centers, including the Systems Research Center (now known as ISR) at the Clark School. Twenty-five years later, ISR is the only center still in existence and arguably the most successful in terms of both significant research programs and the promulgation of its central philosophy—the value of cross-disciplinary research. That philosophy has spread within the Clark School and the University of Maryland and among off-campus partners.

ISR Director Reza Ghodssi

"At a time when it was unusual for faculty members to cross disciplines and departments, we succeeded in putting together teams of researchers with diverse backgrounds to address some of society's and engineering's most important problems," says Ghodssi. Forty of ISR's current faculty members hold joint appointments with ties to both ISR and their respective departments. "Intellectual cross-fertilization is common throughout academia today, but in 1985 it was a new concept," Ghodssi notes. "Cross-disciplinary research at the university, and elsewhere by emulation, grew much faster as a result of the institute." Adds Maryland Robotics Center Director S.K. Gupta, "Because ISR sets high expectations for cross-disciplinary exchanges among faculty members, researchers come to the center prepared to join the ISR legacy. That makes my job so much easier."

ISR's contributions in the system sciences include integrated product and process design for manufacturing applications, helicopter control systems, air traffic control, healthcare systems, mobile ad hoc communications networks, sensory systems based on the echolocation systems of bats and fast and small micro-robots. Three growth areas are the Maryland Robotics Center, micro-systems and green communications.

"We will continue to cultivate a cross-disciplinary community that will move ISR in exciting new directions," says Ghodssi. "We will continue to lead by bringing our expertise in systems science and engineering to take on major societal challenges and solve problems in everyday life."

Partnering with Nearby Federal Agencies

As described throughout this article, Maryland Robotics Center researchers have established significant grant relationships with the major federal laboratories, many of which are located in convenient proximity to the Clark School. Two agencies with especially close ties are the National Institute of Standards and Technology (NIST) and NASA Goddard.

With Elena Messina, acting chief of NIST's Intelligent Systems Division, center members are improving the effectiveness of manufacturing and other robotic systems by defining methods to achieve accurate and unambiguous presentation and measurement of knowledge. "Our relationship with the Clark School refreshes our perspective on the latest research," says Messina. "The Clark School serves as our eyes and ears in terms of developing algorithms for many robotics technologies."

Two center researchers work on site at NIST within Messina's division. Zeid Kootbally, research associate, ME, is developing automated path planning and autonomous navigation for automated guided vehicles that could have applications on the manufacturing factory floor, and Raj Madhavan, assistant research scientist, ISR, is working on performance evaluation and benchmarking of intelligent robotic systems, with an emphasis on robot-generated maps.

At NASA Goddard, Brian Roberts, M.S. '99, AE, is the robotics demonstration and testing manager on the Space Servicing Capabilities Project. He formerly worked in the Clark School's Space Systems Lab and continues to utilize the facility now (see related story, p. 10). "The Space Systems Lab has been studying satellite servicing for years. It is great for NASA to tap into that knowledge and research," explains Roberts. "The Clark School is helping us develop the advanced concepts that we can apply in future missions."

In addition to employing a team of Clark School graduates and opening his labs to current students, Roberts uses Clark School facilities to evaluate NASA prototypes cost-effectively. "By testing our robotics systems at the Neutral Buoyancy Research Facility, we can avoid costly and time-consuming trips to NASA's Houston facility, and we can determine early in the development process if a robotics tool has potential."

PHOTO COURTESY OF NASA GODDARD

Alex Janas, B.S. '09, AE, and member of the NASA Goddard robotics demonstration team, operates one of NASA's robotic refueling tools that will be demonstrated on the International Space Station.

Students and advisers from Phelps High School, Washington, D.C., were among hundreds who visited labs during the first Maryland Robotics Day.

of Scientific Research, National Institutes of Health, Defense Advanced Research Projects Agency (DARPA), National Aeronautics and Space Administration and National Institute of Standards and Technology.

"Many of us have offices or labs within the A.V. Williams Building, and this proximity promotes the sharing of ideas and information among faculty members and graduate students," states Gupta. Relying on his own contacts in academia, industry and the federal labs, as well as the efforts of Jeffrey Coriale, ISR's external relations director (see sidebar, right), Gupta discovers and disseminates news of research opportunities, cultivates partnerships of benefit to the members and organizes members to submit joint grant proposals. This spring the first round of center-based proposals was submitted targeting DARPA, the U.S. Department of Agriculture, NSF and the Office of Naval Research.

Making it Easy to Get Involved

To grow its network of academic, corporate and government partners, the Maryland Robotics Center engages in a range of outreach activities and works with the Maryland Technology Enterprise Institute (Mtech) to encourage interactions with industry and the formation of new robotics companies.

Last September more than 400 people, including Clark School and university faculty members and students, some 100 high school students with their science teachers and parents, and representatives from neighboring federal laboratories, start-up companies and defense contractors gathered for the first Maryland Robotics Day—the center's kickoff outreach activity. The festival-like event, which included demonstrations in the plaza of the Jeong H. Kim Engineering Building and in 16 Clark School laboratories, showcased center research projects and their real-world applications and enabled researchers and attendees to meet, share ideas and consider new ways to work together. Martin Buehler, director of research competency at iRobot,

which has donated equipment to the center, was keynote speaker (see related story, below). The next Maryland Robotics Day is scheduled for September 9, 2011.

Techno-Sciences, Inc., a Beltsville, Md., company founded by Gil Blankenship, ECE, and led by Clark School Board of Visitors member Jean-Luc Abaziou, is sponsoring a robotics seminar series through the center, starting this spring. Representatives of industry, federal research agencies and state economic development organizations are invited to join faculty members and students to learn the latest advances in robotics research and applications. For more information, see www.robotics.umd.edu.

Mtech delivers an extensive array of programs to help businesses and entrepreneurs work with the Maryland Robotics Center and other Clark School researchers, including the Technology Advancement Program incubator; the Maryland Industrial Partnerships program, which links university researchers and Maryland companies; and the Maryland Manufacturing Assistance Program, which helps companies increase productivity, lower costs and develop new markets. Contact David Barbe, Mtech director, at 301-405-3906 or see www.mtech.umd.edu for more information.

9/9/11 Date for upcoming Maryland Robotics Day

(continued on page 16)

Join the Center's New Industrial Affiliates Program

In robotics, the speed of technological development and the emergence of new applications challenge companies to stay current. A new Maryland Robotics Center Industrial Affiliates Program is now being formed to link center researchers with companies and help corporate engineers keep abreast of the latest ideas, engage in joint research, find employees and develop or license intellectual property.

"Our goal is to build high-quality, long-term relationships with established and start-up companies that have a strong interest in robotics," says Jeffrey Coriale, for more than a decade the director of external relations for the Clark School's Institute for Systems Research (ISR). Through the affiliates program, Coriale explains, companies could send visiting scientists to study at the Clark School, gain access to student interns and potential full-time employees and partner with a Robotics Center team on a major proposal or research initiative. He is exploring robotics collaborations with Lockheed Martin and notes that of the five Ph.D. fellowships recently sponsored by L-3 Communications at the Clark School, two were in robotics.

Corporate leaders echo Coriale's advocacy of Clark School-corporate affiliations. Vikram Manikonda, M.S. '94 and Ph.D. '97, EE, is president of Intelligent Automation, Inc. (IAI), a research and development think tank covering a broad range of areas from distributed intelligent systems to signal processing and robotics. Manikonda helped develop a motion-control language for robots as a Clark School graduate student. "Researchers at the Clark School make it easy to work with them," says Manikonda. "They readily share information and are eager to collaborate." Approximately 10 percent of IAI's 120 employees are ISR alumni, including the company's founders Jacqueline Haynes, B.A. '70, English, M.Ed. '76, secondary education and Ph.D. '82, secondary education; and Leonard Haynes, B.S. '67 and Ph.D. '74, electrical engineering. IAI recently began sponsorship of the Intelligent Automation Colloquia Series, a monthly showcase of faculty research, at ISR.

Martin Buehler, director of research competency for industry pioneer iRobot, states, "It is increasingly important for high-technology companies like iRobot to establish relationships with institutions like the Clark School. We have a world-class research and development operation from basic research to technology transition, but we can't possibly cover all bases. By building strategic alliances, we can explore funding opportunities and discover expertise to complement our own." At the same time, partnerships bring benefits to the center's members. "In working with us, Clark School researchers can get an inside view of relevant research problems and build a fruitful, symbiotic relationship based on complementary research."

Intelligent Automation, Inc. President Vikram Manikonda

For more information on partnering with the Maryland Robotics Center, contact Jeffrey Coriale at coriale@umd.edu or 301-405-6604.

The Maryland Robotics Center: From the Cellular to the Planetary

Hurricane forecasting. Satellite repair and retrieval. Treatment of breast cancer. Environmental monitoring. The range of applications for robots seems to grow daily. Robots can assist humans in the most dangerous of jobs, such as locating explosives on the battlefield, as well as the most mundane activities, such as cleaning a home. "As engineers and scientists we sometimes think of our robots in terms of broad technological categories. Are they designed for extreme environments? To work in small spaces with small things? Are they collaborative, designed to work in groups? Are they unmanned vehicles? But in the end," Gupta explains, "we are driven by the good they can do—improving or protecting our lives."

In the following sections we will introduce a variety of robotics projects now underway in the labs of center researchers. These by no means represent the full slate of the center's programs or even of the individual researcher's activities. To obtain a more complete survey of current projects, please visit the center's web site at www.robotics.umd.edu.

Improving Medical Research through Robotic Manipulation of Individual Cells

If medical researchers could reliably and speedily grip, move and otherwise manipulate individual cells, their understanding of cell-cell communications, cell-drug interactions and the differences between healthy and diseased cells would be enormously improved—along with their ability to combat cancer and other illnesses. Yet today, a single experiment can take weeks to set up and perform because it is so difficult to position dynamic living cells safely and accurately. S.K. Gupta, ME/ISR and director of the Maryland Robotics Center, is working with Wolfgang Losert, physics and director of the Partnership for Cancer Technology, and Amitabh Varshney, director of the University of Maryland Institute for Advanced Computer Studies, to solve that problem. Funded by two NSF grants, they are building an autonomous, image-guided "optical tweezers" robot that uses highly focused cones of laser light to trap and move micro-scale glass spheres in a fluid medium. The spheres act as rapidly reconfigurable grippers that, under laser control, gently enclose and move cells injected into the medium, permitting precise positioning of target cells and exclusion of unwanted material. The robot will view and manipulate cells with greater speed and accuracy than human researchers, deciding the best configurations of spheres and best travel paths to complete desired positioning. With minimal training, operators will gain a powerful new tool to study cellular function. For more information, see www.terpconnect.umd.edu/~skgupta/OT.html.

PHOTO BY MIKE MORGAN

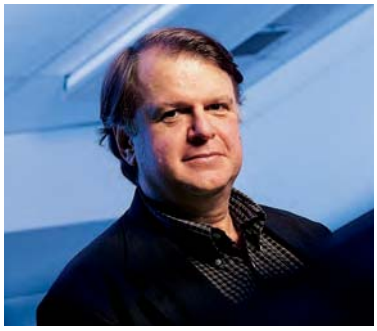
Maryland Robotics Center Director S.K. Gupta

Robots to Help Astronauts Collect Data on the Moon or Mars

Clark School robotics and space suit technologies are tested in the Arizona desert.

Drilling core samples and deploying instrument packages on the moon is hard work for astronauts. Add the effort required to move in a space suit, and it is easy to understand why our Apollo teams were worn out after three days, even when they brought lunar rovers to facilitate travel over the moon's surface. To succeed in the weeks or months-long moon and Mars missions contemplated for the future, astronauts will need help to achieve scientific data collection objectives. Teaming with Arizona State University (ASU) faculty members Kip Hodges and Srikanth Saripalli, in research sponsored by the NASA LASER (Lunar Advanced Science and Exploration Research) program, Professor David Akin, director of the Clark School's Space Systems Lab (SSL), is developing advanced robotics and space suit technologies to assist astronauts in lunar exploration. ASU provides planetary science graduate students as "astronauts" and various sites around Arizona that mimic the lunar landscape. The SSL team supplies specialized space suit simulators developed for analog field trials, plus advanced robotics for the students to use in simulated exploration missions—including a dexterous manipulator repurposed from earlier SSL research for NASA. Based on successful proof-of-concept tests last September, the first focused field trials will be conducted on a field of extinct volcanoes in southwest Arizona this spring.

Ad Hoc Wireless Networks Key to Cooperative Robotics



John Baras

When the cooperative robots being developed by center researchers leave the laboratory and venture into the real world, they will quickly confront some very harsh realities—corrosive environments, threats from enemies, rapidly changing weather, stationary and moving obstacles, low power. One of the greatest challenges is maintaining, in the face of such problems, effective and efficient communications among the robots. John Baras, ECE, ISR, Lockheed Martin Chair in Systems Engineering, and director of the Center for Hybrid and Satellite Communication Networks, is developing essential insights for optimizing communications in this emerging field. In his research, which is funded by the National Science Foundation, the Army Research Laboratory and the Air Force Office of Scientific Research, he collaborates with center members Nuno Martins, David Akin and Sarah Bergbreiter. "We have determined a few key concepts to guide this work," Baras states. "In general, it is better to create a communications topology that is good for multiple situations or robotic tasks than a topology optimized for one. Ad hoc communication networks permit as-needed communications and eliminate network infrastructure and a central node." He notes that communication protocols that are good for voice are not necessarily good for robots. "As alternatives to standard protocols, consider event-, time-, or location-activated communications; combining wireless communications with the sensing of sound signals; and opportunistic communications, in which a robot communicates only when it 'sees' another. When implemented, these ideas will serve to reduce system cost and complexity and increase reliability and performance."

Recon in Complex Environments with Help from Insects and Bats

A small, flapping-wing, autonomous unmanned aerial vehicle (UAV) is sent on a high-speed reconnaissance mission in dense woods or a crowded city street. It will need remarkable sensory and control capabilities to navigate in such a complex environment, combining "inner loop" strategies (high-bandwidth, low-latency sensing, processing and actuation) to avoid immediate threats, obstacles and gusting wind, and "outer loop" strategies (higher latency, far-field sensing and control) to reach a final destination. As part of an Office of Naval Research-sponsored Multidisciplinary University Research Initiative grant, Sean Humbert, assistant professor of AE and director of the Clark School's Autonomous Vehicle Laboratory, and Timothy Horiuchi, associate professor of ECE and ISR, are studying the mechanosensory systems of insects and bats to develop a single-chip sonar that will help to achieve such agile UAV flight. Humbert studies the rotation-sensing hindwings and visual-motion sensing compound eyes of flies, and flow-sensitive hairs in insects and bats, to develop robust inner loop strategies. Horiuchi studies bat vision and echolocation for the outer loop. The two, working with collaborators at the University of Washington and the College of Charleston, will reveal through experimentation how flying animals use and fuse sensory data over different time scales. Transition of these biological principles to engineered systems will enable UAVs to cope with uncertainties while navigating complex environments. For more information, see www.avl.umd.edu/projects/

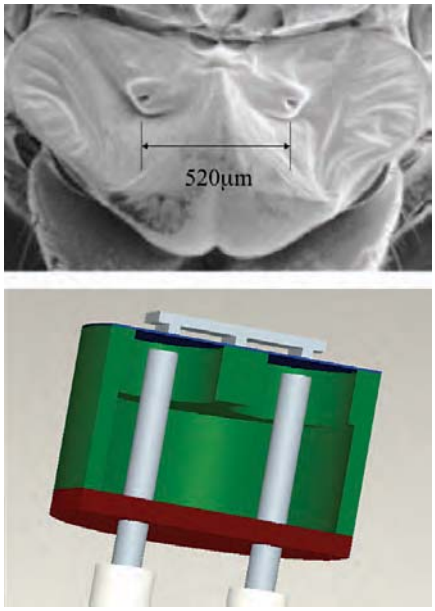


PHOTO COURTESY OF AUTONOMOUS VEHICLE LABORATORY

Insects are inspiration for new sensing devices. Top, a fly ear. Bottom, a fly ear-inspired sensor.

Improving Accuracy, and the Patient Experience, in Breast Cancer Care

By applying semi-autonomous robots in breast cancer diagnosis and care, physicians may one day more accurately and safely identify and ablate breast cancer tumors and enable anxious patients to undergo fewer procedures with less delay and fewer needle insertions. This is the goal of NIH-sponsored research by Jaydev Desai, ME, director of the Robotics, Automation, and Medical Systems Lab, and Howard Richard III, M.D., interventional radiologist at the University of Maryland Medical Center. Imagine an MRI system equipped with two robots, one located inside the MRI bore ("in-bore") made of special materials that are not affected by the strong magnetic field, one in a control room operated by a physician. The MRI system continuously sends images to the physician, allowing him or her to pinpoint the tumor location, and to the in-bore robot to guide insertion of a biopsy needle into the patient's breast. All the while, the in-bore robot sends "haptic" soft-tissue sensory information to the control room robot and physician, allowing him or her to evaluate and verify needle placement by a combination of images and touch feedback. The in-bore robot withdraws the tissue sample, and a pathologist immediately analyzes it to determine tumor status. If necessary, the in-bore robot, again with physician input, inserts an ablation needle into the tumor and destroys it, while the physician views the MRI images on the screen. For more information, see rams.umd.edu.

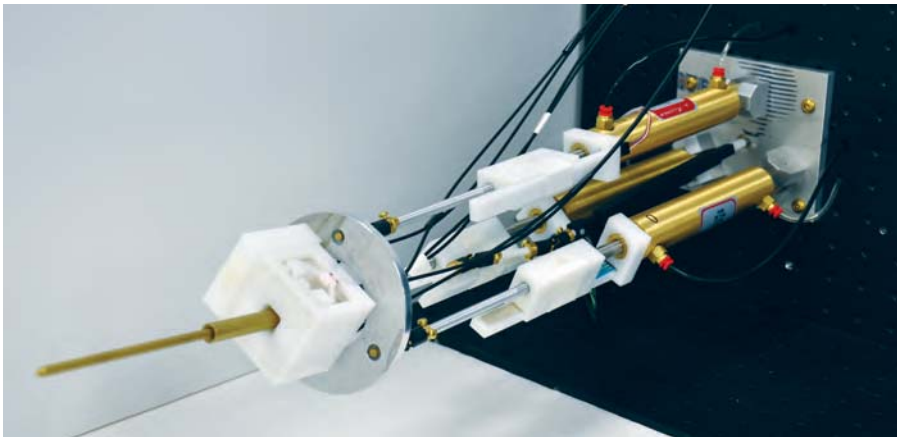


PHOTO BY JAYDEV DESAI

Image-guided, in-bore robot provides haptic feedback to a physician in the control room.

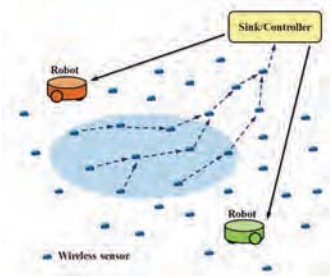
Flea-Like Micro-Robots Bring Mobility to Large-Scale Monitoring Networks

When scientists study phenomena over a large area—the spread of vegetation or pollution, the movement of animals—they often position a network of sensors to capture information for analysis. But natural phenomena change, as do researchers' areas of interest, requiring researchers to re-deploy their sensor networks, often at great expense and delay. The same concerns apply to sensor networks for defense applications. In research sponsored by DARPA, Sarah Bergbreiter, ME and ISR (see related story, p. 9), is developing mechanisms to enable millimeter-sized sensing robots to jump to new locations when placed in natural or man-made environments. Jumping can be an efficient way for robots to move around obstacles and even latch on to moving animals, vehicles or other robots—and then jump off. To enable jumping, Bergbreiter has demonstrated a new micro-fabrication process that incorporates soft elastomers with traditional silicon. Mechanisms only 4 mm on a side have been launched over 35 cm in the air—the first leaps of jumping micro-robots. This new fabrication process can also be used to create flexible joints for small running robots, and composite elastomers can be used to create new actuation technologies at small scales. For more information see terpconnect.umd.edu/~sarahb.

PHOTO BY HAIWEN DING

Jumping micro-robots can travel over 35cm through the air.

Combining Wireless Sensor Networks and Robots in Search and Rescue



Collaborative robots interact with wireless network.

In the future, building construction codes might require wireless motion-sensing networks. In the event of fire or other disasters, the network could provide information as to the location of victims trapped in the building. Collaborative search and rescue robots, guided by the network, could proceed directly to areas where they are needed most—saving valuable time—rather than using only their own sensors and searching the entire building. Nikhil Chopra, assistant professor of ME and ISR, in research funded by the NSF, is laying the groundwork for such network-robot interactions. One crucial capability he is developing is coordination of complex tasks. To clear the way to victims in damaged areas, the robots in many cases would need to work together, using grippers, to manipulate and lift fallen concrete, girders or other heavy objects. Chopra is designing time synchronization algorithms for wireless sensors to effectively exploit the additional sensing provided by the wireless sensor network. In addition, he is studying "task space synchronization" to enable a human operator to control the robots through the wireless network, using algorithms to ameliorate the effect of time delays on the stability of such systems. For more information see terpconnect.umd.edu/~nchopra.

Surviving Low-Altitude Hurricane Forecasting

Derek Paley, AE and director of the Collective Dynamics and Control Laboratory, is working on an NSF grant to improve forecasting of hurricane intensity using a coordinated fleet of unmanned aeronautical vehicles (UAVs). In hurricane development, the ocean's warm water is transferred to the atmosphere just above the ocean surface; this is where continuous readings of air temperature, pressure, humidity and wind speed data, as well as underlying sea surface temperature, are most valuable.

PHOTO COURTESY OF AAI CORP.

A fleet of UAVs could improve the odds of successful forecasting.

It is also where the strongest winds and the greatest danger are found. A UAV can fly as low as 500 feet above the surface of the ocean, permitting capture and transmission of continuous low-level data. But the chances of one UAV completing its mission in a powerful hurricane are low, and so Paley is developing methods to coordinate a fleet of UAVs to improve the odds for successful observation and forecasting. His research combines numerical-modeling methods from atmospheric science with feedback control methods from nonlinear control theory. Conducted in conjunction with the University of Miami Department of Meteorology and Physical Oceanography, the research could help reduce errors in hurricane forecasting, along with loss of lives and property through improved emergency response decisions. For more information see cdcl.umd.edu/.

THE CLARK SCHOOL

A Powerful Node in the International Research Network

Multidis

THE UNIVERSITY OF MARYLAND IS ONE OF FIVE INSTITUTIONS WITH ARWU TOP 20 RANKINGS IN

8 MURIs (IN 10 YEARS)
MANUFACTURING BUILDING

16 NAEs
NEUTRAL BUOYANCY RESEARCH FACILITY

12 DURIPs (IN 10 YEARS)
TECHNOLOGY ADVANCEMENT BUILDING

6 PECASEs (IN 10 YEARS)
J.M. PATTERSON BUILDING

ANIMAL SCIENCES BUILDING

33 CAREERS (IN 10 YEARS)
CHEMICAL & NUCLEAR ENGINEERING BUILDING

200% GROWTH IN RESEARCH EXPENDITURES (IN 10 YEARS)
JEONG H. KIM ENGINEERING BUILDING

204 MIPS PROJECTS (IN 10 YEARS)
POTOMAC BUILDING

CHEMISTRY BUILDING

Recent Developments

- CORPORATE PARTNERSHIPS:
  - Lockheed Martin
  - L-3 Communications
  - Canon Life Sciences
- ROBOTICS CENTER
- CYBERSECURITY CENTER
- $15M NIST GRANT
- $3.2M ADVANCE GRANT

ENGINEERING LABORATORY BUILDING

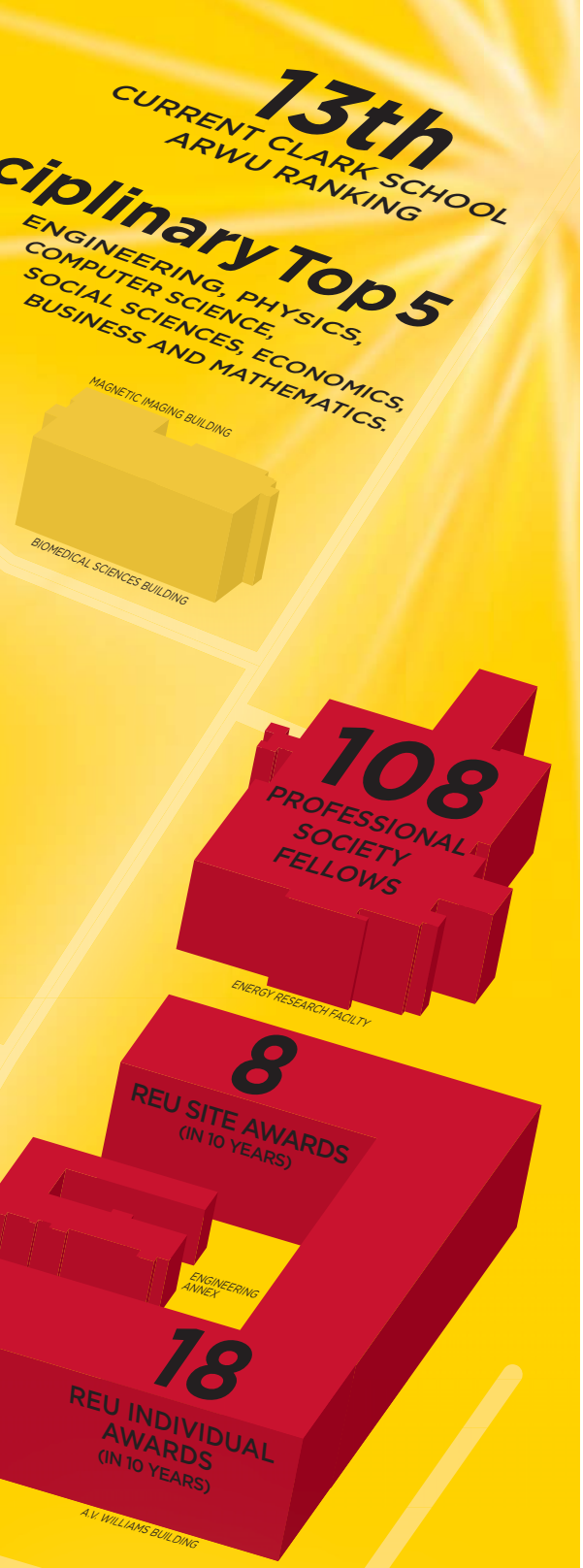
$700,000 CURRENT ANNUAL RESEARCH EXPENDITURES PER FACULTY MEMBER

$134,434,000 CURRENT ANNUAL RESEARCH EXPENDITURES
GLENN L. MARTIN HALL

45 IPAs (IN 10 YEARS)
WIND TUNNEL BUILDING

MATHEMATICS BUILDING

SHOWN HERE ARE THE CLARK SCHOOL'S MAJOR FACILITIES ON THE CAMPUS OF THE UNIVERSITY OF MARYLAND, COLLEGE PARK. IN THE A.V. WILLIAMS BUILDING, THE CLARK SCHOOL SHARES SPACE WITH THE COLLEGE OF COMPUTER, MATHEMATICAL AND NATURAL SCIENCES.



ABBREVIATIONS

ARWU: ACADEMIC RANKING OF WORLD UNIVERSITIES

CAREERs: FACULTY EARLY CAREER DEVELOPMENT AWARDS

DURIPs: DEFENSE UNIVERSITY RESEARCH INSTRUMENTATION PROGRAM AWARDS

IPAs: FACULTY MEMBERS SERVING IN INTERAGENCY PERSONNEL ACT POSITIONS

MIPS: COLLABORATIVE RESEARCH PROJECTS BETWEEN FACULTY MEMBERS AND COMPANIES, THROUGH THE MARYLAND INDUSTRIAL PARTNERSHIPS PROGRAM.

MURIs: MULTIDISCIPLINARY UNIVERSITY RESEARCH INITIATIVE GRANTS

NAEs: FACULTY MEMBERS INDUCTED INTO NATIONAL ACADEMY OF ENGINEERING

PECASEs: PRESIDENTIAL EARLY CAREER AWARDS FOR SCIENTISTS AND ENGINEERS

REU: RESEARCH EXPERIENCES FOR UNDERGRADUATES

Through Agency Posts, Clark School Faculty Members Help Guide National Strategies

Avram "Avi" Bar-Cohen

When Professor Avram "Avi" Bar-Cohen was recruited by the Clark School more than 10 years ago, a key factor in his joining the school was its close proximity to federal research agencies. "Even then I was thinking that, at some point, I could work at a federal agency and help guide the nation's research effort, without moving my family or commuting across the country on weekends," he explains.

Bar-Cohen led the Clark School's Department of Mechanical Engineering to great success for nine years, and was named University Distinguished Professor in 2005. All the while he performed research that, as stated by the International Center for Heat and Mass Transfer in awarding him the Luikov Medal, "laid the foundation for today's state-of-the-art, minimum-energy solutions for air cooling of electronics."

When Bar-Cohen was asked by the Defense Advanced Research Projects Agency (DARPA) to consider serving as a program manager with responsibilities in thermal management technologies, he met with Dean Darryll Pines to discuss a possible Interagency Personnel Act (IPA) assignment to DARPA. IPAs were established to allow federal workers to move between agencies for short-term assignments, and now promote similar exchanges between federal agencies and academia as well. In an IPA, the university signs a contract with an agency, by which the faculty member continues to receive his or her Clark School salary and the agency pays a fee for the faculty member's services. This fee is channeled back to the school to partially subsidize the salary of postdoctoral researchers, who continue the faculty member's research.

Upon completion of the DARPA interview process and his security clearance, Bar-Cohen stepped down as chair, took a leave of absence and began his new assignment in DARPA's MicroTechnology Office. It is conveniently located near the Office of Naval Research, National Science Foundation and Metro subway connection to College Park.

"Part of DARPA's charter is to develop transformative technology that will have a large impact on specific areas of national defense," explains Bar-Cohen. "As a faculty member involved at the national and international levels and as a leader in the thermal management field, this position provides me with a unique opportunity to help plan and impact future areas of research."

Bar-Cohen views his IPA assignment—managing $100 million in current thermal management research projects by industrial and academic researchers (like himself) and scouting for new ideas—as a professional responsibility and an important form of service. "You are providing a service to the profession, the nation and society on a very large stage. You are in charge of putting together a compelling research agenda and justifying why taxpayer money should be allocated to fund that research. At the same time, you are gaining a broad perspective on important issues that will help guide Clark School research."

On completion of Bar-Cohen's appointment, he will return to campus and continue his scholarly activities in the department. ■

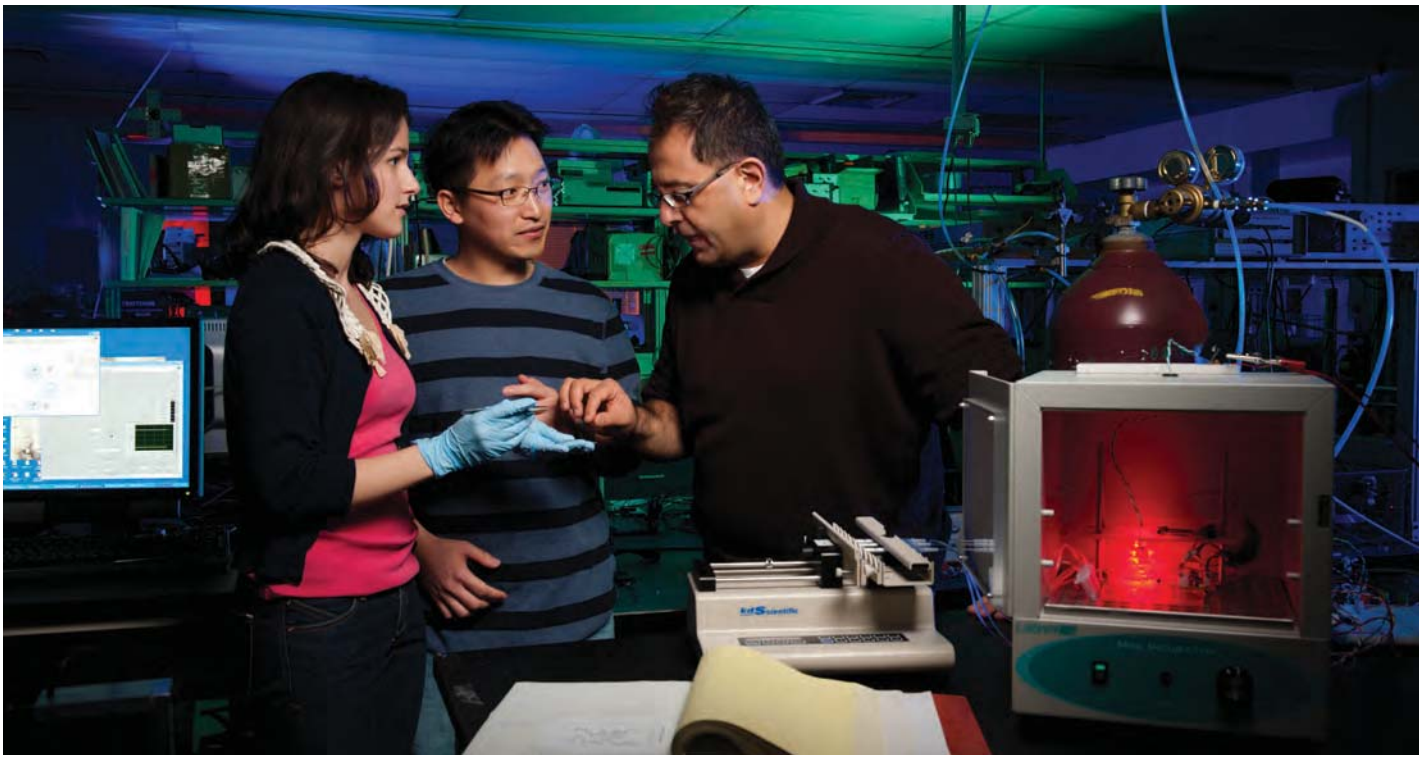


PHOTO BY MIKE MORGAN

Herbert Rabin Distinguished Professor Reza Ghodssi, right, discusses the performance of a microfluidic biochip with Mariana Meyer, Ph.D. '12, bioengineeering, and Young Wook Kim, Ph.D. '12, electrical engineering, center.

Deutsch Foundation Renews Commitment to Clark School

Vision of Robert W. Deutsch Drives Nano-Biotech Advances

When Robert W. Deutsch founded RWD Technologies more than 20 years ago, the company was created on the premise that "the power of an organization resides in the worthy work of individuals and the collaborative way their work is done." That same premise has guided the Clark School's pioneering research in nano-biotechnology, funded, in large part, by the foundation Deutsch established.

Since 1996, the Deutsch Foundation has supported scholarships, organizations and research at the University of Maryland, College Park, and other schools within the University System of Maryland, including a gift of more than $1 million in 2006 to establish the Deutsch Foundation Program in Nano-Biotechnology at the Clark School. In the fall of 2010, the foundation renewed funding for four years with another gift of more than $1 million.

"The harmonious way that the principal Clark School investigators work together is remarkable," says Foundation President Jane Brown, daughter of Robert Deutsch. "We tend to look for individuals working in research areas that align with our interests, but we also seek people whose values align with ours. We found both in the Clark School team."

In affirmation of the foundation's commitment, the university provost's office and various Clark School units will invest, as they did for the first grant, more than $200,000 in the program. "We believe this research is revolutionary in merging the fields of microelectronics and biotechnology," says Clark School Dean Darryll Pines. "During the next four years, we hope to develop new technologies to improve the diagnosis and treatment of disease."

The foundation's support has allowed the Clark School to assemble a stellar team of researchers across disciplines to advance the understanding of cell-to-cell interactions and devise technologies that may influence those interactions. The support also helped the school obtain a four-year National Science Foundation Emerging Frontiers in Research and Innovation—Cellular and Biomolecular Engineering grant. The grant has accelerated the school's development of an innovative biochip technology that promises to give doctors a new way to discover drugs that treat bacterial infections without stimulating resistance-building mutations (see sidebar), making the Clark School a lead institution worldwide for biofabrication.

Principal investigators in the nano-bio research group include Fischell Department of Bioengineering Chair and Robert E. Fischell Distinguished

PHOTO COURTESY OF JANE BROWN

Jane Brown and Robert W. Deutsch

Professor William Bentley; Herbert Rabin Distinguished Professor Reza Ghodssi, electrical and computer engineering and director of the Institute for Systems Research (ISR); Gary Rubloff, materials science and engineering/ISR and director of the Maryland NanoCenter; and Gregory Payne, bioengineering and Institute for Bioscience and Biotechnology Research.

Mariana Meyer, a doctoral student in bioengineering, is one of a number of graduate and undergraduate students who work on biochip development. "The Deutsch Foundation grant has fostered an unusual interdisciplinary approach," she describes. "Collaboration enables us to take our work to the next level, to achieve efficiencies and devise solutions to real-world problems more quickly than we could ever have accomplished individually."

The foundation is confident the collaboration will yield groundbreaking results in the future. "We have made an extremely wise investment in the Clark School—a tremendous legacy for my father," says Brown. "We have seen growth at every level of the school in a relatively short time, and we look forward to building this long-term relationship. The work is exciting on so many levels." ■

About Robert W. Deutsch

Robert W. Deutsch received a B.S. in physics from the Massachusetts Institute of Technology and a Ph.D. in high-energy physics from the University of California at Berkeley. He is both an educator and innovator. After serving as chief professor of nuclear science and engineering at The Catholic University of America, he founded General Physics Corporation, which trained operators of nuclear power plants; and later RWD Technologies, which serves the technology training and performance optimization needs of Fortune 500 companies worldwide. He is a professor of practice within the Fischell Department of Bioengineering, member of the National Academy of Engineering, registered Professional Engineer and veteran of WWII.

Where Nanotechnology and Bioengineering Meet

Pioneering research funded jointly by the Deutsch Foundation and NSF includes:

Nanofactories That Can Decrease Infections, Promote Health

Bacteria secrete signaling molecules that prompt a similar response in nearby bacteria, which enables a self monitoring of population density. At a sufficient density, the bacteria take on a multicellular character and may become pathogenic. Clark School researchers have created biological nanofactories that synthesize signaling molecules on the surface of targeted bacteria. Because this interrupts the natural signaling mechanisms, researchers believe the nanofactory can decrease infections, reduce drug-resistant strains and promote health, particularly when combined with probiotic treatments.

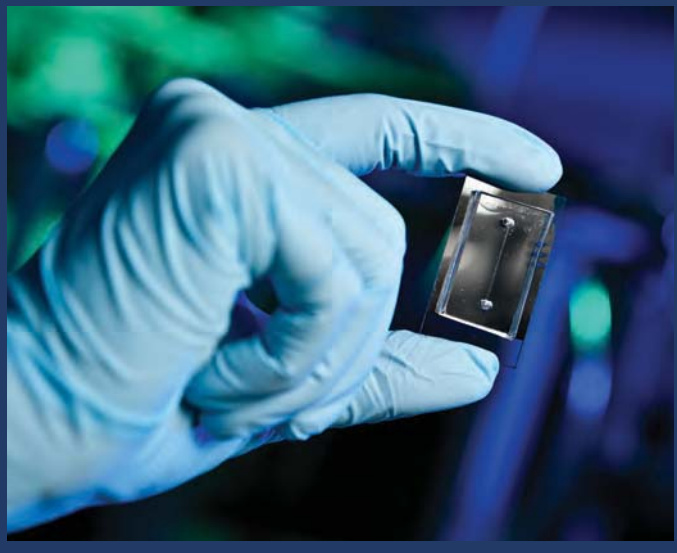


PHOTO BY MIKE MORGAN

Microfluidic channels, pictured here, serve as testbeds for growing and studying bacterial communities called biofilms.

Microscale Living Laboratories Develop and Test Drugs in Human Environment

Clark School researchers have developed an automated fluidic microscale chip system or "living laboratory" that creates a complex animal or human environment, including cells and tissues, into which the system can inject a drug, measure response and modify the testing protocol. The chip, which can be mass-produced and assembled in arrays to permit multiple simultaneous tests, incorporates miniature sensors and actuators for precise measurement and interactions. The system should greatly reduce drug discovery and development time and cost and ensure more successful products.

Creating a Bio-Electronics "Toolkit" for Developing New Technologies

To assist researchers seeking to build new technologies that connect electronics with biological materials, Clark School researchers are fabricating nanoscale devices that can deliver exquisitely controlled electrical signals with nanometer resolution. Incorporating biological polymers that respond to such signals, they create nano systems that perform biological functions under control. The devices will support development of technologies that improve how physicians diagnose disease, first-responders detect threats, and drug companies design, develop and manufacture drugs. ■

"An Even Greater Impact"

Guided by Director David Barbe and His Senior Management Team, Mtech Moves to Build on Exceptional Successes

David Barbe

Since its founding in 1983, the Clark School's Maryland Technology Enterprise Institute (Mtech) has been a leader in tech entrepreneurship education and support. Mtech has created such innovations as the state's first program to partner university faculty members with tech companies, the state's first technology business incubator, the nation's first living-learning entrepreneurship program for undergraduates as well as the university's first technology entrepreneurship courses, technology business plan competition and technology start-up boot camp.

This long outpouring of creative energy was led by Mtech Founding Director Herbert Rabin, together with Executive Director David Barbe and the senior management team of Martha Connolly (Mtech Partnerships), Dean Chang (Mtech Ventures) and James Green (Mtech Education).

In the process, Mtech has made a $25.7 billion impact on the Maryland economy and created or maintained more than 5,300 jobs. In recognition of their contributions, Rabin has been honored with the President's Medal, the highest award bestowed by the University of Maryland, and Barbe received the Olympus 2008 Lifetime Educational Innovation Award. Recently, Rabin announced that he is stepping down from his Mtech position, while remaining as Clark School senior associate dean and professor of electrical and computer engineering (see next page). Barbe, in assuming the director position, is now working with his team to build on Mtech's remarkable successes.

"Mtech has so much to offer both to entrepreneurs and established businesses," states Barbe, "but we believe that we can have an even greater impact. We are well on our way to building what is the most comprehensive set of programs in the field, creating an encompassing 'entrepreneurship ecosystem' that provides education and support in every stage of the venture-building process that already serves as a model for academic programs in the United States and around the world."

In addition, Barbe sees Mtech increasing its role in promoting a "culture of entrepreneurship." "We have helped encourage the growth of a newly emergent venture community on campus, in the state of Maryland and in the federal region. We can do still more to engage, interconnect and assist stakeholders—from students and faculty members to corporations, federal agencies, venture capitalists and support organizations, and philanthropists. The potential here is virtually limitless." Mtech has achieved an outstanding track record in helping companies launch and grow, according to Barbe, and will "use all that we've learned to produce the next billion-dollar Maryland corporations like Digene and Martek."

Further, Mtech seeks to introduce business plan competitions and other entrepreneurship experiences at Maryland high schools to "build a pipeline of students eager to start a company or bring entrepreneurial spirit to an existing one." He also foresees bringing in new philanthropic dollars to support worthy start-ups in early stages, when venture funding is harder to find, and thus "greatly increase the number of start-ups that survive this challenging period. Mtech can have a still more powerful impact here," he concludes, "that will help drive entrepreneurial progress at the campus, state, regional and national levels for decades to come."

Bringing New Expertise to Mtech's Programs

From left, Craig Dye, Bill Barnes and Jay Smith

Three new program directors have recently joined Mtech. Craig Dye, an accomplished entrepreneur, business executive and investor with 15 years of experience in building and mentoring start-up companies, now directs Mtech's VentureAccelerator Program. The program helps university inventors speed the process of launching a venture by guiding and coaching them through new business processes, such as business planning and raising capital. Dye joins Mtech from the university's Robert H. Smith School of Business.

Bill Barnes is the new director of Mtech's Manufacturing Assistance Program, which provides Maryland manufacturers with growth and operational consulting services to help them become more profitable and create additional jobs. The program, which is the Maryland center of the National Institute of Standards and Technology's Manufacturing Extension Partnership (MEP), operates on a combination of MEP funding, university support and client service fees.

Jay Smith is the inaugural director of Mtech's Entrepreneurship and Innovation Program, a new program in the Honors College, managing both its operational aspects as well as teaching and mentoring the living-learning student community members (see related story, next page). Previously, Smith was associate professor of the Inamori Academy of Kagoshima (National) University in Japan and a management consultant, investment banker and entrepreneur in New York, San Francisco and Tokyo. ■

Mtech Founder and Director Herbert Rabin Steps Down

In January, Mtech Founding Director Herbert Rabin announced that he would step down from his Mtech leadership role of nearly 30 years. "The Clark School is most fortunate to have benefited from the expertise and knowledge of one of the nation's pioneers in entrepreneurial education—Dr. Herb Rabin," notes Clark School Dean Darryll Pines. "Dr. Rabin guided Mtech through a period of tremendous growth in programs, services and impact on the state economy. He also served the school as interim dean and continues as senior associate dean and professor of electrical and computer engineering. Speaking for the Clark School and the university, I wish to recognize the deep gratitude we owe Dr. Rabin and thank him for his many years of service and leadership." ■

New Early Launch Pad for Student Start-ups

Mtech Program Immerses Freshmen, Sophomores in Entrepreneurial Experiences

PHOTO COURTESY OF ERIC SCHURR

Students participate in EIP experiential learning exercises.

Incoming students in the University's Honors College who aspire to become tomorrow's innovators can get a head start in bringing their ideas to market through a new living-learning entrepreneurship program offered by the Clark School's Maryland Technology Enterprise Institute (Mtech). Launched in fall 2010, the Entrepreneurship and Innovation Program (EIP) provides honors freshmen and sophomores from all majors the opportunity to live and study together in an entrepreneurial environment. Modeled on Mtech's highly successful Hinman CEOs program for juniors and seniors, EIP helps students develop entrepreneurial mindsets, skill sets and relationships from the onset of their college careers.

"It is never too early to start thinking innovatively and entrepreneurially," says EIP Director Jay Smith. "That approach applies whether you are starting your own business or you want to make creative contributions to a company that you join." Smith should know: The Harvard MBA graduate launched his own multi-million dollar technology company in Japan in the 1990s before working as an investment banker in Silicon Valley during the dot-com boom. He went on to develop and teach courses in venture business, entrepreneurship and business communications at a national university in Japan.

Nearly one-third of EIP students are engineering majors—no surprise given the Clark School's emphasis on innovation. Mechanical engineering major Luke Catherine, one of the program's 74 initial participants, aspires to launch his own technology company after gaining experience working for an established firm. "EIP is helping me develop leadership and team-building skills that will be important in taking on project management roles as an engineer," says Catherine. When he's ready to create his own venture, Catherine predicts that EIP experience will be crucial. "The program not only focuses on the design process but also on business aspects, like how to market a product, which are not necessarily covered in traditional engineering classes."

The four-course EIP track starts with a seminar on entrepreneurship basics and continues with a course on contemporary issues in entrepreneurship and innovation and a course that provides a global perspective on entrepreneurship. In a capstone course, students develop an innovative for-profit product or service designed to benefit society. Top ventures can compete for a portion of the $50,000 Mtech Impact Seed Fund for promising new businesses. In its initial year, EIP is open only to freshmen; next year enrollment is expected to jump to 150 with the participation of both freshman and sophomore cohorts.

During the program, EIP students live together on campus on reserved floors of LaPlata Hall. The program offices are located in the residence hall, providing students with easy access to resources and mentoring services. "Students live in a community where members think entrepreneurially, which catalyzes and accelerates the learning experience," says Smith. "You learn from each other and bounce ideas off one another."

Participants in Mtech's Hinman CEOs program act as role models, providing a resource for EIP students and serving as teachers' assistants. Launched in 2000, Hinman CEOs is the nation's first living-learning entrepreneurship program. "We're part of one big Mtech family," says Smith. "We've got a good older brother in Hinman and good parents in Mtech." While both EIP and Hinman are designed as stand-alone programs, EIP students may choose to apply for Hinman to continue their entrepreneurial studies. "The students would be strong candidates and would enter the Hinman CEOs program with some extra polish," says Smith.

Guest speakers and experiential learning opportunities, such as a ropes course challenge that promotes communication and problem-solving skills, round out EIP offerings. The intended outcome, according to Smith: "Students will learn to create their own companies or be entrepreneurial and innovative in any endeavor they undertake." ■

Share Your Entrepreneurial Expertise

If you have entrepreneurial experience you would like to share with EIP students, volunteer to serve as a guest speaker or mentor. Provide valuable experiences for students and benefit from their newfound entrepreneurial knowledge by offering internships at your organization. To learn more about EIP partnership opportunities, contact the EIP office at 301-314-9410, eip@umd.edu.

Solar Decathlon Team Receives Constellation Grant

As the University of Maryland's student team begins construction of its entry in the U. S. Department of Energy Solar Decathlon 2011, its efforts will be boosted by a $50,000 grant from Constellation Energy, a leading U.S. supplier of energy products and services based in Baltimore. The team was one of only 10 recipients nationally of the firm's E2: Energy to Educate grants, which recognize environmental projects that inspire students to use science and technology to address energy challenges.

Some 100 undergraduates from the Clark School; the School of Architecture, Planning, and Preservation; the College of Computer, Mathematical, and Natural Sciences; and the School of Agriculture and Natural Resources are collaborating on *WaterShed*, the university's submission to the fifth Solar Decathlon. *LeafHouse*, the university's entry in the 2007 competition, placed first among U.S. teams, second overall.

"This grant provides our *WaterShed* team with the resources to complete its mission: to research, design and build a solar-powered

The *WaterShed* house

house inspired by the rich, complex ecosystems of the Chesapeake Bay watershed," says Amy Gardner, associate professor of architecture and one of the faculty advisors to the Solar Decathlon team.

A major goal of the event is to provide students with unique training to enter the nation's clean-energy workforce. David Daily, B.S. '12, electrical engineering, who serves as the engineering project manager for *WaterShed* and coordinates the work of more than 20 Clark School Solar Decathlon team members, attests, "We are at the forefront of using green technology, and this event allows us to showcase our knowledge to the world."

WaterShed serves as a mini-ecosystem that captures and fully utilizes the energy of sun, wind and rain and recycles household wastes that retain valuable energy and nutrients. The university's entry will compete with 19 other project houses from collegiate teams all over the world this September. Previously staged on the National Mall, this year's event has a new location: adjacent to the mall at West Potomac Park, between the Lincoln and Jefferson Memorials and beside the Potomac River.

Daily describes how today's Solar Decathlon project could translate into tomorrow's solution to a critical environmental challenge. "In the future, access to clean, drinkable water will be an issue for all of us. Through *WaterShed*, we are taking a proactive approach to this problem by trying to mitigate our effect on the Chesapeake Bay ecosystem." ■

Modeling Mother Nature to Predict Avalanches

Bartelt Pursues a Cool Career

Perry Bartelt's Clark School education has taken him to the top of his field in more ways than one. As a leading expert on avalanche dynamics, Bartelt, B.S. '81 and M.S. '83, civil engineering, heads a research group at the WSL Institute for Snow and Avalanche Research SLF, situated a mile high in the Swiss Alps. His team develops methods to mitigate the effects of avalanches and other natural disasters that plague the region.

Bartelt recalls a series of avalanches in February 1999 that killed 36 people and caused more than $400 million in damage, according to the institute. With his help, future avalanches will not wreak such havoc. His team has developed a model that predicts how far an avalanche will run as well as its impact pressure and velocity. "This information can help determine whether an area is safe from avalanches," says Bartelt, noting that his model is also used for land-planning purposes and evacuation decisions.

He credits his Clark School education with providing a strong foundation for his work. "The Clark School was at the forefront of applying computer methods to engineering, which gave me the right background to formulate complicated models."

For his master's thesis, Bartelt studied structural failures under the guidance of Civil Engineering Professor Donald Vannoy. "We looked at why buildings collapse," explains Bartelt, who now applies the techniques to Mother Nature's structures. "Snow is a unique material," he says. "Because it is so close to its melting point, snow is very unstable."

Bartelt surveys avalanche damage.

His work also focuses on debris flows and rock falls, two problems that are increasing with global climate change. Increased precipitation, coupled with rising temperatures, is expected to increase debris flows that carry heavy boulders, leaving a path of destruction. Among other measures, Bartelt's team tests nets designed to catch boulders, protecting people and property below.

While he enjoys the challenges of mathematically modeling the forces of nature, Bartelt also appreciates nature as his playground. He skis with his wife and three daughters, hikes and mountain bikes. "Throughout my career, I've been open to possibilities off the beaten path," says Bartelt. "That's led me to interesting work where I can use my engineering and mathematical background to make a real difference." ■

Two Innovation Hall of Fame Inductees Reunite

Former Roommates Rekindle 60-year Friendship

C. Frank Wheatley, Jr., B.S. '51, electrical engineering (EE), earned a reputation as a math wizard early in his Clark School career. George J. Laurer, B.S. '51, EE, in need of a math tutor, entered the school after serving in World War II and attending technical school to learn television and radio repair. It was the perfect match. "I can remember sitting in the cellar well of the Physics Building, and Frank would drum math into my head," says Laurer.

The tutoring sessions were a success, the two became roommates, and following graduation they enjoyed illustrious careers. In a remarkable coincidence, the men are today both members of the Clark School's Innovation Hall of Fame. Laurer, a 36-year veteran of the International Business Machine Corporation (IBM), holds 25 patents and was inducted into the hall in 1991 for creating the standard form of the universal product code. Wheatley was inducted into the hall in May 1999, following nearly 50 years at the Radio Corporation of America (RCA), for pioneering developments in solid-state electronics, including the invention of the insulated gate bipolar transistor. He holds 51 U.S. patents and several hundred foreign patents.

Frank Wheatley, left and George Laurer

Last fall, when Laurer and Wheatley visited campus, they shared memories, toured the Clark School facilities, and attended the Innovation Hall of Fame induction ceremony of Robert Briskman (see the fall 2010 issue of *E@M*). While their friendship endured through cards and letters, they had not seen each other in nearly 60 years.

Wearing their Innovation Hall of Fame medallions, Frank Wheatley (left) and George Laurer (right) attend the induction of Robert Briskman. Frank's brother Tom Wheatley, B.S. '60, electrical engineering, sits to his right; George's wife Marilyn sits to his left.

"I was so pleased to share time with George, and it was pleasant to go back to the Clark School. I keep tabs on it since four of my five children went to the Clark School, and three of my children are currently electrical engineers," says Wheatley, who now lives with his daughter in Highland, Md.

Laurer, who lives in North Carolina, says the visit "was one of my most memorable trips back to the university. I was so impressed by the Clark School labs; it makes me wish I could go back to school today." His induction into the hall predated the presentation of medallions to inductees, so Laurer received his medal belatedly while on campus.

He is quick to point out the unusual coincidence. "With so many people in the Hall of Fame, it is truly amazing that two roommates who graduated in the same year in the same field are members. It is wonderful that the Clark School has recognized our contributions to the field." ■

Alumni News

AMR A. ADLY, Ph.D. '92, electrical engineering (EE), has been appointed faculty of engineering vice dean for undergraduate studies at Cairo University, Egypt. He also was elected a fellow of the Institute of Electrical and Electronic Engineers.

HOWARD C. "SKIP" HARCLERODE II, B.S. '70 and M.S. '71, chemical engineering, was named a fellow of the National Society of Professional Engineers.

FRANK HERTSCH, B.S. '69 and M.S. '70, civil engineering, has been appointed to the Maryland Sustainable Growth Commission by Maryland Gov. Martin O'Malley.

DENNIS P. NOLAN, B.S. '77, fire protection engineering, published *Loss Prevention and Safety Control: Terms and Definitions* (Taylor and Francis/CRC Press). The second edition of his *Handbook of Fire and Explosion Protection Engineering Principles for Oil, Gas, Chemical and Related Facilities* (Elsevier) was released in December.

ZOLTAN SAFAR, M.S. '01 and Ph.D. '03, EE, is the new director of the Master in Telecommunications program at the Clark School.

ZHAOYANG WANG, Ph.D. '03, mechanical engineering, is a tenured associate professor at The Catholic University of America.


John Cumings


Joonil Seog


Sarah Bergbreiter

NSF Names Three Clark School CAREER Award Winners

The National Science Foundation (NSF) has recognized **JOHN CUMINGS**, materials science and engineering (MSE), **JOONIL SEOG**, MSE and the Fischell Department of Bioengineering, and **SARAH BERGBREITER**, mechanical engineering and the Institute for Systems Research, as outstanding junior faculty members who most effectively integrate research and education in their work. As recipients of the NSF Faculty Early Career Development Award (known as the CAREER award) they will each obtain grants to support their research.

Cumings received his $500,000 award for a proposal titled "Frustration on Nanomagnetic Lattices." When liquids become solids, their atoms usually lock into perfect, repeating patterns. Some materials settle into imperfect, disordered arrangements of patterns and are called "frustrated." Cumings seeks to learn the aspects and causes of frustration in artificial materials and to determine if nanoscale magnets with frustrated molecular structures can be encouraged to overcome their nature and align themselves into repeating patterns.

Seog received his $500,000 award for a proposal titled "Direct Observations of Dynamic Self-Assembly at the Single Molecule and Nanoscale Level," which describes a novel technique to study self-assembly of peptides, polymers that perform crucial cellular functions. At the molecular level, Seog will use a combination of optical mini-tweezers and a novel single-molecule construct to provide fundamental information about the behavior of the amyloid beta and tau peptides. These self-assemble into a nanofiber that can be used as a platform to create bio-inspired materials. At the nanoscale level, he will use atomic force microscopy to study the nanofiber growth.

Bergbreiter received her $400,000 award for "Micro-robot Legs for Fast Locomotion over Rough Terrain." She will model viscoelastic micro-robot legs in a dynamic simulation environment and experimentally validate the models using a new micro-fabrication process that includes viscoelastic materials. Her work will lead to the first sub-centimeter robots that can move quickly over complex surfaces, and provide a wealth of data to enhance understanding of insect locomotion. Micro-robots that move through real-world environments at insect-like speeds can search through small cracks in rubble after natural disasters, provide low-cost sensor deployment over civil infrastructure and engage in surveillance. ■

Service Award Renamed for Berman Pollans

Hodgson Honored in 2010

The **DR. MARILYN BERMAN POLLANS OUTSTANDING SERVICE AWARD FOR STAFF** is the new name of the Clark School's highest honor for staff members. The award honors the exceptional leadership and service Marilyn Berman Pollans contributed during her 25-year career at the Clark School. Pollans served as counselor, assistant dean and associate dean until her retirement in 1996. Known for her work in increasing opportunities for women and minorities in engineering, Pollans created the Women in Engineering (WIE) Advisory Board, served as its first chair, and continues to be a leading force in the WIE program and the new FLEXUS living-learning program for female engineering students also named in her honor. Pollans was named Woman of the Year on the College Park campus in 1991 and later was awarded a Fulbright grant for administrators to study in Germany.

SHARON HODGSON, director of administrative services in the Department of Fire Protection Engineering, is the 2010 Dr. Marilyn Berman Pollans Outstanding Service Award winner. Hodgson coordinates fiscal, facilities, communications, development and staff and alumni activities for the department. ■

Faculty Highlights

AMR BAZ, mechanical engineering (ME), will receive the SPIE Smart Structures and Materials Lifetime Achievement Award for 2011. The award is presented to a distinguished scientist or engineer in the field of smart structures and materials to recognize significant service to SPIE (formerly Society of Photographic Instrumentation Engineers) as well as lifetime contributions to the field.

SHUVRA BHATTACHARYYA, electrical and computer engineering (ECE), and **MIN WU**, ECE and Institute for Systems Research (ISR), have been elected fellows of the Institute of Electrical and Electronics Engineers. Bhattacharyya was recognized for his significant contributions to design optimization for signal processing, while Wu was recognized for her significant contributions to multimedia security and forensics.

CAROL ESPY-WILSON, ECE and ISR, has been honored as a 2010 Maryland Innovator of the Year, for "Multi-Pitch Tracking in Adverse Environments," her invention that radically improves sound quality in cell phones and hearing aids, among other devices. The award is sponsored by the *Maryland Daily Record*.

PINO MARTIN and **DEREK PALEY**, both aerospace engineering, have been elected associate fellows of the American Institute of Aeronautics and Astronautics.

JOSEPH SILVERMAN, professor emeritus, materials science engineering (MSE), received a Lifetime Achievement Award for his fundamental and applied work in radiation physics and chemistry at the 9th International Symposium on Ionizing Radiation and Polymers.

ICHIRO TAKEUCHI, MSE, has been elected a fellow of the American Physical Society "for pioneering contributions to the creation of novel classes of materials using combinatorial synthesis and probing their properties with novel probes."

Scholarships Relieve Financial Pressure, Allow Students To Excel

AFCEA Bethesda Renews Commitment to Engineering Education

At a time when growing numbers of students finance their educations by obtaining loans and juggling full-time course loads with part-time employment, the Bethesda Chapter of the Armed Forces Communications and Electronics Association (AFCEA Bethesda) has come to the rescue. AFCEA Bethesda recently committed to provide $200,000, or $50,000 per year for four years, in scholarship funding to students at the University of Maryland's Clark School and College of Computer, Mathematical and Natural Sciences.

Since the 2007-2008 academic year, the chapter has awarded $380,000 in scholarship funds to the University of Maryland, College Park. The chapter's gifts are inspired by its desire to help qualified students, many of whom could not pursue higher education without financial support, and to help produce greater numbers of young people competent in the science, technology, engineering and math (STEM) fields, which are critical to global competitiveness and a healthy economy.

"The AFCEA Bethesda scholarships will help ensure that students achieve success within our challenging curriculum," says Clark School Dean Darryll Pines. "By reducing students' financial concerns, AFCEA scholarships allow students to focus on their studies, take advantage of the many entrepreneurship and research opportunities we offer, graduate on time and with reduced debt and secure great jobs that strengthen our state's competitiveness."

Angela Wu and Michael Priddy

Supporting the Next Generation of Leaders

"The success of the United States in the global marketplace is largely dependent upon more students entering the science and technology fields," says Steve Krauss, president of AFCEA Bethesda. "We recognize the vital role that area colleges play in providing high-quality, affordable education for the next generation of leaders."

Marco Regalado Jr., B.S. '13, mechanical engineering, and chair of the Clark School chapter of the Society of Hispanic Professional Engineers (SHPE), is part of that next generation. "This scholarship allowed me to continue college debt-free. I am so relieved that I am able to concentrate on my studies without the burden of student loans," he explains. Regalado began researching scholarship options while still a senior at Wheaton High School in Silver Spring, Md., where he now visits their junior chapter of SHPE to raise student interest in engineering.

Founded in 1998, AFCEA Bethesda is an educationally-based, nonprofit organization that encourages greater government and industry partnerships, information exchanges and networking. The chapter, one of the largest in the country with more than 700 members, has been annually designated a "Model Chapter of the Year" since 2000.

Michael Priddy, the chapter's vice president of education (who also chairs the advisory board for University of Maryland Shady Grove and serves on the board of the National Academy of Information Technology), notes, "We want these scholarships to improve students' opportunities for success, assist families in financial need and ultimately strengthen the U.S. workforce."

Scholarship recipient Angela Wu, B.S. '13, fire protection engineering (FPE), was first exposed to engineering as a high school student. "In a high school engineering class, my teacher discussed how the field contributed to the investigation of the World Trade Center collapse. I felt that a career in FPE could make a difference and save lives," recalls Wu, who has worked with the Nuclear Regulatory Commission to review fire protection licensing for nuclear power plants.

"The AFCEA scholarship took a tremendous weight off me and my parents," adds Wu, who has a twin sister and an older brother in college as well. "I was able to concentrate more fully on my studies without the demands of a part-time job."

Priddy explains the chapter has long wanted to help strengthen STEM programs and grow the number of graduates in those areas. "If you can handle the rigor of mathematics and the complexity of engineering, you can prepare yourself for any number of careers. Our scholarships are intended to assist students in these types of pursuits." ■

To learn more about making a gift to the Clark School, please call or write:

Leslie Borak, assistant dean for external relations, Clark School of Engineering, University of Maryland, College Park, Maryland 20742-2831 ■ 301.405.0317 ■ lborak@umd.edu

A. JAMES CLARK
SCHOOL OF ENGINEERING

3214 Kim Engineering Building
University of Maryland
College Park, Maryland 20742-2831

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Celebrating the Clark School from Coast to Coast

Dean Darryll Pines and Director of Alumni Relations Josey Simpson invite you to take advantage of some of the outstanding events the Clark School sponsors throughout the year. For a full calendar listing, visit www.eng.umd.edu/events/index.php. We look forward to seeing you soon!

Bright Ideas for Your New Start-up Company

A Whiting-Turner Lecture
Thursday, May 5, 5 p.m.
Room 1110, Kim Engineering Building

You are invited to this semester's Whiting-Turner Business and Entrepreneurial Lecture by Asghar Mostafa, founder of Entourage Systems, Inc., who will provide ideas for starting your own company. For more information, visit www.eng.umd.edu/events/whiting-turner.

Baltimore Alumni Networking Event

Thursday, May 12, 6-8 p.m.
The Engineers Club, Downtown Baltimore

Enjoy a wonderful evening of networking with alumni and friends, and learn the latest news about the Clark School from Dean Darryll Pines. For more information, contact Josey Simpson, director of alumni relations, at 301.405.2150 or josey@umd.edu.

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California Networking Receptions

April 13 and April 14
Del Mar and Menlo Park, Calif.

San Diego alumni can reconnect and meet Clark School Dean Darryll Pines on the evening of Wednesday, April 13. Alumni in the San Francisco Bay area can catch up with classmates and meet the dean the evening of Thursday, April 14. For more details and to reserve your spot, visit www.alumni.umd.edu/CA2011 or contact Josey Simpson, director of alumni relations, at 301.405.2150 or josey@umd.edu.

Explore Our World: Maryland Day

Saturday, April 30

Celebrate the diverse range of programs and services offered by the university and the Clark School. Participate in learning activities, demonstrations, exhibits and performances throughout the day-long event. To learn more about specific Clark School activities, visit www.marylandday.umd.edu.