Research Horizons

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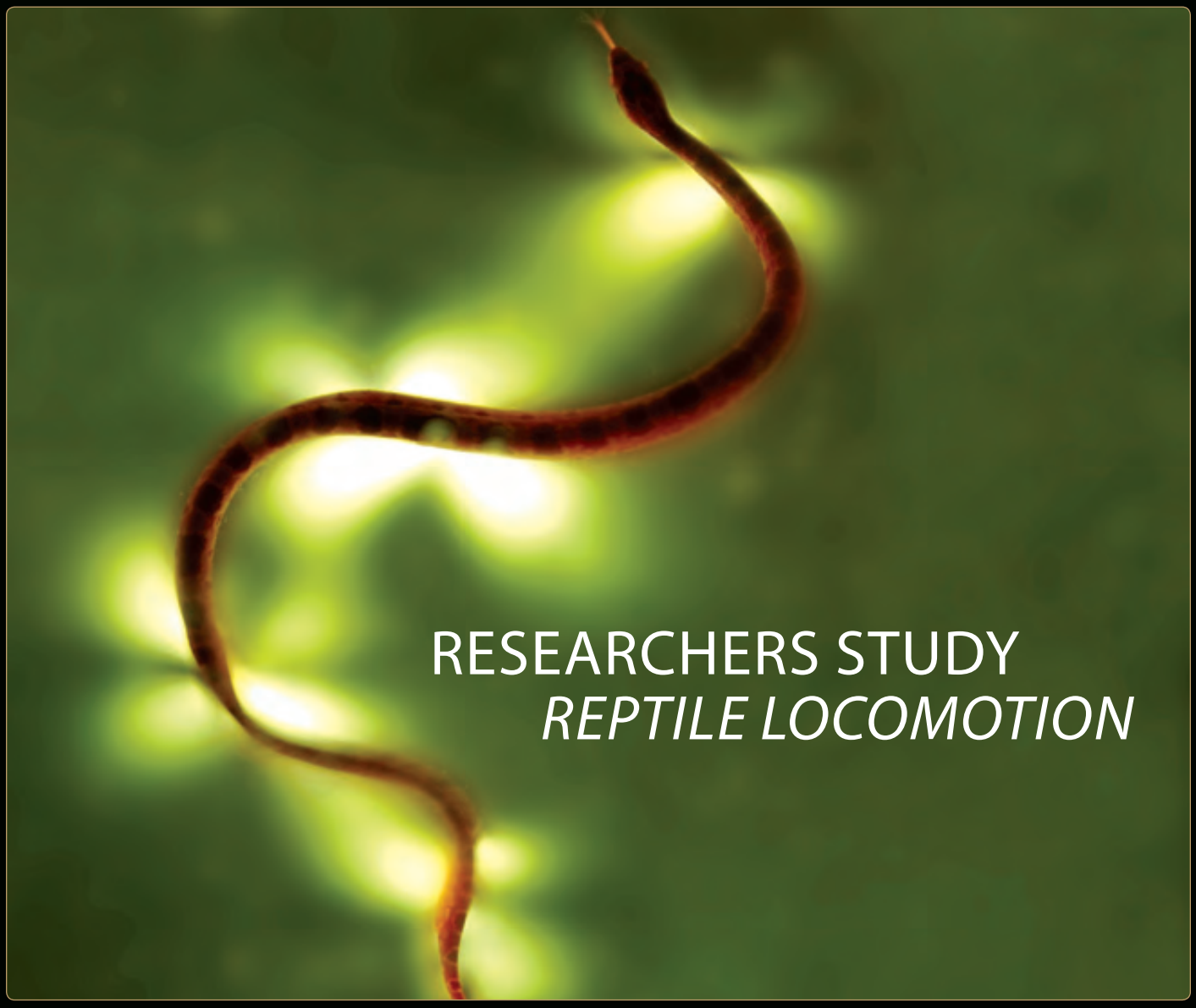


RESEARCHERS STUDY *REPTILE LOCOMOTION*

Georgia Institute of Technology

- *FalconView Open Source*
- *Cooling Data Centers*
- *Diagnosing Cancer*
- *Automatic Defense*
- *Measuring Nano*

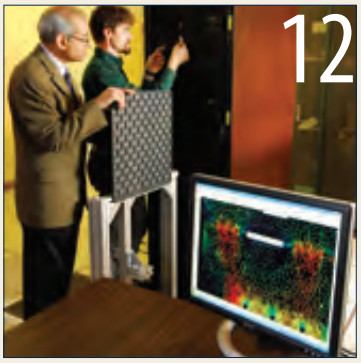
"The results demonstrate that burrowing and swimming in complex media like sand can have intricacy similar to that of movement in air or water, and that organisms can exploit the solid and fluid-like properties of these media to move effectively within them."

– Daniel Goldman, assistant professor in the School of Physics

COVER STORY

"Nanomaterials grown under environmentally friendly conditions can be as good as synthetic materials that are produced under harsh conditions. This technique allows us to grow very useful materials under natural conditions."

– Vladimir Tsukruk, professor in the School of Materials Science and Engineering



"The growth of cooling requirements parallels the growth of computing power, which roughly doubles every 18 months. That has brought the energy requirements of data centers into the forefront."

– Yogendra Joshi, professor in the Woodruff School of Mechanical Engineering

"Plants and animals in the wild use chemistry as a way to fight with one another. Using this new technology, scientists can 'listen in' on this fight to perhaps learn from what's going on and steal some of the strategies for human biomedical applications."

– Julia Kubanek, professor in the School of Biology

"In the 21st century with modern communication and all that has been learned about cyclones in the Bay of Bengal, there is no need for 138,000 people to be killed by a storm like this. With adequate planning, education and shelters, it should be possible to reduce fatality rates from future cyclones by at least one order of magnitude."

– Hermann Fritz, associate professor in the School of Civil and Environmental Engineering

"Ovarian cancer is the fourth leading cause of death in women, but it is a relatively rare cancer, so a functionally useful diagnostic test has to be 99 percent accurate or you are going to get too many false positives."

– John McDonald, chief scientist of the Ovarian Cancer Institute and associate dean for biology development in the School of Biology

"The pilot's real job is to fly the plane and to accomplish his mission. If he has to also monitor and manually control the state of all of the electronic warfare equipment, he's really got a lot to do."

– Mike Willis, GTRI principal research engineer

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Cover: By shining light through a gelatin, researchers can observe the forces applied by a snake as it slithers. White regions show high force. (Photo: David Hu and Grace Pryor)

Georgia Tech Research Horizons Magazine

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The number of copies of this issue being distributed has been reduced because of state budget reductions.

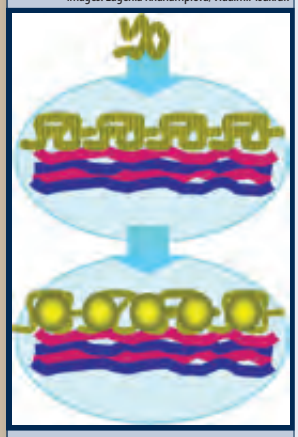
Thin films of silk serve as templates for inorganic nanoparticles that join with the silk to create strong and flexible composite structures that have unusual optical and mechanical properties. This bio-enabled, surface-mediated approach mimics the growth and assembly processes of natural materials.

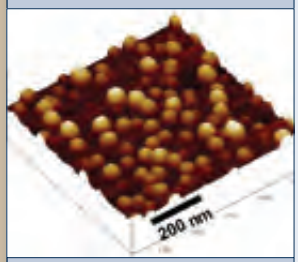
Strong as Silk:

Researchers Use Bio-Enabled Technique to Produce Unique Nanoparticle Composites

By John Toon

Images: Eugenia Kharlampieva/Vladimir Tsukruk





(Above) Illustration shows how nanoparticles form in the silk template. (Below) Atomic force microscope image shows a silk film on which gold nanoparticles have been grown.

Using thin films of silk as templates, researchers have incorporated inorganic nanoparticles that join with the silk to form strong and flexible composite structures that have unusual optical and mechanical properties. This bio-enabled, surface-mediated approach mimics the growth and assembly processes of natural materials, taking advantage of the ability of biomolecules to chemically reduce metal ions to produce nanoparticles – without harsh processing conditions.

Less than 100 nanometers thick, silk-silver nanoparticle composite films formed in this process can be used as flexible mirrors. The technique could also be used to create films that reflect light in specific wavelengths, anti-microbial coatings, thin film sensors, self-cleaning coatings, catalytic materials and potentially even flexible photovoltaic cells.

"We are taking advantage of biological molecules that have the ability to bind metallic ions of silver or gold from solution," says Vladimir Tsukruk, a professor in the Georgia Tech School of Materials Science and Engineering. "These molecules can create mono-dispersed metallic nanoparticles of consistent sizes under ambient conditions – at room temperature and in a water-based environment without high vacuum or high temperatures."

Sponsored by the Air Force Office of Scientific Research and the Air Force Research Laboratory, the research was described at the Fall 2009 National Meeting of the American Chemical Society.

The nanoparticles produced range in size from four to six nanometers in diameter, surrounded by a biological shell of between one and two nanometers. The silk template permits good control of the nanoparticle placement, creating a composite with equally dispersed particles that remain separate. The optical properties of the resulting film depend on the nanoparticle material and size.

"This system provides very precise control over nanoparticle sizes," says Eugenia Kharlampieva, a post-doctoral researcher in Tsukruk's laboratory. "We produce well-defined materials without the problem of precipitation, aggregation or formation of large crystals. Since the silk fibroin is mono-dispersed, we can create uniform domains within the template."

Fabrication of the nanocomposites begins by dissolving silk cocoons and making the resulting fibroin water soluble. The silk is then placed onto a silicon substrate using a spin-coating technique that produces multiple layers of thin film that is then patterned into a template using a nanolithography technique.

"Because silk is a protein, we can control the properties of the surface and design different kinds of surfaces," explains Kharlampieva. "This surface-mediated approach is flexible at producing different shapes. We can apply the method to coat any surface we want, including objects of complex shapes."

Next, the silk template is placed in a solution containing ions of gold, silver, or other metal. Over a period of time ranging from hours to days, nanoparticles form within the template. The relatively long growth process, which operates at room temperature and neutral pH in a water-based environment, allows precise control of the particle size and spacing, Tsukruk notes.

"We operate at conditions that are suitable for biological activities," he explains. "No reducing agents are required to produce the particles because the biomolecules serve as reducing agents. We don't add any chemicals that could be toxic to the protein."

Use of these mild processing conditions could reduce the cost of producing the composites and their potential environmental impact. When dried, the resulting silk-nanoparticle film has high tensile strength, high elasticity and toughness.

"Silk is almost as strong as Kevlar, but it can be deformed by 30 percent without breaking," says Tsukruk. "The silk film is very robust, with a complicated structure that you don't find in synthetic materials."

For the future, the researchers plan to use the bio-assisted, surface-mediated technique to produce nanoparticles from other metals. They also hope to combine different types of particles to create new optical and mechanical properties.

"If we combine gold-binding and silver-binding peptides, we can make composites that will include a mixture of gold and silver nanoparticles," says Kharlampieva. "Each particle will have its own properties, and combining them will create more interesting composite materials."

The researchers also hope to find additional applications for the films in such areas as photovoltaics, medical technology and anti-microbial films that utilize the properties of silver nanoparticles.

Beyond Tsukruk and Kharlampieva, the research team has included Dmitry Zimnistky, Maneesh Gupta and Kathryn Bergman of Georgia Tech; David Kaplan of the Department of Biomedical Engineering at Tufts University, and Rajesh Naik of the Materials and Manufacturing Directorate of the Air Force Research Laboratory at Wright-Patterson Air Force Base.

"Nanomaterials grown under environmentally friendly conditions can be as good as synthetic materials that are produced under harsh conditions," Tsukruk adds. "This technique allows us to grow very useful materials under natural conditions." rh

Photo: Gary Meek

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"Nanomaterials grown under environmentally friendly conditions can be as good as synthetic materials that are produced under harsh conditions. This technique allows us to grow very useful materials under natural conditions."

— Vladimir Tsukruk, professor in the School of Materials Science and Engineering

Georgia Tech researcher Eugenia Kharlampieva studies the properties of composite materials containing silk and metallic nanoparticles.

Designers of future generations of robots may get some new ideas from two recent studies of how reptiles – lizards and snakes – move through their environments. This natural locomotion depends on friction from scales, generation of waves and other tricks to help the animals move around.

Slithering Snakes, Swimming Lizards:

Researchers Study Reptile Locomotion for Insights into Future Robotics

By Abby Vogel

Photo: David Hu and Grace Pryor

Snakes are covered with smooth scales that resemble the overlapping shingles on a house. These scales engage with bumps on the ground while the snake is moving.

Reptiles use unique forms of locomotion to get around in the world. Legless reptiles use their entire bodies for movement, while some reptiles with legs choose between using legs or their bodies – depending on the environment.

Georgia Tech researchers recently published studies detailing how lizards and snakes move across and through different environments. Insights from this research could give the developers of future generations of robots more options for locomotion, especially in confined areas.

How Sandfish Swim

A study published in the July 17, 2009, issue of the journal *Science* details how sandfish – small lizards with smooth scales – move rapidly within desert sand. In this first thorough examination of subsurface sandfish locomotion, Georgia Tech researchers found that the animals place their limbs against their sides and create a wave motion with their bodies to propel themselves through granular media.

"When started above the surface, the animals dive into the sand within a half second. Once below the surface, they no longer use their limbs for propulsion – instead, they move forward by propagating a traveling wave down their bodies like a snake," says study leader Daniel Goldman, an assistant professor in Georgia Tech's School of Physics.

With funding from the National Science Foundation and the Burroughs Wellcome Fund, the research team used high-speed X-ray imaging to visualize sandfish – formally known as *Scincus scincus* – burrowing into and through sand. The team used that information to develop a physics model of the lizard's locomotion.

The sandfish used in this study inhabits the Sahara desert in Africa and is approximately four inches long. It uses its long, wedge-shaped snout and countersunk lower jaw to rapidly bury into and swim within sand. The sandfish's body has flattened sides and is covered with smooth shiny scales, its legs are short and sturdy with long and flattened fringed toes and its tail tapers to a fine point.

To conduct controlled experiments with the sandfish, Goldman and graduate students Ryan Maladen, Yang Ding and Chen Li built a seven-inch by eight-inch by four-inch-deep glass bead-filled container with tiny holes in the bottom through which air could be blown. The air pulses elevated the beads and caused them to settle into a loosely packed solid state. Repeated pulses of air compacted the material, allowing the researchers to closely control the density of the material.

"Because loosely packed media is easier to push through and closely packed is harder to push through, we thought there should be some difference in the sandfish's locomotion," says Goldman. "But the results surprised us because the density of the granular media did not affect how the sandfish traveled through the sand; it was always the same undulatory wavelike pattern."

CONTINUED ON PAGE 9

Photo: Gary Meek

Georgia Tech assistant professor Daniel Goldman found that sandfish, shown here, place their limbs against their sides and create a wave motion with their bodies to swim through sand.

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"The results demonstrate that burrowing and swimming in complex media like sand can have intricacy similar to that of movement in air or water, and that organisms can exploit the solid and fluid-like properties of these media to move effectively within them."

— Daniel Goldman, assistant professor in the School of Physics

Georgia Tech graduate student Ryan Maladen (left) and School of Physics assistant professor Daniel Goldman set up a high-speed X-ray imaging system to record the movements of sandfish swimming in the clear box.

Photo: Gary Meek

By tracking the sandfish in the X-ray images as it swam through the glass beads, Goldman was able to characterize the sandfish's motion – called its kinematics – using a single-period sinusoidal wave that traveled from the head to the tail.

"The large amplitude waves over the entire body are unlike the kinematics of other undulatory swimming organisms that are the same size as the sandfish, like eels, which propagate waves that start with a small amplitude that gets larger toward the tail," explains Goldman.

After collecting the experimental data, Goldman's team developed a physics model to predict the speed at which sandfish swim. The model allowed the researchers to partition the body of the sandfish into segments, each of which generated thrust and experienced drag when moving through the granular environment.

To establish the equations for drag through sand, the researchers measured the granular thrust and drag forces on a small stainless steel cylindrical rod, thus allowing them to predict the wave efficiency and optimal kinematics. They found that the faster the sandfish propagate the wave, the faster they move forward through granular media – up to speeds of six inches per second. This speed allows the animal to escape predators and the heat of the desert surface, and to quickly swim to ambush surface prey they detect from vibrations.

"The results demonstrate that burrowing and swimming in complex media like sand can have intricacy similar to that of movement in air or water, and that organisms can exploit the solid and fluid-like properties of these media to move effectively within them," notes Goldman.

Understanding the mechanics of subsurface movement could reveal how small organisms like worms, scorpions, snakes and lizards can transform landscapes by their burrowing actions. This research may also help engineers build sandfish-like robots that can travel through complex environments.

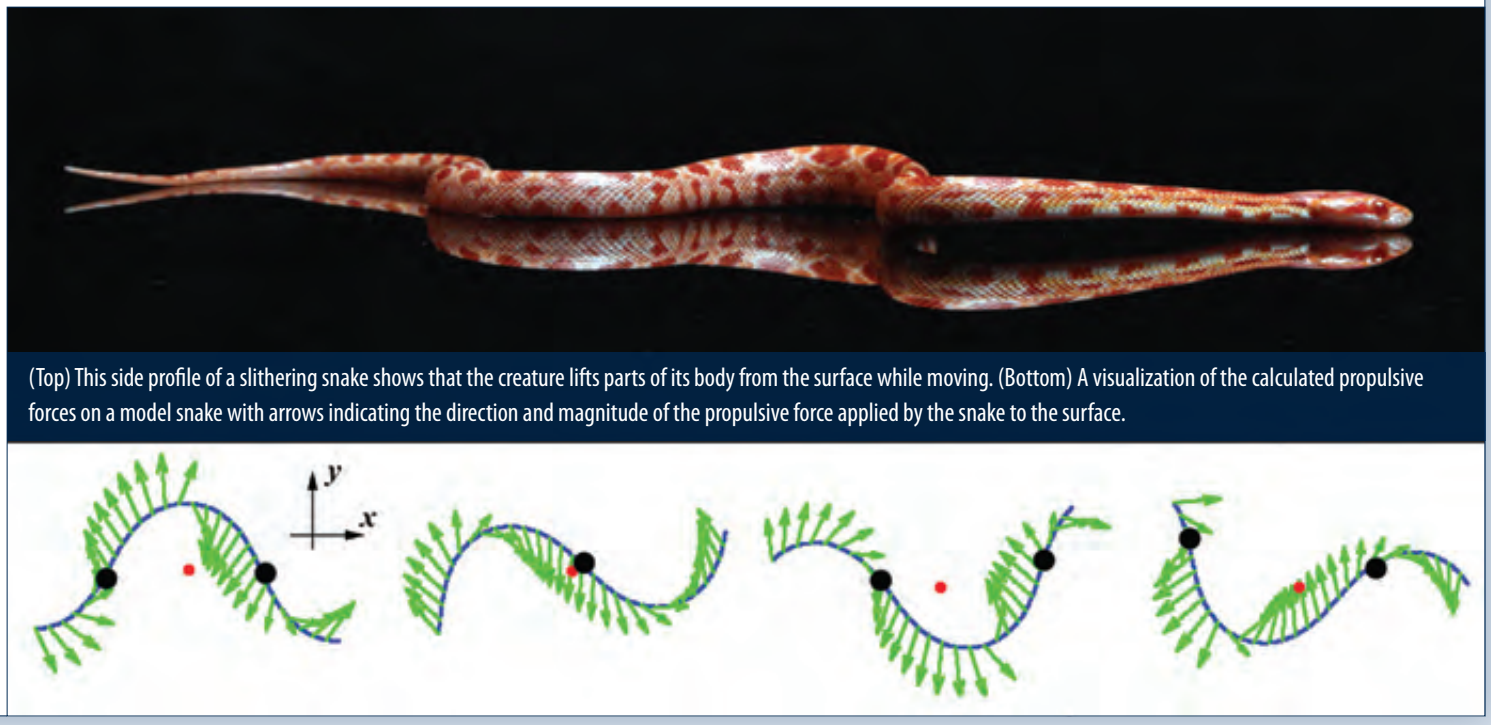
"If something nasty was buried in unconsolidated material, such as rubble, debris or sand, and you wanted to find it, you would need a device that could scamper on the surface, but also swim underneath the surface," Goldman says. "Since our work aims to fundamentally understand how the best animals in nature move in these complex unstructured environments, it could be very valuable information for this type of research."

How Snakes Slither

Snakes use both friction generated by their scales and redistribution of their weight to slither along flat surfaces, researchers at Georgia Tech and New York University have learned. Their findings, which appeared June 8, 2009, in the journal *Proceedings of the National Academy of Sciences*, run counter to previous studies that have suggested snakes move by pushing laterally against rocks and branches.

Insights from the research could give developers of future generations of robots more options for locomotion, especially in confined areas.

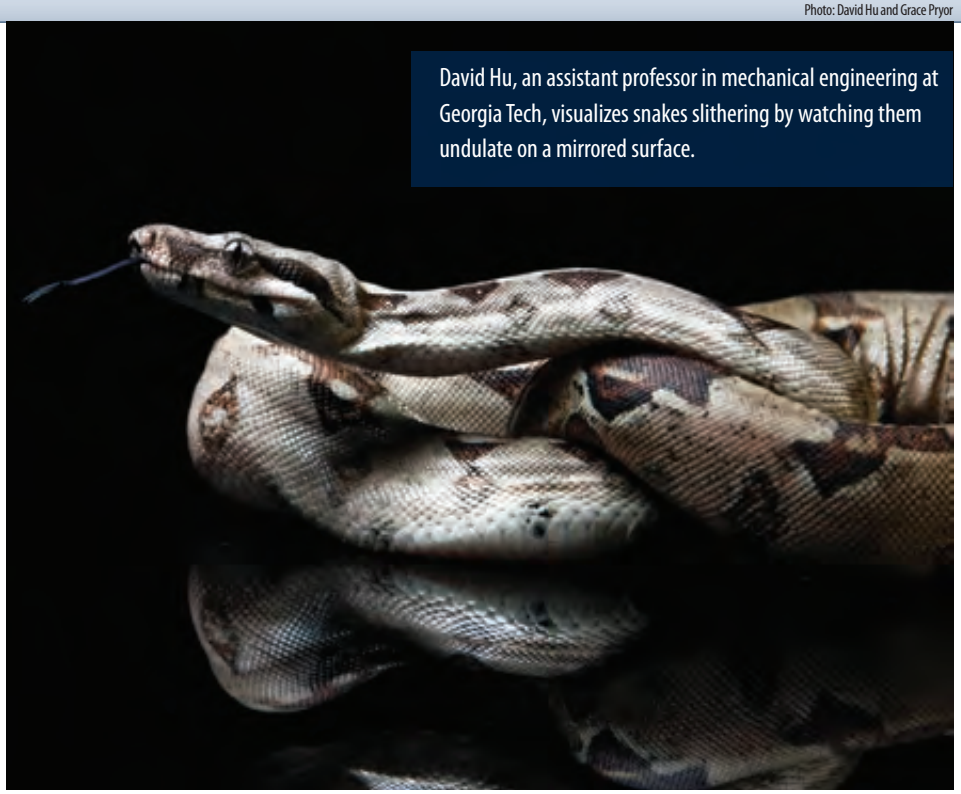
"We found that snakes' belly scales are oriented so that snakes resist sliding toward their tails and flanks," says the paper's lead author, David Hu, an assistant professor in Georgia Tech's George W. Woodruff School of Mechanical Engineering. "These scales give the snakes a preferred direction of motion, which makes snake movement a lot like that of wheels, cross-country skis, or ice skates. In all these examples, sliding forward takes less work than does sliding sideways."



(Top) This side profile of a slithering snake shows that the creature lifts parts of its body from the surface while moving. (Bottom) A visualization of the calculated propulsive forces on a model snake with arrows indicating the direction and magnitude of the propulsive force applied by the snake to the surface.

Photo: David Hu and Grace Pryor

Photo: David Hu and Grace Pryor



David Hu, an assistant professor in mechanical engineering at Georgia Tech, visualizes snakes slithering by watching them undulate on a mirrored surface.

The study, conducted while Hu was a postdoctoral researcher at New York University's Courant Institute of Mathematical Sciences, centered on the frictional anisotropy – or resistance to sliding in certain directions – of a snake's belly scales. While previous investigators had suggested that the frictional anisotropy of these scales might play a role in locomotion over flat surfaces, the details of this process had not been understood.

To explore this issue, the researchers first developed a theoretical model of a snake's movement. The model determined the expected speed of a snake's center of mass as a function of the speed and size of its body waves, taking into account the laws of friction and the scales' frictional anisotropy. The model suggested that a snake's motion arises through the interaction of surface friction and its internal body forces.

"The animals propel themselves using their muscles to move their bodies in a wave. As the wave travels backwards through its body, the snake's scales catch the ground, generating a frictional force that propels it forward," explains Hu.

To study the model's accuracy in describing the movement of real snakes, the researchers measured the sliding resistance of snake scales and monitored the movement of snakes through a series of experiments on flat, inclined, smooth and rough surfaces. They employed video and time-lapse photography to gauge movements of the snakes.

First, the research team measured the ability of milk snakes to slither on rough cloth and a smooth plank. The snakes had trouble moving on the smooth surface, but could move more easily on the cloth-covered one. However, the snakes ran into movement difficulties again when researchers fitted them with a cloth jacket, which eliminated the scale frictional anistropy.

Hu also anesthetized snakes and placed them head-first, backwards and sideways over inclined smooth and rough surfaces. On the smooth surface, friction was fairly evenly matched in all directions, whereas on the rough surface, snakes slid easily in the forward direction, but their scale friction resisted sliding backwards or sideways. The researchers found that it was twice as hard to move the snakes sideways as it was to slide the animals forward.

"The friction was caused by the orientation of the snakes' scales, which are arranged like shingles on a roof to resist such movements," notes Hu.

That test provided a friction coefficient that could be studied with the computer model. With that value included, the theoretical snake followed roughly the same path as the real snakes. However, the speeds predicted by the model were lower than those the researchers observed in the snake experiments.

To find out why, Hu's team placed moving snakes on a photoelastic gelatin that lit up when force was applied. They found that the snakes lift parts of their bodies slightly off the ground when moving. This helps reduce unwanted friction and applies greater pressure to the parts of the body wave that are pushing the snake forward. While friction accounts for about 65 percent of the forward movement, this weight redistribution by the snake accounts for the other 35 percent, according to Hu.

After factoring this into the model, the results showed a close relationship between what the model predicted and the snakes' actual movements. The theoretical predictions of the model were generally consistent with the snakes' actual body speeds on both flat and inclined surfaces.

"In the future, understanding snake locomotion might help engineers design better snake robots, which can be used to maneuver into tight spaces," Hu adds.

The study's other co-authors were Jasmine Nirody and Terri Scott, both undergraduate researchers at New York University, and Michael Shelley, a professor of mathematics and neural science and the Lilian and George Lyttle Professor of Applied Mathematics at Courant.

The information on the sandfish is based upon work supported by the National Science Foundation (NSF) under Award No. PHY-0749991 and the Burroughs Wellcome Fund. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the researcher and do not necessarily reflect the views of the NSF. James Devitt, deputy director for media relations at New York University, contributed to the portion of this article relating to snakes.

Photos: David Hu and Grace Pryor

A study by mechanical engineering assistant professor David Hu found that snake scales are necessary for locomotion. Enveloping the snakes in cloth renders their scales ineffective, making the snakes unable to slither forward.

Researchers are using a simulated data center to study improved cooling strategies and develop new heat transfer models that could reduce the amount of electricity needed to cool large computer data centers by as much as 15 percent.

Keeping Their Cool:

Researchers Develop Improved Techniques for Controlling Heat in Large Data Centers

By John Toon

Photo: Gary Meek

Former Georgia Tech graduate student Shawn Shields shows the computer room air conditioning unit that provides chilled air to the subfloor plenum seen beneath the lifted floor tile.

Approximately a third of the electricity consumed by large data centers doesn't power the computers that conduct online transactions, serve Web pages or store information. Instead, that electricity must be used for cooling the servers, a demand that continues to increase as computer processing power grows and the trend toward cloud computing expands.

At Georgia Tech, researchers are using a 1,100-square-foot simulated data center to optimize cooling strategies and develop new heat transfer models that can be used by the designers of future facilities and equipment. The goal is to reduce the portion of electricity used to cool data center equipment by as much as 15 percent.

"Computers convert electricity to heat as they operate," says Yogendra Joshi, a professor in Georgia Tech's Woodruff School of Mechanical Engineering. "As they switch on and off, transistors produce heat, and all of that heat must be ultimately transferred to the environment. If you are looking at a few computers, the heat produced is not that much. But data centers generate heat at the rate of tens of megawatts that must be removed."

Summaries of the research have been published in the *Journal of Electronic Packaging* and the *International Journal of Heat and Mass Transfer* and presented at the Second International Conference on Thermal Issues in Emerging Technologies, Theory and Applications. The research has been sponsored by the U.S. Office of Naval Research, and by the Consortium for Energy Efficient Thermal Management.

Five years ago, a typical refrigerator-sized server cabinet produced about one to five kilowatts of heat. Today, high-performance computing cabinets of about the same size produce as much as 28 kilowatts, and machines already planned for production will produce twice as much.

"Some people have called this the Moore's Law of data centers," observes Joshi, who is also the John M. McKenney and Warren D. Shiver Chair in the School of Mechanical Engineering. "The growth of cooling requirements parallels the growth of computing power, which roughly doubles every 18 months. That has brought the energy requirements of data centers into the forefront."

Most existing data centers rely on large air conditioning systems that pump cool air to server racks. Data centers have traditionally used raised floors to allow space for circulating air beneath the equipment, but cooling can also come from the ceilings. As cooling demands have increased, data center designers have developed complex systems of alternating cooling outlets and hot air returns throughout the facilities.

"How these are arranged is very important to how much cooling power will be required," Joshi says. "There are ways to rearrange equipment within data centers to promote better air flow and greater energy efficiency, and we are exploring ways to improve those."

Before long, centers will likely have to use liquid cooling to replace chilled air in certain high-

power machines. That will introduce a new level of complexity for the data centers, and create differential cooling needs that will have to be accounted for in their design and maintenance.

Joshi and his students have assembled a small, high-power-density data center on the Georgia Tech campus that includes different types of cooling systems, partitions to change room volumes and both real and simulated server racks. They use fog generators and lasers to visualize airflow patterns, infrared sensors to quantify heat, airflow sensors to measure the output of fans and other systems, and sophisticated thermometers to measure temperatures on server motherboards.

Beyond studying the effects of alternate airflow patterns, they are also verifying that cooling systems are doing what they're supposed to do.

Because tasks are dynamically assigned to specific machines, heat generation varies in a data center. Joshi's group is also exploring algorithms that could help even out the computing load by assigning new computationally intensive tasks to cooler machines, avoiding hot spots.

Another issue they're studying is what happens when utility-system power to a data center is cut off. The servers themselves continue to operate because they receive electricity from an uninterruptible power supply. But the cooling equipment is powered by backup generators, which can take minutes to get up to speed.

During the brief time without cooling, heat builds up in the servers. Existing computer models predict that temperatures will reach dangerous levels in a matter of seconds, but actual measurements done by Joshi's graduate students show that the equipment can run for as much as six minutes without cooling.

Data obtained by the researchers with thermometers and airflow meters is being used to validate computer models that are reasonably accurate, but run rapidly. In the future, these models will help data center operators do a better job of optimizing cooling in real time, Joshi says.

"Our data center laboratory is a complete sandbox in which we can study all sorts of options without affecting anybody's computing projects," he adds. "We can look at interesting ways to improve rack-level cooling, liquid cooling and thermoelectric cooling." rh

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"The growth of cooling requirements parallels the growth of computing power, which roughly doubles every 18 months. That has brought the energy requirements of data centers into the forefront."

— Yogendra Joshi, professor in the Woodruff School of Mechanical Engineering

Photo: Gary Meek

Professor Yogendra Joshi shows perforated floor tiles from the cold-aisle used to supply chilled air from beneath the floor of a simulated server room. The chilled air is entrained at the front of the server cabinets to provide cooling.

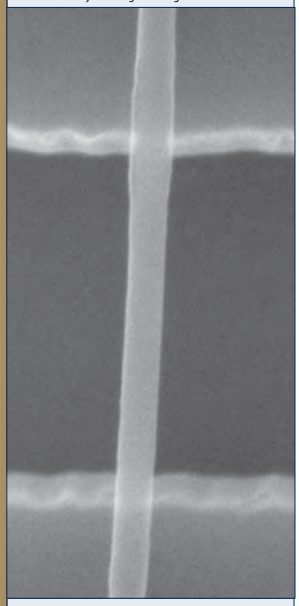
A new statistical analysis technique may help researchers in nanoscience and nanotechnology improve the precision and reliability of the data they gather. Known as sequential profile adjustment by regression, the technique could also reduce the amount of data needed.

Measuring Nanomaterials:

New Statistical Technique Detects and Removes Errors to Improve the Precision of Experimental Data

By John Toon

Photo courtesy of Zhong Lin Wang



This scanning electron microscope image shows a zinc oxide nanobelt on a trenched substrate. Data from measuring deflection of the nanobelt was analyzed with the new technique.

A new statistical analysis technique that identifies and removes systematic bias, noise and equipment-based artifacts from experimental data could lead to more precise and reliable measurement of nanomaterials and nanostructures likely to have future industrial applications.

Developed at Georgia Tech and known as sequential profile adjustment by regression (SPAR), the technique could also reduce the amount of experimental data required to make conclusions, and help distinguish true nanoscale phenomena from experimental error. Beyond nanomaterials and nanostructures, the technique could also improve reliability and precision in nanoelectronics measurements – and in studies of certain larger-scale systems.

Accurate understanding of these properties is critical to the development of future high-volume industrial applications for nanomaterials and nanostructures because manufacturers will require consistency in their products.

"Our statistical model will be useful when the nanomaterials industry scales up from laboratory production because industrial users cannot afford to make a detailed study of every production run," says C. F. Jeff Wu, a professor in the Stewart School of Industrial and Systems Engineering at Georgia Tech. "The significant experimental errors can be filtered out automatically, which means this could be used in a manufacturing environment."

Sponsored by the National Science Foundation, the research was reported June 25, 2009, in the early edition of the journal *Proceedings of the National Academy of Sciences*. The paper is believed to be the first to describe the use of statistical techniques for quantitative analysis of data from nanomechanical measurements.

Nanotechnology researchers have long been troubled by the difficulty of measuring nanoscale properties and separating signals from noise and data artifacts. Data artifacts can be caused by such issues as the slippage of structures being studied, surface irregularities and inaccurate placement of an atomic force microscope tip onto samples.

In measuring the effects of extremely small forces acting on extremely small structures, signals of interest may be only two or three times stronger than experimental noise. That can make it difficult to draw conclusions, and it potentially can mask other interesting effects.

"In the past, we have really not known the statistical reliability of the data at this size scale," says Zhong Lin Wang, a Regents' professor in Georgia Tech's School of Materials Science and Engineering. "At the nanoscale, small errors are amplified. This new technique applies statistical theory to identify and analyze the data received from nanomechanics so we can be more confident of how reliable it is."

In developing the new technique, the researchers studied a data set measuring the deformation of zinc oxide nanobelts, research undertaken to determine the material's elastic modulus. Theoretically, applying force to a nanobelt with the tip of an atomic force microscope should produce consistent linear deformation, but the experimental data didn't always show that.

In some cases, less force appeared to create more deformation, and the deformation curve was not symmetrical. Wang's research team attempted to apply simple data-correction techniques, but was not satisfied with the results.

"The measurements they had done simply didn't match what was expected with the theoretical model," explains Wu, who holds a Coca-Cola chair in engineering statistics. "The curves should have been symmetric. To address this issue, we developed a new modeling technique that uses the data itself to filter out the mismatch step-by-step using the regression technique."

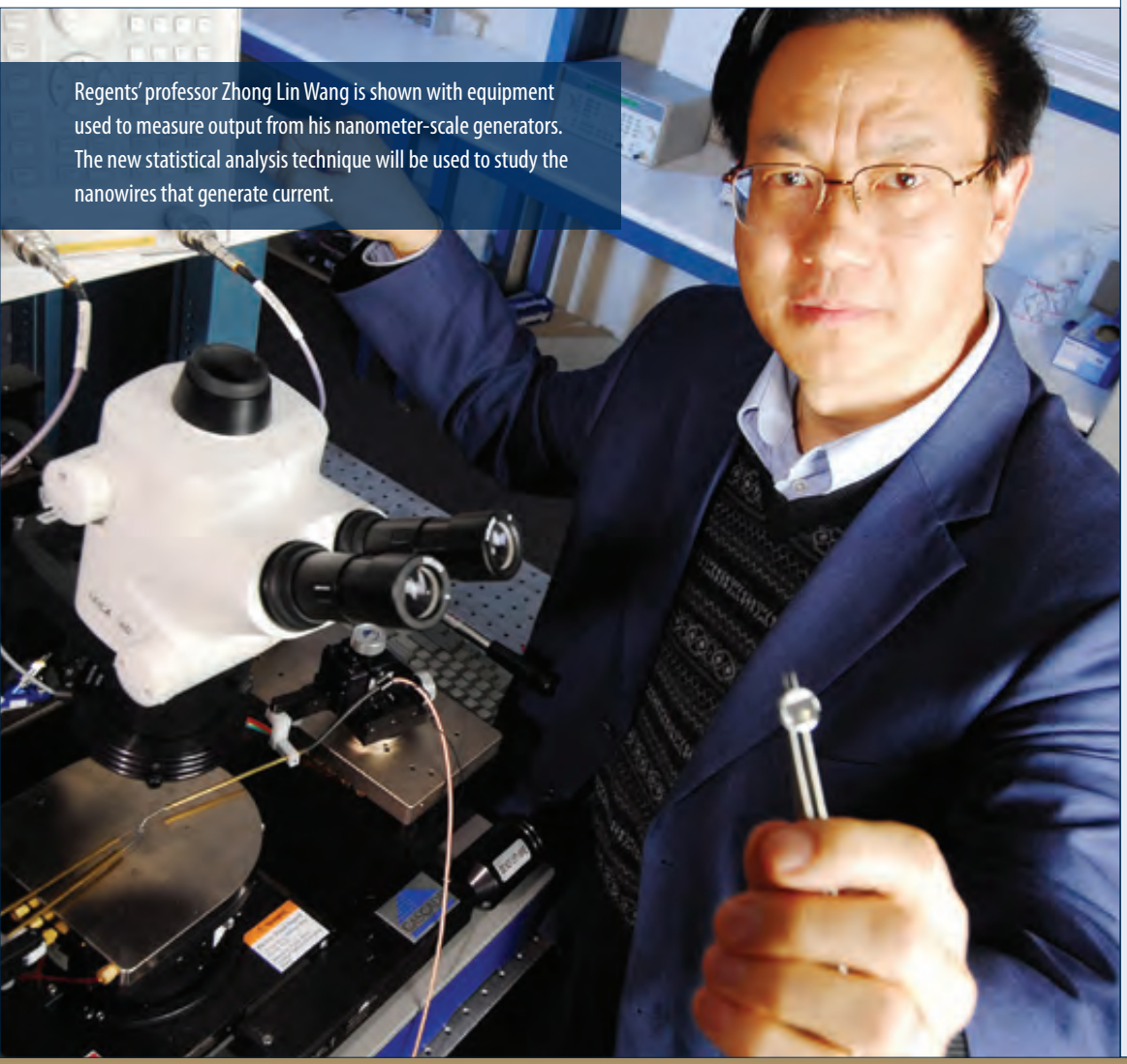
Ideally, researchers would search out and correct the experimental causes of these data errors, but because they occur at such small-size scales, that would be difficult, notes V. Roshan Joseph, an associate professor in the Georgia Tech School of Industrial and Systems Engineering.

"Physics-based models are based on several assumptions that can go wrong in reality," he says. "We could try to identify all the sources of error and correct them, but that is very time-consuming. Statistical techniques can more easily correct the errors, so this process is more geared toward industrial use."

For the future, the research team – which includes Xinwei Deng and Wenjie Mai in addition to those already mentioned – plans to analyze the properties of nanowires, which are critical to the operation of a family of nanoscale electric generators being developed by Wang's research team. Correcting for data errors in these structures will require development of a separate model using the same SPAR techniques, Wu says.

Ultimately, SPAR may lead researchers to new fundamental explanations of the nanoscale world.

"One of the key issues today in nanotechnology is whether the existing physical theories can still be applied to explain the phenomena we are seeing," adds Wang, who is also director of Georgia Tech's Center for Nanostructure Characterization and Fabrication. "We have tried to answer the question of whether we are truly observing new phenomena, or whether our errors are so large that we cannot see that the theory still works." rh



Regents' professor Zhong Lin Wang is shown with equipment used to measure output from his nanometer-scale generators. The new statistical analysis technique will be used to study the nanowires that generate current.

Photo: Gary Meek

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"Our statistical model will be useful when the nanomaterials industry scales up from laboratory production because industrial users cannot afford to make a detailed study of every production run. The significant experimental errors can be filtered out automatically, which means this could be used in a manufacturing environment."

— C. F. Jeff Wu, professor in the Stewart School of Industrial and Systems Engineering

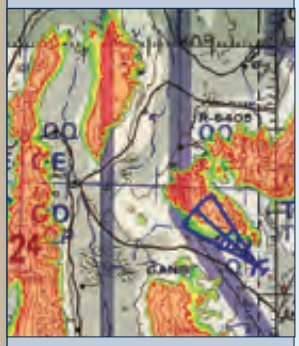
An open-source version of the popular FalconView™ software has been released by the Georgia Tech Research Institute. The release makes FalconView's ability to display maps, charts and images available to local and state governments, police agencies, architects and others in the civilian world.

Mapping and Imagery Display:

FalconView™ Goes Open Source for Corporate, Environmental, Government and Other Users

By Abby Vogel

Using the open-source FalconView software, global positioning system data is overlaid on this topographic map, allowing users to track their movements on a "moving" map.



The Georgia Tech Research Institute (GTRI) has released an open-source version of its popular FalconView™ software. The program displays topographical maps, aeronautical charts, satellite images and other maps, along with overlay tools that can be displayed on any map background.

The U.S. Department of Defense has used the FalconView software program since the 1990s to analyze and display geographical and other data crucial to mission planners. The program's ease of use, open architecture and interoperability all contribute to its popularity. There were an estimated 45,000 users at the time the open-source version was released.

"We are excited to broaden our user base outside of the Department of Defense," says Chris Bailey, GTRI principal research engineer and FalconView project director. "We expect that individual municipalities, including state, city and town governments; police forces; architects; environmental researchers and utility companies will be among those who will benefit from this new FalconView open-source software."

Police forces can use FalconView to track vehicles, plan operations or plot locations of incidents such as burglaries, traffic accidents or drug activities, according to Bailey. School districts can reformat school zones easily using a number of different data analyses and visualization techniques. FalconView can also be valuable for companies trying to determine the best locations for their businesses to meet customer needs.

In the past, the U.S. Department of Defense typically funded companies to develop software and these companies rarely shared the source code, which led to "knowledge monopolies" because there were usually not mechanisms for secondary vendors to make improvements to the software, Bailey says. Open-source practices allow third parties to freely use source code and provide formal mechanisms to submit improvements or patches back to the main source code repository. With open-source software, bugs are typically caught and repaired faster.

Since FalconView already had hundreds of registered developers creating "plug-in" tools for the software, and because third parties within the Department of Defense had developed programs that were integrated with FalconView, the software was a perfect candidate for the transition to open source.

In July 2008, the U.S. Air Force Office of Advanced Systems and Concepts funded GTRI to create the open-source version of FalconView, which involved removing components that were not applicable to non-defense users and code that depended on government data. Since its release in June 2009, more than 1,000 copies of open-source FalconView have been downloaded from the FalconView Web site (http://www.falconview.org).

The Windows-based FalconView software package allows users to view many different imagery formats, including popular geographic information systems formats and KML, which is the code used by Google Earth and Google Maps. Municipalities can upload archived maps of their localities into FalconView and users can also download topographical, nautical,

aeronautical and satellite maps from the Internet for use in FalconView.

"FalconView has advantages over most of the free mapping software products because FalconView can be used without an active Internet connection," says GTRI research scientist Joel Odom, a member of the 11-person FalconView development team. "Someone can take a file they're viewing in another program and look at it in FalconView to get a top-down two-dimensional view that they can thoroughly analyze even if they're in a boat in the middle of the ocean without a satellite uplink and downlink."

The open-source version of FalconView also contains several analysis tools. The drawing utility allows users to create custom shapes in an overlay that can be saved and shared. Calculating distances between points on a map is easy with the analysis tool. The tool also allows users to calculate the visibility between areas on the map if elevation data is available.

In addition, a global positioning system and camera can be hooked up to the FalconView software to allow users to track their movements on a "moving" map and record the exact locations where they snapped photographs.

Bailey and his team plan to continue creating new features for FalconView and accepting components developed by non-GTRI programmers. GTRI will also continue to serve as the systems integrator for the software.

"This new open-source version of FalconView allows us to share all of the interesting mapping capabilities of this once defense-only software with users around the world," adds Bailey. rh

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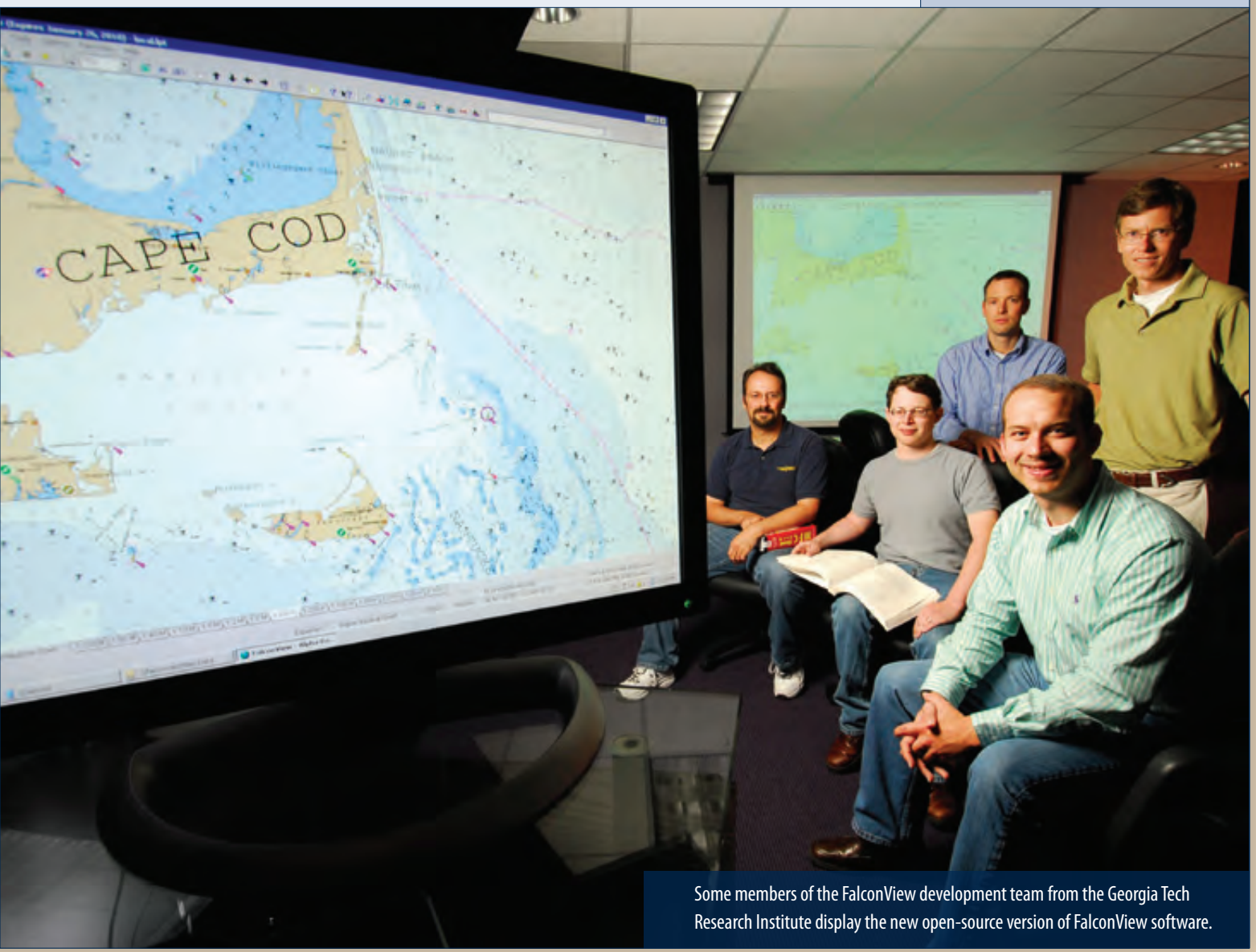
"We expect that individual municipalities, including state, city and town governments; police forces; architects; environmental researchers and utility companies will be among those who will benefit from this new FalconView open-source software."

— Chris Bailey, GTRI principal research engineer



Some members of the FalconView development team from the Georgia Tech Research Institute display the new open-source version of FalconView software.

Photo: Gary Meek

Using a new analytical technique that allows study of compounds from the surfaces of organisms, researchers are learning how seaweed protects itself against microbial threats such as fungus. The new technique is known as desorption electrospray ionization mass spectrometry.

Chemical Defense:

New Technique Analyzes Seaweed for New Drug Compounds

By John Toon

Photo: Julia Kubanek

Samples of the red seaweed *Callophycus serratus* were found in a section of ocean off this beach in the Fiji Islands.

A new analytical technique is helping scientists learn how organisms as simple as seaweed can mount complex chemical defenses to protect themselves from microbial threats such as fungus. Known as desorption electrospray ionization mass spectrometry (DESI-MS), the technique for the first time allows researchers to study unique chemical activity taking place on the surfaces of these organisms.

Understanding this surface chemistry could one day allow scientists to borrow and adapt some of those defensive chemical compounds for use against cancer, HIV, malaria, drug-resistant bacteria and other human diseases. In a paper published April 6, 2009, in the early edition of the journal *Proceedings of the National Academy of Sciences*, Georgia Tech researchers described a sophisticated chemical defense system that uses 28 different compounds to protect a species of seaweed against a single fungus.

"Plants and animals in the wild use chemistry as a way to fight with one another," says Julia Kubanek, a professor in Georgia Tech's School of Biology. "Using this new technology, scientists can 'listen in' on this fight to perhaps learn from what's going on and steal some of the strategies for human biomedical applications."

As part of a long-term project sponsored by the National Institutes of Health, Georgia Tech scientists have been cataloging and analyzing natural compounds from more than 800 species found in the waters surrounding the Fiji Islands. They have been particularly interested in *Callophycus serratus*, an abundant species of red seaweed that seems particularly adept at fighting off microbial infections.

Using a DESI-MS technique adapted for this project in the laboratory of associate professor Facundo Fernandez in Georgia Tech's School of Chemistry & Biochemistry, researchers Leonard Nyadong and Asiri Galhena analyzed recently collected samples of the seaweed and found groups of potent anti-fungal compounds in light-colored microscopic surface patches covering what may be wounds on the surface of the seaweed. In laboratory testing, graduate student Amy Lane found that these bromophycolide compounds and callophycoic acids effectively inhibited the growth of *Lindra thalassiae*, a common marine fungus.

"It is possible that the alga is marshalling its defenses and displaying them in a way that blocks the entry points for microbes that might invade and cause disease," Kubanek says. "Seaweeds don't have B cells, T cells and immune responses like humans do. But instead, they have some chemical compounds in their tissues to protect them."

Though all the seaweed they studied was from a single species, the researchers were surprised to find two distinct groups of anti-fungal chemicals. From one seaweed subpopulation, dubbed the "bushy" type for its appearance, 18 different anti-fungal compounds were identified. In a second group of seaweed, the researchers found 10 different anti-fungal compounds – all different from the ones seen in the first group.

"This species is producing some unique chemical compounds that other seaweeds don't

produce, and it is producing a large number of compounds, each of which has a role to play in the overall defense against the fungus," Kubanek notes. "We think the compounds work together in an additive way."

Though chemically different, the compounds are structurally related and seem to arise from a similar metabolic pathway in the seaweed. Why one species of simple organism would produce 28 different anti-fungal compounds remains a mystery, though Kubanek believes the chemicals may also have other uses that are not yet understood.

The DESI-MS technique allowed the researchers for the first time to analyze chemical activity occurring on the surface of the seaweed. Earlier techniques allowed identification of chemicals in the organism's tissue, but being able to confirm their location on the surface – the first line of defense against infection – confirms the role they play as defensive chemicals.

In DESI-MS, a charged stream of polar solvent is directed at the surface of a sample under study at ambient pressure and temperature. The spray desorbs molecules, which are then ionized and delivered to the mass spectrometer for analysis.

"Our collaborative team of researchers from the Department of Biomedical Engineering and the College of Sciences has worked within the newly formed Bioimaging Mass Spectrometry Center at Georgia Tech to better understand the mechanisms of chemical defenses in marine organisms," says Fernandez. "This is an example of cross-cutting interdisciplinary research that characterizes our institute."

In addition to the scientists mentioned above, other researchers contributing to the study are Tonya Shearer, Paige Stout, R. Mitchell Parry, Mark Kwasnik, May Wang and Mark Hay, all from Georgia Tech. Beyond the National Institutes of Health support, the research has also been sponsored by the National Science Foundation and seed funding from the Georgia Tech College of Sciences and College of Engineering.

For the future, Kubanek and graduate student Paige Stout are working to modify the most promising of the anti-malarial compounds, replacing some oxygen atoms for nitrogen atoms and bromine for chlorine and fluorine.

"We are doing reaction chemistry using these 28 compounds as a starting point," Kubanek explains. "Learning about how other species avoid diseases may give us something we can use to avoid or treat our own diseases." rh

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"Plants and animals in the wild use chemistry as a way to fight with one another. Using this new technology, scientists can 'listen in' on this fight to perhaps learn from what's going on and steal some of the strategies for human biomedical applications."

— Julia Kubanek, professor in the School of Biology

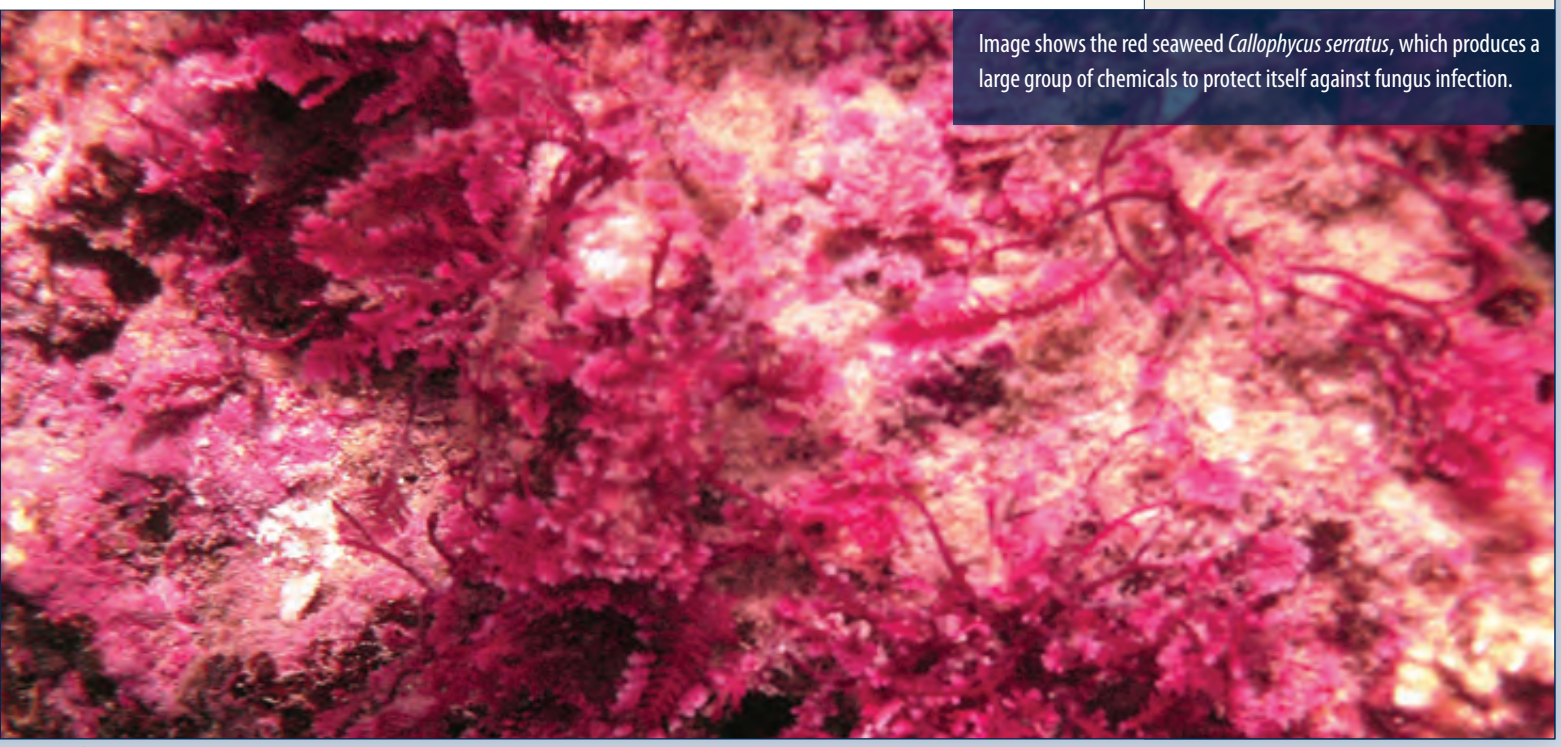

Image shows the red seaweed *Callophycus serratus*, which produces a large group of chemicals to protect itself against fungus infection.

Photo: Paige Stout

Researchers from the Georgia Tech Research Institute recently helped the operators of a nuclear power facility near New York City verify that their siren warning system met federal requirements. The work involved unique acoustical testing, using both indoor chambers and an outdoor range.

Safety First:

Investigators Test Compliance of Nuclear Plant's Warning System

By Rick Robinson

GTRI tested the siren warning system used at New York's Indian Point nuclear facility.

Photo: Rick Gaeta

Nuclear power plants in the United States are subject to numerous federal and state regulations aimed at maintaining safe operation, but demonstrating compliance with each regulation can be a challenge for power-plant managers.

A team at the Georgia Tech Research Institute (GTRI) is working with the owner-operators of a major New York State nuclear facility to ensure that a critical safety measure will work correctly if a problem occurs.

At issue is a siren warning system surrounding the Indian Point Energy Center, a nuclear plant owned by Entergy Corp. about 25 miles north of New York City. The Federal Emergency Management Agency (FEMA) recently ordered Entergy to show that its system of 150-plus pole-mounted warning sirens, which covers a 10-mile radius around the plant, fully complied with regulations.

"FEMA wanted proof that these horns produce sound at a given frequency that is repeatable and steady," says Rick Gaeta, a GTRI senior research engineer who led the project. "We were able to test the horns in both an anechoic environment as well as outdoors."

Federal regulations require a loudness of at least 70 decibels just outside every building in the warning zone. But real-world testing can jangle area residents' nerves, so it can't be done frequently. To help show regulatory compliance, Entergy turned to laboratory testing and evaluation.

A GTRI acoustics team supported Entergy's testing and evaluation effort with two crucial tasks:

- Testing to demonstrate that the sirens' warning tone has the requisite volume, reliability and steadiness in the quiescent environment of an anechoic chamber;
- Field testing to demonstrate siren performance in realistic atmospheric and meteorological conditions.

Moreover, GTRI conducted its testing under aggressive time constraints. Failure to comply with regulations could result in the big power plant losing its approval to operate.

"Time has definitely been an issue here," Gaeta says. "We were able to move quickly and complete the first part of this project – testing the sirens in an anechoic chamber – in about a month. The entire project lasted about two and a half months."

To demonstrate that the sirens installed around the plant are functioning properly, Gaeta and his team first evaluated a number of units in an anechoic chamber, a shielded room capable of deadening echoes to produce accurate results. To test multiple sirens swiftly, the investigators devised a rotating stand they called a "siren spit;" it allowed them to easily turn the devices in different directions.

The team found that the sirens produced acceptable levels and steadiness in the anechoic chamber. Then they moved on to outdoor testing at GTRI's Cobb County Research Facility.

To reproduce the sirens' real-world environment, Gaeta and his team placed multi-siren units brought from the New York plant on utility poles at their usual height. Then they placed microphones on several man-lift machines – crane-like devices used to elevate workers to the top of power poles.

The microphone-man-lift ap-

proach allowed investigators to test the sirens' effectiveness rapidly at specific distances under various conditions. They placed microphones at 18, 100, 200 and 400 feet, moving each microphone in a four-foot circle and taking the average decibel level as the final result.

The GTRI team evaluated old sirens from the Indian Point site along with brand-new sirens. Graduate students spent long hours atop the testing towers, with sirens mounted on a lazy-Susan design that allowed numerous testing approaches.

"Just as at the power plant, we encountered a great deal of variability due to meteorological conditions such as wind and temperature gradients, as well as terrain effects," Gaeta says. "We tested in clear weather and in overcast weather, which produced different effects at long distances from the source – namely, we received some community complaints during tests with overcast weather."

The bottom line: the GTRI team found that the sirens functioned as expected and that the outdoor measurements showed remarkable consistency with the anechoic chamber measurements.

GTRI is working toward a new program with Entergy that will validate computer models that predict siren coverage around the Indian Point facility. Investigators are using computer models rather than live testing so residents don't have to endure the blaring sirens that would be required to test sound levels.

"Demonstrating that these computer models reflect actual conditions is difficult because of the many variables of terrain and weather," Gaeta says. "That said, the models are being improved rapidly, and we're working with the sponsor to conclusively validate the findings." rh

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"The Federal Emergency Management Agency wanted proof that these horns produce sound at a given frequency that is repeatable and steady. We were able to test the horns in both an anechoic environment as well as outdoors."

— Rick Gaeta, GTRI senior research engineer

GTRI researchers used man-lifts to precisely position microphones as part of a program that tested nuclear plant warning sirens.

Photo: Rick Gaeta

A Georgia Tech civil engineer was the only international scientist leading a team that surveyed damage caused by Cyclone Nargis in the Asian nation of Myanmar, formerly known as Burma. Information gathered by the team could improve predictions for how future storms will affect the area.

Assessing the Disaster:

Scientists Report on Damage from Cyclone Nargis, Which Killed 138,000 in Myanmar

By John Toon

Vertical erosion caused by Cyclone Nargis can be seen on these palm tree roots, and is being measured by the survey team.

Photo: Hermann Fritz

Tropical Cyclone Nargis made landfall in the Asian nation of Myanmar on May 2, 2008, causing the worst natural disaster in the country's recorded history – with a death toll that may have exceeded 138,000. In the July 2009 issue of the journal *Nature Geoscience*, researchers reported on a field survey done three months after the disaster to document the extent of the flooding and resulting damage.

The information – which may be the first reliable measurements of cyclone damage in the area – could lead to development of computer models for predicting how future storms may impact the geologically complex Ayeyarwady River delta. Those models could be the basis for planning, construction and education that would dramatically reduce future loss of life.

Among the findings of the study: the cyclone created a storm surge as much as five meters high – topped by two-meter storm waves – that together inundated areas as much as 50 kilometers inland. Fatality rates reached 80 percent in the hardest-hit villages, and an estimated 2.5 million people in the area lived in flood-prone homes less than 10 feet above sea level.

"The recorded high water marks serve as benchmarking for numerical models for the complex hydraulic response of the giant Ayeyarwady delta," notes Hermann M. Fritz, an associate professor in Georgia Tech's School of Civil and Environmental Engineering. "Ongoing numerical simulations will allow us to determine flood zones and vulnerabilities for future cyclone scenarios. Based on those, evacuation scenarios and evaluation plans will be derived in collaboration with international partners and the Myanmar government."

Already, a local non-governmental organization in the nation has developed a cyclone education program to raise awareness among residents, says Fritz, the only international scientist leading a team that surveyed 150 kilometers of the country's coastline during a two-week period August 9-23, 2008.

"The aim of our project was to document the extent of the flooding and associated damage in the delta," Fritz explains. "Field surveys in the immediate aftermath of major disasters focus on perishable data, which would otherwise be lost forever – such as infrastructure damage prior to repair and reconstruction."

In the flood zone, the researchers searched for evidence of water marks on buildings, scars on trees and rafted debris as indicators of the maximum water height.

"Nargis washed away entire settlements, often without leaving a single structure standing, which forced us to focus on evidence left on large trees," adds Fritz, who has studied other natural disasters in Asia, Africa and the United States. "High water marks were photographed and located using global positioning system instruments. Transects from the nearest beach or waterway to the high water marks were recorded with a laser range finder."

The survey team documented soil erosion of as much as one meter vertically and more than 100 meters horizontally. Highlighting the loss of land was a golden Buddhist dome – originally constructed on

dry land – that was left 150 meters offshore following the storm. Cyclone Nargis also scoured several drinking-water wells, leaving them in the beach surf zone.

While the storm surge and waves weren't unusually high, the impact may have been amplified by the lack of nearby high ground for evacuation and loss of coastal mangrove forests that could have slowed the storm waves, Fritz says. Structures in the area were not built to survive cyclones, and there was no evacuation plan for the area – where people had no previous experience with such storms.

Those findings point to recommendations, including implementation of a cyclone education program, development of flood and vulnerability maps, construction of cyclone-safe buildings to serve as shelters, implementation of an improved warning system, and planning for evacuation, Fritz says. Partial reconstruction of the mangroves that had been removed for agriculture and fuel could also help protect the coastline.

The expedition's itinerary was planned based on unofficial damage reports, physical storm and cyclone track data, satellite imagery, numerical model benchmark requirements and experience gained in surveying other disasters. The group traveled to the country by cargo boat and did most surveying from the vessel.

The research was in part supported by the Pyoe Pin Programme of the Department for International Development in the United Kingdom. The program is also sponsoring detailed modeling and a follow-up study being done at Georgia Tech by Fritz and Christopher Blount, one of his doctoral students.

Fritz hopes the work done by the survey team – which also included Swe Thwin of the Myanmar Coastal Conservation Society and Moe Kyaw and Nyein Chan of the Mingalar Myanmar NGO – will ultimately help reduce the human cost of major cyclones.

"In the 21st century with modern communication and all that has been learned about cyclones in the Bay of Bengal, there is no need for 138,000 people to be killed by a storm like this," Fritz says. "With adequate planning, education and shelters, it should be possible to reduce fatality rates from future cyclones by at least one order of magnitude." rh

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"In the 21st century with modern communication and all that has been learned about cyclones in the Bay of Bengal, there is no need for 138,000 people to be killed by a storm like this. With adequate planning, education and shelters, it should be possible to reduce fatality rates from future cyclones by at least one order of magnitude."

— Hermann Fritz, associate professor in the School of Civil and Environmental Engineering

Photo: Hermann Fritz

Drinking water wells formerly on dry land are shown in surf zone at Aya in Myanmar. Their loss removed a source of clean water for the area.

Work of Georgia Tech Researchers is Covered in the News Media

Research into how snakes move about on flat terrain proved appealing to media from all around the world. Published in the journal *Proceedings of the National Academy of Sciences*, the work turned up some surprising secrets of snake locomotion: the creatures use both friction generated by their scales and redistribution of their weight to slither. The work, done by David Hu in the Woodruff School of Mechanical Engineering, could have implications for future robots. Among the media outlets covering these findings were ABC News, the British Broadcasting Corporation (BBC), *Discover*, Live Science, *National Geographic*, *Nature*, National Public Radio, *The New York Times*, *New Scientist*, *Science News*, the *Smithsonian*, the *Telegraph of London*, and *USA Today*. The National Science Foundation, which helped sponsor the work, also produced a video. (See story on page 6 of this issue of *Research Horizons*.)

Also following the theme of learning from nature, a researcher from the School of Polymer, Textile and Fiber Engineering reported on how "jeweled beetles" get their metallic green colors. Instead of using dyes, the beetle gets its remarkable color through optics: a unique helical structure that reflects light of two colors in only one polarization. This feat of optical engineering also involves chemical engineering – the beetle uses optical structures produced from liquid crystal materials. The British Broadcasting Corporation (BBC), *Discover*, Live Science, *Photonics Spectra*, *Physics World*, *R&D Magazine*, *Science News*, *Small Times*, *Technology Review*, and *U.S. News & World Report* covered the research, which was published in the journal *Science*. Professor Mohan Srinivasaro led the research.

Thin sheets of graphite known as graphene have attracted attention because of their unique electronic properties including low resistivity. Georgia Tech researchers have demonstrated that graphene's attractive properties could make it useful for replacing copper interconnects in future generations of integrated circuits. In papers published in the journals *Electron Device Letters* and *Applied Physics Letters*, the researchers showed that the material has high current capacity, excellent thermal properties and low resistivity in nanoribbons as narrow as 18 nanometers. Among the outlets reporting on the research were *Electronic Engineering Times*, *Electronics Weekly*, *Machine Design*, *R&D Magazine*, *Small Times*, and *Solid State Technology*.

How an African lizard swims through sand was the focus of another interesting research project that attracted worldwide media attention. The work, by Daniel Goldman in the School of Physics, used high-speed X-ray imaging to uncover the way in which the sandfish lizard moves rapidly underground through desert sand. Goldman learned that the creatures move by folding their limbs against their bodies

Photo: David Hu and Grace Pryor

(Top) A study conducted by mechanical engineering assistant professor David Hu showed that snakes use both friction generated by their scales and redistribution of their weight to slither along flat surfaces.
(Bottom) Dan Goldman (front), an assistant professor in the School of Physics, and graduate student Ryan Maladen developed a physics model showing how sandfish like the one shown here travel through granular media.

Photo: Gary Meek

and propagating a traveling wave that propels them through the sand. Among the media outlets reporting on this work were *Discover*, MSNBC, *The New York Times*, *Physics World*, *Scientific American*, *U.S. News & World Report*, and *USA Today*. The study was reported in the journal *Science*. (See story on page 6 of this issue of *Research Horizons*)

A new statistical technique for improving the accuracy of measurements done on the nanometer scale was reported in the journal *Proceedings of the National Academy of Sciences*. Known as sequential profile adjustment by regression (SPAR), the method systematically identifies and removes minor errors caused by systematic bias, noise and equipment-based artifacts. The work could help open the door for industrial use of nanostructures by improving their consistency. The research resulted from collaboration between C. Jeff Wu in the Stewart School of Industrial and Systems Engineering and Zhong Lin Wang in the School of Materials Science and Engineering. Among outlets reporting on the work were *In Tech*, *Laboratory Equipment*, *R&D Magazine* and *Small Times*. (See story on page 14 of this issue of *Research Horizons*.)

Georgia Tech Faculty and Staff Receive Recognition

The Georgia Cancer Coalition named biomedical engineering assistant professor **Manu Platt** among its Distinguished Cancer Clinicians and Scientists for 2009-2010.

Alexander Gray, assistant professor in the School of Computational Science and Engineering, received a CAREER Award from the National Science Foundation.

Industrial and systems engineering professors **William Cook**, **Ellis Johnson** and **George Nemhauser**, and mathematics professor **Prasad Tetali**, were named inaugural Fellows of the Society for Industrial and Applied Mathematics.

Tom Fuller, principal research engineer in the Georgia Tech Research Institute and professor in the School of Chemical & Biomolecular Engineering, and mechanical engineering professor **Peter Hesketh**, were recently named Fellows of the Electrochemical Society.

Georgia Tech Research Institute senior research engineer **Dan Cook**, principal research engineers **Don Davis** and **Lou Fertig**, principal research scientist **Mahendra Mallick**, senior research engineer **Jud Ready**, and senior research scientist **David Roberts** were elected as senior members of the IEEE.

Gabriel Rincón-Mora, an associate professor in the School of Electrical and Computer Engineering, was elected as a Fellow of the Institution of Engineering and Technology.

School of Chemistry & Biochemistry professors **Jean-Luc Bredas**, **Mostafa El-Sayed** and **Laren Tolbert** were elected into the inaugural group of American Chemical Society Fellows.

John McIntyre, professor in the College of Management and Sam Nunn School of International Affairs, received the Order of Merit from the French government.

Polymer and fiber engineering professor **Fred Cook** was named an honorary member of Great Britain's Society of Dyers and Colourists.

Stelios Kavadias, operations management associate professor, was named a fellow at the Batten Institute for Entrepreneurship and Innovation at the University of Virginia.

Electrical and computer engineering assistant professor **Justin Romberg** received the Presidential Early Career Award for Scientists and Engineers (PECASE).

Physics professor **Predrag Cvitanović** received a 2009 Alexander von Humboldt Award.

The U.S. Manufacturing Extension Partnership named **Alan Barfoot**, the Enterprise Innovation Institute's central Georgia region manager, "Practitioner of the Year."

Ajeet Rohatgi, electrical and computer engineering professor, was honored by the U.S. Environmental Protection Agency as an Individual Climate Protection Award winner and the American Solar Energy Society selected him as this year's Hoyt Clarke Hottel Award winner.

Scott Bair, principal research engineer in the School of Mechanical Engineering, received the 2009 Society of Tribologists and Lubrication Engineers International Award.

The National Society of Black Engineers awarded **Ayanna Howard**, associate professor in electrical and computer engineering, its 2009 Golden Torch award.

Carol Paty, assistant professor in Earth and Atmospheric Sciences, received the NASA Group Achievement Award given to the Cassini Plasma Spectrometer Team.

The U.S. Manufacturing Extension Partnership named **Don Pital**, Enterprise Innovation Institute growth services manager, "Innovator of the Year."

Andrea Thomaz, assistant professor in Interactive Computing, was named one of 2009's Top Innovators Under 35 by *Technology Review*.

Electrical and computer engineering associate professor **Emmanouil "Manos" Tentzeris** was the first recipient of the Science Foundation Ireland's E.T.S. Walton Visitor Award.

Blair MacIntyre, associate professor of Interactive Computing, was awarded a Professor-Partnership by NVidia.

GTRI communications director **Kirk Englehardt** and his team received the national award from the Public Relations Society of America for the best annual report from a nonprofit organization and received the TAMY award for the best external Web site from the Technology Association of Georgia.

Minoru Shinohara, associate professor in applied physiology, received the 2009 American College of Sports Medicine Visiting Scholar Award.

The International Academy of the History of Science bestowed the prestigious Alexandre Koyré Medal on the European Space Agency Project for which History, Technology and Society professor **John Krige** was the lead historian.

Yajun Mei, assistant professor in Industrial and Systems Engineering, received the 2009 Abraham Wald Prize for the best publication in the journal *Sequential Analysis*.

Professors **Hongyuan Zha** (Computational Science and Engineering) and **Karsten Schwan** (Computer Science) won research program awards from HP Labs.

Mathematics professor **Robin Thomas** received the 2009 Fulkerson Prize from the Mathematical Programming Society and American Mathematical Society.

Adjo Amekudzi, associate professor in the School of Civil and Environmental Engineering, received the Recent Alumni Award from her alma mater, Carnegie Mellon University.

Marketing professor **Ajay Kohli** won the Vijay Mahajan Award from the American Marketing Association.

David McDowell, Regents' professor in mechanical engineering, received the Distinguished Alumni Award from the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign.

- compiled by Abby Vogel


Amekudzi


Cook, Fred


Howard


Cook, William


Platt


Ready


Thomaz

Georgia Tech researchers from across many disciplines are developing new approaches to providing early detection and diagnosis of cancer. These range from measuring biomarkers in the breath to developing microfluidic devices that characterize tumor cells in a drop of blood.

Diagnosing Cancer:

Researchers Pursue Many Different Directions Toward Early Detection and Diagnosis

By Abby Vogel

More than a third of all Americans – some 120 million people – will be diagnosed with cancer sometime during their lives. Because the odds of survival approach 90 percent if the disease is found early, scientists worldwide are on a quest to develop ways to detect and diagnose cancer early.

At the Georgia Institute of Technology, researchers are pursuing many different directions into cancer detection and diagnostic techniques including:

- Using gold nanoparticles to locate and kill cancer cells inside the body;
- Creating software programs that improve the process of identifying cancer biomarkers from gene expression data;
- Collecting and characterizing tumor cells in a person's bloodstream with microfluidic devices;
- Determining which gases exhaled in a person's breath indicate the presence of breast cancer;
- Detecting ovarian cancer from patterns of metabolites found in a drop of blood; and
- Developing algorithms to visualize the prostate in real-time during robotic biopsy and radioactive seed-placement procedures.

This is the second in a series of three reports focusing on cancer research at Georgia Tech. The first, published in the Winter/Spring 2009 issue of *Research Horizons*, highlighted efforts to understand how cancer arises. The third report will highlight new cancer treatments.

John McDonald, chief scientist of the Ovarian Cancer Institute and associate dean for biology development in the School of Biology, is using patterns of metabolites found in a drop of blood to detect ovarian cancer.

Photo: Gary Meek

Using the Power of Gold Against Cancer

A precious metal long used for jewelry, gold may soon be considered precious for cancer detection and treatment.

"Once you cut the size of gold down to a few nanometers, its properties change and it reacts with other elements, catalyzes reactions and interacts with light, which makes it valuable for medical applications," says Mostafa El-Sayed, the Julius Brown Chair and Regents' Professor in the Georgia Tech School of Chemistry and Biochemistry.

While his wife was fighting breast cancer – a battle she ultimately lost – El-Sayed began reading journal articles about cancer research and realized that the properties of gold might make it useful for detecting and killing cancer cells. To investigate the possibility, he began collaborating with his son, Ivan El-Sayed, a head and neck cancer surgeon at the University of California, San Francisco.

Mostafa El-Sayed designed nanometer-sized spheres of gold and attached them to antibodies targeting specific receptors on cancer cells, which were provided by his son. Using dark-field imaging, they were able to detect the cancer cells to which the antibodies had attached. They could see the cancer cell surfaces and distinguish them from healthy cells due to the strong scattering of light from the gold nanoparticles.

Then the father-son team observed that these metal nanoparticles could also act as light-activated

heaters for killing cancer cells. By shining visible laser light on cells, they were able to selectively destroy cancer cells with much lower power than was required to kill healthy cells.

"During these experiments, we realized that gold nanoparticles have advantages over other nanostructures because they can achieve both diagnostics and therapy simultaneously," notes Mostafa El-Sayed.

After seeing the clinical potential of gold nanospheres on cells, the researchers conducted mouse experiments in collaboration with John McDonald, associate dean for biology program development at Georgia Tech, and Erin Dickerson, formerly a research scientist in McDonald's laboratory. Xiaohua Huang, a postdoctoral fellow at Georgia Tech and Emory University, and graduate student Erik Dreaden also contributed to this research.

By changing the shape of the nanospheres to cylindrical gold nanorods, the researchers were able to use near-infrared laser light to detect malignant tumors hidden more deeply under the skin and selectively destroy them without harming the healthy cells. Currently, research is being conducted to investigate the effects of gold nanoparticles on animals to clear the way for human clinical trials.

"The unique ability to tune the gold nanoparticle properties by varying their size, shape, composition and medium has allowed us to design nanostructures geared for specific bio-applications," explains Mostafa El-Sayed. "Since light converted into heat selectively kills cancer cells, this treatment can be used for different kinds of cancers, avoids normal drug resistance and does not require invasive surgery, thus avoiding post surgery infections."

This work was funded by grant number DE-FG02-97ER14799 from the U.S. Department of Energy (DOE). The content is solely the responsibility of the principal investigator and does not necessarily represent the official view of the DOE or the United States Government. Significant funding to support this research was also provided by the Julius Brown endowment to Georgia Tech.

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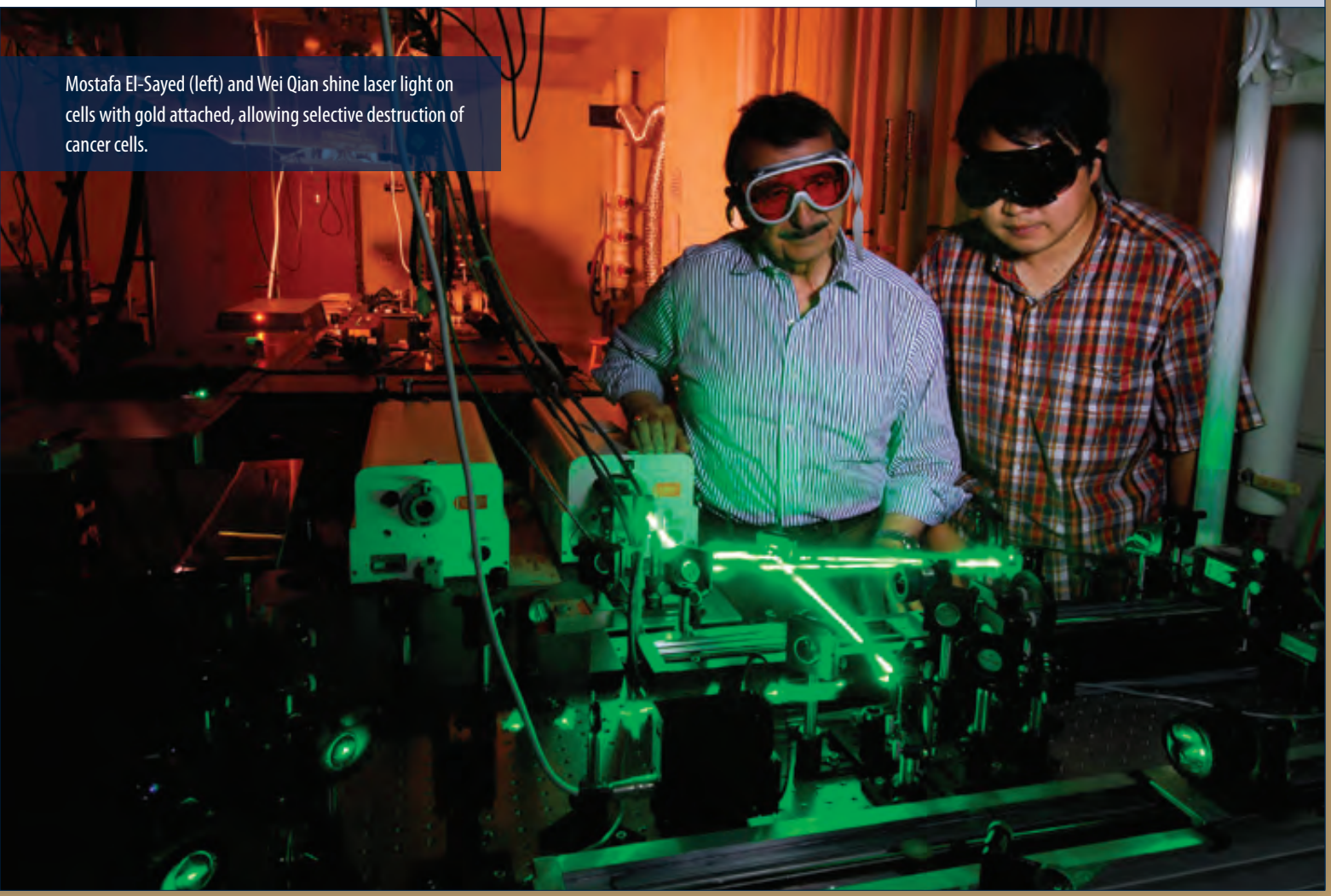
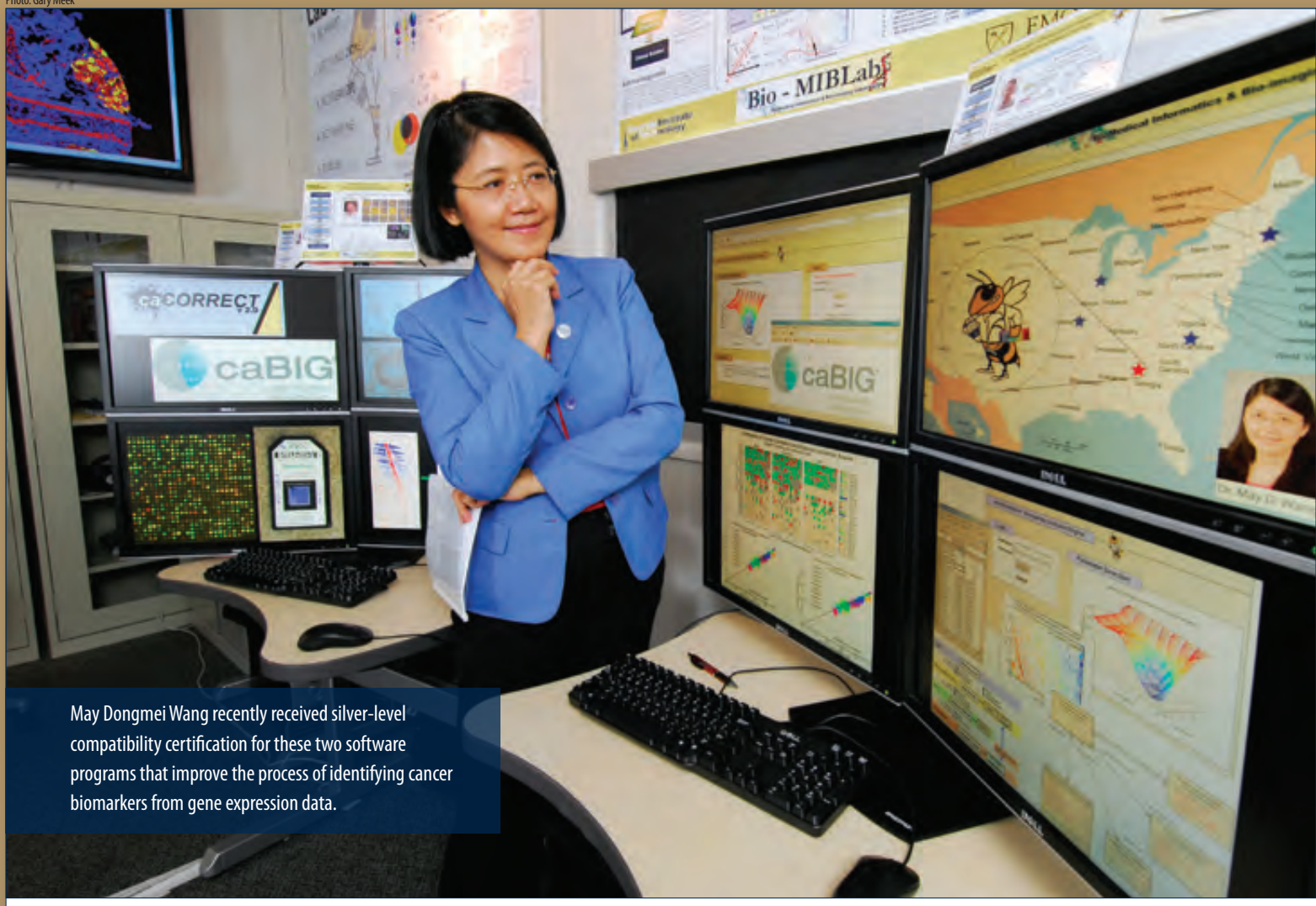


Mostafa El-Sayed (left) and Wei Qian shine laser light on cells with gold attached, allowing selective destruction of cancer cells.

Photo: Gary Meek

Photo: Gary Meek



May Dongmei Wang recently received silver-level compatibility certification for these two software programs that improve the process of identifying cancer biomarkers from gene expression data.

Cancer Biomarker Identification Software Tools Earn Certification

The explosive growth of genomic and proteomic data has ushered in a new era of molecular medicine in which cancer detection, diagnosis and treatment are tailored to each individual's molecular profile. But this personalized medicine approach requires that researchers discover and link biomarkers – such as genes or proteins – to specific disease behaviors, such as the rate of tumor progression and different responses to treatments.

Two new software programs that help address that challenge have recently earned silver-level compatibility certification from the National Cancer Institute's cancer Biomedical Informatics Grid®, also known as caBIG®.

Developed by May Dongmei Wang and her team in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University, the programs – caCORRECT and omniBioMarker – remove noise and artifacts, and identify and validate biomarkers from microarray data. Funding to develop the programs was provided by the National Institutes of Health – primarily the Emory-Georgia Tech National Cancer Institute Center for Cancer Nanotechnology Excellence (CCNE), the Georgia Cancer Coalition, Microsoft Research and Hewlett-Packard.

"Certification by caBIG means the tools can be easily used by everyone in the cancer community to improve approaches to cancer detection, diagnosis, treatment and prevention," says Wang, an associate professor in the Coulter Department, a Georgia Cancer Coalition Distinguished Cancer Scholar and director of the CCNE biocomputing and bioinformatics core.

caCORRECT – chip artifact CORRECTion – is a software program that improves the quality of collected microarray data, ultimately leading to improved biomarker selection. Because each microarray chip contains thousands of spots, it is easy for a few spots to become marred due to experimental variations by different laboratory technicians or errors that create scratches, edge effects and bubble effects on the data.

caCORRECT removes the noise and artifacts from the data, while retaining high-quality genes on the array. The software can also effectively recover lost information that has been obscured by

artifacts. In collaboration with Andrew N. Young, an associate professor in pathology and laboratory medicine at Emory University's School of Medicine and clinical laboratory director at Grady Health System, Wang and graduate students Todd Stokes, Martin Ahrens and Richard Moffitt validated the caCORRECT software.

The caBIG-certified omniBioMarker software identifies and validates biomarkers from high-throughput gene expression data. Candidate cancer biomarkers are typically genes expressed at different levels in cancer patients compared to healthy subjects.

omniBioMarker searches these groups of patient data for genes with the highest potential for accurately determining whether a patient has cancer. However, because individual genes are not expressed independently, the software also identifies groups of genes that act in concert. Wang, Young and graduate student John Phan tested the ability of the software to identify biomarkers in clinical renal cancer microarray data.

Since receiving caBIG silver-level compatibility certification for caCORRECT and omniBioMarker, Wang and her team have been working on getting two more software programs certified: Q-IHC and omniVisGrid.

This work was funded by grant numbers R01CA108468, P20GM072069 and U54CA119338 from the National Institutes of Health (NIH). The content is solely the responsibility of the principal investigator and does not necessarily represent the official view of the NIH.

Building Microdevices That Separate and Analyze Cancer Cells

Microfluidic devices developed at Georgia Tech are enabling cancer researchers to collect and characterize tumor cells in a person's bloodstream. Analyzing the quantity and diversity of the cancerous cells allows for early detection of tumors and cancer metastasis, as well as the monitoring of treatment. The analysis can also indicate the type of cancer, its aggressiveness and its receptiveness to particular treatments.

"Microfluidic devices have advantages over many typical laboratory analysis systems like flow cytometry because they cost less, require only a small population of cells, demand less time and can be combined for multiple sequential analyses," says Georgia Tech School of Electrical and Computer Engineering professor Bruno Frazier.

Frazier and graduate student Youngdo Jung designed a microfluidic device that attracts and collects magnetically labeled cells into a center channel while allowing untagged cells to travel along outer channels. To test the device with cancer cells,

Bruno Frazier, Georgia Chen and Dong Shin (left-right) examine a microdevice designed to separate and analyze cancer cells, allowing for early detection of tumors and cancer metastasis, as well as the monitoring of treatment.

Photo: Gary Meek

they teamed with Emory University researchers Lily Yang, an associate professor of surgical oncology research; Georgia Chen, an associate professor of hematology and oncology; and Dong Shin, a professor of hematology and oncology.

Because the proteins located on the surfaces of cancer and normal cells are different, the researchers selectively targeted the proteins on the cancer cell surfaces and tagged them with magnetic nanoparticles. In experiments, the researchers were able to collect 86 percent of the tagged cancer cells in the center outlet and 95 percent of the non-tagged red blood and white blood cells in the side outlet, with a flow rate of 100 microliters per hour.

Excited with the experimental results, Frazier's team combined the microseparator with a downstream impedance spectroscopy microsystem, which traps a single cell in an analysis cavity and measures its electrical impedance.

"This impedance spectroscopy system allows us to determine the heterogeneity of a tumor, including the percentages of normal cells and different stage cancer cells, which is information that can be used to create a personalized treatment regimen," explains Frazier.

In experiments with normal and cancerous breast cells, the researchers observed significant differences in the magnitude and phase of the impedance signal, enabling them to easily classify the cells. The technique can distinguish normal human breast tissue cells, early-stage breast cancer cells, invasive breast cancer cells and metastasized breast cancer cells.

Since completing the cellular experiments, the Georgia Tech and Emory researchers have begun testing the microsystems with blood and tissue samples from breast and head/neck cancer animal models.

"We believe that the microfluidic devices we've built will eventually play a key role in numerous aspects of cancer diagnosis and treatment, including detecting and evaluating metastatic disease, selecting and individualizing initial surgical and medical therapies, monitoring disease progression and understanding the fundamental biology of metastasis," notes Frazier.

This work was funded by grant number ES10846 from the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health (NIH). The content is solely the responsibility of the principal investigator and does not necessarily represent the official view of the NIEHS or the NIH.

Photo: Gary Meek

Emory researcher Dana Allen blows into a device that traps specific compounds found in breath. The compounds are then examined to confirm the presence or absence of breast cancer.

Breath Test Studied for Detecting Breast Cancer

Early breast cancer detection can significantly improve survival rates. However, current diagnostic tests expose women to the potentially harmful effects of radiation – and often fail to detect cancer in the earliest stages.

A team of researchers from Georgia Tech, Emory University and the University of Ulm in Germany are using a portable, non-invasive device to determine which biomarker gases exhaled in a person's breath indicate the presence of breast cancer.

"Scientists know that it's possible to detect different chemical compounds from a person's breath and relate them to illness," explains Charlene Bayer, principal research scientist at the Georgia Tech Research Institute (GTRI). "Yet they haven't been able to quantify results – such as determining a patient has a tumor because he or she has X amount of Y compounds in his or her breath."

Breath biomarkers are volatile organic compounds originating in the lower lungs. Certain compounds are related to oxidative stress, the body's response to inflammation, and are often an indication of disease.

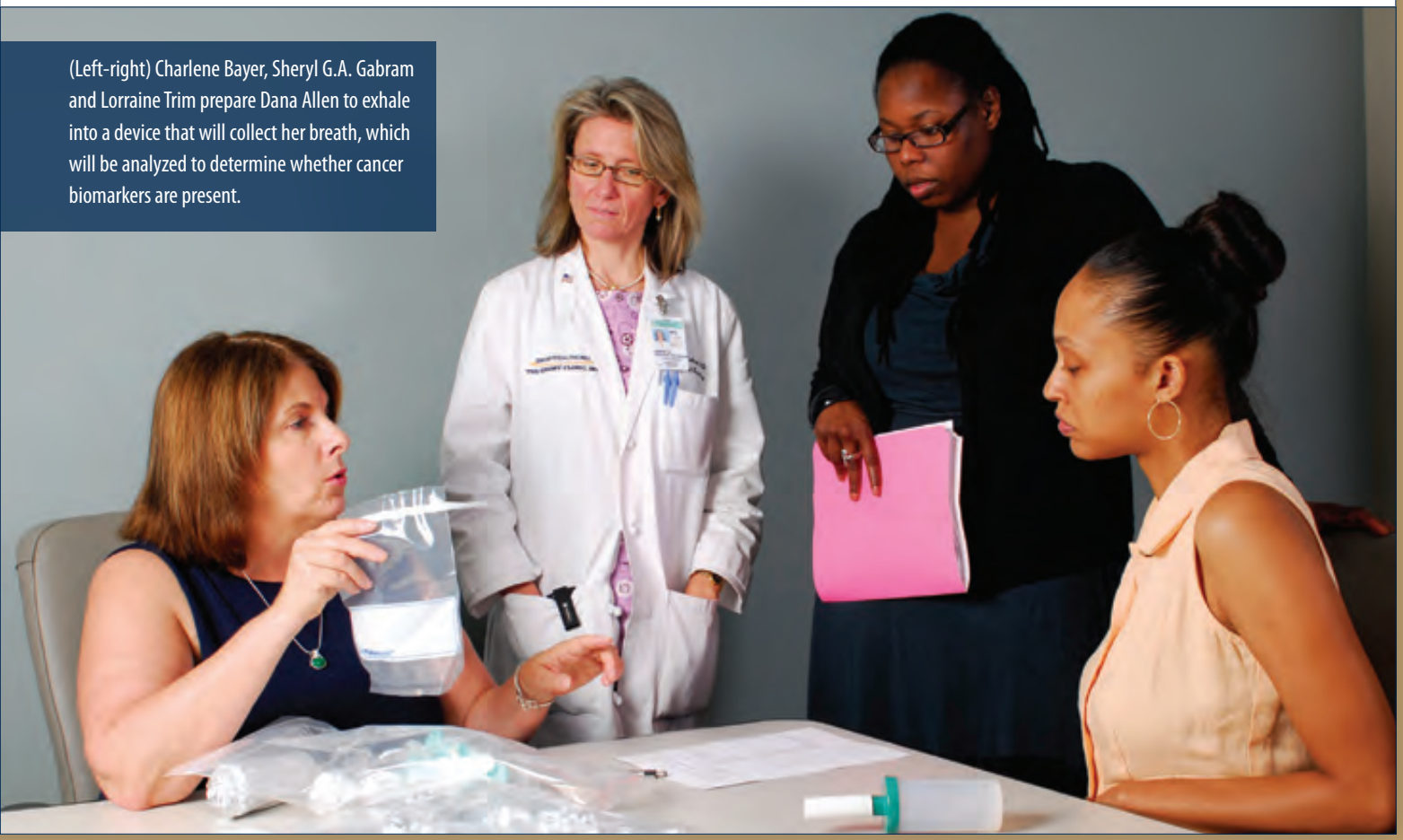
As a patient breathes into the device, these compounds are trapped and examined by a sensor. The researchers' sensing methodology combines gas chromatography – a technique for separating complex compounds – with mass spectrometry, which identifies the chemical makeup of a substance. Specific patterns in the compounds are then found and used to confirm the presence or absence of the disease.

The team recently conducted a clinical study analyzing more than 300 volatile organic compounds in breath samples of 20 healthy women over the age of 40 and 20 women recently diagnosed with stage II-IV breast cancer and who had not received treatment. The results showed that the breath analysis was able to determine whether the sample came from a cancer patient or healthy subject 78 percent of the time.

The researchers are currently adding to their clinical database of breath data and trying to determine which compounds are most important for detecting breast cancer. That could help reduce the number of compounds tested.

Because it can offer immediate results right in a physician's office, Bayer expects the device will help increase early detection among those who do not have the resources for a mammogram, more easily conduct interval testing for those with a genetically high risk for breast cancer, and facilitate recurrence testing after breast cancer treatment.

Other researchers involved in this project include Brani Vidakovic, a professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University; Sheryl G.A. Gabram, a professor of surgery in the Division of Surgical Oncology at Emory University; and University of Ulm professor Boris Mizaikoff.



(Left-right) Charlene Bayer, Sheryl G.A. Gabram and Lorraine Trim prepare Dana Allen to exhale into a device that will collect her breath, which will be analyzed to determine whether cancer biomarkers are present.

Photo: Gary Meek

Creating an Ovarian Cancer Detection Tool

Scientists at Georgia Tech are using patterns of metabolites found in a drop of blood to detect ovarian cancer. Using an analytical technique called mass spectrometry, the researchers have been able to differentiate between serum samples taken from patients with ovarian cancer and those from unaffected individuals.

"Ovarian cancer is the fourth leading cause of death in women, but it is a relatively rare cancer, so a functionally useful diagnostic test has to be 99 percent accurate or you are going to get too many false positives," says John McDonald, chief scientist of the Ovarian Cancer Institute and associate dean for biology development in the School of Biology.

McDonald teamed with mass spectrometry expert Facundo Fernandez, an associate professor in the Georgia Tech School of Chemistry and Biochemistry, to sort molecules in the serum based on their weight and electrical charge.

"We focused on metabolites as opposed to proteins or peptides because we get better quantification and higher resolution for the smaller molecules that comprise the human metabolome," explains Fernandez.

With the help of Alexander Gray, an assistant professor in the Georgia Tech College of Computing's Computational Science and Engineering Division, the research team was able to detect patterns of key metabolites in the blood. Using a sophisticated artificial intelligence computer program, they were able to "train" the computer to distinguish patterns of small metabolites found in the blood of cancer patients from those of control subjects.

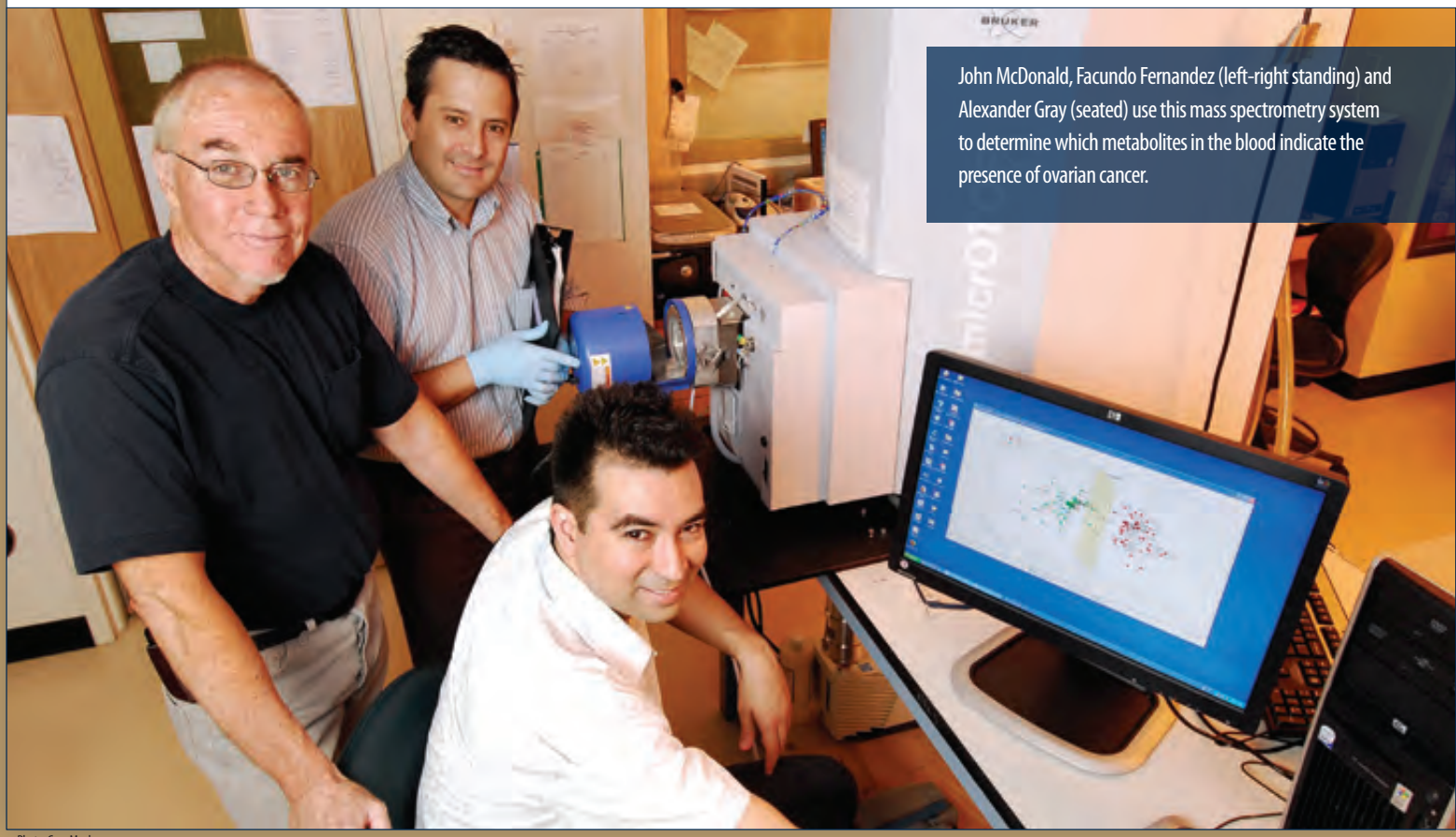
The scientists first used serum samples from known cancer patients and unaffected individuals to establish metabolomic patterns that were present at different levels in the two groups. The machine learning program identified a pattern consisting of only a few dozen metabolites, among thousands of candidates, which could be used to distinguish between women with ovarian cancer and women with non-cancerous conditions.

Once these patterns were identified, the researchers tested the patterns of the same metabolites in a different set of serum samples from other patients with and without cancer. The researchers identified the samples with 99 percent accuracy.

The identity of the key metabolites and the role they may play in ovarian cancer is still under investigation, but the development of an accurate and reliable diagnostic test will save lives when combined with existing therapies, according to McDonald.

"Another great thing about this approach is that it may be possible to extend it for the early detection of any type of cancer or any disease from a droplet of blood," adds McDonald.

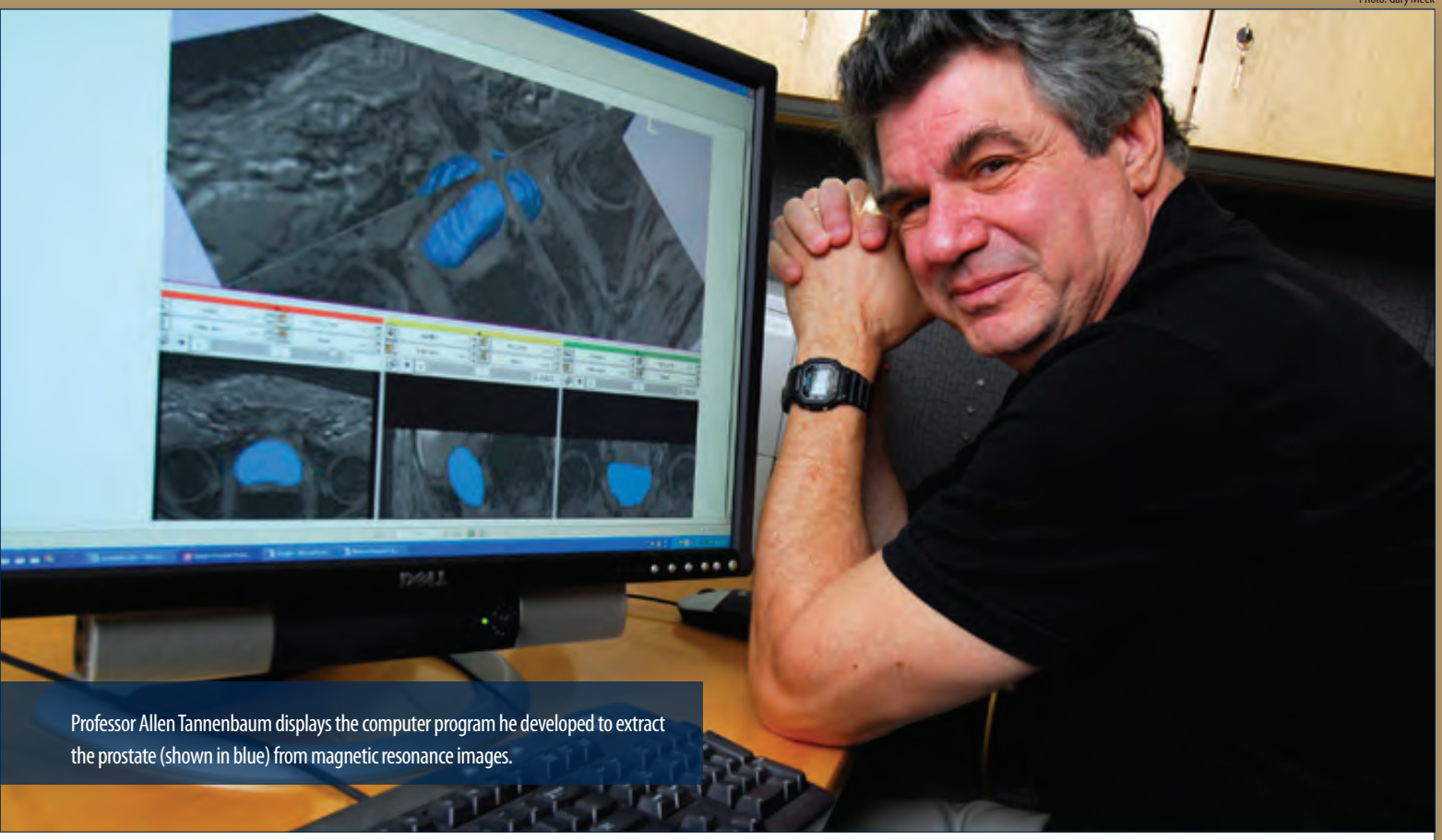
This work is supported by the Ovarian Cancer Institute, Deborah Nash Harris Endowment Fund, the Ovarian Cycle Foundation and the Georgia Research Alliance VentureLab program.



John McDonald, Facundo Fernandez (left-right standing) and Alexander Gray (seated) use this mass spectrometry system to determine which metabolites in the blood indicate the presence of ovarian cancer.

Photo: Gary Meek

Photo: Gary Meek



Professor Allen Tannenbaum displays the computer program he developed to extract the prostate (shown in blue) from magnetic resonance images.

Perfecting Robotic Image-Guided Surgical Procedures

Robots are being used more frequently today in hospitals around the country. Many of these robots, like the one developed by Queen's University associate professor Gabor Fichtinger to perform needle-based prostate biopsy and therapy procedures, require medical images to accurately guide the surgical tool to the desired target.

"Magnetic resonance imaging enables real-time scanning of the needle from its insertion through the skin to contact with the target, but the difficulty lies in being able to develop algorithms that immediately display and analyze the images while the patient is in the imaging scanner," says Allen Tannenbaum, who holds a joint appointment as the Julian Hightower Chair in the Georgia Tech School of Electrical and Computer Engineering and the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University.

To visualize the prostate in real-time during biopsy and radioactive seed-placement procedures, Tannenbaum and graduate student Yi Gao developed fast image segmentation and registration algorithms to locate the prostate in magnetic resonance images and correct for movement during the procedure. The algorithms have been integrated into the transrectal prostate magnetic resonance imaging module of Slicer3, an open-source surgical navigation software.

Tannenbaum employed two methods to "extract" the prostate from the magnetic resonance images: a shape-based algorithm and a semi-automatic method. The shape-based algorithm required inputting manually segmented three-dimensional prostate images into an artificial intelligence program. Then, given a new image, the program was able to isolate the prostate from nearby structures. For the semi-automatic method, users selected points inside and outside of the prostate and the program used that information to decide whether a pixel belonged to the organ or the background.

In addition to segmentation, images of the same patient taken at different points in time require registration to cope with deformation of the organ.

"Imagine you have a balloon – that's the prostate – and you take a needle and push on the balloon. Pushing on it deforms the prostate and these changes have to be accounted for," explains Tannenbaum.

The prostate presents a number of difficulties for traditional image registration approaches because there are no easily discernable landmarks. However, because the surface of the prostate is almost half convex and half concave, Tannenbaum was able to capture the concave region in each image and use it to register the whole prostate.

"Our segmentation and registration algorithms provide much greater accuracy for the robot to stick a needle in the prostate, while also requiring less than a second for computation and no special supercomputers," adds Tannenbaum.

This research was funded by the National Institutes of Health (NIH) Roadmap Initiative called The National Alliance for Medical Imaging Computing (NA-MIC). The content is solely the responsibility of the principal investigator and does not necessarily represent the official view of the NIH.

The recent automation of several electronic warfare systems aboard U.S. combat jets has reduced pilot workload. The innovation enables a suite of threat-response systems to work together automatically without the pilot's intervention.

Full Automatic:

Missile Protection Upgrade Helps Military Pilots Focus on Job One

By Rick Robinson

Photo: Gary Meek

GTRI research engineers Luke Starnes, left, and Byron Coker demonstrate an ALQ-213 electronic warfare system mounted in a portable test bench.

Pilots of many U.S. combat jets can now fly with greater security and reduced in-flight workload, thanks to the recent automation of several electronic warfare (EW) systems.

The innovation enables a suite of threat-response systems to work together automatically, protecting the aircraft from hostile action without requiring the pilot's involvement. The upgrade, now operational on the F-16 and the A-10, was developed by a research team at the Georgia Tech Research Institute (GTRI).

"The pilot's real job is to fly the plane and to accomplish his mission," says Mike Willis, a GTRI principal research engineer who participated in the project. "If he has to also monitor and manually control the state of all of the electronic warfare equipment, he's really got a lot to do."

Yet, Willis explains, that was formerly the case. Combat aircraft typically carried multiple EW systems, often including a radar warning receiver, a missile warning system, a pod for jamming enemy signals and a protective chaff-and-flare dispenser. Each system was separately monitored and operated by the pilot.

In the 1990s, the Air Force adopted the AN/ALQ-213(V), a central controller that took information from the individual EW systems and processed it in a coordinated manner. But even with the ALQ-213, the EW systems were still operated manually.

Today, a pilot can turn a knob on the ALQ-213 and the controller will automatically monitor and operate the aircraft's entire EW suite, including the ALR-69 radar warning receiver, the ALQ-131 or ALQ-184 active jamming pods and – on the A-10 – the AAR-47 missile warning system, which provides a warning about shoulder-launched weapons.

If the upgraded ALQ-213 detects an immediate threat, it can activate the ALE-47 chaff-and-flare dispenser without pilot involvement.

"The new automation is the result of algorithms developed over the past decade that we call the threat response processor, or TRP," Willis says. "This software runs in the ALQ-213 and fully automates the EW decisions that a pilot used to have to make on top of everything else."

Led by GTRI principal research engineer Bob Beasley, Willis worked with GTRI engineers Byron Coker, Lee Montaña and Luke Starnes on the TRP automation project. Coker, Montaña and Starnes have also been extensively involved in research aspects of the deployment of the automated ALQ-213 in U.S. aircraft.

TRP-enabled units can now be found throughout the F-16 and A-10 fleets. The project was sponsored by the Warner Robins Air Logistics Center at Robins Air Force Base.

Air Force testing indicates that the automated ALQ-213 is doing an effective job of protecting

A-10 and F-16 pilots, Willis says. However, when conditions require it, a pilot can still operate the ALQ-213 manually.

Testing of ALQ-213 units running TRP has been enhanced by the addition of the Virtual Electronic Combat Training System (VECTS) into the ALQ-213. VECTS, developed by a GTRI team led by principal research scientist Linda Viney, can simulate realistic enemy threats on an aircraft's actual cockpit displays.

VECTS can also simulate accurate defensive responses, such as electronic jamming of enemy signals or maneuvering of the aircraft to avert a threat. And because VECTS is built in, it allows pilots to test the ALQ-213 at their convenience, without the need to fly their aircraft over a ground-based military test range.

"The ALQ-213 can operate using VECTS data through the threat response processor and make decisions about how to perform self-protection for the aircraft," Willis says. "That helps us to know that the automated system is working well."

GTRI continues to develop further improvements for the ALQ-213. A project now being done under Montaña's direction seeks to upgrade the unit's processing capability by adding updated hardware.

In turn, that hardware enhancement is expected to give the ALQ-213 the capacity to handle further software upgrades and to offer improved future functionality. rh

Photo: U.S. Air Force

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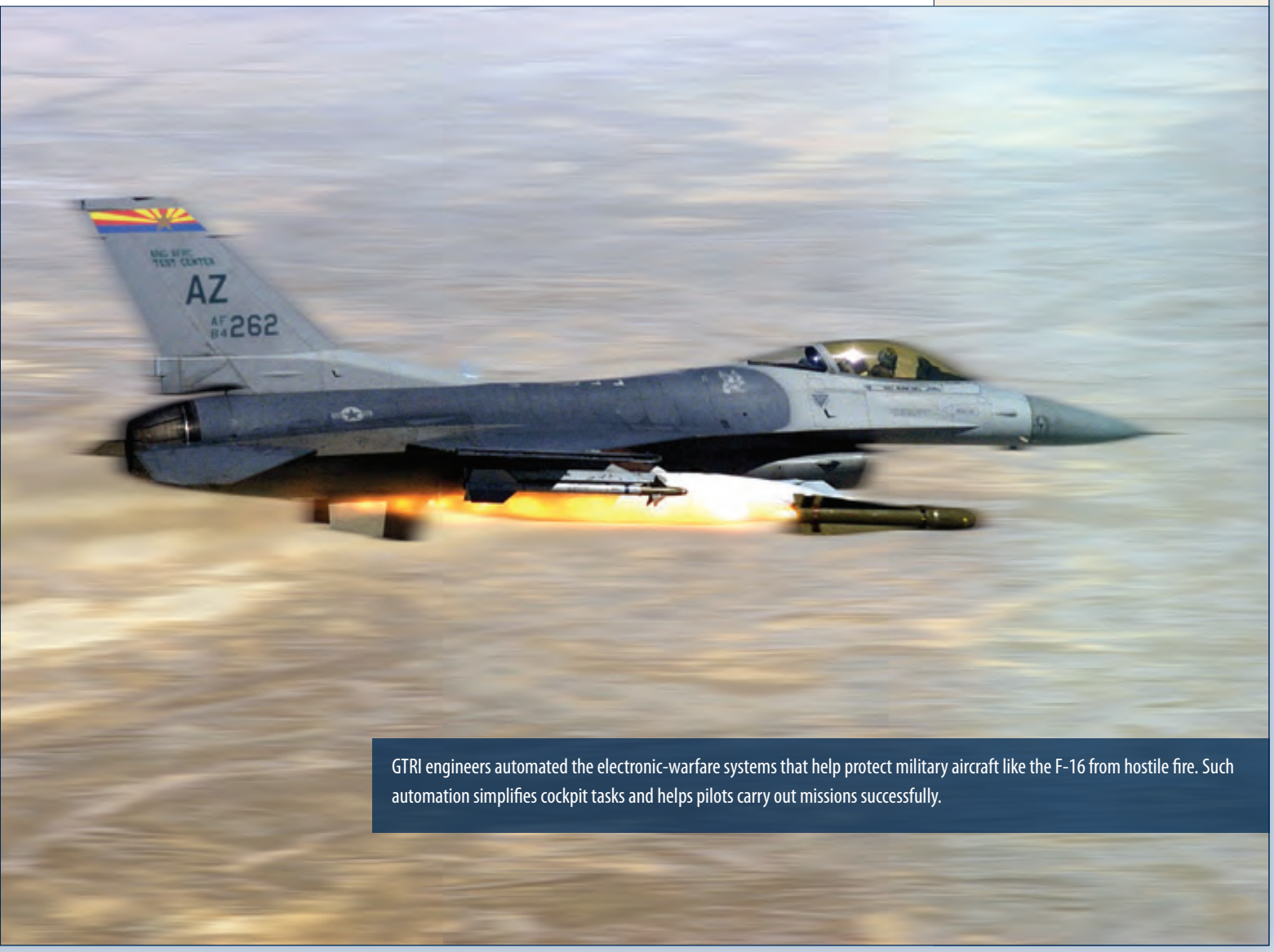

GTRI engineers automated the electronic-warfare systems that help protect military aircraft like the F-16 from hostile fire. Such automation simplifies cockpit tasks and helps pilots carry out missions successfully.

A new Georgia Tech test facility is helping researchers evaluate and enhance the sensors that are designed to detect buried land mines. The unique automated system measures a sensor's response to mines and other metallic objects.

Buried Danger:

New Testing Facility Is Helping Improve Land Mine Detection Equipment

By Abby Vogel

A land mine is placed in the test facility built to evaluate and enhance sensors designed to detect buried land mines.

Photo: Gary Meek

Georgia Tech researchers have built a test facility to evaluate and enhance sensors designed to detect buried land mines. The unique automated system measures the response of individual electromagnetic induction sensors or arrays of sensors against land mines buried at many possible angles.

Electromagnetic induction sensors work by sending out magnetic fields and detecting the response from the electric currents generated when the field interacts with a metallic target. While simple versions of these sensors are capable of detecting most land mines, advanced sensors are required to tell the difference between a land mine and harmless buried metal objects, which can include bottle tops, nails, shrapnel and spent bullets.

"We built this facility to aid in the development of advanced electromagnetic induction sensors and associated detection algorithms, mainly because little was known about how the signals collected by these sensors from land mines changed when the mines were buried underground at odd angles," explains Waymond Scott, a professor in Georgia Tech's School of Electrical and Computer Engineering.

Scott and Gregg Larson, a senior research engineer in Georgia Tech's George W. Woodruff School of Mechanical Engineering, constructed the facility with funding from the U.S. Army and described it at the recent SPIE Defense, Security and Sensing Symposium.

The testing structure was built with five computer-controlled axes – three translational stages and two rotational stages – and one manual axis. During testing, an individual sensor or array of sensors is fixed in the middle of the measurement region while the rotational stages orient a target and move it along a prescribed path around the sensor.

For testing, the researchers place the sensor in the center of the area so that it is located as far as possible from any surrounding metal, including the floor that contains structural steel and the aluminum beams of the positioner frame. In the procedure used to measure individual targets, they also controlled for the response from the surrounding metal structures.

The system can collect measurements of typical targets, including shell casings, wire loops, ball bearings and land mines. The data from each target is plotted as response curves, which are a function of the metal content and structure of the target and help discriminate a land mine from other metal buried in the ground. Previous field tests have shown that the shape of the response curves did not change when targets were buried at different depths, but the researchers wanted to know if the same was true for targets buried at different angles.

"This facility allows us to collect measurements of typical targets and clutter objects with respect to location and orientation, which would be very difficult to measure in the field due to the difficulty of accurately

placing and rotating the target," says Scott.

At the symposium, the researchers presented data collected in the facility from three targets: a single wire loop, a composite target with three wire loops and a 9-millimeter shell casing. Their results with the single wire loop and shell casing showed that the shape of the response curve was the same for all of the rotation angles, but the amplitude of the response changed with rotation angle. The more complex three-loop target exhibited changes in the shape and amplitude of the curve when the rotation angle was modified.

The researchers plan to use these results to make improvements to the sensor hardware and processing algorithms. Future efforts in the experimental facility will focus on measuring more targets and investigating methods for summarizing the massive amounts of collected data into simple physical models. The researchers also plan to improve the processing algorithms to help characterize more complicated targets and refine the detection and discrimination methods for electromagnetic induction sensors.

Experiments conducted in the facility will ultimately help researchers better discriminate between land mines and harmless metal objects, which will lead to reduced false alarm rates.

"This facility will help us develop advanced electromagnetic induction sensors that are most effective and able to quickly, accurately and repetitively measure the response of a buried target," notes Scott. rh

This work is supported in part by the U.S. Army Night Vision and Electronic Sensors Directorate, Science and Technology Division, Countermine Branch and in part by the U. S. Army Research Office under Contract Number W911NF-05-1-0257. The views and conclusions contained in this document are those of the researchers and should not be interpreted as representing the official policies, either expressed or implied, of the Army Research Office or the U.S. government.

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"This facility allows us to collect measurements of typical targets and clutter objects with respect to location and orientation, which would be very difficult to measure in the field due to the difficulty of accurately placing and rotating the target."

— Waymond Scott, professor in the School of Electrical and Computer Engineering

Electrical and computer engineering professor Waymond Scott sets up an experiment in this new facility that will ultimately help researchers better discriminate between land mines and harmless metal objects.

Photo: Gary Meek

3-D Surface Treatment Could Boost Efficiency for Photovoltaic Cells

Photo: Gary Meek

A three-dimensional surface treatment for photovoltaic cells could help keep arrays like this one cleaner. The array is shown atop the Georgia Tech Campus Recreation Center.

Using two different types of chemical etching to create features at both the micron- and nanometer-size scales, Georgia Tech researchers have developed a surface treatment that could boost the light absorption of silicon photovoltaic cells in two complementary ways.

The surface treatment increases absorption both by trapping light in three-dimensional structures and by making the surfaces self-cleaning – allowing rain or dew to wash away the dust and dirt that can accumulate on photovoltaic arrays. Because of its ability to make water bead up and roll off, the surface is classified as superhydrophobic.

"The more sunlight that goes into the photovoltaic cells and the less that reflects back, the higher the efficiency can be," says C.P. Wong, Regents' professor in Georgia Tech's School of Materials Science and Engineering. "Our simulations show that we can potentially increase the final efficiency of the cells by as much as 2 percent with this surface structure."

Supported by the National Science Foundation (NSF) and the National Electric Energy Testing Research and Applications Center (NEETRAC) at Georgia Tech, the research was described at the Spring 2009 National Meeting of the American Chemical Society.

The silicon etching treatment mimics the superhydrophobic surface of the lotus leaf, which uses surface roughness at two different size scales to create high contact angles that encourage water from rain or condensation to bead up and run off. As the water runs off, it carries with it any surface dust or dirt – which also doesn't adhere because of the unique surface properties.

In the silicon surface treatment, the two-tier roughness – created with both micron- and nano-scale structures – works in the same way as the lotus leaf, minimizing contact between the water or dust and the surface, Wong notes.

Preparation of the superhydrophobic surface begins with use of a potassium hydroxide (KOH) solution to etch the silicon surface. The solution preferentially removes silicon along crystalline planes, creating micron-scale pyramid structures in the surface.

An electron beam process is then used to apply nanometer-scale gold particles to the pyramid structures. Using a solution of hydrogen fluoride (HF) and hydrogen peroxide (H_2O_2), a metal-assisted etching process – with gold as the catalyst – produces the nanometer-scale features. The feature size is controlled by the diameter of the gold particles and the length of time the silicon is exposed to the etching.

Finally, the gold is removed with a potassium iodide (KI) solution and the surface coated with a fluorocarbon material, perfluorooctyl tricholosilane.

The combination of increased light absorption from the textured surface and the self-cleaning ability helps boost absorption of sunlight hitting the silicon surface.

"A normal silicon surface reflects a lot of the light that comes in, but by doing this texturing, the reflection is reduced to less than 5 percent," says Dennis Hess, a professor in the Georgia Tech School of Chemical and Biomolecular Engineering. "As much as 10 percent of the light that hits traditional cells is scattered because of dust and dirt of the surface. If you can keep the cells clean, in principle you can increase the efficiency. Even if you only improve this by a few percent, that could make a big difference."

The research team, which also included Yonghao Xiu, Shu Zhang and Yan Liu, is working with Georgia Tech's University Center of Excellence for Photovoltaics Research and Education – headed by Professor Ajeet Rohatgi of the Georgia Tech School of Electrical and Computer Engineering – to evaluate the long-term robustness of the surface treatment with real solar cells.

"Because the structures are so small, they are fairly fragile," Hess notes. "Mechanical abrasion to the surface can destroy the superhydrophobicity. We have tried to address that here by creating a large superhydrophobic surface area so that small amounts of damage won't affect the overall surface."

– John Toon

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Flu Vaccine Given in Microneedle Patches Proves Effective

Photo: Gary Meek

This photograph shows an array of stainless steel microneedles similar to those used in the study.

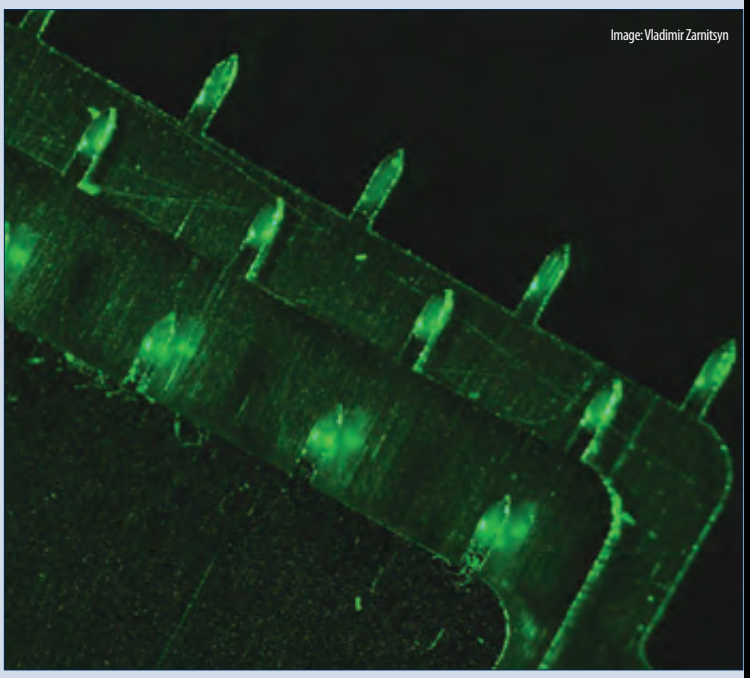

Image: Vladimir Zarnitsyn

Image shows stainless steel microneedles coated with a model fluorescent vaccine under green illumination.

Flu vaccine delivered through skin patches containing microneedles has proven just as effective at preventing influenza in mice as intramuscular, hypodermic flu immunization. A team of researchers at Emory University and Georgia Tech believes the new microneedle skin patch method of delivering flu vaccine could improve overall seasonal vaccination coverage in people because of decreased pain, increased convenience, lower cost and simpler logistics over conventional hypodermic immunization.

The research was published in the early online edition of the journal *Proceedings of the National Academy of Sciences* (PNAS). Another study by the research team on a different influenza strain was described in the journal *Public Library of Science (PLoS) One*.

The patches used in the experiments contained an array of stainless steel microneedles coated with inactivated influenza virus. The patches were pressed manually into the skin, and after a few minutes the vaccine coating dissolved off within the skin. The coated microneedle immunizations were compared to conventional intramuscular hypodermic injections at the same dose in another group of mice.

The researchers found that the microneedle vaccinations induced strong immune responses against influenza virus that were comparable to immune responses induced by the intramuscular, hypodermic immunizations. One month after vaccination, the researchers infected both groups of mice with a high dose of influenza virus. While all mice in a control group of unvaccinated mice died of influenza, all mice in both the hypodermic and the microneedle groups survived.

"Our findings show that microneedle patches are just as effective at protecting against influenza as conventional hypodermic immunizations," says Richard Compans, Emory professor of microbiology and immunology and one of the paper's senior authors. "In addition, vaccine delivery into the skin is desirable because of the skin's rich immune network."

Even though cutaneous immunization has been shown to induce a broad range of immune responses, and to be especially effective in individuals over age 60, this method has not been widely used because it has not been convenient and has required highly trained personnel.

"Unlike conventional hypodermic injections, microneedles are prepared in a patch for simple administration, possibly by patients themselves, and inserted painlessly onto the skin without specialized training," says Mark Prausnitz, professor in the Georgia Tech School of Chemical and Biomolecular Engineering and co-senior author. "These micron-scale needles can be mass produced using low-cost methods for distribution to doctors' offices, pharmacies and, possibly, people's homes."

Other advantages of the microneedle patches could include more convenient storage, easier transportation and lower dosage requirements. Lower doses could be particularly important because flu vaccine production capacity sometimes is limited for seasonal vaccine, and a future influenza pandemic would require much greater production of vaccine.

Replacing a hypodermic needle with a microneedle patch also could significantly impact the way other vaccines are delivered, and could be particularly beneficial in developing countries. A microneedle patch could fit inside an envelope for delivery by the postal service and would occupy much less storage space. Patches also would increase vaccine safety by reducing the dangers of accidental or intentional hypodermic needle reuse.

Other authors of the papers are Emory microbiologists Ioanna Skountzou and Chinglai Yang, and first authors Ling Ye, Qiyun Zhu, Dimitrios Koutsonanos, and Maria del Pilar Martin from Emory and Vladimir Zarnitsyn from Georgia Tech. Other authors and contributors were Yulong Gao, Lei Pan, and Zhiyuan Wen from Emory, and Harvinder Gill and Sean Sullivan from Georgia Tech.

– Emory University

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Korean Government and Georgia Tech Form Historic Agreement

Photo: Gary Meek

Electrical and computer engineering graduate research assistant Ted Wada provides an overview on acoustic signal enhancements for immersive and intelligent collaboration to a group of visitors.

Imagine watching a favorite TV show and talking about it with one friend on the phone, while at the same time trading messages with others on Twitter and e-mail.

A team of Georgia Tech faculty has formed an historic partnership with the Korean government, industry and universities to develop a single platform where these and even more multimedia functions can take place.

Awarded a $9 million contract through the 2008 KORUS Tech Program, an initiative of the Korean Industrial Technology Foundation, Georgia Tech was chosen out of 109 universities to lead the development and design of the next generation of digital devices that will let users establish and participate in digitally connected communities.

This marks the first time that the Korean government has chosen a U.S. university to lead one of its research and development programs.

Project investigators will develop immersive technologies on a hybrid graphics processing unit (GPU)-central processing unit (CPU) platform, which will be created at the newly established KORUS Research Center for Informersive Systems (CIS). The center will be headed by School of Electrical and Computer Engineering (ECE) assistant professor Jongman Kim, based at the GT Savannah campus.

An enabling technology for personalized, interactive media convergence, the platform will consist of a custom-designed massively parallel architecture with a hybrid GPU accelerated many-core and heterogeneous multicore fusion system for new machine learning and multimedia algorithms and techniques. To balance resources and computationally demanding applications for high performance, Kim and his team are developing new mechanisms.

"The interdependence among speed/throughput, energy and fault-tolerance shows the importance of having this new metric that can identify the best tradeoffs among these three competing traits and desired design goals," says Kim, who leads the computer architecture part of the project.

Plans call for the system to be a smart, updated engine that understands user behavior. Associate professor Ghassan Al-Regib, also in Savannah, leads the multimedia processing and communications portion of the project, where data about home environments, modes of entertainment, and preferences are captured.

"Georgia Tech and ECE have long been world leaders in digital media and its supporting technologies," says Gary S. May, Steve W. Chaddick School Chair of ECE. "The Korean government's decision to ask Georgia Tech to lead this effort further solidifies our international reputation in this arena."

Helping Kim and Al-Regib tackle these technical challenges are ECE faculty members Monson H. Hayes III, professor and associate director at GT Savannah; Biing-Hwang "Fred" Juang, Motorola Foundation Chair Professor and Georgia Research Alliance Eminent Scholar; and associate professor Sung-Kyu Lim. Kim and Al-Regib will create undergraduate and graduate courses related to the project, while students at the Atlanta and Savannah campuses will assist with developing technologies and testing prototypes.

– Jackie Nemeth

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Providing Information to People with Disabilities

Researchers at the Georgia Tech Research Institute (GTRI) are making it easier for people with disabilities to receive important information at public venues such as hospitals, museums, airports and sports stadiums.

They are building on the wearable captioning system they developed previously, which sent the same information to all recipients. Now the researchers, led by GTRI senior research scientist Leanne West, are sending personalized information to individual recipients based on who they are or where they are located.

At the Shepherd Center, an Atlanta-based catastrophic care hospital, the technology is helping automate check-in for patients. The research team is designing a system that detects when a patient enters the facility, queries the hospital patient database and sends a text message to the patient directing the individual to the correct waiting room.

To ensure that the technology does not interfere with medical devices, the researchers are working with Ralph Herkert, director of GTRI's Medical Device Test Center.

GTRI researchers are also installing technology at the Mystic Aquarium in Connecticut that will provide location-specific video captions to the deaf and hard of hearing. Wireless tracking will determine where the visitor is located so that the system can send the appropriate video caption to a visitor's iPod or cell phone.

"If you walk through an exhibit

with videos and just see the video but can't hear what the people in the video or the narrator are saying, you aren't getting the whole experience," says West.

GTRI researchers are also working with Delta Air Lines' Disability Working Group and the National Center for Accessible Transportation to develop a system that will send airport announcements, both general and flight-specific, as cell phone text messages to passengers who are deaf and hard of hearing.

In sports stadiums, the captioning system can provide the deaf and hard of hearing with stadium and play-by-play announcements and even song lyrics in real-time through their iPods or cell phones. The system can also provide captioning on ribbon boards located at the 50-yard lines on both sides of the stadium.

Research scientists Ethan Adler, Jeffrey Jo, Brian Parise and Jeffrey Wilson are also working on these projects. This research is supported by the Wireless Rehabilitation Engineering Research Center, which is funded by the National Institute on Disability and Rehabilitation Research, a unit of the U.S. Department of Education.

– Abby Vogel

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Photo: Georgia Department of Economic Development

GTRI researchers are developing a system that will send information such as airport announcements and color commentary to the cellular phones of persons who are deaf and hard of hearing. This will allow them to more fully participate in events like baseball games.

Testing Product Usability for Arthritis Australia

Many people dread buying products wrapped in hard plastic clamshell containers with fused seams. While the heat-sealed edges protect the product in stores, they also keep many purchasers from opening the packages at home – especially the millions of people who live with arthritis.

Many individuals with arthritis have upper- and lower-body mobility issues, including difficulty grasping and lifting, as well as reduced sensation, all of which can make opening products and packaging very difficult.

To encourage manufacturers to design arthritis-friendly products and packaging, and to provide individuals with a way to distinguish products that are comfortable, effective and easy to use, Arthritis Australia recently began an "Ease of Use" program that will involve testing by the Georgia Tech Research Institute (GTRI).

"Almost 4 million Australians are living with arthritis and it can really limit their lifestyles," says Fergal Barry, strategic partnerships manager at Arthritis Australia. "This new program will allow these people to choose user-friendly products over the competition."

Similar to programs developed by the U.S. Arthritis Foundation and the Arthritis Society of Canada, products are tested for their ease of use by GTRI. If a product passes rigorous testing, the company can use the arthritis organization's logo in its advertisements and on its packaging.

"We are excited for Australians to be able to feel confident that when they choose a product that has this logo on it that the product has been rigorously tested by a world-class testing center under strict scientific methods," adds Barry.

As the sole independent laboratory authorized to test products for all three organizations, GTRI evaluates products based on an arthritis-specific set of accessibility guidelines, as well as user testing by people with arthritis. Research participants, recruited from the local community, perform a series of tasks with the products being tested while researchers monitor their performance on these tasks.

"The results of this user testing and the checklist evaluation provide us with objective data about product accessibility, which we provide to the product manufacturer so that changes can be made in the design if necessary," says GTRI senior research scientist Brad Fain, who leads this research.

Products evaluated for ease-of-use commendation from the U.S. and Canadian organizations include appliances, exercise equipment, grooming tools, health aids, home and garden equipment, home furnishings, kitchen products, mobility aids, office products, orthopedic devices and sporting goods.

"This new program will greatly benefit those people with arthritis in Australia, as well as every person who has ever been frustrated opening a package or using a product," notes Barry.

– Abby Vogel

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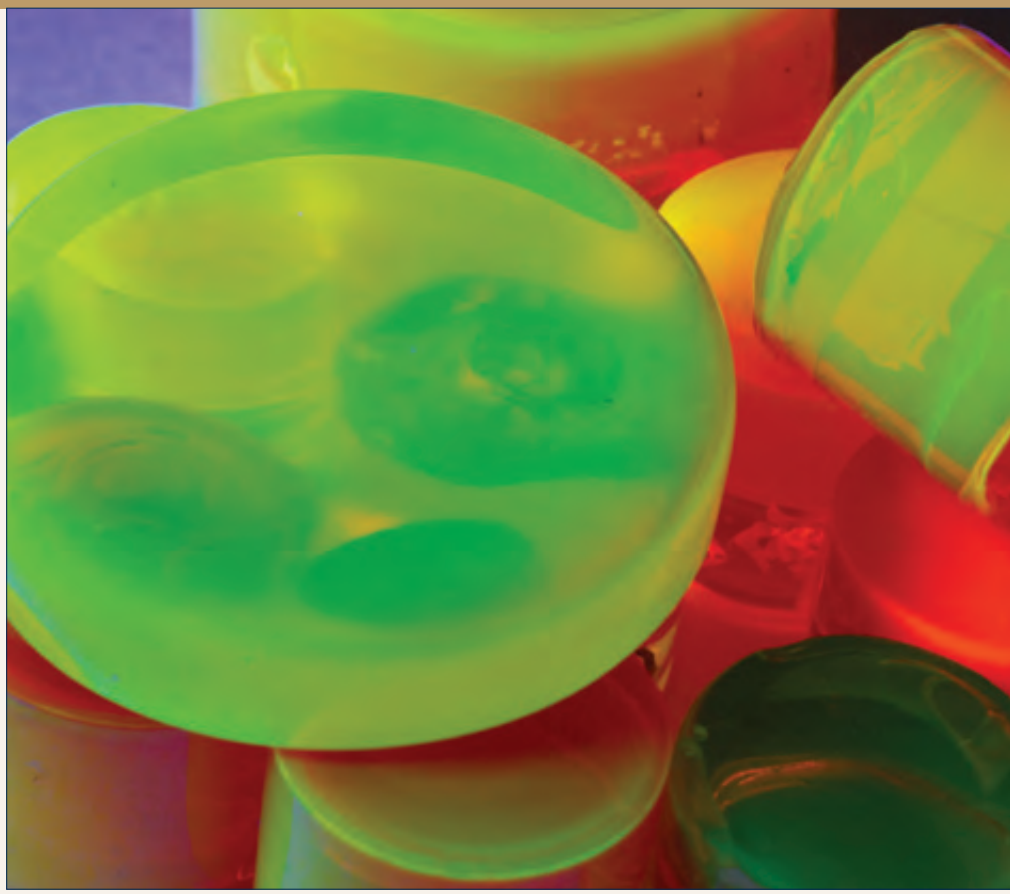
Fergal Berry (left) and GTRI researcher Brad Fain discuss the process involved in assessing how well products can be used by persons who have disabilities.

Photo: Gary Meek

Using Nanotechnology to Detect Gamma Radiation

Photo: Gary Meek



GTRI researchers are developing new radiation detector materials that contain different types of quantum dots or nanoparticles.

One of the many challenges in homeland security is detecting materials associated with potential nuclear threats while effectively filtering out the many legitimate radioactive objects commonly found in commerce and the environment.

One type of gamma radiation detector contains an inorganic single-crystal scintillator, such as sodium iodide, which absorbs the high energy radiation and coverts it to light pulses. The light-pulse intensities are then measured and compared to the energies of known nuclides. While crystals typically have a high stopping power, meaning not much radioactive energy is lost during interaction with the crystal, they are plagued by low energy resolution and long decay times, and typically need to be protected from the environment.

Researchers at the Georgia Tech Research Institute (GTRI) are investigating replacing the crystals with composite materials made of nanoparticles or quantum dots embedded in a polymer matrix.

"Scintillators made of quantum dots or nanoparticles may have many advantages over a single crystal, including better resolution, meaning they can better distinguish differences in energy intensity, and have better stopping power," says Bernd Kahn, associate director of GTRI's Environmental Radiation Center.

Fabricating the composites is also less expensive than growing a single crystal, and the size and shape of the fluorescent material is not constrained by crystal growth. Also, the particles are automatically sealed off from the environment because they are suspended in plastic.

Because nanoparticles and quantum dots are so small, the properties they exhibit differ substantially from the properties of the same material in bulk. Quantum dots become more efficient as they become smaller and their decay times become faster, meaning more gamma rays can be detected in a given amount of time.

"Quantum dots are promising because they can be tuned to certain wavelengths by making them a specific size, and suspending several different types of quantum dots in the plastic allows for a broader wavelength range to be utilized," explains principal research scientist Brent Wagner. "But to get the best performance and higher stopping power, we need to use quantum dots made of heavier elements."

In the proper format, nanoparticles of standard scintillator materials, like sodium iodide, could also have a major advantage over the crystalline form – a reduction in light scattering.

The researchers are currently developing and testing polymer composites containing several different types of quantum dots or nanoparticles, including barium and lanthanum halides, lead sulfide, and cerium-doped yttrium aluminum garnet (YAG).

ERC director and principal research scientist Robert Rosson, research engineer Jason Nadler, research scientist Zhitao Kang, and senior research scientists David Roberts and Hisham Menkara are also working on this project, which is supported by the U.S. Department of Homeland Security.

– Abby Vogel

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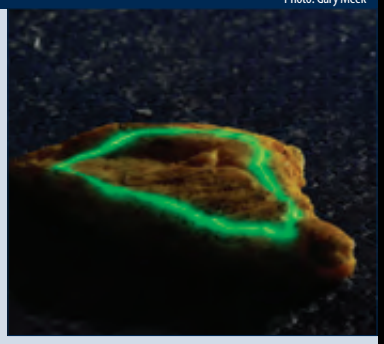
Relaying Information to Food Processing Technicians

Photo: Gary Meek



A laser projection system designed by GTRI shines a laser light symbol to alert technicians to a substandard chicken breast.

Alerting technicians in a food processing plant about a substandard item on the processing line could be much easier in the future with a laser projection system developed by GTRI researchers.

"We've developed a system that shines a laser light symbol onto the imperfect food product so that it can be removed from the conveyor belt, allowing the technicians to maintain their focus on the product stream without the need to look up at a monitor," says GTRI research scientist Simeon Harbert.

With funding from GTRI's Agricultural Technology Research Program, Harbert designed and fabricated the system, which consists of equipment installed in two plant-ready, waterproof enclosures. One contains a laser, high-speed laser-pointing mirrors and a small camera, while the other houses the controller and power systems, and software to control the system.

The camera is used to track the substandard product while galvanometers move the mirrors that reflect the laser beam and essentially create line drawings of geometric shapes – such as circles, squares, triangles and stars – on top of the food product. Different symbols are used for the various types of defects.

"The inspectors will know immediately what's wrong with the food item based on the symbol and they can make adjustments to the forming, cooking or conveyor equipment as needed," explains Harbert.

The laser projection hardware is driven by software with several modules:

- A product list module that keeps information about multiple product items in the laser projection area,
- A tracking module that uses the built-in camera to track locations of product in the viewing area,
- A laser projection control module that translates the product list information into laser projection symbols on the product, and
- A computer server that receives product defect information relayed by an inspection system.

Harbert recently integrated the laser projection system with an inspection system designed by GTRI research scientist Colin Usher. The researchers are currently inspecting sausage patties for defects and relaying that information to the laser projection system. They plan to test the combined system in a food processing plant soon, and envision that the laser projection system could be used for other applications.

"Because the system is modular and self-contained, it can be used whenever information that is not readily apparent to a worker viewing the product needs to be relayed," adds Harbert.

– Abby Vogel

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New Type of El Niño Could Mean More Hurricanes Will Make Landfall

El Niño years typically result in fewer hurricanes forming in the Atlantic Ocean. But a new study suggests that the form of El Niño may be changing, potentially causing not only a greater number of hurricanes than in average years, but also a greater chance of hurricanes making landfall, according to Georgia Tech climatologists. The study appeared in the July 3, 2009, edition of the journal Science.

"Normally, El Niño results in diminished hurricanes in the Atlantic, but this new type is resulting in a greater number of hurricanes with greater frequency and more potential to make landfall," says Peter Webster, a professor in Georgia Tech's School of Earth and Atmospheric Sciences.

That's because this new type of El Niño, known as El Niño Modoki (from the Japanese meaning "similar, but different"), forms in the Central Pacific, rather than the Eastern Pacific as the typical El Niño event does. Warming in the Central Pacific is associated with a higher storm frequency and a greater potential for making landfall along the Gulf coast and the coast of Central America.

Even though the oceanic circulation pattern of warm water known as El Niño forms in the Pacific, it affects the circulation patterns across the globe, changing the number of hurricanes in the Atlantic. This regular type of El Niño is more difficult to forecast, with predictions of the December circulation pattern not coming until May. At first glance, that may seem like plenty of time. However, the summer before El Niño occurs, the storm patterns change, meaning that predictions of El Niño come only one month before the start of hurricane season in June. But El Niño Modoki follows a different prediction pattern.

"This new type of El Niño is more predictable," says Webster. "We're not sure why, but this could mean that we get greater warning of hurricanes, probably by a number of months."

As to why the form of El Niño is changing to El Niño Modoki, that's not entirely clear yet, he adds.

"This could be part of a natural oscillation of El Niño," he says. "Or it could be El Niño's response to a warming atmosphere. There are hints that the trade winds of the Pacific have become weaker with time and this may lead to the warming occurring farther to the west. We need more data before we know for sure."

In the study, Webster, along with Earth and Atmospheric Sciences Chair Judy Curry and research scientist Hye-Mi Kim, used satellite data along with historical tropical storm records and climate models.

The research team is currently looking at La Niña, the cooling of the surface waters in the Eastern and Central Pacific.

"In the past, La Niña has been associated with a greater than average number of North Atlantic hurricanes and La Niña seems to be changing its structure as well," says Webster. "We're vitally interested in understanding why El Niño-La Niña has changed. To determine this we need to run a series of numerical experiments with climate models."

– David Terraso

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GTRI Demonstrates Cargo Container Security Technologies

Photo courtesy Department of Homeland Security

Top: GTRI's Container Security Device is shown being installed on a test cargo container. The device detects unauthorized door openings.

Bottom: The Port of Savannah is the fourth largest container port in the United States, handling cargo in large metal containers carried on ships like this one.

The Georgia Tech Research Institute (GTRI) demonstrated two cargo container security systems at a recent event sponsored by the U.S. Department of Homeland Security (DHS).

The two projects – GTRI's Container Security Device (CSD) and the Composite Container Security System – were developed under contract to the Department of Homeland Security's Science and Technology Directorate. They were among projects demonstrated in simulated and realistic supply chain scenarios at the Cargo Conveyance Security Technology Demonstrations held Aug. 17-28 at Sandia National Laboratory in Albuquerque, N.M.

"GTRI was awarded a contract to develop a container security device based on a unique solution to this complex problem," says Gisele Bennett, director of GTRI's Electro-Optical Systems Laboratory. "The GTRI Container Security Device is a small, inexpensive system that will detect unauthorized door opening or removals on ISO marine containers."

ISO containers by design can flex because of forces applied to them as they travel through the supply chain. The GTRI design can account for the normal flexing of the containers without indicating a door opening when one has not occurred.

"The GTRI CSD design has been assessed by the government test team to be highly promising for its resistance to tamper or compromise," Bennett adds. "The GTRI CSD is integrated with another DHS-funded system, the Marine Asset Tag Tracking System (MATTS) developed by iControl Inc. MATTS will communicate GTRI CSD alarm data to customs organizations and industry."

In collaboration with the University of Maine, Georgia Tech has also developed a system to secure lightweight composite containers. Teaming with the University's AEWC: Advanced Structures and Composites Center and Maine Secure Composites LLC, Georgia Tech has developed a novel, lightweight sensor grid to incorporate within the walls, doors and floors of the composite container developed at the University of Maine.

"When combined with GTRI's CSD, the resulting container will be approximately 10-15 percent lighter and more durable than current generation steel containers, but with an embedded security and communication system that will detect breaches to any of the container's six sides and communicate security information, via MATTS, to customs organizations or carriers," Bennett notes.

Shipping containers are potential means for smuggling weapons, drugs and other contraband items across national borders. Security systems are part of the solution because they can sound an alarm if the containers are tampered with in-transit.

The two-week demonstration was held in Albuquerque for those in government, research and industry to highlight technologies being developed to ensure that the contents of cargo containers are not tampered with or removed.

– Georgia Tech Research Institute

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Center Aims to Improve Recovery of Soldiers with Severe Injuries

Technologies that could improve the repair and regeneration processes for severely wounded soldiers are being developed in research laboratories across the country, but they are not being moved quickly enough into military trauma centers. Organizers of the recently established Georgia Tech Center for Advanced Bioengineering for Soldier Survivability want to change that.

"The goal of the center is to rapidly move new technologies from the laboratory to patients so that we can improve the quality of life for our veterans as they return from the wars the United States is fighting," says center director Barbara Boyan, the Price Gilbert, Jr. Chair in Tissue Engineering at the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University.

The center will leverage the expertise of Georgia Tech researchers in musculoskeletal biology and regenerative medicine to quickly move tools that are clinically valuable, safe and effective from laboratories to use in trauma centers. To reduce the amount of time from invention to clinical use, engineers and scientists in the center work in teams that include a clinician with experience in combat medical care and a medical device industry partner.

Support for the center is provided by the Armed Forces Institute of Regenerative Medicine, the U.S. Army Institute of Surgical Research's Orthopedic Trauma Research Program, the U.S. Department of Defense and industry.

Researchers in the center will initially focus on ways to improve the healing of wounds, segmental bone defects and massive soft tissue defects. Traumatic injuries that affect the arms, legs, head and neck require technologies for treatment at the time of injury and in the ensuing days and months.

"These combat injuries are complicated to treat because they are large and typically infected, so even determining when a soldier should be treated for optimal recovery is a challenge," says Boyan, who is also a Georgia Research Alliance eminent scholar and the associate dean for research in Georgia Tech's College of Engineering. "It is not known whether a regenerative therapy will be most effective if used immediately following injury or at some later time after scar tissue has been established at the wound site."

By developing models that accurately reflect the complex aspects of injuries sustained by soldiers in combat, the researchers will be able to test assumptions about when to employ specific strategies and how to ensure their effectiveness. The models must also allow them to examine the use of technologies on both male and female patients, and on complex tissues that consist of nerves, a blood supply and multiple cell types.

"Since the processes of bone, vascular and neural formation are naturally linked during normal tissue development, growth and repair, our approach is to harness this knowledge by developing delivery strategies that present the right biologic cues in the right place at the right time to promote functional regeneration of multiple integrated tissues," says Robert Guldberg, associate director of the center and a professor in Georgia Tech's Woodruff School of Mechanical Engineering.

To enhance tissue repair and regeneration following a traumatic injury, the researchers are focusing their efforts on stem cells. Even though stem cells have tremendous potential for repairing such defects, effective methods do not yet exist for delivering them to an injury site and of ensuring that they survive and remain at that site long enough to impact the regeneration process.

Since effective treatment of traumatic injuries is an important goal for the general public as well as the military population, the researchers also hope to adapt their technologies for use in civilian hospitals.

– Abby Vogel

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Georgia Tech Played a Key Role in NCR's Relocation to Georgia

Georgia Tech played a significant role in one of Georgia's largest economic development successes – the recent move of Fortune 500 Corporation NCR to Georgia. And the company will be looking to Georgia Tech as a source of engineering talent and as a partner in development of future technology innovations.

Flanked by NCR officials, Georgia Governor Sonny Perdue on June 2 announced that the company would move more than 2,100 jobs to the state by relocating its headquarters to Duluth and by developing a new advanced manufacturing facility in Columbus.

"The opportunity to partner with top-tier academic institutions such as Georgia Tech was one reason among many that we made this decision," says Bill Nuti, NCR's chairman and chief executive officer.

Currently based in Dayton, Ohio, NCR is best-known for automated teller machines (ATMs), self-service kiosks and other assisted- and self-service solutions. The Columbus, Ga. facility, which will employ 870 people over the next five years, will produce advanced technology equipment enabling consumers to use ATM kiosks for a growing number of financial transactions.

Working with Georgia Tech's Strategic Partners Office, NCR officials learned about a broad range of Georgia Tech resources and expertise – in collaboration with the University System's Intellectual Capital Partnership Program (ICAPP) and the Georgia Research Alliance (GRA).

"The company is interested in both ensuring access to a highly educated work force and in linking to the innovation in Georgia Tech's research and development network," explains Georgia Tech strategic partners officer Greg King. "There are many advanced technology areas in which Georgia Tech and NCR have interests in common."

More than a year ago, King began meeting with NCR officials to learn about the company's needs and to pinpoint potential areas of interest at Georgia Tech. That led to a campus meeting for NCR management with Mark Allen, Georgia Tech's Senior Vice Provost for Research and Innovation. Additional follow-on discussions about potential collaborations were also held.

"Georgia Tech is committed to sup-

porting innovation through university-industry collaborations, and we believe there are many opportunities for us to work with NCR," says Allen. "We welcome this opportunity to work with NCR as the company develops new cutting-edge products and processes."

Georgia Tech will be involved in assisting the development of NCR's Columbus manufacturing operation through an ICAPP-supported project in production design, agile manufacturing and continuous improvement. The project will include faculty and staff from the Enterprise Innovation Institute, Stewart School of Industrial and Systems Engineering and College of Management.

"This project and the future collaborations are excellent examples of how Georgia Tech works with organizations such as the Georgia Department of Economic Development, the University System of Georgia's ICAPP program and the Georgia Research Alliance to impact investment and growth in the state," says Carl Rust, acting director of the Georgia Tech Strategic Partners Office.

NCR joins 13 other Fortune 500 companies and 29 other Fortune 1,000 companies already headquartered in Georgia.

– John Toon

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Health and Safety Program Celebrates Three Decades of Assistance

Photo : GTRI Archive

Working with OSHA, GTRI has helped Georgia companies maintain a safe workplace for 30 years.

The Georgia Tech Research Institute's (GTRI) Occupational Health and Safety Program, which helps businesses comply with requirements of the federal Occupational Safety and Health Administration (OSHA), marked its 30th year of service recently.

"Reaching our 30th year of OSHA-related activity is a significant milestone," says Dennis Folds, GTRI's chief scientist and head of its Human Systems Integration Division. "It underscores both the state of Georgia's need for OSHA programs and GTRI's success in handling those programs."

Science and engineering consultants from GTRI currently provide two separate services to Georgia business and industry:

- The OSHA 21D Consultation Program provides free, on-site safety and health consulting to Georgia companies with fewer than 500 employees.
- The OSHA Training Institute Education Center offers safety and health courses in more than 20 topics, principally through Georgia Tech's Distance Learning and Professional Education.

"It can be challenging for smaller businesses to deal with OSHA and state requirements, and we're here to help them comply fully and stay safe," says Daniel Ortiz, a GTRI principal research scientist who directs the OSHA programs at Georgia Tech.

The health and safety program has a staff of 17, composed mainly of research scientists and engineers. This team performs fact-finding and idea development in Georgia and other states to help businesses improve the workplace.

Students can take courses that cover a wide variety of subjects and industries, from hazardous materials and machine safety to the prevention of falls and respiratory problems. By taking multiple courses, participants can earn OSHA certificates.

The consultation program is funded mainly by OSHA, which provides 90 percent of the program's $1.38 million annual budget; the state of Georgia provides the balance. GTRI consultants provide on-site services to more than 200 Georgia manufacturing companies and other businesses each year and make some 450 visits to job sites.

The education program, under which Georgia Tech teaches OSHA courses to the private sector, is paid for by the students themselves or by their employers. Occupational Health and Safety Program instructors – typically the same GTRI consultants who work with industry -- train about 2,500 people yearly in these courses.

In addition, the program provides training interventions for companies around the state. Nearly 100 such interventions were done last year, and those efforts reached more than 14,000 persons. The program saved Georgia companies almost $2.5 million in OSHA penalties, the cost of injuries and lost work days prevented through GTRI assistance.

One important new strategic area for the health and safety program involves teaching courses to high school students who are preparing for the workplace by taking vocational courses. Those graduating from the course receive the OSHA 10-hour card, a qualification that can give them an advantage with employers.

– Rick Robinson

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Using Military Antenna Technology to Relay Ocean Data

Photos: Liquid Robotics

California-based Liquid Robotics Inc. has developed a wave-powered autonomous surface vehicle called Wave Glider. The vehicle provides a persistent presence on the ocean surface to perform a wide variety of sensor functions and communicate the collected information back to the operator via satellite.

However, the amount of information that could be communicated by the unique Wave Glider platform was constrained by the limits of traditional antenna solutions, including available data bandwidth and/or high power consumption. In need of a more reliable and faster way to receive high-bandwidth information such as streaming audio and video from the Wave Glider, the company turned to the Georgia Tech Research Institute (GTRI).

GTRI researchers had developed a reconfigurable aperture antenna technology several years earlier for a military software-defined radio that could be repurposed to quickly send and receive the required information. For Liquid Robotics, this information included environmental and global positioning data, video, audio from a hydrophone, and instructions telling the vehicle where to go.

"We're very pleased with the results of the Wave Glider platform to date and we're excited about the additional capabilities that GTRI's technologies will bring to the platform," says Tim Richardson, chief operating officer at Liquid Robotics.

The original antenna technology was developed by GTRI Signature Technology Laboratory director Lon Pringle, principal research engineer Paul Friederich and principal research engineer Jim Maloney.

"The antenna technology being developed at GTRI allows for fast data transfer because it can be steered electronically with very low power so that it stays pointed toward the satellite as the boat is moving around and bobbing back and forth on the waves," says GTRI principal research engineer Don Davis.

The antenna's performance can be optimized because it is reconfigurable, which means the electrical structure of the antenna can be easily changed. The antenna consists of a thin dielectric substrate that supports an array of square, metallic patches that can be switched on or off as needed to provide the proper configuration. The researchers simulate the antenna patterns to determine which switches should be open and which should be closed to maximize the antenna performance.

"This antenna technology allows limited space on a vessel to be used most effectively because it can conform to the surface of an object. Additionally, it gives the user the ability to repurpose an antenna for other frequencies, bandwidths or directivity requirements," adds Davis.

– Abby Vogel

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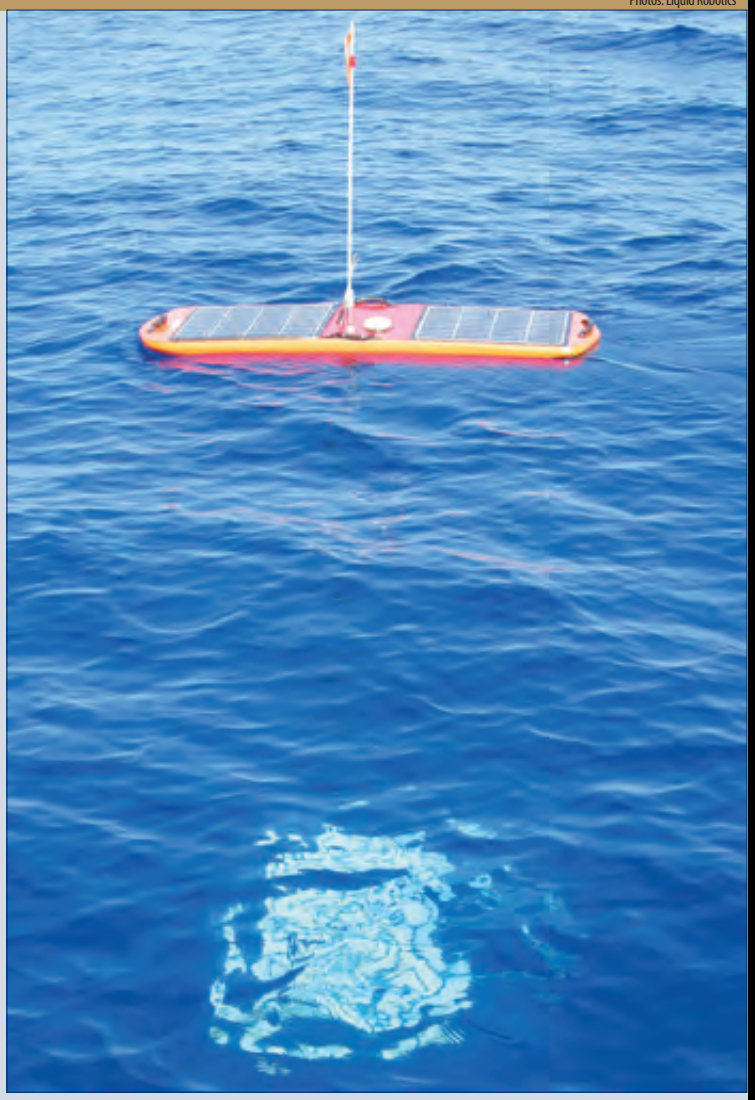
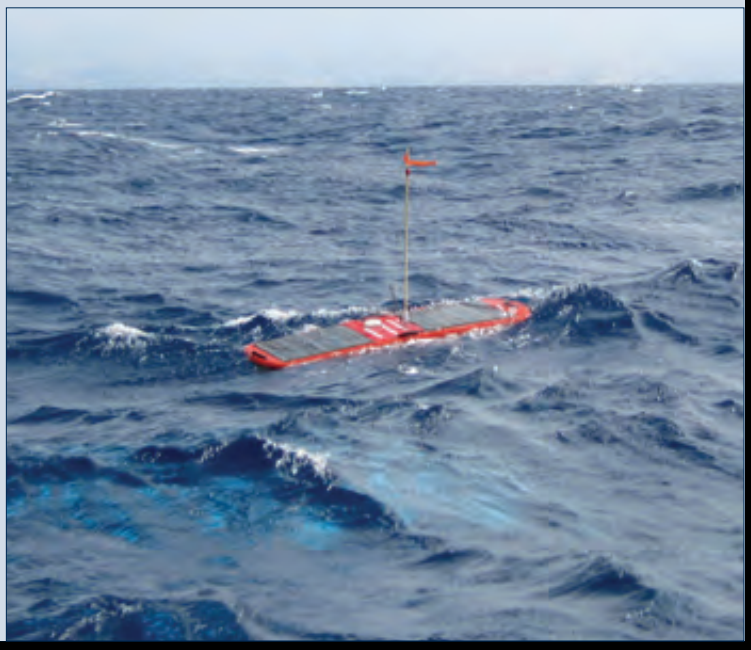
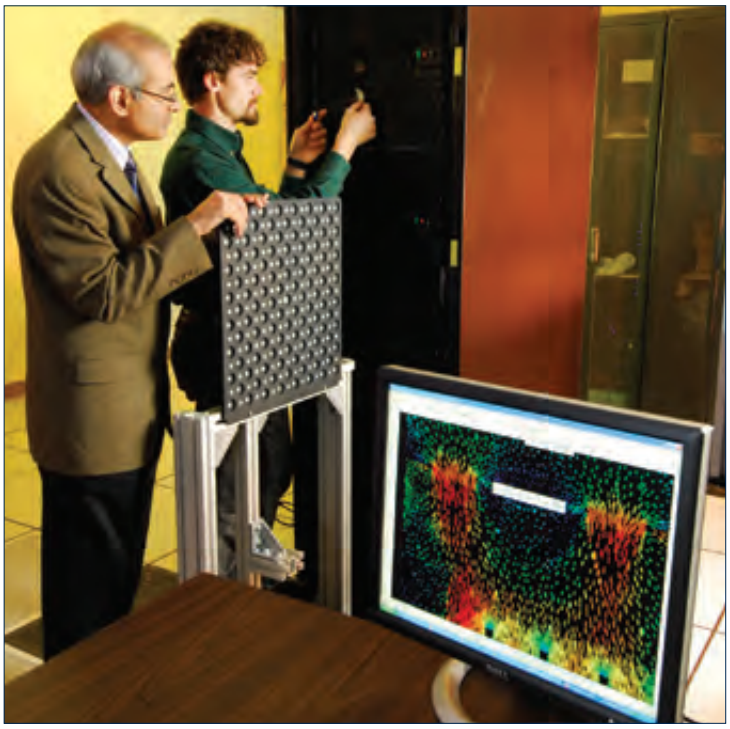


Antenna technology developed by GTRI will enable this Wave Glider to communicate information to its operator via satellite.





Helping Data Centers Stay Cool

Approximately a third of the electricity consumed by large data centers doesn't power the computers that conduct online transactions, serve Web pages or store information. Instead, that electricity must be used for cooling the servers, a demand that continues to increase as computer processing power grows and the trend toward cloud computing expands.

At Georgia Tech, researchers are using a 1,100-square-foot simulated data center to optimize cooling strategies and develop new heat transfer models that can be used by the designers of future facilities and equipment. The goal is to reduce the portion of electricity used to cool data center equipment by as much as 15 percent.

See story on page 12.

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