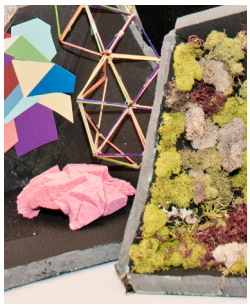
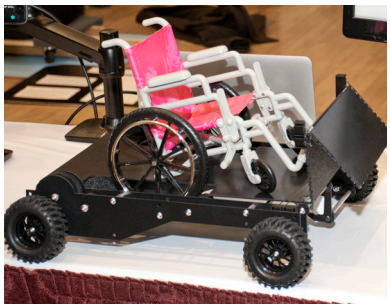
Innovation Palooza

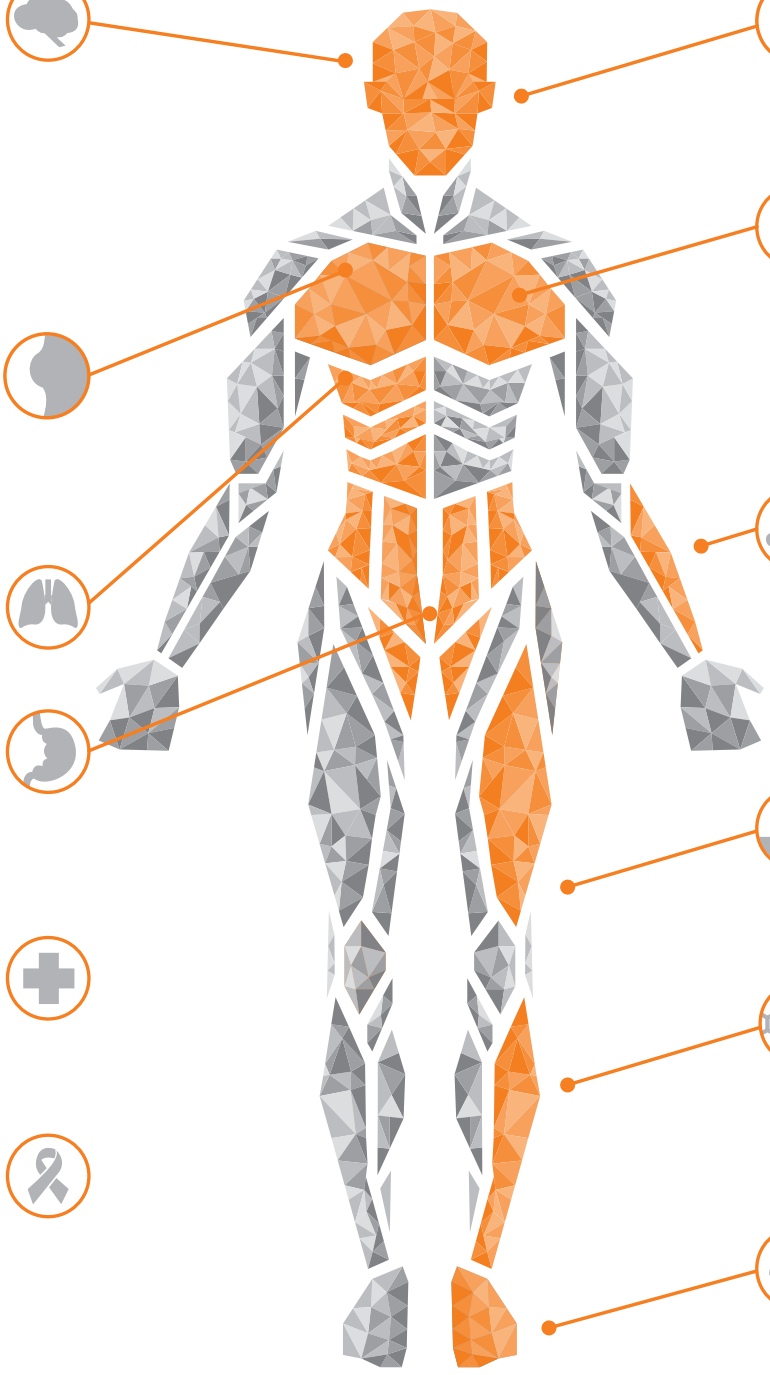


Students, faculty, and industry leaders gathered in the Rangos Ballroom on November 13, 2015, for the 2nd annual Innovation Palooza and Impact-a-Thon student competition, all with a single goal in mind: coming up with innovative ways to make playgrounds more accessible to children with physical and cognitive disabilities. Over the course of the four-hour event, demonstrations from leading tech companies such as 4Moms, Amazon Robotics, and Kennametal, interspersed with lighting talks from pioneers of innovation provided students with a look into the incredible doors their degree paths can open for them. In exchange, 15 interdisciplinary student teams from across the College of Engineering and the university at large displayed the prototypes and ideas they'd developed over the course of three days in response to the Impact-a-Thon's innovation challenge – all hoping to wow the judges and win the top prize of $1,000. *– A.D.*



The "6 Trillion" Dollar Man

Researchers from every department in the College of Engineering are working to build a better you. Below are a few examples.



BRAIN
- Brain-computer interfaces
- Brain imaging
- Brain cell mechanics
- Polymers and nanotechnology for brain-machine interfaces
- Transport of cargos in nervous system
- Neuromorphic computing

BREAST
- Breast cancer automated pathology
- Breast cancer imaging and monitoring

LUNGS
- Artificial lung

GASTROINTESTINAL TRACT
- Bacterial microbots
- Inflammatory bowel disease
- Liver/diabetes
- Swalloable electronics

MEDICINE
- Drug delivery
- Cryopreservation and transplant medicine

CANCER TREATMENT
- Cancer cell signaling models
- Cryosurgery
- Hyperthermia
- Interstital photodynamic therapy
- Thermal surgery education

EYES AND EARS
- Biometrics
- Cornea tissue engineering
- Retinal implants
- Ear infection diagnosis

HEART AND BLOOD
- Cardiac assist devices
- Cardiac tissue engineering
- Cardiac mechanics and imaging
- Detection of malaria
- Magnetic resonance image processing

BONES AND MUSCLES
- Bone imaging
- Bone regeneration
- Bone surgery
- Emery Dreyfus muscular dystrophy
- Implantable sensors
- Muscle contraction sensing and human body motion capture

SKIN
- Artificial skin
- Engineering skin tissue
- Wound healing

TISSUE
- Tissue on a chip
- Assigning synthetic myosin, building blocks of muscle
- Growing vascularized tissue
- Tissue image analysis

LIMBS
- Artificial hip lubrication
- Exoskeleton

Dear Friends,

It has been an exciting year! Our students have won a number of prestigious awards: Josh Kubiak received a prestigious Goldwater Scholarship; our Society of Women Engineers (SWE) chapter won numerous achievement awards; and our CMU Racing Team won a first-place design award for their new hybrid racing car design. Faculty have also received significant awards: Jay Whitacre (MSE and BME) won the MIT-Lemmelson Prize for his entrepreneurship; Katie Whitehead (ChemE) was named one of the Brilliant 10 by Popular Science; and, Marios Savvides (ECE and CyLab) received the Edison Award for his work on biometrics for security.

This year, we were selected by the Young Presidents Organization/World Presidents Organization (YPO/WPO) to be a member of their invitation-only Faculty to Global Leaders Program. CMU was selected to provide the YPO/WPO with exciting content related to engineering and robotics. We held a kickoff in September with over 100 local YPO/WPO members attending (see page 14).

The White House Office of Science and Technology Policy announced the creation of the MetroLab Network, a collection of over 24 collaborations between cities and their local universities. The MetroLab Network will be led by Carnegie Mellon University's Metro21 Initiative and receive support from the MacArthur Foundation. The Metro21 Initiative, directed by ECE's Raj Rajkumar, aims to improve the quality of life in metropolitan areas by delivering higher-quality and more cost-effective infrastructure and public services. Metro21 involves faculty and students from the College of Engineering, the Heinz College, the School of Computer Science, the Dietrich College of Humanities and Social Sciences, and the College of Fine Arts. Metro21 and the City of Pittsburgh signed a Memorandum of Understanding this year to use the city as a testbed for smart infrastructure and smart city concepts being developed by Metro21 researchers. This is an exciting development and builds on a variety of research projects highlighted in this newsletter.

The College of Engineering recently received a grant from The Bosch Group to create the Bosch Distinguished Professor in Security and Privacy Technologies that will support the directorship of CyLab, currently Director David Brumley. CyLab is a university-wide, multidisciplinary institute which addresses cybersecurity and privacy issues. We are grateful to Bosch for this generous gift and for their recognition of the quality of cybersecurity and privacy research taking place at CMU.

We have also received significant support from numerous other corporations and alumni. My colleagues and I are tremendously grateful for this funding which allows us to hire and retain the best and brightest faculty and provides students the opportunity to learn and grow through participation in hands-on research. These investments allow the College of Engineering to continue and be recognized for our cutting-edge research and education. Thanks to all of you for your support toward the continuous improvement of the College of Engineering.

Sincerely,
James H. Garrett Jr.
Dean, College of Engineering

Carnegie Mellon University
Engineering

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We want to hear from you!

Send email to stokes@cmu.edu
Please include your name and, if applicable, major and date of graduation. Letters will be edited for clarity and space.

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CMU-R Is First Beneficiary of SMART Africa Scholarship Fund

by Aoife Hegarty

During the Transform Africa Summit 2015, which hosted over 2500 delegates from 81 countries, the SMART Africa Scholarship Fund was officially launched. The fund will support African students pursuing their education at recognized African centers of excellence that focus on information and communication technology (ICT), such as Carnegie Mellon University in Rwanda (CMU-R).

The fund awarded its first scholarships to seven students pursuing master's degrees at CMU-R. These students from Uganda, Kenya and Tanzania will be able to complete their master's degree programs in Information Technology and Electrical and Computer Engineering.

Carnegie Mellon's goal is to boost the ICT skills capacity in Sub-Saharan Africa by nurturing highly qualified engineers and preparing Africa's next generation of technology leaders and innovators. The establishment of the fund complements the efforts of the Government of Rwanda and the College of Engineering to make CMU-R's programs more accessible to Africa's brightest young minds.

Initial support for the scholarship fund came from the International Telecommunications Union (ITU), as well as the governments of Gabon, Rwanda and South Sudan, with total contributions of $800,000 USD. During the summit, other governments of the SMART Africa Alliance from Burkina Faso, Uganda, and Kenya also pledged their support.

On the last day of the summit, H.E. Paul Kagame President of the Republic of Rwanda, affirmed the vision of the SMART Africa Alliance "to unleash the energy and unexploited talent we know exists on our continent."

Turning the Page on Unsafe Drinking Water

By Georgia Schumacher

Worldwide, 780 million people lack access to clean water, according to estimates from the World Health Organization. Armed with sheets of paper and an expert knowledge of nanoparticles, **Teri Dankovich**, a Civil and Environmental Engineering (CEE) postdoctoral researcher at Carnegie Mellon University, is working to solve that problem with support from CEE students.

This summer, CEE student **Angela Ng** (BS '16) traveled to Bangladesh to test Dankovich's innovative technology called pAge Drinking Paper—thick pieces of paper embedded with silver and copper nanoparticles that are lethal to bacteria.

In a talk at the 250th American Chemical Society National Meeting & Exposition, Dankovich presented results from these and other field trials showing that when you pour contaminated water through a sheet of pAge drinking paper, the paper removes over 99% of bacteria in the water. This simple process produces filtered water that is very similar to tap water consumed every day across the United States.

This paper is perhaps best known as the technology behind the Drinkable Book, a collection of pAge drinking papers presented as a book. Each paper can be easily torn from the book, placed in a filter holder, and used to clean water whenever needed. As a whole, one Drinkable Book could provide its owner four years of clean drinking water.

"I had always wanted to work on The Drinkable Book project. It was actually the reason I chose my major," explains Ng.

In Bangladesh, Ng and fellow team members worked with International Development Enterprises to create a design that would allow pAge drinking paper to filter water directly into jugs called kolshis, which are commonly used to collect water throughout the country.

Gathering information and water samples, the group travelled to cities and rural areas and asked people which designs they preferred and how they collected water. The team created and tested various models before identifying the most successful design, which Ng describes as similar to a coffee filter.

As part of her honors thesis, Ng is continuing her work with Dankovich. "There's a lot more to discover — for example, figuring out the longevity of this new design and seeing if it doesn't only kill bacteria but also key species like Giardia, Microsporidia, and other waterborne pathogens," explains Ng.

When asked about her own future, Ng does not hesitate. "This is the type of work I want to do for the rest of my life—to create solutions that better communities around the world."

A Smarter Way To Build Things

by Sherry Stokes

Fifty thousand miles of electric power lines, 4.5 million commercial buildings, 600,000 bridges, and 4 million miles of roads — our nation's infrastructure profoundly affects our lives and economy. Yet for as much as we rely on these systems, we haven't maintained them, and the neglect is evident. From 2000 to 2008, 161 bridges failed, including the I-35W Mississippi River Bridge that collapsed, killing 13 people. Power outages cost up to $75 billion a year and buildings account for 39% of all CO_2 emissions. Estimates by the American Society of Civil Engineers estimate that an investment of $3.6 trillion is needed by 2020 to shore up US infrastructure. In light of urbanization, climate change, and constricting budgets, if we want to remain a functioning society we must rethink our approach to infrastructure problems, and that is precisely what faculty and students in the College of Engineering are doing. They are creating sensor-driven solutions to the problems ailing the structures and systems that literally support modern life.

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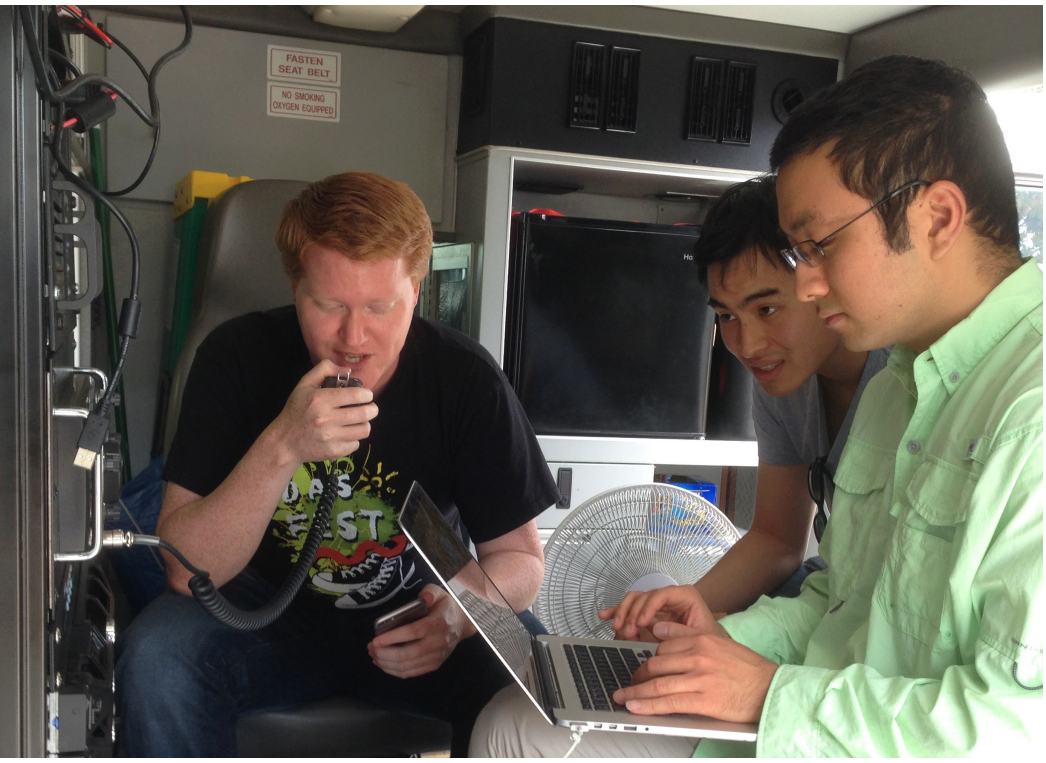


Wireless Innovators Come In Loud and Clear at National Amateur Radio Event

by Hannah Diorio-Toth

Camped out in the foothills of the Santa Cruz Mountains, Electrical and Computer Engineering (ECE) graduate student Yalei Song announced the W6CMU amateur radio call sign into a microphone. Next to her, ECE Ph.D. student Joao Diogo De Menezes Falcao searched through static for an answer to their call while another Wireless Innovator club mate sat ready to record any response that came through the speakers.

As part of an annual event called Field Day, the Carnegie Mellon University Silicon Valley (CMU-SV) students attempted to contact as many amateur radio operators across the country as possible within 24 hours. Organized by the American Radio Relay League, the event promotes emergency communications preparedness and has become the biggest amateur radio-operating event in North America, with more than 35,000 participants.

During the event, amateur radio operators, or "hams," use emergency and alternative power sources to simulate a disaster emergency situation. This is where the CMU-SV club had a particular advantage. The group used the CROSSMobile van, a former ambulance converted into a mobile radio research laboratory. They took advantage of the van's ability to operate on a standalone power supply.

Bob Iannucci, distinguished service professor of ECE and faculty advisor for the Wireless Innovators, says amateur radio has important real-world applications. "What many people don't realize is that our society's communications systems are fragile," explains Iannucci. "Disasters of all sorts threaten our normal communications systems. Amateur radio works when all else fails."

In preparation for Field Day, the group spent several weeks assembling and testing an impressive antenna — 32 feet from front to back and weighing 100 pounds. The antenna was fitted atop the CROSSMobile van on a pneumatic mast, which uses pressurized air to raise and lower. With sponsorship from the Palo Alto Office of Emergency Services, the team was given the opportunity to operate from an advantageous vantage point overlooking Silicon Valley.

The antenna allowed the group to make connections from Hawaii to Puerto Rico and enabled them to reach more than 200 different contacts.

The CMU-SV Wireless Innovators want to promote understanding of the fundamentals of radio and wireless communications. "Designing a radio or antenna in the lab is one thing, but matching the performance of their system against the best of the best in a real-world setting is a whole new challenge," says Iannucci. This was the first Field Day for the CMU-SV group.

Several alumni, including Software Management alum Nathan Martin, joined old friends at the event. "I really enjoyed the Field Day experience because I got to spend it with my fellow classmates. It was like a reunion," says Martin.

The group is already looking forward to next year's event, where they hope to reach even more operators across the country with the help of an even larger group of Wireless Innovators.

SMART SYSTEMS MAKE SMART DECISIONS

Burcu Akinci is taking the guesswork out of construction management of facilities and infrastructure systems with data-driven tactics that provide engineers with comprehensive, real-time information about structures and their operations.

Replacing outdated, reactionary practices with technologies that streamline decision-making will deliver big payoffs contends Akinci, a professor of Civil and Environmental Engineering and co-director of the Carnegie Mellon Smart Infrastructure Institute.

Akinci augments building information models (BIM) with sensing technologies to get realistic, operations-rich information about a building. BIMs are used during design and construction in the industry, and many time and cost savings are documented. However, more often than not, these models alone do not truly depict reality, especially as changes occur during the service lives of the facilities.

To complement BIMs, Akinci uses a variety of sensors to collect data from job sites, existing facilities and infrastructure systems. For example, building automation embedded in HVAC systems and laser scanners, on the ground or mounted on unmanned air vehicles, can provide temperature and spatial information respectively. Through her research, it is possible to feed such data into existing building information models and continuously update information about a facility to create what Akinci calls a "living information model" that provides accurate and timely information about what is happening in a facility. Through these models, it is possible to develop new and more proactive methods for operations and maintenance — soon managers will look at living information models to virtually identify possible problems and prevent them before they occur.

Sensors provide copious amounts of data, and that is where challenges lie: Is the data accurate? Did we introduce calibration errors into the data? How do we process data so we can tell if we are looking at a wall or a window? How do we fuse data from multiple sources?

As is the nature of research, there are always obstacles to overcome; however, in this case, the rewards will be significant. Akinci points out that the late detection of defects contribute an extra 6% to 12% to the cost of construction projects, and $4.8 billion is spent annually on construction verification. Akinci's research, which span across all aspects of the life-cycle of facilities and infrastructure systems, offers smart solutions at a time when we need them.

POSITIONING SYSTEM MOVES INDOORS

Akin to the way global positioning systems (GPS) track objects in the vast outdoors, College of Engineering researchers are creating a powerful new technology to tame the great indoors. The National Science Foundation (NSF) awarded a Carnegie Mellon team $998,387 dollars to develop a cost-effective indoor location service that will incorporate Internet of Things (IoT) technologies to manage commercial facilities. The CMU team, partnering with Bosch RTC Pittsburgh and the Sports & Exhibition Authority, will test the service in the David L. Lawrence Convention Center in Pittsburgh.

Electrical and Computer Engineering professors Bruno Sinopoli and Anthony Rowe co-lead the interdisciplinary team that will reveal information about a building's interior and track its occupants and content through the use of indoor-mounted beacons and building information models (BIMs).

"We intend to demonstrate that it is possible to track the evolution of a building and its occupants," say Sinopoli, who along with Burcu Akinci co-directs the Smart Infrastructure Institute.

Novel technologies and data processing provide building information through an interface that's accessed with a smartphone, tablet or smart watch. Ultimately, users will customize the service to address building operations management, emergency response, building security and other unique needs.

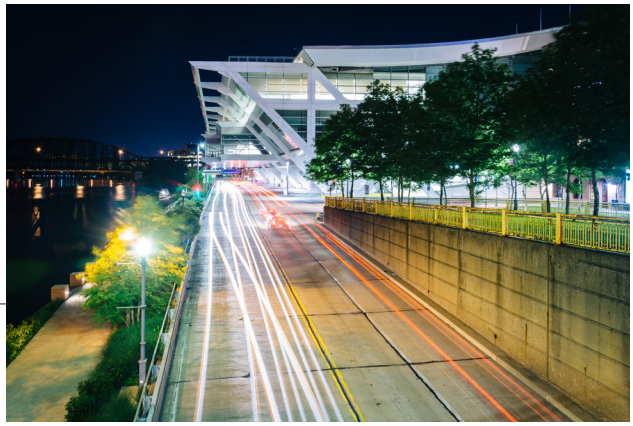
Indoor localization, or the ability to locate objects in buildings, promises to revolutionize how people interact with the world. Outdoor localization relies on GPS signals emitted from satellites to provide geographical locations. These signals, however, cannot penetrate walls. This predicament led the CMU team to devise a unique multi-prong approach for determining indoor positioning that will be extremely accurate, reliable and installed at low cost.

Throughout the convention center, the researchers installed beacons that employ light, sound, wireless local area networks (WLAN) and radio frequency (RF) technologies and techniques. On this front, Rowe is contributing his expertise in large-scale embedded systems and their supporting technologies. By incorporating these technologies with building information models (BIM), which is Akinci's area, greater accuracy and reliability can be achieved. This system will piggyback off of the convention center's existing lighting and communication capabilities and keep installations and maintenance costs in check. Smartphone technologies will also contribute to the service's heightened accuracy. Bosch, a longtime collaborator with Carnegie Mellon, will contribute sensors and other equipment for the project.

Stakeholders from the convention center will help maintain the beacons and offer input on the design and use of the management applications. Understanding how users interact with the service will help the engineering team refine the service so that it can serve as a platform for other commercial endeavors.

Drawing parallels to GPS, Sinopoli explains that when GPS became available, new apps followed and he predicts that the same will happen with indoor positioning systems. "In the future, it will be up to people to figure out how they want to use this service," he says.

In addition to Rowe and Akinci, Anind Dey, from the School of Computer Science, is a co-principal investigator on this project. He is designing the interface that will operate on users' devices.



Right: David L. Lawrence Convention Center
Far right: Scott Hall

David Dzombak

Hamerschlag University Professor in Civil and Environmental Engineering, 2014

Head of the Department of Civil and Environmental Engineering, Dzombak's research delves into water quality engineering, environmental restoration and energy-environment issues. Among his many projects, he works on adapting infrastructure for climate change and forecasts water supply sustainability.

Chris Hendrickson

Hamerschlag University Professor Emeritus in Civil and Environmental Engineering, 2014

Hendrickson is the director of the Traffic 21 Institute at CMU and editor-in-chief of the ASCE Journal of Transportation Engineering. His research, teaching and consulting are in the area of engineering planning and management, including design for the environment, system performance, construction project management, finance and computer applications.

Jelena Kovačević

David Edward Schramm Memorial Professor, 2015

Jelena Kovačević, the head of the Electrical and Computer Engineering Department, is a passionate educator whose recent research focuses on providing signal representation tools for use in communication and biomedical systems. She's developed a toolbox containing an extensive list of tools with structure. (Structure distinguishes various classes of tools.) These can be multiresolution, multidimensional, wavelet-type, etc. A prolific writer, she co-authored the textbooks, *Wavelets and Subband Coding*, *Foundations of Signal Processing*, and *Fourier and Wavelet Signal Processing*.

Philip LeDuc

William J. Brown Professor in Mechanical Engineering, 2015

LeDuc links mechanics to biochemistry at the cellular and molecular levels through examining structural regulation. Significant improvements in the prevention and treatment of cancer, birth defects and aging, as well as novel applications such as engineered tissues, nutrition and biological nanomachines may be achieved by manipulating mechanical interactions in biological systems at the molecular, cellular and multi-cellular scales.

Greg Lowry

Walter J. Blenko, Sr. Professor in Civil and Environmental Engineering, 2014

Lowry specializes in water quality. At the nanoparticle level, his research includes developing and testing groundwater and soil remediation technologies to improve water quality. He is the Deputy Director of the National Science Foundation's Center for Environmental Implications of Nanotechnology (CEINT).

M. Granger Morgan

Hamerschlag University Professor of Engineering, 2015

Morgan's research addresses problems in science, technology and public policy with a particular focus on energy, environmental systems, climate change and risk analysis. His work involves the development and demonstration of methods to characterize and treat uncertainty in quantitative policy analysis. Morgan served as the founding department head of the Department of Engineering and Public Policy for 38 years, before stepping down in August 2014.

Burak Ozdoganlar

Ver Planck Professor in Mechanical Engineering, 2015

Ozdoganlar, the director of the Institute for Complex Engineered Systems (ICES), is a leader in the field of advanced manufacturing. His research focuses on mechanical, micro- and nano-machining processes and equipment. His work in manufacturing processes finds cutting-edge applications in the medical and bio-medical fields, aerospace, energy and robotics.

Douglas Sicker

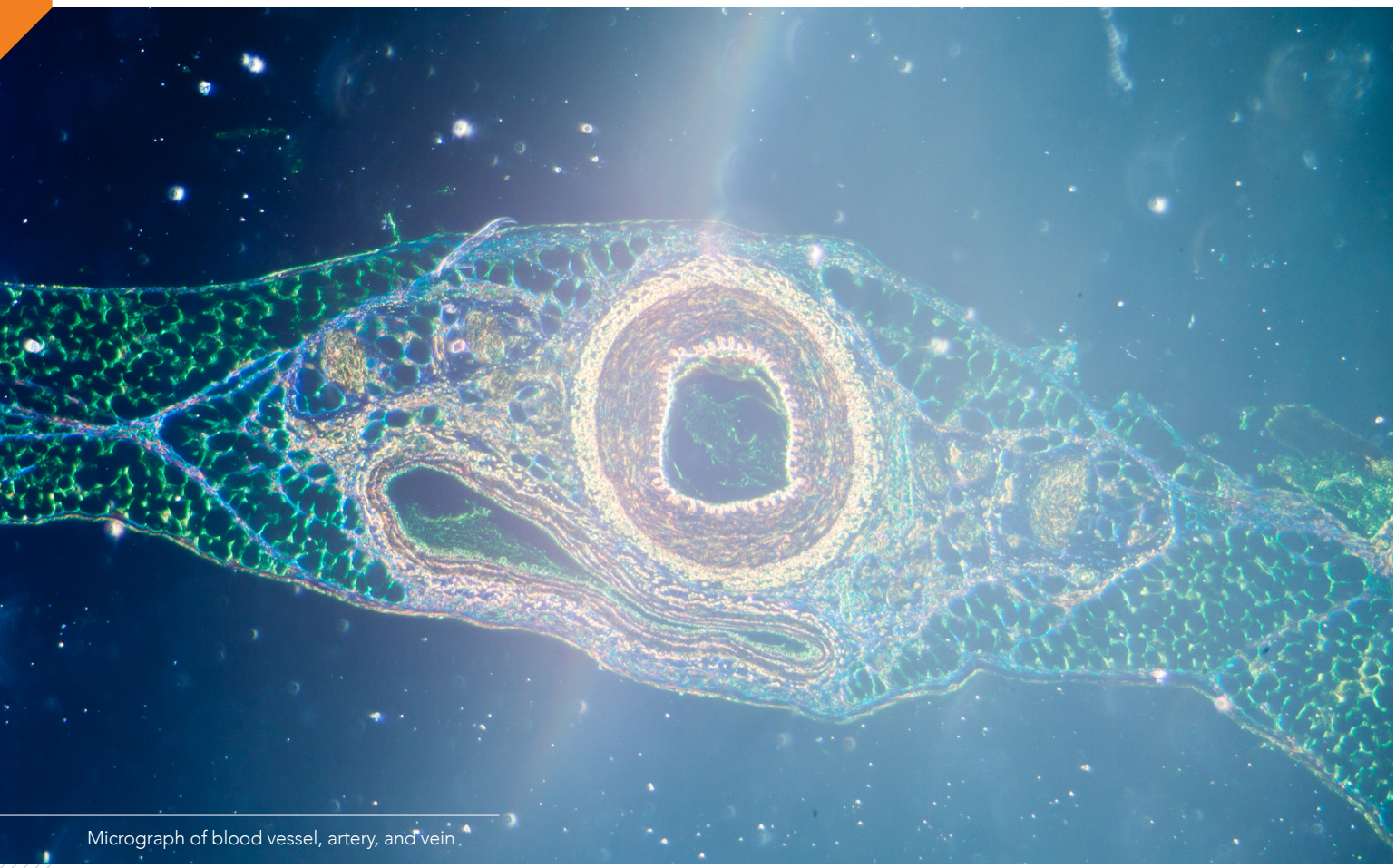
Lord Endowed Chair of Engineering and Public Policy, 2015

Sicker, professor and head of the Department of Engineering and Public Policy, is an international leader in telecommunications technology and policy with broad experience across academia, government and industry. At the highest levels, his research interests include dynamic spectrum access, security and privacy, broadband networking and network policy. His prolific research has produced over 180 peer-reviewed publications.

Jeanne VanBriesen

Duquesne Light Company Professor in Civil and Environmental Engineering, 2014

VanBriesen, the Director of the Center for Water Quality in Urban Environmental Systems, is an expert in water quality engineering. She focuses on biotechnology, monitors approaches for drinking water distribution systems and the formation of disinfection byproducts in drinking water treatment. Her recent research assesses the environmental impacts of hydraulic fracturing and unconventional gas processes. Her work on the treatment and discharge of drilling wastewater was instrumental in developing Pennsylvania state policy.



Micrograph of blood vessel, artery, and vein

Saving Lives Through Advanced Cryopreservation

by Lisa Kulick

Mechanical Engineering Professor Yoed Rabin received a $1.6 million award from the National Heart, Lung and Blood Institute of the National Institutes of Health to develop technology for cryopreservation, the preservation of tissues and organs at extremely low temperatures. This research will impact the future of biobanking and transplant medicine.

Rabin is leading a team that seeks to protect biomaterials from the harmful effects of ice crystals during cryopreservation, which is so devastating to cells, tissues and organs that they cannot regain viability and functionality after cryogenic storage. By introducing solutions known as cryoprotective agents (CPAs) and rapid cooling, the biological material can be trapped in a glassy-like state, in a process known as vitrification. The unique contribution of the current research is in the addition of synthetic ice modulators (SIMs), a special class of compounds that can create favorable conditions to deter the formation and growth of ice crystals.

"THERE ARE MORE THAN 123,000 PEOPLE ON THE WAITING LIST FOR A LIFESAVING ORGAN TRANSPLANT IN THE UNITED STATES, AND ANOTHER NAME IS ADDED EVERY 12 MINUTES. CRYOPRESERVATION IS THE ONLY ALTERNATIVE FOR LONG-TERM PRESERVATION OF HIGH-QUALITY TISSUES AND ORGANS." –YOED RABIN

Rabin, who directs the Biothermal Technology Laboratory at Carnegie Mellon, is a renowned leader on thermo-mechanical stress and structural damage in cryopreservation. His team combines expertise from the fields of cryobiology, chemistry, physics, thermal engineering and solid mechanics, and they collaborate with leaders in the cryopreservation industry.

This project places an emphasis on blood vessels as a key building block of complex tissues and organs. "Vitrification techniques for cryopreservation have been investigated for decades," he said. "While cryopreservation research has traditionally focused on phenomenological studies and diagnostic tools, our research aims at developing modeling and simulation tools to plan and optimize cryopreservation protocols. These developments are informed by experimental investigation on the physical effects of CPA-SIM cocktails with cutting-edge, proprietary instrumentation."

Collaborators include: Mechanical Engineering professors Jonathan A. Malen and Paul S. Steif; Adjunct Mechanical Engineering Professor and Senior Scientist at Tissue Testing Technologies LLC Michael J. Taylor; and Vice President and Chief Scientific Officer at 21stCentury Medicine, Inc., Gregory M. Fahy.

Photo courtesy of the Lemelson-MIT Program

Whitacre Wins Lemelson-MIT Prize

by Tara Moore

Jay Whitacre, a professor of Materials Science and Engineering and of Engineering and Public Policy, received the 2015 $500,000 Lemelson-MIT Prize. The Lemelson-MIT Prize honors outstanding mid-career inventors who are improving the world through technological invention and demonstrating a commitment to mentorship in science, technology, engineering and mathematics (STEM).

The greatest technical challenge with harnessing electricity from renewable sources is its intermittency; storing energy for use when the sun isn't shining or a breeze isn't blowing remains an expensive hurdle. Further, energy storage batteries for stationary applications have historically been based on lead-acid chemistry that pollutes and is largely unreliable, or lithium-ion chemistry that has proven unsafe at times.

To address this problem, Whitacre invented the Aqueous Hybrid Ion (AHI™) battery, an environmentally benign and cost-efficient energy storage system. This first-of-its-kind battery, often used in combination with solar and wind energy systems, stores energy at a low cost and allows for around-the-clock consumption. Whitacre's AHI™ battery, developed using inexpensive resources including water, sodium and carbon, can help reduce dependence on fossil fuels and make sustainable energy a viable alternative.

Whitacre founded Aquion Energy in 2008, with the goal of bringing to market a new class of aqueous sodium ion functional battery. The Aquion battery systems help customers increase use of renewables, reduce reliance on diesel, control peak energy costs, provide power stability, bring access to electricity in under-electrified regions, and improve power reliability to areas with unstable grid infrastructure. Aquion Energy has fully scaled manufacturing and commercialized the battery with global distribution channels and installations in many locations including Australia, California, Germany, Hawaii, Malaysia and the Philippines.

Whitacre plans to contribute a significant portion of the Lemelson-MIT Prize money to create a fellowship to support graduate students and nurture interest in innovative energy solutions.

Unorthodox Approach to Drug Delivery Research Lands Professor on Popular Science's 2015 Brilliant 10 List

by Sherry Stokes

Kathryn Whitehead, an assistant professor of chemical engineering, has been named by Popular Science as a 2015 Brilliant Ten winner for her work on drug delivery systems.

Annually, Popular Science combs through hundreds of nominations to select the brightest minds in engineering and science. Whitehead was selected for designing nanoparticles that treat disease by delivering therapeutic drugs to specific areas in the body. Her research will revolutionize how we treat diseases, such as cancer, diabetes and hereditary disorders.

Whitehead synthesized and tested nearly 5,000 nanoparticle delivery vehicles en route to identifying a select few that potently shuttle drugs into exactly the right cells. This feat was challenging, in part, because the body's immune system considers therapeutic nanoparticles to be foreign substances that need to be destroyed. However, Whitehead's nanoparticles circumvent the immune system and are free to deliver medicine to cells in many parts of the body. Whitehead's research group is now using nanoparticles to engineer therapies for maladies that include inflammatory bowel disease, chronic wounds and Non-Hodgkin's lymphoma.

"Cancer therapy is so difficult for patients, in large part, because of the toxic side effects of chemotherapy," says Whitehead. "In contrast, our targeted nanoparticles deliver drugs only to cancerous tissue, sparing healthy cells. We expect these targeted treatments to extend the lives of cancer patients while increasing their quality of life through a reduction in side effects."

Whitehead's approach to finding the right nanoparticles for drug delivery was unorthodox in that it required her to examine a very large number of nanoparticles using high-throughput screening.

"Although high-throughput screening has not been a well-accepted approach to scientific discovery, I felt strongly that we needed to test many compounds to maximize our chances of success," says Whitehead. Her hard work has paid off in the discovery of these nanoparticles, and she has broadened the scientific community's understanding of how drug delivery chemistry affects efficacy.

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TRANSFORMATIONAL EFFECT ON SOCIE
3-D BIOPRINTING CONTINUE TO GROW
LARGE NUMBE
–JAMES G

Models of hearts, arteries, bones and brains are 3-D printed out of biological materials

nanoGriptech Is First Mass Manufacturer of a Strong and Sensitive Gecko-Inspired Adhesive

by Sherry Stokes

Carnegie Mellon University spinoff nanoGriptech has announced the launch of Setex™, the first commercially available gecko-inspired adhesive. Because it is dry and can repeatedly grip to surfaces without leaving a residue, Setex™ addresses the needs of many industries, including automotive, manufacturing, medical, defense, aerospace and apparel.

nanoGriptech was founded by Mechanical Engineering Professor Metin Sitti, who worked for nearly a decade to understand and synthesize biologically inspired micro/nanostructured adhesives. Headquartered in Pittsburgh, nanoGriptech exemplifies how universities and industry work together to support innovation and economic growth.

"Much like Velcro™ or Kevlar™, we believe Setex™ will disrupt markets because of its many commercial applications. Setex™ is residue-free, strong and reusable," says Roi Ben Itzhak, nanoGriptech CFO and vice president of business development.

Setex's™ glue-free fibers mimic the adhesive qualities of gecko foot hair. Intermolecular forces found at the tips of the hairs enable geckos to walk across ceilings. Like a gecko's foot, Setex™ can be applied to a variety of surfaces and lifted repeatedly. The synthetic fibers are strong – several square inches of Setex™ will support hundreds of pounds. nanoGriptech researchers can customize their manufacturing techniques at the microscale level to produce materials that are modified for different applications, such as enhancing a robot's ability to pick up a part or improving the fit of prosthetic limbs on skin.

Founded in 2009, nanoGriptech has earned the university four patents and eight more are pending. The company's customers include NASA, the Department of Defense and Fortune 500 companies.

Spinoff Ottomatika Acquired by Delphi

by Sherry Stokes

Ottomatika Inc., a Carnegie Mellon University spinoff company that provides software and systems development for self-driving vehicles, was acquired by the vehicle technology company Delphi Automotive PLC.

Led by Electrical and Computer Engineering Professor Raj Rajkumar, Ottomatika spun off from Carnegie Mellon in 2013 and received an investment from Delphi in November 2014.

The Ottomatika deal highlights Carnegie Mellon's advanced expertise in complex autonomous vehicle systems and in creating exciting companies and technologies that are highly sought after by industry. Ottomatika's software acts as the brain powering Delphi's advanced network of sensor technology for autonomous vehicles. Together, they create a platform that enables vehicles to make safe, highly complex decisions in an instant.

> "THE FOUNDING AND PURCHASE OF OTTOMATIKA VALIDATES CARNEGIE MELLON'S PIONEERING STRENGTHS IN AUTOMATION, ROBOTICS AND SOFTWARE ENGINEERING. CREATING HIGH-TECH COMPANIES IN PITTSBURGH BENEFITS THE UNIVERSITY AND REGIONAL ECONOMIC DEVELOPMENT." –RAJ RAJKUMAR

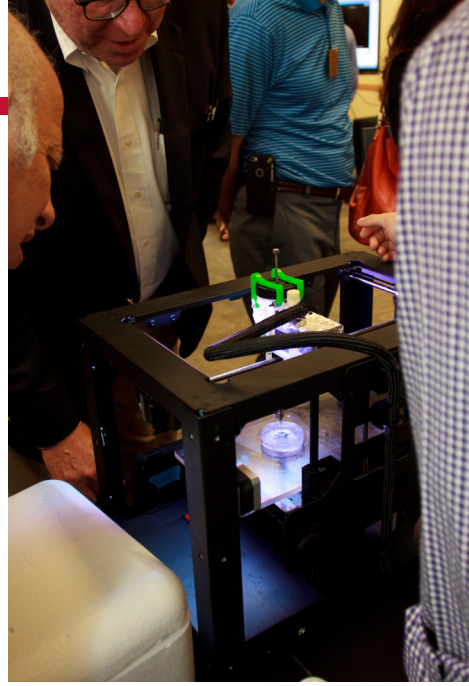
The Delphi Drive system, powered with software from Ottomatika, was recognized at the Consumer Electronics Show among Mashable's Best of CES 2015. In addition, the combined software from Delphi and Ottomatika enabled the longest drive by an automated vehicle in North America in April 2015. The Delphi vehicle completed a 3,400-mile trip from San Francisco to New York in autonomous mode 99 percent of the time. During the nine-day trip, the vehicle navigated through construction zones and met a variety of traffic and weather conditions.

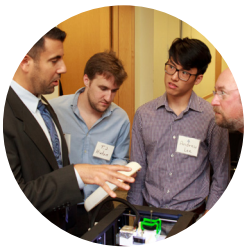
Carnegie Mellon has been at the forefront of autonomous vehicle research and development for more than 30 years. The university has filed more than 140 invention disclosures for related technologies and has created 14 generations of self-driving vehicles.

"Carnegie Mellon is known for its excellent and innovative research and an entrepreneurial culture that translates research results into high-quality companies like Ottomatika," said James H. Garrett, dean of the College of Engineering.

"Faculty to Global Leaders" Program Connects Research and Industry

by Hannah Diorio-Toth





Photographs by Neil Richmond

Whether partnering with a large corporation or with a small startup, industry relationships are integral to the College of Engineering. In an effort to increase unique opportunities for collaboration, Carnegie Mellon's College of Engineering and Robotics Institute partnered with the Young Presidents' Organization and World Presidents' Organization (YPO-WPO), an international networking organization for top executives, on an initiative called Faculty to Global Leaders.

Carnegie Mellon is one of only eight institutions chosen to participate in the new program, which connects the university to a worldwide network of 20,000 chief executives in more than 120 countries.

To solidify the promising relationship, Carnegie Mellon welcomed to campus nearly 80 YPO-WPO members from the Pittsburgh chapter. Eight faculty from the College of Engineering and Robotics Institute were selected as Faculty to Global Leader Fellows and gave presentations about their research. As faculty fellows, their role is to enhance YPO-WPO members' understanding of topics that could impact business and the community.

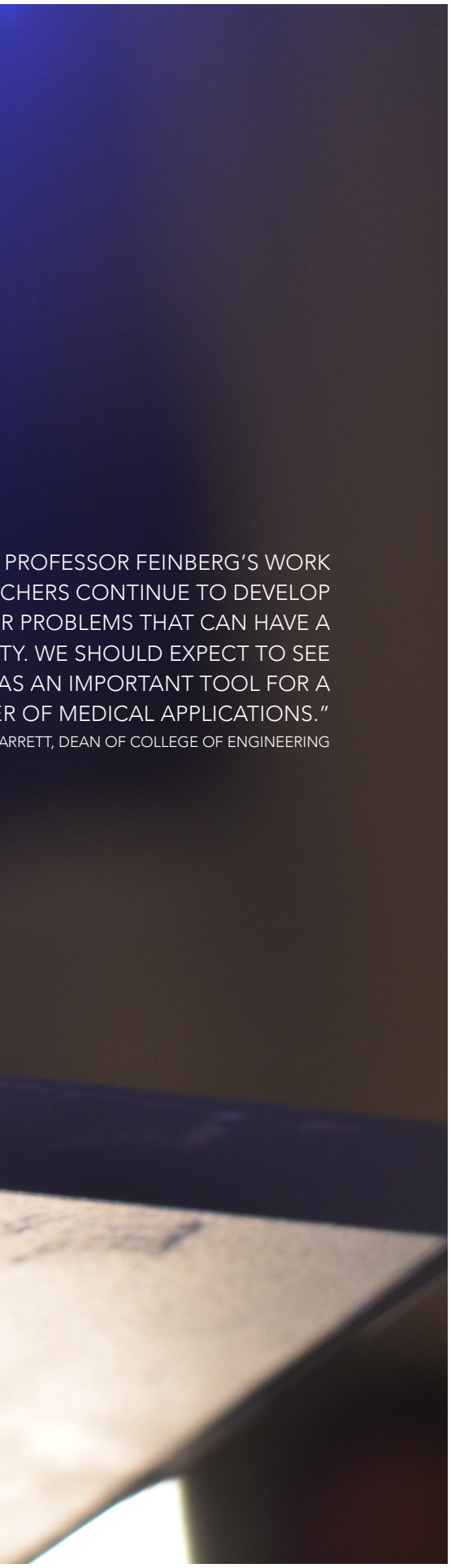
At the event, YPO-WPO members were introduced to a number of topics, including self-driving vehicles, smart building infrastructure and intelligent machines. A subject that resonated with the group was additive manufacturing, or 3-D printing, and its potential to have a huge impact on industries, ranging from aerospace to healthcare. Jack Beuth, professor of mechanical engineering, spoke about his cutting-edge work in optimizing the process of 3-D printing with metals for industry manufacturing. Adam Feinberg, assistant professor of materials science and biomedical engineering, talked about the 3-D printing of soft biomaterials such as blood vessels and heart muscles, which he hopes will someday be used as a method of heart repair.

The event included demonstrations where faculty informally talked with the YPO-WPO attendees and presented their technologies. Hae Young Noh, assistant professor of civil and environmental engineering, demonstrated ground sensor technology which monitors vibrations to determine not only where people are, but who they are. Noh and her collaborator Pei Zhang, associate research professor of electrical and computer engineering at the Silicon Valley campus, view their technology as a particularly impactful tool to prevent the elderly from falling in medical facilities and residential homes.

The interactive design of the event mimicked the hands-on relationship that the Faculty to Global Leader Fellows will continue to have with YPO-WPO members. As fellows, the faculty are able to speak and network at YPO-WPO events worldwide. Another benefit of the Faculty to Global Leaders program is that it provides opportunities for Carnegie Mellon graduate students to get involved in YPO-WPO business initiatives.

"The partnership between Carnegie Mellon and YPO-WPO is phenomenal. It opens up new connections between research and business. We learned that we can knock on these doors when we have questions or see an opportunity," says regional YPO-WPO member Ed De La Torre.

"THIS PARTNERSHIP WITH YPO-WPO IS AN EXCELLENT OPPORTUNITY FOR CARNEGIE MELLON TO EXPOSE A GROUP OF HIGH-QUALITY BUSINESS LEADERS AND INNOVATORS FROM AROUND THE WORLD TO OUR RESEARCH. THE COLLEGE OF ENGINEERING VALUES OUR CORPORATE COLLABORATIONS BECAUSE THEY SHARE OUR GOALS TO DELIVER HIGH-IMPACT RESULTS AND TACKLE REAL WORLD PROBLEMS." –JAMES GARRETT, DEAN OF COLLEGE OF ENGINEERING



Engineer Hacks Off-the-Shelf 3-D Printer Toward Rebuilding the Heart

by Daniel Tkacik

Right now more than 4,000 Americans are on the waiting list to receive a heart transplant. With failing hearts, these patients have no other options; heart tissue, unlike other parts of the body, is unable to heal itself once it is damaged. Fortunately, recent work coming out of the College of Engineering could one day lead to a world in which transplants are no longer necessary to repair damaged organs.

"We've been able to take MRI images of coronary arteries and 3-D images of embryonic hearts and 3-D bioprint them with unprecedented resolution and quality out of very soft materials like collagens, alginates and fibrins," said Adam Feinberg, an associate professor of Materials Science and Engineering and Biomedical Engineering. Feinberg leads the Regenerative Biomaterials and Therapeutics Group, and the group's study was published in the October 23 issue of the journal Science Advances.

"As excellently demonstrated by Professor Feinberg's work in bioprinting, our CMU researchers continue to develop novel solutions like this for problems that can have a transformational effect on society," said Jim Garrett, Dean of Carnegie Mellon's College of Engineering. "We should expect to see 3-D bioprinting continue to grow as an important tool for a large number of medical applications."

Traditional 3-D printers build hard objects typically made of plastic or metal, and they work by depositing material onto a surface layer-by-layer to create the 3-D object. Printing each layer requires sturdy support from the layers below, so printing with soft materials like gels has been limited.

"3-D printing of various materials has been a common trend in tissue engineering in the last decade, but until now, no one had developed a method for assembling common tissue engineering gels like collagen or fibrin," said TJ Hinton, a graduate student in biomedical engineering at Carnegie Mellon and lead author of the study.

"The challenge with soft materials — think about something like Jello that we eat — is that they collapse under their own weight when 3-D printed in air," explained Feinberg. "So we developed a method of printing these soft materials inside a support bath material. Essentially, we print one gel inside of another gel, which allows us to accurately position the soft material as it's being printed, layer-by-layer."

One of the major advances of this technique, termed FRESH, or "Freeform Reversible Embedding of Suspended Hydrogels," is that the support gel can be easily melted away and removed by heating to body temperature, which does not damage the delicate biological molecules or living cells that were bioprinted. As a next step, the group is working towards incorporating real heart cells into these 3-D printed tissue structures, providing a scaffold to help form contractile muscle.

Bioprinting is a growing field, but to date, most 3-D bioprinters cost over $100,000 and/or require specialized expertise to operate, limiting wider-spread adoption. Feinberg's group, however, has been able to implement their technique on a range of consumer-level 3-D printers, which cost less than $1,000 by utilizing open-source hardware and software.

"Not only is the cost low, but by using open-source software, we have access to fine-tune the print parameters, optimize what we're doing and maximize the quality of what we're printing," Feinberg said. "It has really enabled us to accelerate development of new materials and innovate in this space. And we are also contributing back by releasing our 3-D printer designs under an open-source license."

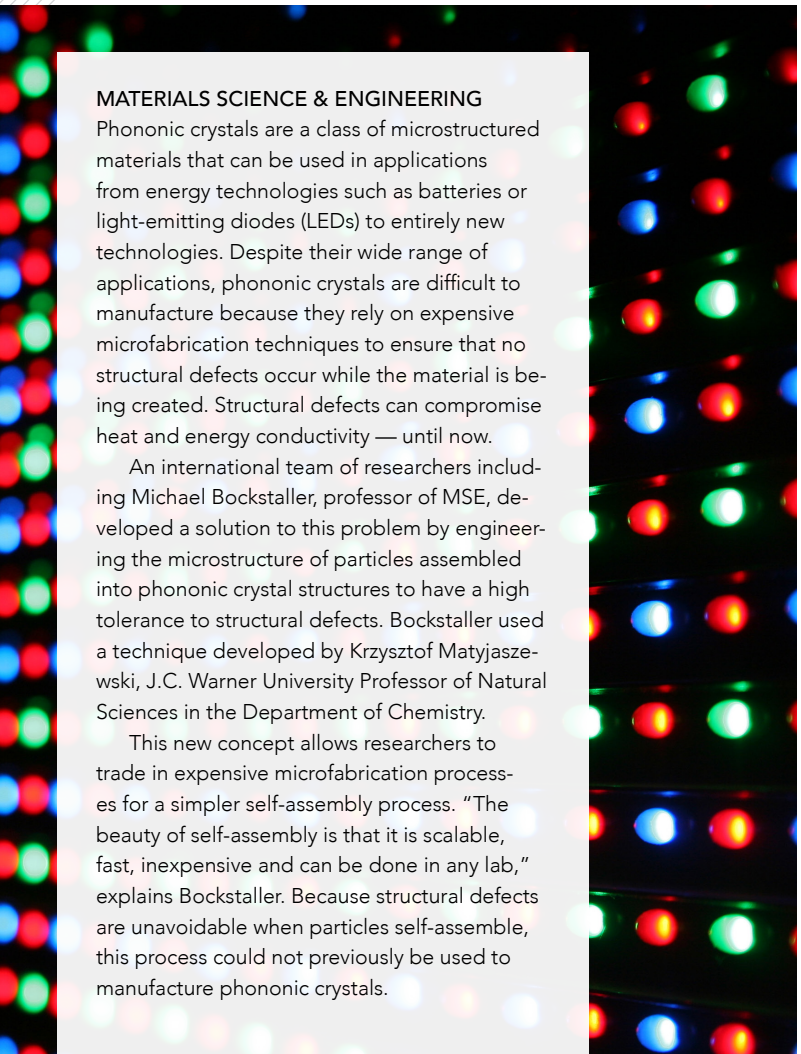
Department News

The initiatives underway in the College's departments embody the value we place on progress. Here are some of our current projects and prides.

BIOMEDICAL ENGINEERING Heart pumps, which assist more than three million Americans with congestive heart failure each year, lead to a staggering number of infections; many of which are deadly. To be exact, one in three patients with heart pumps develop infection. The National Institutes of Health (NIH) is keenly aware of the problem, and they have awarded a $1.2 million grant to Assistant Professor of BME Dennis Trumble to make a better, safer heart pump.

Because the vast majority of heart pump infections occur at the spot where the pump's power cord exits the body, Trumble believes the power cord should never exit the body, instead drawing power from an internal source. That power source, Trumble believes, could be a muscle in the patient's back.

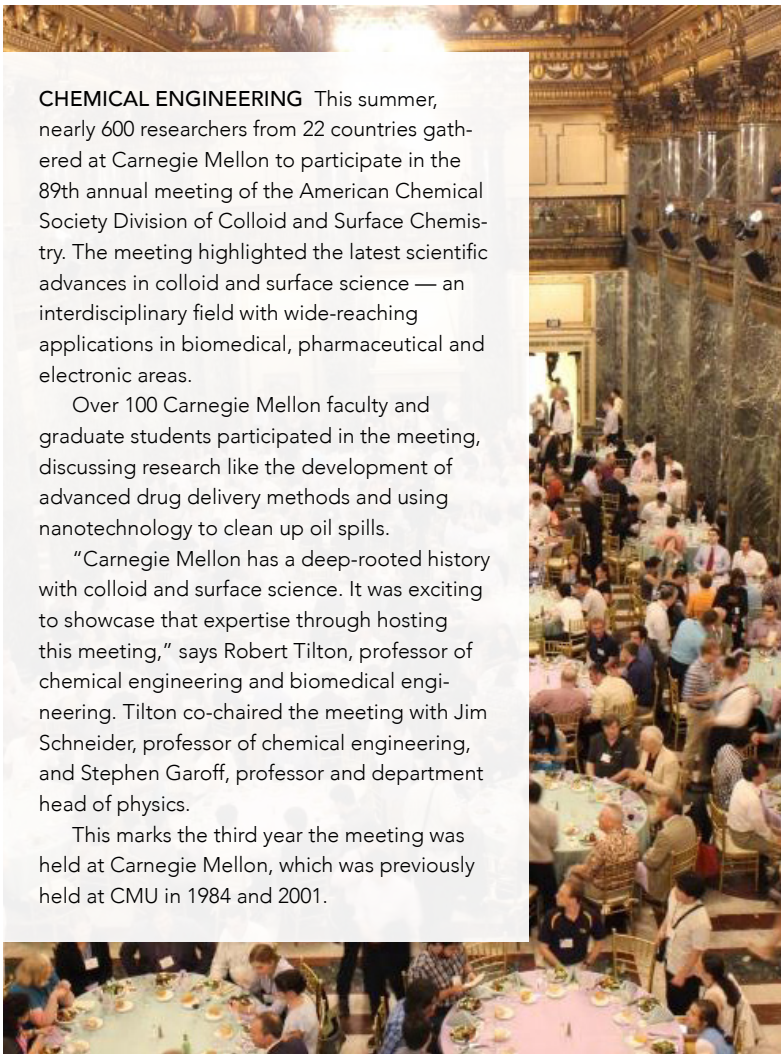
"The idea is to collect energy generated by the latissimus dorsi, a large muscle in the back," says Trumble. "Then we can convert that energy into hydraulics that can be used to activate the heart pump."



MATERIALS SCIENCE & ENGINEERING
Phononic crystals are a class of microstructured materials that can be used in applications from energy technologies such as batteries or light-emitting diodes (LEDs) to entirely new technologies. Despite their wide range of applications, phononic crystals are difficult to manufacture because they rely on expensive microfabrication techniques to ensure that no structural defects occur while the material is being created. Structural defects can compromise heat and energy conductivity — until now.

An international team of researchers including Michael Bockstaller, professor of MSE, developed a solution to this problem by engineering the microstructure of particles assembled into phononic crystal structures to have a high tolerance to structural defects. Bockstaller used a technique developed by Krzysztof Matyjaszewski, J.C. Warner University Professor of Natural Sciences in the Department of Chemistry.

This new concept allows researchers to trade in expensive microfabrication processes for a simpler self-assembly process. "The beauty of self-assembly is that it is scalable, fast, inexpensive and can be done in any lab," explains Bockstaller. Because structural defects are unavoidable when particles self-assemble, this process could not previously be used to manufacture phononic crystals.



CHEMICAL ENGINEERING This summer, nearly 600 researchers from 22 countries gathered at Carnegie Mellon to participate in the 89th annual meeting of the American Chemical Society Division of Colloid and Surface Chemistry. The meeting highlighted the latest scientific advances in colloid and surface science — an interdisciplinary field with wide-reaching applications in biomedical, pharmaceutical and electronic areas.

Over 100 Carnegie Mellon faculty and graduate students participated in the meeting, discussing research like the development of advanced drug delivery methods and using nanotechnology to clean up oil spills.

"Carnegie Mellon has a deep-rooted history with colloid and surface science. It was exciting to showcase that expertise through hosting this meeting," says Robert Tilton, professor of chemical engineering and biomedical engineering. Tilton co-chaired the meeting with Jim Schneider, professor of chemical engineering, and Stephen Garoff, professor and department head of physics.

This marks the third year the meeting was held at Carnegie Mellon, which was previously held at CMU in 1984 and 2001.

CIVIL & ENVIRONMENTAL ENGINEERING

In January, 2015, the Department of Civil and Environmental Engineering formally established the Center for Engineering and Resilience for Climate Adaptation (CERCA).

CERCA is an interdisciplinary research center committed to developing a suite of novel methods, tools and analyses needed to incorporate the impacts of climate change into engineering infrastructure designs and decision-making.

With a foundation in civil and environmental engineering methods, the Center adds expertise from multiple engineering disciplines, public policy, social and decision sciences, and other fields with a goal of changing the way we think about infrastructure.

"We feel that understanding climate change adaptation for infrastructure will be essential for civil and environmental engineers, whether they are just starting out or already leaders in the field," says Costantine Samaras.

MECHANICAL ENGINEERING

Associate Professor Steve Collins of MechE and his collaborator Greg Sawicki at North Carolina State University have developed a lightweight, unpowered, wearable exoskeleton device called the Walking Assist Clutch to reduce the energy cost of human walking. This wearable boot-like apparatus, when attached to the foot and ankle, reduces the energy expended in walking by around 7% by using a spring that acts like the Achilles' tendon and a clutch that mimics the calf muscles.

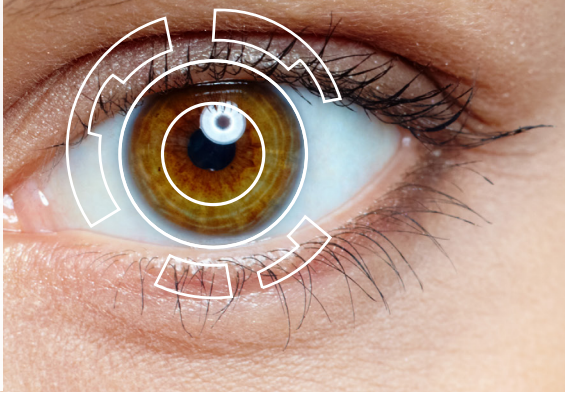
While 7% may seem like a small reduction in energy, the added support will benefit many populations — particularly those recovering from injuries or whose professions require much standing or walking.

"Think of nurses, emergency response workers, soldiers, or the millions of other people who walk many hours a day," says Collins. "7% would make a difference to them."

ELECTRICAL & COMPUTER ENGINEERING Marios Savvides, research professor of ECE and director of the CyLab Biometrics Center, is developing a long-range iris enrollment and recognition system. This "iris scanner" system is able to acquire images of eyes from a range of up to 12 meters, with image quality comparable to shorter range systems that are already being deployed.

Innovative devices and technologies capable of analyzing such traits as retinas, irises, voice patterns, facial features and hand measurements are already being used for biometric authentication across a wide array of areas including corporate and public security systems, military surveillance, counter-terrorism initiatives and point of sale applications. But Savvides' long-range acquisition capability, in conjunction with the iris segmentation and matching techniques developed within the Center, pushes the boundaries of existing iris recognition systems.

Such marked improvement of this technology will have many applications for the future, such as prevention of human trafficking, reduction of traffic violence and increase in biometric password security.



ENGINEERING & PUBLIC POLICY Associate Department Head and Professor Scott Matthews and Assistant Teaching Professor Deanna Matthews have received a grant from the National Institute of Standards and Technology (NIST) to develop online and traditional course materials related to environmental performance standards, with a specific focus on ISO 14040. This is a life cycle assessment standard designed to highlight the environmental impact of a product throughout its lifespan and areas for improvement in its production and use.

Center for Faculty Success Open for Business

by Emily Durham

The College of Engineering has founded a brand-new initiative to provide support to the university's most valuable resource: its faculty.

"Faculty are our most important asset," says Diana Marculescu, founding director of the Center for Faculty Success and professor of Electrical and Computer Engineering. "They drive innovation, and they create successful stories."

Successful stories indeed: our faculty's research, dedication and innovation in the classroom are world-renowned, the pillars of our global reputation. But pillars can't stand without a strong foundation — a foundation the newly established Center for Faculty Success aims to provide.

From junior faculty members to senior, the Center for Faculty Success's programs — which just kicked off this fall — will support their professional and personal interests, provide opportunities for professional development and leadership training, and advocate for supportive and family-friendly policies within the university.

In particular, for junior faculty who are new to the university, the Center will provide numerous opportunities that will help them adjust to our university's culture. Such opportunities will include mentoring by senior faculty, workshops to enhance skills in practical areas such as grant writing and networking, and training to learn how to avoid implicit bias in the workplace. Other activities through the Center for Faculty Success will include advocacy on behalf of diversity in the workplace, faculty recruitment opportunities and more.

"[The Center for Faculty Success] will help us achieve our goals as a department and as a college," says Dave Dzombak, Hamerschlag University Professor and head of Civil and Environmental Engineering. "It will help faculty achieve their goals and overall elevate the happiness and performance of faculty working in our department and in the college."

Learn more about the Center for Faculty Success here:
engineering.cmu.edu/faculty_staff/services/center_faculty_success/index.html

Book Corner

Here are some books our Department Heads are currently reading:

Pride and Prejudice
Jane Austen

Promise at Dawn
Romain Gary

Tuesdays with Morrie
Mitch Albom

Lawrence in Arabia
Scott Anderson

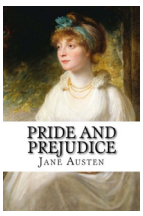
Battling the Inland Sea
Robert Kelley

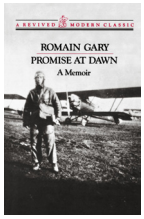
The Wright Brothers
David McCullough

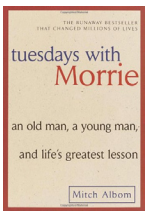
Blink
Malcolm Gladwell

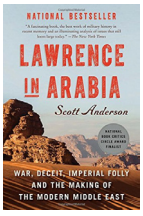
One Nation
Ben Carson

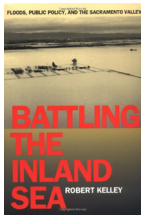
The Checklist Manifesto
Atul Gawande

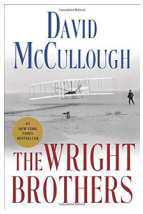


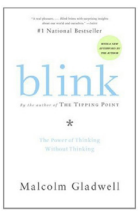


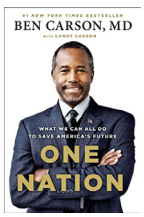


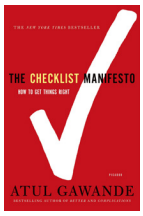












"Intelligent" Training Training Tool to Treat Prostate Cancer

by Lisa Kulick

Professor Yoed Rabin is leading a team that's developing a new approach to improve training for cryosurgery procedures used to treat prostate cancer. This approach will shorten the learning curve and improve the quality of the minimally invasive treatment by reducing complications, shortening recovery times and lowering health care costs.

Rabin's team has developed the first computerized training tool that provides feedback to the trainee and offers advice on how to maximize the freezing of cancer tumors while preserving the healthy tissues surrounding the site.

Prostate cancer is the second leading cause of cancer death in men according the American Cancer Society, which predicts that one in seven men will be diagnosed with the disease during his lifetime and one in 38 will die from the disease.

In an article published in Technology in Cancer Research & Treatment, Rabin's team demonstrated how its intelligent tutoring approach could shorten the learning curve of surgical residents. The computerized system, which runs about 100 times faster than the actual cryosurgery procedure, uses algorithms to create 3-D thermal images of tumors in patients in a variety of scenarios. This allows the trainees to see firsthand the effects of the tissue they are freezing.

"Cryogenic technology today is far more advanced than the surgical treatment methods used by surgeons," Rabin explained. "As engineers and surgeons collaborate, we can improve the quality of the applied methods and advance the widespread use of cryotherapy."

Carnegie Mellon co-authors on the paper include Kenji Shimada, professor of mechanical engineering and recent Ph.D. graduates Anjali Sehrawat and Robert Keelan.

Can Microchips Be Trusted?

by Krista Burns

Technology. We're immersed in it every day. Your cell phone, computer, television and automobile are all pieces of technology—hardware designed with software for practical purposes. We've all been warned about the implications of malicious software: viruses, data breaches and identity theft. But what about the hardware? Are you sure the hardware in your device is trustworthy?

We assume the microchips in our devices were made under strict guidelines and will perform as intended. Unfortunately, that is not always the case.

As the global leader in manufacturing, China produces the majority of microchips used in electronics. However, the production of microchips is not currently regulated in China. Without adhering to strict guidelines, factories can manufacture counterfeit microchips, resulting in underperformance and shorter life spans. Counterfeiting microchips can take many forms: improper recycling, unauthorized production and cloning, introducing hardware Trojans and illegally brand-stamping are all ways counterfeit microchips are making their way into technology we use.

In 2010, the United States Navy unknowingly purchased 59,000 counterfeit Chinese computer microchips to be used aboard warships, fighter planes and anti-missile systems. Robert Ernst, head of research for the Naval Air Systems Command's Aging Aircraft Program, estimates as many as 15% of all the spare and replacement microchips that the Pentagon buys are counterfeit. A 2012 Defense Science Board survey estimates that one in three deployed military systems have counterfeit chips in them.

While these statistics are worrying, the future is hopeful. Researchers in Carnegie Mellon's Department of Electrical and Computer Engineering (ECE) are training people and creating the technology needed to combat hardware security threats. Principal Systems Scientist Ken Mai is developing new, low-cost, hardware-level methods of securing electronic systems against illegal counterfeiting.

Imagine if each microchip were produced with a unique fingerprint, or a secure chip odometer, that would allow it to be tracked from production to installation. The secure chip odometer would gauge authentication of provenance to enable differentiation between genuine and counterfeit parts. Much like a vehicle identification number, the secure chip odometer would allow users to track if a microchip is new or used, when it was manufactured, how long it has been in operation and whether it has been tampered with.

To support his research in combatting microchip counterfeiting, Mai received one of nine awards given by the National Science Foundation (NSF) and the Semiconductor Research Corporation (SRC) under the Secure, Trustworthy, Assured and Resilient Semiconductors and Systems Program (STARSS).

Mai and the rest of the ECE department have a unique angle for approaching the topic of hardware security. "We saw an opportunity to approach hardware security from a hardware design perspective, versus a security perspective," says Mai. "Most of the people working in the space are security people trying to do hardware. We are hardware people applying our skill set to provide security."

Mai believes we could be using the secure chip odometer in a few years. And in the meantime? "Be smart about the hardware you use," says Mai. "Purchase hardware from trusted sources and recycle properly. Common sense goes a long way toward protection."

Professorships Honor Academic Leaders

The College of Engineering searches the world to hire the brightest people as its faculty. Among the college's pool of brilliant and respected educators is a cadre of individuals who merit special recognition for outstanding contributions. This recognition comes in the form of endowed professorships or chairs. Chairs symbolize the confidence that industry, philanthropic organizations and generous benefactors have in a faculty member's work. Through endowed professorships, the college honors and supports faculty by providing the resources they need to remain at the forefront of their fields. Below are some of our newly endowed professors and a glimpse into their work.

Burcu Akinci

Paul P. Christiano Professor in Civil and Environmental Engineering, 2014

The complexities of construction projects and facility operations lie at the heart of Akinci's research. As the co-director of the Smart Infrastructure Institute, she works with sensor-data-driven management and builds information-rich history models to aid decision-making during construction planning and execution. She aims to streamline construction and facility management processes.

Kumar Bhagavatula

U.A. and Helen Whitaker Professor in Electrical and Computer Engineering, 2014

One way of matching biometric signatures (face or iris images) with stored templates is to correlate the two. Bhagavatula is developing methods to perform these correlations in the presence of significant appearance variability in the biometric signatures (e.g. illumination changes, expression differences). His research interests also include: computer vision for autonomous/assisted driving, signal processing for two-dimensional magnetic recording (TDMR) and coding for flash memory systems. Bhagavatula is the Associate Dean for Graduate and Faculty Affairs for the college.

Jacobo Bielak

Hamerschlag University Professor in Civil and Environmental Engineering, 2014

Bielak's research focuses on monitoring bridge structures, earthquake engineering and engineering seismology. He creates 3-D models to simulate earthquake effects on buildings and bridges. He is a member of the original Applied Technology Council committee that drafted the first seismic provisions for soil-structure interaction in the US, based mainly on his work. These provisions are now part of the National Earthquake Hazards Reduction Program (NEHRP) seismic provisions.

Neil M. Donahue

Thomas Lord Professor in Chemistry, 2015

Donahue, the director of the Steinbrenner Institute for Environmental Education and Research, is one of the most cited scientists in the field of geoscience. A leading expert in atmospheric chemistry and air-quality engineering, his research focuses on oxidation chemistry in the earth's atmosphere and on aerosols, which have a negative impact on human health and the atmosphere.

Mario Bergés, associate professor of Civil and Environmental Engineering, is using sensing and data analysis to make built environments more adaptive and efficient by, for example, detecting anomalous behavior in embankment dams before they occur, or detecting and localizing structural damages in pipelines using acoustic waves. The majority of his present work, however, involves collecting and integrating data about buildings and using it to make better-informed decisions about the operation of these facilities under resource and occupant comfort constraints. One of the biggest challenges in this space, he says, is that "none of the software solutions we have for managing and/or controlling buildings systems scales well across the entire building stock." In other words, software applications are generally custom developed for each facility. "There is no Windows or OS X for buildings," says Bergés.

Along with other faculty members in the Smarter Infrastructure Institute at CMU, he has been tackling this problem by developing a common software platform that can be used to integrate not just building systems, but all the various internet-connected devices present in large built environments. This "operating system" will improve our ability to monitor and control our infrastructure and will contribute significantly to energy savings.

Matteo Pozzi, assistant professor in Civil and Environmental Engineering, focuses on probabilistic risk analysis and decision optimization related to civil infrastructures. He uses various types of sensors to measure strain and vibrations in an effort to mitigate risks and extend the life-spans of civil infrastructure systems.

In one of his projects, the new Scott Hall Building is a testbed for developing and testing a new platform for wireless sensor monitoring. "It is an interesting structure: a cantilever suspended on slender steel columns," says Pozzi. The monitoring system can collect measurements for the condition assessment of those columns, of the horizontal steel girders, and of the overall performance of the building. During the building's construction, fiber optic strain sensors were permanently installed and they provide continual information about the condition of the columns. The monitoring of Scott Hall is intended as pilot study for extensive monitoring of other buildings on campus.

Civil and Environmental Engineering Assistant Professor **Sean Qian** uses data collected from transportation agencies and private sector to manage aging and overcrowded transportation infrastructure systems. The various agencies that manage highway, public transit and parking systems don't communicate with each other. By integrating all their data, Qian is learning how people travel — their routes and parking choices, modes of transportation, and departure times. By understanding human behavior he can help agencies better manage passenger and vehicle flow. In one research project, he is studying how roadway reconstruction on the I-95 and the Center City Philadelphia's Vine Street Expressway affects traffic flow. He is working with the Pennsylvania Department of Transportation to find the best ways to detour traffic by using signaling, signage and social media to mitigate congestion in the real time.

Hae Young Noh takes a different approach in her use of sensing technologies — she wants to turn "structures into sensors." Instead of using cameras and sensors to monitor people or environments, she explores how buildings themselves provide clues about human activity or environmental conditions. People moving through a building create vibrations, while temperature and other factors affect how buildings vibrate, too. Noh, an assistant professor Civil and Environmental Engineering, believes that she can use fewer sensors that measure vibrations to reveal where people are in a building and what they are doing. Her work will make outfitting buildings with sensors less expensive because there will be fewer sensors and reduced installation and maintenance costs.

Noh is collaborating with Electrical and Computer Engineering Associate Research Professor **Pei Zhang** on a project in a Californian nursing home in which sensors are used to prevent elderly patients from falling. By monitoring vibrations, the sensors detect if a person is fatigued or about to fall. The system alerts caretakers if a patient is moving erratically because the individual may be tired or dizzy from medication.

SURF Summer

by Adam Dove

Through the Summer Undergraduate Research Fellowship (SURF) program, students in the College of Engineering work to bring new technologies into the world. Here are two students who chose to spend their summer SURFing.

HOW CAN YOU KEEP HACKERS FROM CONTROLLING YOUR CAR?

Mechanical Engineering junior Andrew Sun was planning his summer break when fascinating research in Assistant Professor Venkat Viswanathan's lab piqued his interest.

"The project looked into the process of possibly having your battery drained in an electric car," says Sun.

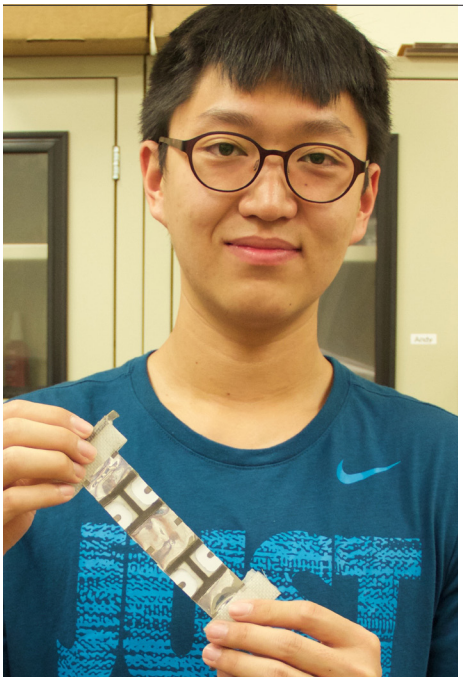
"INSIDE AN ELECTRIC CAR, THERE'S A PROGRAMMING CONTROL UNIT WHICH CONTROLS THE OPERATION OF THE BATTERY. IF HACKERS CAN ACCESS THIS CONTROL UNIT, THEY CAN FEED IT THEIR OWN CODE AND CAUSE IT TO BEHAVE IN WAYS IT SHOULDN'T, MAKING THE CAR LESS EFFECTIVE." –ANDREW SUN

As our vehicles become increasingly more intelligent, they also become more vulnerable. "Inside an electric car, there's a programming control unit which controls the operation of the battery," he explains. "If hackers can access this control unit, they can feed it their own code and cause it to behave in ways it shouldn't, making the car less effective."

The research team split into two groups: one trying to hack into the car, the other — the team Sun was on — studying all of the things that could possibly go wrong with an electric vehicle battery. They pored over mountains of data, learning everything they could about the normal operation of a battery, in order to find ways to ensure the safety of the driver.

This isn't research that can be completed in just a couple of months — although the summer ended, Sun's passion for the work hasn't.

"This research is something I'm very interested in continuing," Sun says. "We want to see the results of where this can go."



WHY DO ROBOTS NEED MUSCLES?

Mechanical Engineering senior Yichu Jin spent his summer flexing — electronics, that is. As an undergraduate research assistant in Assistant Professor Carmel Majidi's Soft Machines Lab, Jin devoted his time developing flexible materials that go rigid in response to an electric charge, much like our muscles do.

"The idea is to start by building one cell," Jin explains, "and then expand that to an array design." Each of these cells is really two layers of material applied one on top of the other. In its resting state, the material can be pulled and stretched like a rubber band. However, when a current is applied at each end, the material locks up and becomes rigid. "If you apply around 200 volts, you're able to increase the rigidity of the material by about 17 times," Jin says. "That's the best result I've gotten in the lab so far."

These flexible cells have all sorts of applications in the future of soft robotics — including robotic muscles — that might one day make the bodies of our robots just as pliable and responsive as our own.

"There are a lot of possible applications for this rigidity-tuning device — artificial muscles for humanoid and bio-inspired robots, exoskeletons that prevent injury during collisions or even clothing-embedded technology for military use," Jin says.

"One thing I learned about doing research is that you have to have a calm mindset," says Jin, "because this is the nature of research: You fail and then you try again, and then it gives you hope, and then you fail again. But eventually you do succeed."

INI Celebrates Women in Computing at Grace Hopper

by Christa Jones and Daniel Tkacik

Janet George, SanDisk chief data scientist, said it best at the 2015 Grace Hopper Celebration of Women in Computing (GHC): "Technology is great. It won't change the world. People will."

For three days this October, the most ambitious women in tech gathered at the world's largest technical conference for women in computing to inspire, support and engage one another to ignite change. Among these 12,000 women technologists were students and alumnae of the Information Networking Institute (INI), representing Carnegie Mellon University (CMU) for the ninth year at the GHC.

INI has been a strong supporter of the annual conference since 2006 as a silver-level sponsor and, in 2012, became a gold-level academic sponsor. Each year, the INI selects at least six INI students to attend through Women@INI scholarships. Alumnae are also present as representatives for the likes of Google, Facebook, Yahoo, Hewlett-Packard and Cisco.

Admiral Grace Hopper once said, "the most dangerous phrase in the English language is 'it's always been done this way.'" In an effort to shake up the traditionally male-dominated engineering field, Dena Haritos Tsamitis has spearheaded a number of initiatives as director of the INI. "Attending and sponsoring Grace Hopper for the past nine years is just one example of the INI's long-standing commitment to increasing diversity in the field of engineering," said Tsamitis. "We embrace this year's GHC theme because it is indeed 'our time to lead' to a future where every person, no matter their gender, ethnicity or background, can thrive in the field."

At this year's conference, INI students mingled with pioneering women in tech, including Sheryl Sandberg, Facebook Chief Operating Officer; Megan Smith, U.S. Chief Technology Officer; and Manuela M. Veloso, one of Carnegie Mellon's own. Dr. Veloso, who is the Herbert A. Simon University Professor of Computer Science, accepted the INI's invitation to visit the CMU booth and meet with GHC attendees, as well as join the evening networking mixer. Her presence, alongside a number of successful INI alumnae, was a testament to the strength of Carnegie Mellon's science and technology programming.

Several INI students met extraordinary female role models at the conference and some even walked away with job offers, but all left with the knowledge that they play an important part in changing the world.

"After GHC, you come back as a totally different person," concluded INI student Arushi Grover. "A woman more confident, a woman more tolerant, a woman who now knows how to take on the world."

An Integrated Vision for Collaborative Learning, Making and Research

by Lisa Kulick

Hamerschlag Hall, the iconic flagship building of the university, is ready for a transformation. The College of Engineering plans to reenergize 40,000 existing square feet into a new Maker-Wing to fuse hands-on learning experiences with high impact, solutions-based research in one multidisciplinary hub.

The MakerWing will feature integrated student-focused maker spaces, clustered research environments, open work areas, advanced manufacturing facilities, and micro/nanosystems laboratories.

This unique wing will lower barriers to multidisciplinary collaboration while cultivating creative problem solving and "learning by doing." It will create an epicenter of ideas becoming real solutions in the education/research fusion that only Carnegie Mellon can deliver.

Students across the college will be able to pursue pragmatic designs and functional applications for coursework and independent projects such as Design II capstone projects and Build18, the freestyle tinkering competition.

The MakerWing represents a $23 million investment in students, faculty and the future of the College of Engineering. It will include a $5 million endowed equipment fund.

"We must commit to this Hamerschlag Hall renovation project for the future success of our students and faculty," says James H. Garrett Jr., Dean of the College of Engineering.

We invite College of Engineering alumni and friends to be a part of this exciting transformation. To learn more about the MakerWing and opportunities to support this ambitious reinvention of Hamerschlag Hall, please visit: **engineering.cmu.edu/giving/maker_wing.html**.

A Ripe Solution To End Hunger

by Hannah Diorio-Toth

According to the Food and Agricultural Organization of the United Nations, approximately 795 million people go undernourished daily. That's about one in nine people—a staggering statistic. Even more shocking is that the world is producing more than enough food to feed the entire population, but one third of food produced is wasted, often due to spoilage.

James Rogers (B.S. MSE, BME, '07)

When Materials Science and Engineering alum James Rogers (B.S. MSE, BME, '07) learned of this alarming reality, he decided to make a difference. "It's shocking that we are throwing away so much produce. By some reports, fifty percent here in the United States is lost!" says Rogers. "So I thought, 'what is causing this produce to spoil?'"

The answer brought memories of Rogers' undergraduate materials science courses flooding back to him. The two primary causes of produce spoilage, oxidation and water loss, also cause iron to rust. At Carnegie Mellon, Rogers learned how scientists created stainless steel to be rust resistant: they add specific kinds of atoms into the iron so that the atoms react with oxygen on the iron's surface to form a thin protective barrier.

"The question became, 'Can we solve the oxidation problem for produce the same way that the challenge was solved for stainless steel, by creating a thin barrier on the outside of the produce,'" explains Rogers.

The result from his inquiry was an edible barrier that increases the shelf life of produce two to five times. Made entirely from unused plant materials, the protectant is natural, clear, tasteless and odorless. This technology is the backbone of Rogers' company, Apeel Sciences, which is based in Santa Barbara, California. Roger founded the company in 2012 while finishing his Ph.D. in Materials Science at University of California, Santa Barbara.

This increase in shelf life can have a huge impact in developing countries where inadequate infrastructure and no access to refrigeration makes it difficult to keep produce fresh. Rogers is currently working to take the technology that he developed for fruits like strawberries and tailor it to crops relevant in developing countries in South America and sub-Saharan Africa. His first target is cassava, a large root vegetable that is a staple in the diet of millions of people in the developing world. Unfortunately, cassava only has a shelf life of about 48 hours, which makes the storing and transporting of cassava difficult. With a $1.5M grant and valuable mentoring from the Bill and Melinda Gates Foundation, Rogers and his team have begun working with the root to extend its shelf life and provide better nutrition to some of the world's poorest communities and access to market.

"Carnegie Mellon provided me with a broad exposure to a diversity of problems and a fundamental understanding of the underlying concepts of materials science," says Rogers. "When I got to graduate school, I discovered this problem of produce preservation, but I already had the vocabulary and core understanding that was developed during my undergraduate studies. I would certainly be at a different place in my life if I didn't go to Carnegie Mellon."

Associate Professor Steve Collins of Mechanical Engineering and his collaborator Greg Sawicki at North Carolina State University have developed a lightweight, unpowered, wearable exoskeleton device called the walking assist clutch to reduce the energy cost of human walking. Read about this and other department highlights on pages 12 and 13.

Carnegie Mellon University
Engineering

WINTER 2015

Carnegie Mellon University
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Final Words

What new strategies for manufacturing or entirely new business opportunities do you envision 3D printing with metals will allow?

STUDENT

Colt Montgomery

PhD Mechanical Engineering

As 3D printing technology and the ability to print in a variety of metal alloys become mainstream, the price of the technology drops and more businesses start to take advantage of the ability, design for manufacturing will drastically change. Corporations such as General Electric are already starting to use the ability to 3D print metals to design and build more functional parts that save weight as well as improve performance. As the industry develops, other companies will likely follow suit and then small businesses, if the price point drops low enough. This will open a new avenue for the manufacture of highly complex metal parts in low volumes without the expense of molds or complex machining. In addition to the ability to produce complex geometries, 3D printing of metals allows the production of structures that were previously impossible to make, such as cellular meshes in three dimensions. It is a very exciting prospect to be at the forefront of a new industrial revolution that has such strong roots here at Carnegie Mellon!

FACULTY

Jack Beuth

Professor, Mechanical Engineering

With respect to manufacturing strategies, 3D printing of metals will soon allow the tailoring of material microstructure and properties at every location in a part. Traditional processes cannot do this. Our research is showing machine users how to achieve this and more.

With respect to business opportunities, there will be a great need for software to help guide engineers in the vastly more complicated design process for 3-D printed parts. That includes guiding part design that has few limits on geometric complexity and guiding process design that tailors the process to the part. It also includes integrating cost metrics into the design process – so that the many options for making parts by 3D printing are filtered based on reducing cost.

ALUMNAE

Joy Gockel, PhD

Assistant Professor
Mechanical and Materials Engineering
Wright State University
PhD MechE '14

3D printing with metals seems to be infiltrating many areas of the manufacturing community. The key to success in implementation of 3D printing with metals is the identification of the applications that can best exploit the complexity of design available. However, increased complexity in design may require many design iterations. A key strategy in manufacturing is the ability to retool quickly to accommodate design changes. The relatively fast turn around time and low tooling requirements of the 3D printing process allows design changes to be welcomed for continuous improvement without incurring increased manufacturing costs. The low tooling requirements also provide the ability to easily customize small batch parts for a given application. New business opportunities lie in the niche markets. Applications that would not traditionally seek industrial manufacturing technologies are able to achieve high quality parts with low overhead.

Carnegie Mellon University

Engineering

Winter 2015 Carnegie Institute of Technology Alumni Magazine

A Smarter Way To Build Things

Off-the-Shelf 3-D Printer for Rebuilding the Heart

"Faculty to Global Leaders" Program Connects Research and Industry

Turning the Page on Unsafe Drinking Water

A Ripe Solution To End Hunger