Carnegie Mellon University

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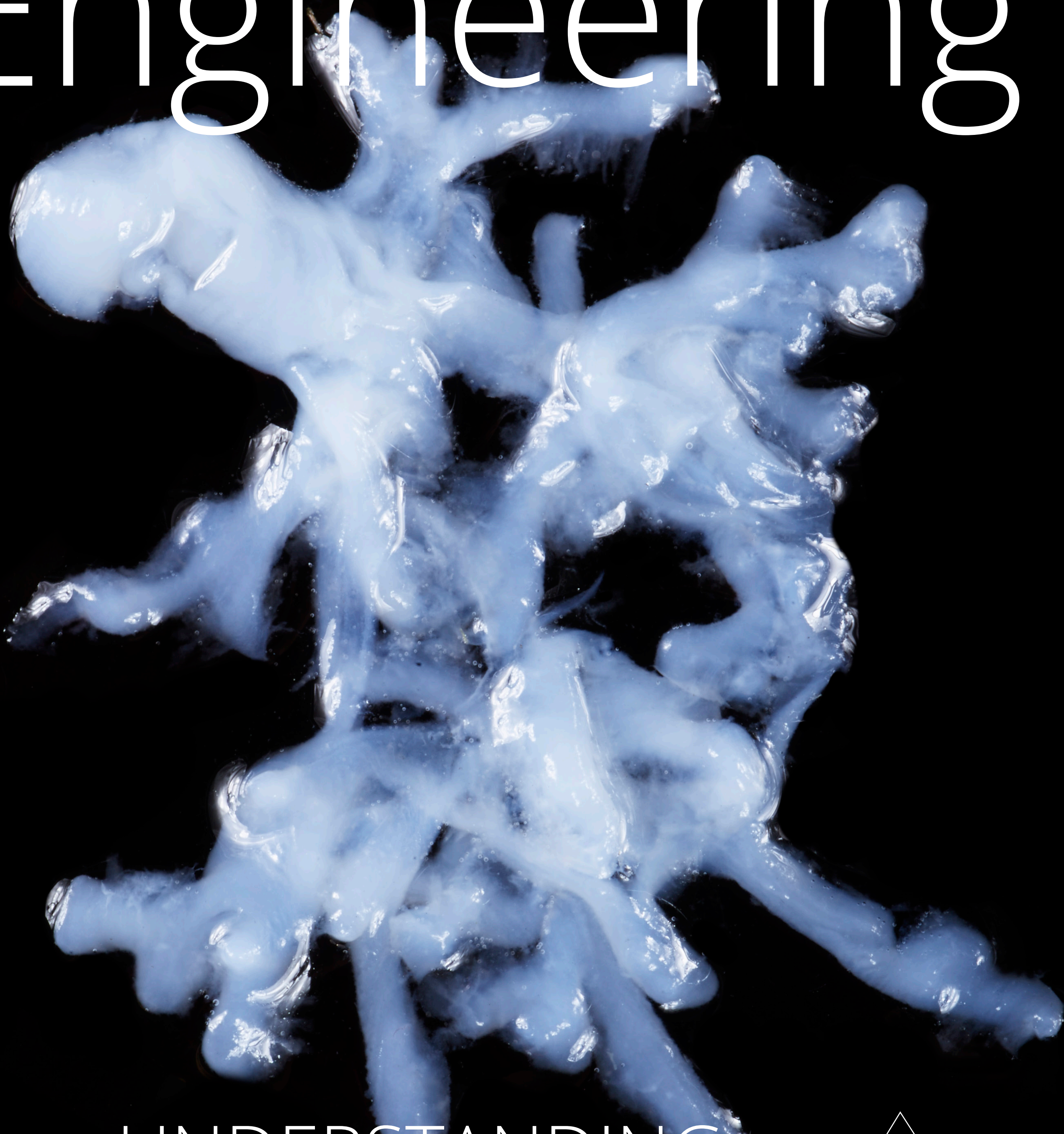
SPRING 2017

Engineering



UNDERSTANDING MATERIALS

FOR NOVEL AND INNOVATIVE USES

PAGES 2–6

SCIENCE AND ENGINEERING

Dear Friends,

WE IN THE COLLEGE OF ENGINEERING acknowledge the important role that science plays in our research. Without the fundamental scientific research done across all of the colleges at Carnegie Mellon informing our work, we would not be able to make the groundbreaking discoveries that are the source of our global reputation.

Science informs engineering, but engineering enables science. We think of this collaboration as a symbiotic relationship—sciences such as math, chemistry, biology, and physics form the backbone of our research, but all fields of science progress with the boundary-pushing innovations in exploratory and analytical technology that come out of engineering.

THEREFORE, WE BELIEVE THAT WE PUSH THE DIMENSIONS OF SCIENCE BY DOING ENGINEERING.

Science and engineering are fundamentally united—it is nearly impossible to tease out the separation between computer science and engineering, for example. All engineering disciplines make use of concepts from computer science; for example, to create sophisticated physics-based simulation systems. Likewise, computer science could not exist without the engineers who built the first computers and the computational devices upon which new areas of computer science are implemented and tested, e.g., machine learning

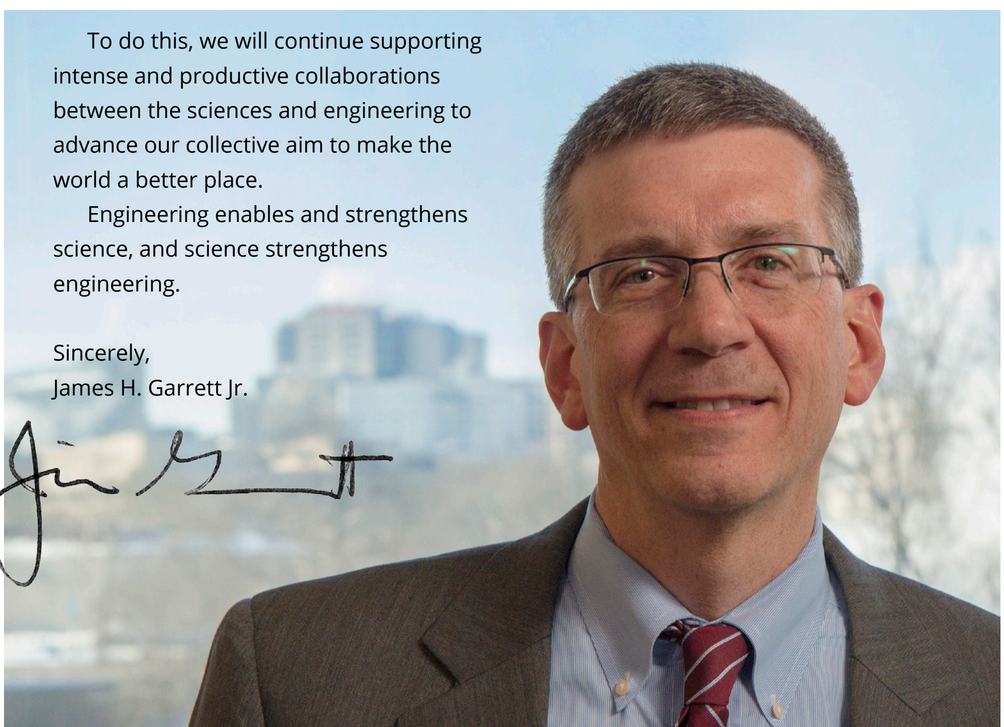
Engineering will push boundaries harder and faster as science at Carnegie Mellon advances. As such, we want to increase our research and interactions with non-engineering disciplines. We have contributed our expertise to several initiatives over the past few years that require this relationship between science and engineering. These initiatives—such as cybersecurity, biotechnology, smart cities, and advanced manufacturing—are a clear collection of significant societal issues impacted by our researchers' cross-disciplinary collaborations.

WE WANT TO ADDRESS MORE OF THESE LARGE, MULTIDISCIPLINARY GLOBAL CHALLENGES WE'RE KNOWN FOR.

To do this, we will continue supporting intense and productive collaborations between the sciences and engineering to advance our collective aim to make the world a better place.

Engineering enables and strengthens science, and science strengthens engineering.

Sincerely,
James H. Garrett Jr.



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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Caption about NextM,
Maker Ecosystem, etc.

Carnegie Mellon University
College of Engineering

SPRING 2017

MACHINE LEARNING WILL SEE ALL

BY HANNAH DIORIO-TOTH

Whether you realize it or not, machine learning makes your online experiences more efficient. The technology, designed by computer scientists, is used to better understand, analyze, and categorize data. When you tag your friend on Facebook or click on a suggested YouTube video, you're benefitting from machine learning algorithms.

MACHINE LEARNING ALGORITHMS are designed to improve as they encounter more data, making them a versatile technology for understanding large sets of photos such as those accessible from Google Images. Professor of Materials Science and Engineering Elizabeth Holm is leveraging this technology to better understand the enormous number of research images accumulated in the field of materials science. This unique application is an interdisciplinary approach to machine learning that hasn't been explored before.

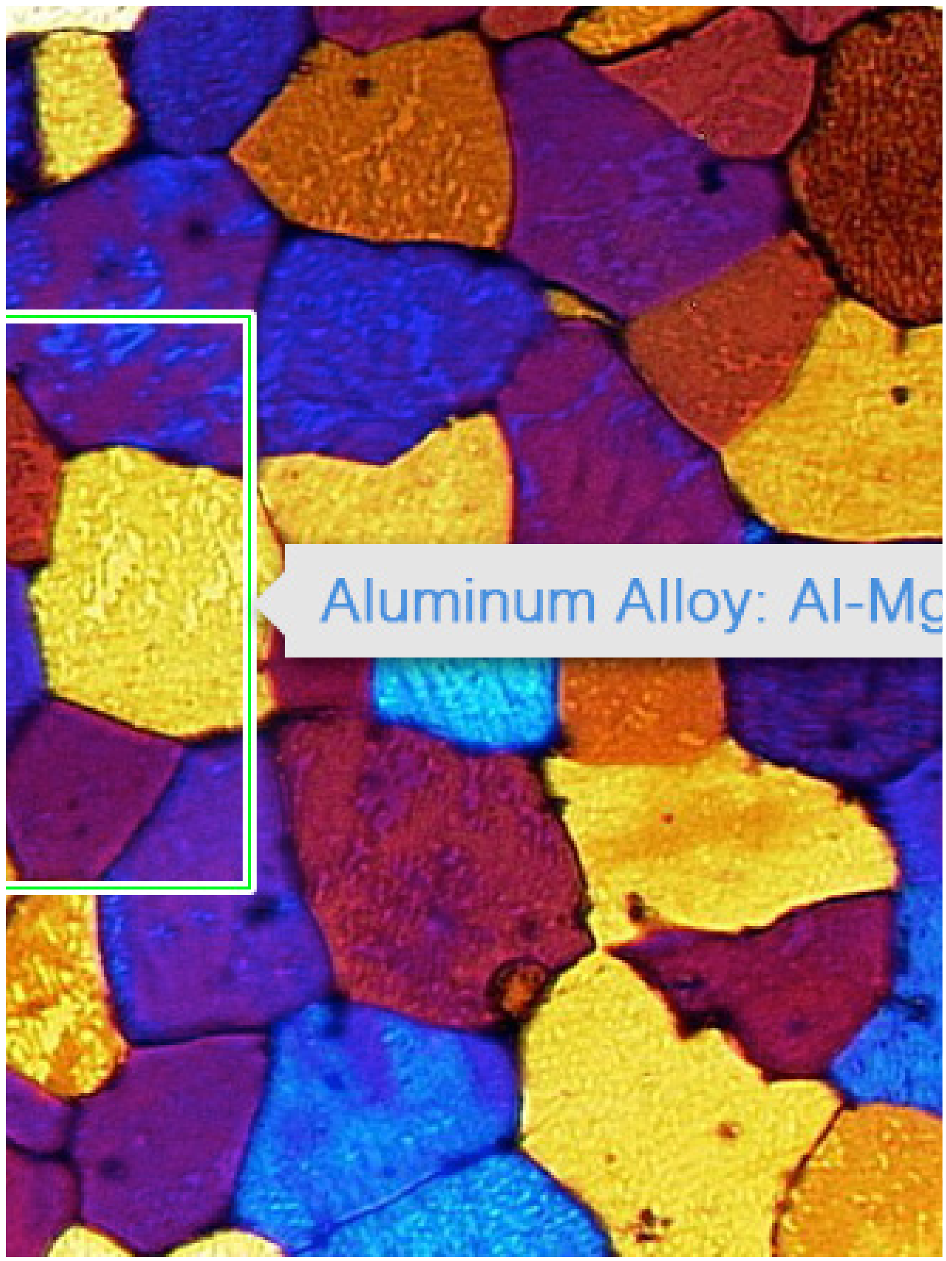
"Just like you might search for cute cat pictures on the internet, or Facebook recognizes the faces of your friends, we are creating a system that allows a computer to automatically understand the visual data of materials science," explains Holm.

The field of materials science usually relies on human experts to identify research images by hand. Using machine learning algorithms, Holm and her group have created a system that automatically recognizes and categorizes microstructural images of materials. Her goal is to make it more efficient for materials scientists to search, sort, classify, and identify important information in their visual data.

"In materials science, one of our fundamental data is pictures," explains Holm. "Images contain information that we recognize, even when we find it difficult to quantify numerically."

Holm's machine learning system has several different applications within the materials science field including research, industry, publishing, and academia. For example, the system could be used to create a visual search of a scientific journal archives so that a researcher could find out whether a similar image had ever been published. Similarly, the system can be used to automatically search and categorize image archives in industries or research labs. "Big companies can have archives of 600,000 or more research images. No one wants to look through those, but they want to use that data to better understand their products," explains Holm. "This system has the power to unlock those archives."

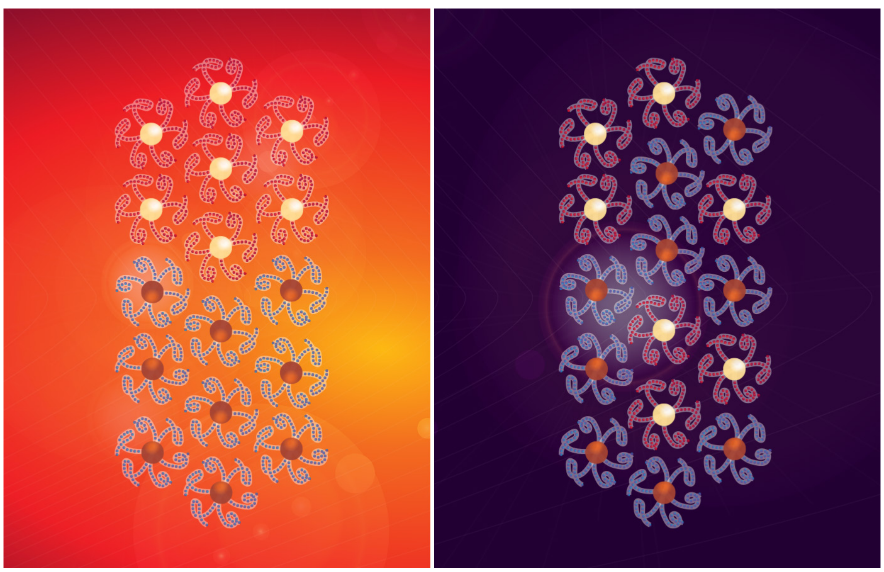
Holm and her group have been working on this research for about three years and are continuing to grow the project, especially as it relates to the metal 3-D printing field. For example, they are beginning to compile a database of experimental and simulated metal powder micrographs in order to better understand what types of raw materials are best suited for 3-D printing processes. ■



HOLM'S RESEARCH IS SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION.

Oh, Behave
Controlling how nanoparticles self-assemble

BY HANNAH DIORIO-TOTH



To create new nanomaterial technologies such as next-generation lighting, challenges underpinning the science and engineering of nanoparticles must be resolved. For example, many proposed technologies hinge on the organization of particles into layers called films that have a precise microstructure. However, fabricating these films is a challenging because it is difficult to control the structure of nanoparticle assemblies on micrometer scales.

Researchers at Carnegie Mellon University have found a solution—nanoparticles can be organized in a more predictable, organized fashion when surface-modified with polymer chains.

By harnessing the organizational properties of polymeric tethers, nanoparticles can be programmed to self-assemble into a variety of micron-sized domain structures in a reversible way.

These findings were published in the December 23 issue of Science Advances, in an article called "Polymer ligand-induced autonomous sorting and reversible phase separation in binary particle blends."

"We have shown that you can control interactions between nanoparticle building blocks, and therefore you now have the ability to create molecular structures with particles which was not previously possible," says Professor of Materials Science and Engineering Michael Bockstaller, a lead author on the study.

"No one has ever been able to control particles in this way before, so this finding is very exciting," says Bockstaller.

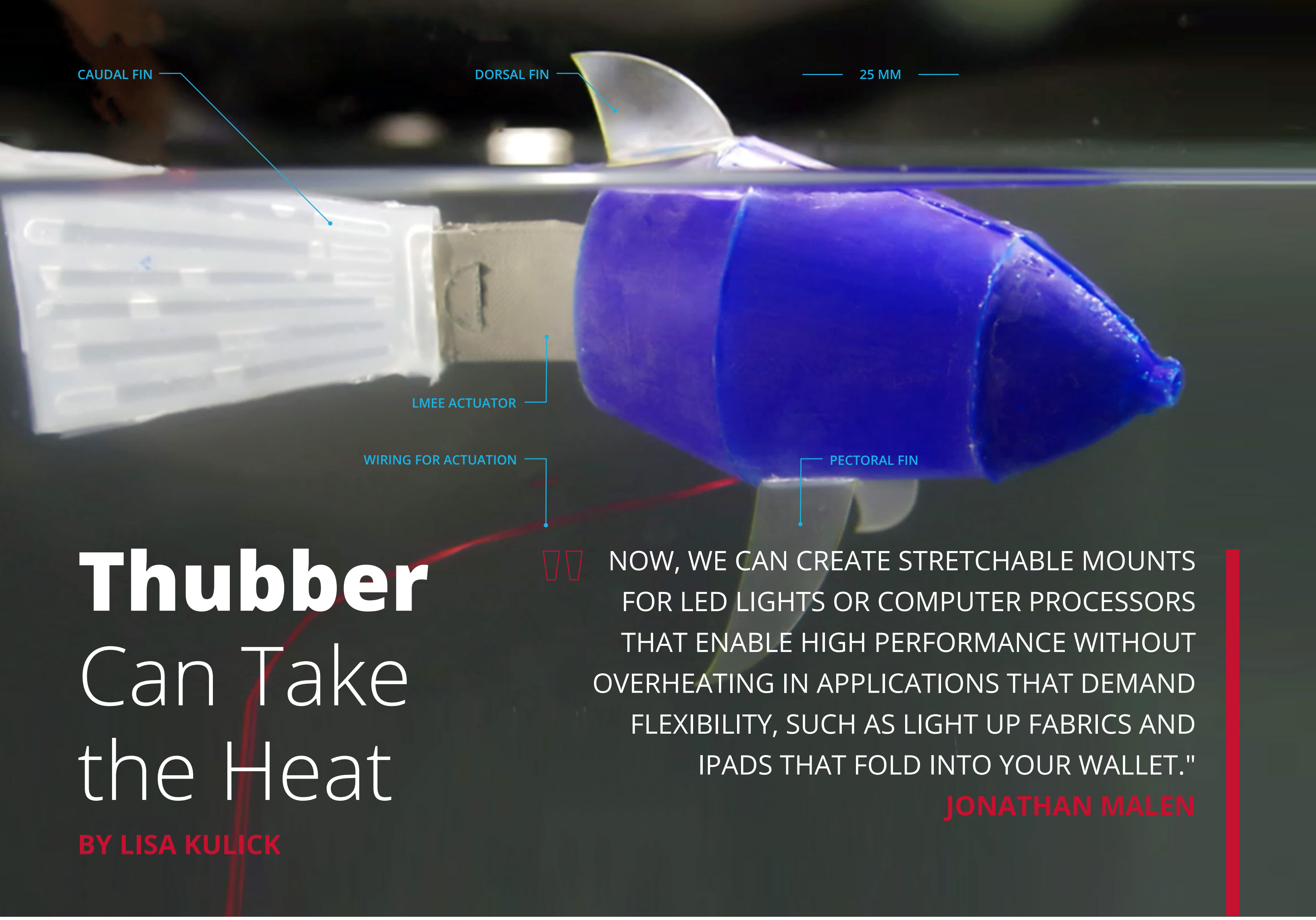
The researchers have demonstrated this new approach for a model particle system that will act as a synthetic testbed for a range of other nanoparticle materials.

Their results mark an important stepping stone for improving the efficiency of sensors and solar panels. Because these technologies rely on the organization of particles to propagate light and heat, this new finding has the potential to dramatically change the way materials function in the future.

For example, Bockstaller explains that better control over the organization of fluorescent particles called quantum materials could result in brighter and more energy efficient television and smartphone screens.

Moving forward, the research team has plans to explore the organization of new nanoparticle systems including quantum dot materials. The team, which includes Chemistry Professor Krzysztof Matyjaszewski, hopes to further extend the level of sophistication in controlling the morphology and properties of nanoparticle assembly structures.

"This fundamental research opens the door to new ideas in the realm of nanoparticle-based materials, from photonic to luminescent materials. Imagine if we were able to dynamically change the properties of these materials in defined ways. With our understanding of how to organize particles, we hope to make this possible in the future," says Bockstaller.



Thubber Can Take the Heat

BY LISA KULICK

> "NOW, WE CAN CREATE STRETCHABLE MOUNTS FOR LED LIGHTS OR COMPUTER PROCESSORS THAT ENABLE HIGH PERFORMANCE WITHOUT OVERHEATING IN APPLICATIONS THAT DEMAND FLEXIBILITY, SUCH AS LIGHT UP FABRICS AND IPADS THAT FOLD INTO YOUR WALLET."
> **JONATHAN MALEN**

CARMEL MAJIDI AND JONATHAN MALEN OF MECHANICAL ENGINEERING have developed a thermally conductive rubber material that represents a breakthrough for creating soft, stretchable machines and electronics.

The new material, nicknamed "thubber," is an electrically insulating composite that exhibits an unprecedented combination of metal-like thermal conductivity and elasticity similar to soft, biological tissue that can stretch over six times its initial length.

"Our combination of high thermal conductivity and elasticity is especially critical for rapid heat dissipation in applications such as wearable computing and soft robotics, which require mechanical compliance and stretchable functionality," said Majidi, an associate professor of mechanical engineering.

Applications could extend to industries like athletic wear and sports medicine—think of lighted clothing for runners and heated garments for injury therapy. Advanced manufacturing, energy, and transportation are other areas where stretchable electronic material could have an impact.

"Until now, high power devices have had to be affixed to rigid, inflexible mounts that were the only technology able to dissipate heat efficiently," said Malen, an associate professor of mechanical engineering. "Now, we can create stretchable mounts for LED lights or computer processors that enable high performance without overheating in applications that demand flexibility, such as light up fabrics and iPads that fold into your wallet."

The key ingredient in "thubber" is a suspension of non-toxic, liquid metal microdroplets. The liquid state allows the metal to deform with the surrounding rubber at room temperature. When the rubber is pre-stretched, the droplets form elongated pathways that are efficient for heat travel. Despite the amount of metal, the material is also electrically insulating.

To demonstrate these findings, the team mounted an LED light onto a strip of the material to create a safety lamp worn around a jogger's leg. The "thubber" dissipated the heat from the LED, which would have otherwise burned the jogger. The researchers also created a soft robotic fish that swims with a "thubber" tail, without using conventional motors or gears.

"As the field of flexible electronics grows, there will be a greater need for materials like ours," said Majidi. "We can also see it used for artificial muscles that power bio-inspired robots.

The findings from this research were published in Proceedings of the National Academy of Sciences. Majidi and Malen acknowledge the efforts of lead authors Michael Bartlett, Navid Kazem, and Matthew Powell-Palm in performing this multidisciplinary work. They also acknowledge funding from the Air Force, NASA, and the Army Research Office.

U.S. DOT AWARDS UNIVERSITY $14 MILLION MOBILITY RESEARCH CENTER

BY SHERRY STOKES

Carnegie Mellon University will receive $14 million over the next five years from the U.S. Department of Transportation (U.S. DOT) to establish a new National University Transportation Center (UTC).

THE UTC, NAMED MOBILITY21, will safely and efficiently improve the mobility of people and goods in the 21st century by investigating and deploying novel technologies, incentives, policies, and training programs. The center is a partnership between the College of Engineering and The Heinz College of Information Systems and Public Policy.

Transportation costs are the second largest expense for U.S. households. On average, we spend more than 40 hours stuck in traffic each year, and congestion costs are estimated to be $121 billion. Truck congestion alone wastes $27 billion in time and fuel, annually.

To address challenges spanning multiple modes of transportation, the College of Engineering and its consortium partners, including the Community College of Allegheny Country, University of Pennsylvania, and Ohio State University, will explore:

- smart city technologies;
- connected and autonomous vehicles;
- improved transportation access to disadvantaged neighborhoods;
- multi-modal traveling;
- assistive technologies for people with disabilities;
- data modeling for monitoring traffic control systems;
- regional planning to establish priorities and aid transportation deployment.

"This significant award from the U.S. DOT recognizes Carnegie Mellon's national and global leadership in the computational technologies that are revolutionizing transportation. Building on the real-world experience and expertise we have established with other CMU initiatives such as Metro21 and Traffic21, this cross-disciplinary effort, led by our College of Engineering, will rely on innovative research from across Carnegie Mellon to develop and deploy solutions that will fuel our economy, keep our nation's drivers safe, and deliver efficient and reliable transportation," says Farnam

40 **HOURS**
time we spend stuck in traffic annually (on average)

121,000,000,000
DOLLARS
estimated annual traffic congestion costs

27
BILLION DOLLARS
wasted annually by truck congestion (in time and fuel)

2
RANK
transportation costs are second largest expense for U.S. households

CONTINUES ON NEXT PAGE

Jahanian, provost and chief academic officer of Carnegie Mellon.

Raj Rajkumar, the George Westinghouse Professor of Electrical and Computer Engineering, will lead Mobility21. Rajkumar is a globally recognized expert in autonomous vehicle research.

"Carnegie Mellon's research has helped establish Pittsburgh and Pennsylvania as a national hub for developing safe automated vehicles and has attracted technology companies to Pennsylvania," says Pennsylvania Department of Transportation (PennDOT) Secretary Leslie S. Richards.

CARNEGIE MELLON UNIVERSITY WILL RECEIVE $14 MILLION OVER THE NEXT FIVE YEARS FROM THE U.S. DEPARTMENT OF TRANSPORTATION (U.S. DOT) TO ESTABLISH A NEW NATIONAL UNIVERSITY TRANSPORTATION CENTER (UTC).

PennDOT is one of a number of partners that Mobility21 will tap to deploy projects. Deployment partners will help identify real-world transportation needs, aid technology licensing and commercialization, and provide venues for testing technologies.

"Pittsburgh is a testbed for deploying new technologies that can connect communities and provide access to new opportunities. With the City and Carnegie Mellon working together, residents throughout the city will have safer, faster, and more reliable commutes," says Pittsburgh Mayor Bill Peduto.

"Mobility21 will actively bridge the bold ideas of its research team to meet the pressing needs of our increasingly congested transportation system. The benefits of infrastructure investments can be multiplied with the infusion of innovative technologies and forward-looking policies," adds Rajkumar, who also directs Metro21, Carnegie Mellon's Smart and Connected City Initiative.

Mobility21 is the second national UTC located at Carnegie Mellon. Since 2013, the university has been home to the Technologies for Safe and Efficient Transportation National UTC on Safety, which develops and deploys innovations pertaining to in-vehicle technologies, infrastructure technologies, human-vehicle

HERE ARE SOME TOPICS THAT ENGINEERING RESEARCHERS IN MOBILITY21 WILL EXPLORE:

PREDICTING REAL-TIME TRAFFIC CONGESTING AND MITIGATION AT A CITY SCALE
Thanks to ubiquitous wireless connectivity, connected cars, and millions of mobile devices, we can leverage data analytics and machine learning to develop a real-time traffic prediction system and subsequently, ways to mitigate congestion in major cities.

EXTRACTING ROAD INFORMATION FROM VEHICLE SENSOR DATA
Seeing and being seen are tantamount in driving scenarios. Researchers are developing computer vision algorithms that use data gathered from vehicle sensors and stored in the cloud to understand traffic challenges such as detecting pedestrians, vehicles, signage, and even potholes.

BUILDING AN ACCESSIBLE, LOW-STRESS, SAFE, AND SUSTAINABLE BICYCLE INFRASTRUCTURE NETWORK
Bicycles are the most efficient way to travel short distances, but to keep people cycling for the long term, there is need for systematic infrastructure planning that considers pedestrians, bicycles, and vehicles. Engineers are tapping transportation datasets to expand infrastructure networks for bikes and to provide cyclists with route information, like riding ease and safety risks.

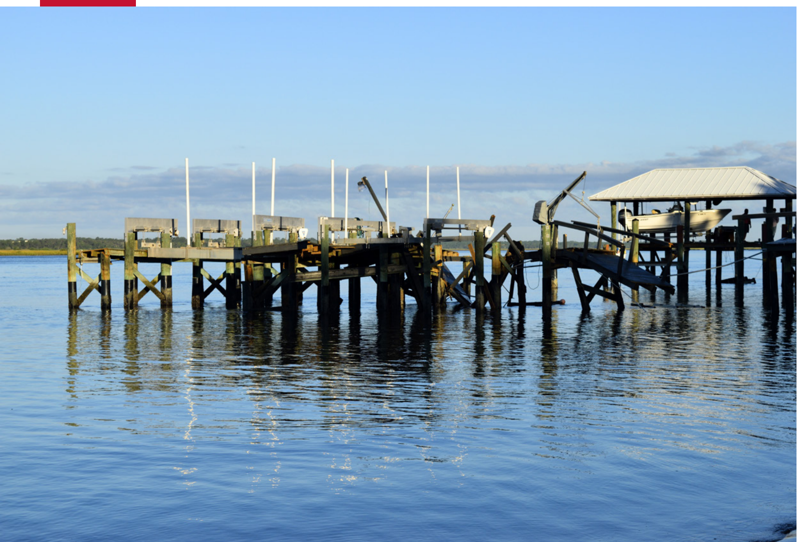
LATENCY-AWARE CLOUD-BASED ROUTE PLANNING
Freight trucks are a major source of greenhouse gas emissions, and because they accelerate slowly, they cause traffic delays. By minimizing left-hand turns at intersections, freight trucks and automated vehicles would realize improvements in safety, latencies and emissions. By implementing routing policies that consider vehicle types, delay implications, hazards and GPS availability, vehicles can be rerouted depending on their needs and destinations.

ESTIMATING CHANGES IN PARKING AND URBAN FORM FROM VEHICLE AUTOMATION
Parking in urban areas is expensive, takes up space, and causes congestion as drivers hunt for parking spots. By examining rideshare and traveler information services, researchers will assess cost saving and changes in urban form, and the results will be generalized for 100 large metropolitan areas.

MANAGEMENT OF MOBILITY IMPACT OF UTILITY AND ROADWAY CONSTRUCTION THROUGH INCENTIVES
When pipelines or utility systems fail, often roadway pavement is cut to make repairs, which disrupts motorists. Researchers will study infrastructure maintenance operations to predict repairs and minimize disruptions in communities. They will also develop incentive models to help motorists improve their mobility when repairs occur.

We Know Climate Change Is Affecting Our Planet— **But What About Our Buildings?**

BY ADAM DOVE



Coming generations face challenges that were inconceivable fifty years ago. Due to our changing climate, sea levels are rising, our cities getting warmer. These and many other factors are putting wear and tear on our roads, buildings, and bridges like never before. As the world changes, both our infrastructure and our civil and environmental engineering education need to adapt.

"At Carnegie Mellon, we're lucky to have a large number of faculty addressing the big, wicked problems of climate change," says Assistant Professor of Civil and Environmental Engineering Costa Samaras. "We want our engineering students to be leaders in making our communities more resilient. That's why we designed the master's degree concentration."

In 2014, the Department of Civil and Environmental Engineering, led by Department Head David Dzombak, developed a master's concentration in Climate Change Adaptation for Infrastructure. The program allows students to learn and develop methods to face the changing needs of our climate-threatened cities and towns.

"People hear about climate change on TV or in the newspaper and think, 'Rising sea levels might affect some islands in the Pacific, but what about my community?'" Dzombak says. "The big need in adapting to a changing climate is to think 'how are things going to change here?' That's what we think about at Carnegie Mellon, and what we're training our students to think about."

Increased precipitation has already led to some cities experiencing greater flooding, putting roads under water and inundating structures. Pittsburgh is no exception. A team of students from the program is tracking precipitation data in Pittsburgh for as far back as 1830, to investigate how rainfall amounts have changed over time, and how they can be expected to change in the future. That way, civil and environmental engineers can prepare sewer systems, roads and other infrastructure to handle the increased load.

Due to a number of climate change related factors, our cities are getting warmer. This is known as the Urban Heat Island Effect, which causes illness and even death in many elderly people during periods of extreme heat in cities across the country every year. Students in the master's program are researching this problem, and how civil and environmental engineers can mitigate this heat by installing green roofing and establishing cooling stations around the city—places for more vulnerable populations to go when things heat up.

These are just a few of the myriad issues that our urban infrastructure faces as the result of an ever-changing climate. Thanks to Carnegie Mellon's new Climate Change Adaptation for Infrastructure program, future generations of civil and environmental engineers will be ready to face them. Courses range from Infrastructure Management, to Climate Change Science and Adaptation, to Data Acquisition, Sustainable Buildings, and more.

"Taking risks on big systems engineering challenges is part of Carnegie Mellon's ethos," says Samaras. "This is a big systems engineering problem, and it requires a widespread, interdisciplinary approach." ■

Economic Growth Through Shale Gas Optimization

BY HANNAH DIORIO-TOTH

TO SOME, "OPTIMIZATION" MAY SIMPLY BE A WORD TO USE WHEN "BETTER" WON'T DO. But to Ignacio Grossmann, professor of chemical engineering, optimization is the key to unlocking huge cost savings for shale gas companies who are struggling to stay afloat as oil and gas prices drop.

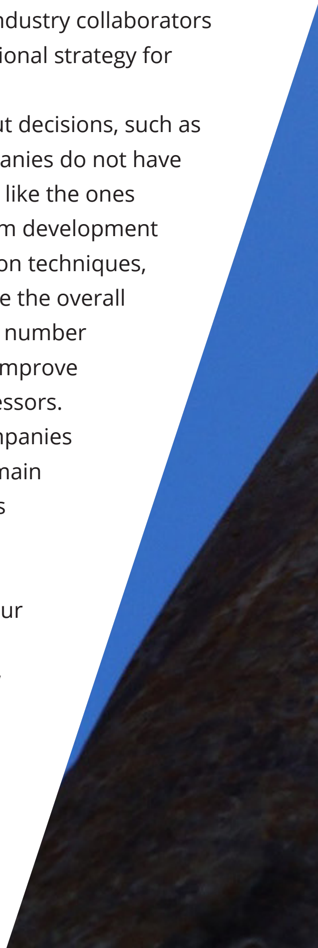
The process engineering strategy uses novel mathematical programming models to save companies money, time, and resources. Grossmann, along with chemical engineering Ph.D. students Markus Drouven and Linlin Yang, and Universidad Nacional del Litoral Associate Professor Diego Cafaro, pioneered research in this area. They have spent the last four years focused on the strategic planning, design, and development of the shale gas supply chain network, including the water management in shale gas operations.

The recent drop in natural gas prices has threatened the profitability of many operators, resulting in over 65,000 layoffs in 2015 by big industry players, according to Forbes Energy. Grossmann and his team used their optimization techniques to try to reverse this trend by helping companies make better investment decisions that relate to the planning of drilling shale gas wells. As part of this research, the group determined the most cost-effective drilling and completions schedule for a shale gas development area in Southwestern Pennsylvania that contained over 18 well sites and 40 prospective wells. This research was published in the AIChE Journal in 2016.

"In this project, we used novel mathematical models [known as mixed-integer programs] and related optimization software to rigorously evaluate millions of possible development strategies and then provide clear recommendations for action," explains Grossmann. "It is very exciting for us and our industry collaborators because there is currently no similar computational strategy for planning in the shale gas industry."

Currently, spreadsheets are used to plan out decisions, such as when and where wells should be drilled. Companies do not have the capabilities to use strategic computer tools like the ones that Grossmann's group uses to make long-term development and planning decisions. Using these optimization techniques, Grossmann and his group were able to increase the overall gas production and profit while decreasing the number of wells needed. Their recommendations also improve equipment utilization for pipelines and compressors.

"There is a lot of pressure on upstream companies [focused on production and exploration] to remain profitable while the price of gas decreases. This means that the role of optimization becomes even more important to help make better economic decisions for these companies and our communities at-large," says Grossmann. "We hope that research we are doing will help grow businesses and promote growth in regions that rely on shale gas production as an important economic driver."



DIY Smart Tattoos

BY ALEXANDRA GEORGE

IMAGINE IF YOUR ELECTRONIC WEARABLE DEVICE, like your Fitbit, adhered to you like a sticker and could read your pulse or measure hand gestures. As electronics are becoming thinner, lighter, and more power efficient, they can be populated on stickers and temporary tattoos to create soft wearables that adhere to the skin. And the most exciting news is that one day you may be able to print these wearable electronics from a home printer.

Mechanical Engineering Professor Carmel Majidi, Ph.D. student Eric Markvicka, and previous postdoctoral fellow Michael Bartlett (now a professor at Iowa State University) have created a method to print skin-mountable electronics in a quick and cost-effective way.

"One of the remaining challenges in skin-mounted electronics is to interface soft circuits with the rigid microchips and electronics hardware required for sensing, digital processing, and power," said Majidi. "We address this with a breakthrough digital fabrication technique that enables efficient creation of wireless electronics on a soft, water-resistant, medical-grade adhesive."

Electronics produced from this method contain rigid components that you typically see on a circuit board (such as transistors, microprocessors, and power regulators) with soft deformable wiring that stretches and bends.

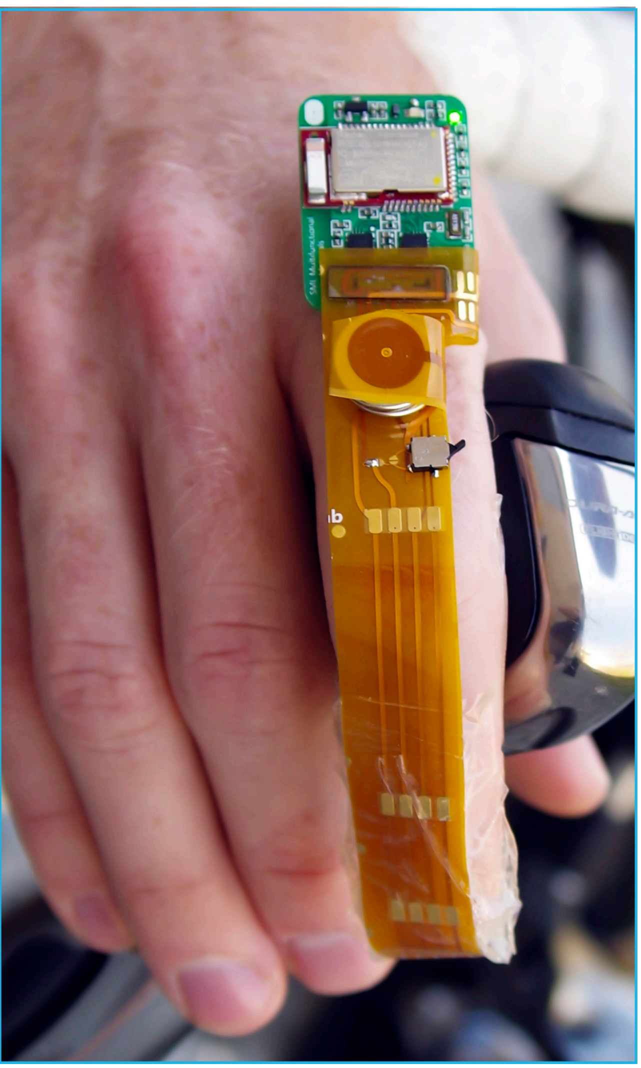
The method uses commercially available films to create wearable electronics through rapid prototyping and assembly techniques. Using a combination of laser cutting with alignment control, they create individual layers and assemble them through a soft transfer printing technique.

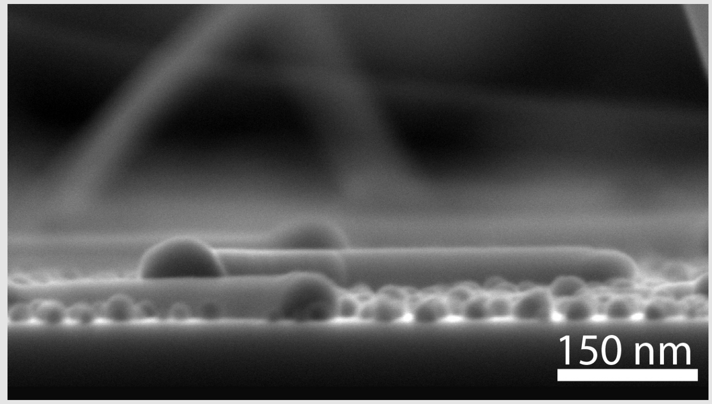
Majidi and his team created a fully functional "data skin" in under an hour. Since the method is based on inexpensive processing tools and materials, the circuits can be produced for less than a dollar.

When wrapped around the fingertip, a "data skin" embedded with an optical pulse oximetry chip can measure heart rate and blood oxygenation, or can bond to the back of the hand to monitor hand gestures. After use, the "data skin" can be painlessly peeled from the skin and discarded.

Because the production is fast and inexpensive, users can create their own highly customizable wearable data skins. This is a big step toward fabrication of customized wearables by non-experts.

"This new and versatile method to print skin-mountable electronics represents a first step towards a fully automated method in which non-experts can create their own customized wearables," said Majidi. "No longer limited to smartphones and smartwatches, the next generation of personal electronics will be soft, stretchable, and stick to skin or clothing. Moreover, they can be produced at home with an inexpensive printer not unlike a desktop laserjet."





Crawling Nanowires That Will Help Harvest Energy From Sunlight

BY DANIEL TKACIK

The future of electronics may be in nanowires, tiny wires nearly a thousand times slimmer than a human hair. Electronics are getting smaller and smaller, and these wires enable useful amounts of electricity to flow in ever-shrinking devices. At Carnegie Mellon, a team of researchers just made the first observation of nanowires that seemed to "crawl" along the surface of a graphene films.

"We looked at the results, and they were kind of mind-blowing," says Tzahi Cohen-Karni, a professor of materials science and engineering as well as biomedical engineering. "We set forth to understand why the nanowires crawled on the surface." The team of researchers published their results in the July 2016 issue of Nano Letters.

Cohen-Karni's excitement comes because the advantage of having nanowires "crawl" along the surface as opposed to growing vertically out of the surface is that they could make photodetectors—devices that convert light to electricity—more sensitive.

"Photodetectors made with nanocrawlers could potentially detect smaller amounts of light than their vertical nanowire counterparts," he says.

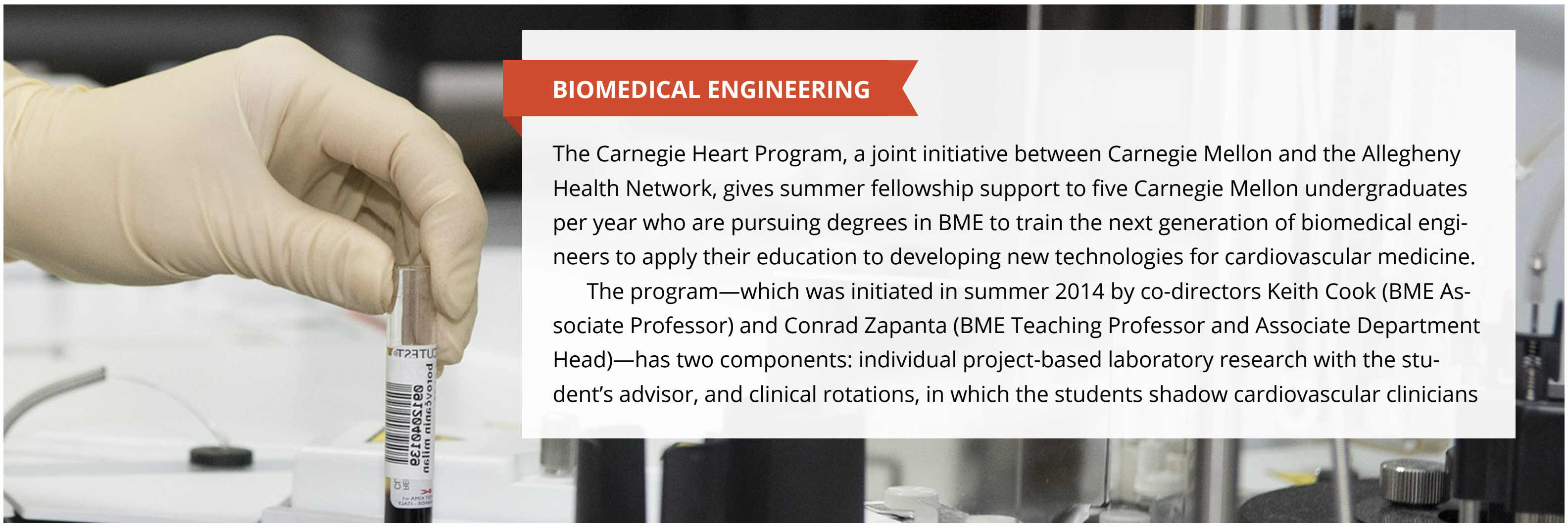
The discovery of nanowires on graphene was a happy accident, according to Cohen-Karni.

"We tried a few experiments where we wanted to grow the nanowires up, out of the surface," Cohen-Karni recalls. "My students told me that it didn't work, so we looked at the results, and we were very surprised by what we saw."

The team decided to investigate further what it was that made the nanowires crawl along the surface, so that they could have better control of the process in the future. The team found that adding hydrogen chloride gas at a certain point during the synthesis process made the wires more likely to crawl along the graphene surface than to grow vertically out of the graphene.

"This is why science can be so mind-blowing," Cohen-Karni says. "You start out with some odd observation, and you think you messed up, but then you can investigate and learn why it happened." ■

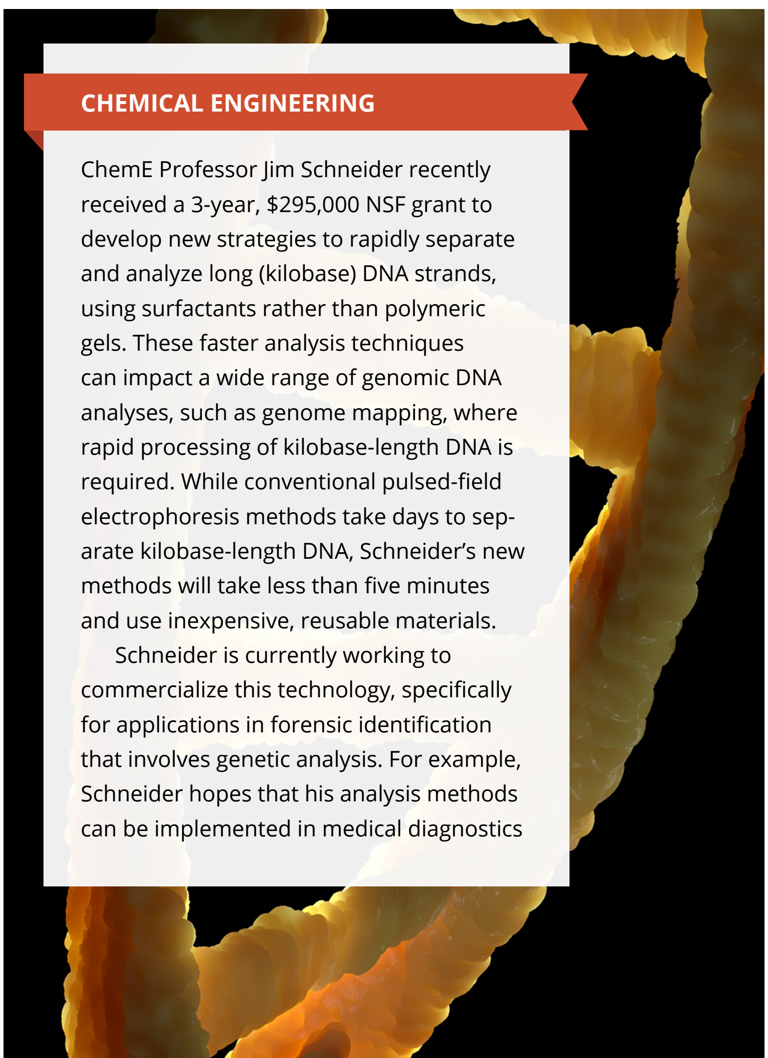
DEPARTMENT NEWS



BIOMEDICAL ENGINEERING

The Carnegie Heart Program, a joint initiative between Carnegie Mellon and the Allegheny Health Network, gives summer fellowship support to five Carnegie Mellon undergraduates per year who are pursuing degrees in BME to train the next generation of biomedical engineers to apply their education to developing new technologies for cardiovascular medicine.

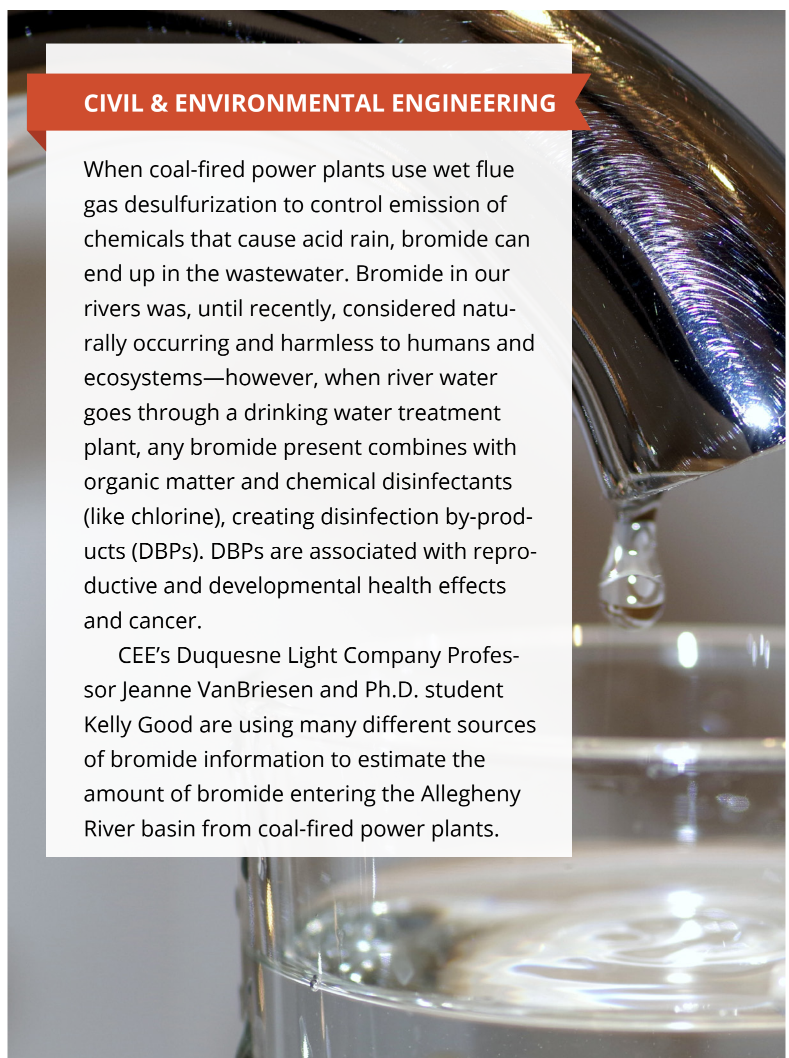
The program—which was initiated in summer 2014 by co-directors Keith Cook (BME Associate Professor) and Conrad Zapanta (BME Teaching Professor and Associate Department Head)—has two components: individual project-based laboratory research with the student's advisor, and clinical rotations, in which the students shadow cardiovascular clinicians



CHEMICAL ENGINEERING

ChemE Professor Jim Schneider recently received a 3-year, $295,000 NSF grant to develop new strategies to rapidly separate and analyze long (kilobase) DNA strands, using surfactants rather than polymeric gels. These faster analysis techniques can impact a wide range of genomic DNA analyses, such as genome mapping, where rapid processing of kilobase-length DNA is required. While conventional pulsed-field electrophoresis methods take days to separate kilobase-length DNA, Schneider's new methods will take less than five minutes and use inexpensive, reusable materials.

Schneider is currently working to commercialize this technology, specifically for applications in forensic identification that involves genetic analysis. For example, Schneider hopes that his analysis methods can be implemented in medical diagnostics



CIVIL & ENVIRONMENTAL ENGINEERING

When coal-fired power plants use wet flue gas desulfurization to control emission of chemicals that cause acid rain, bromide can end up in the wastewater. Bromide in our rivers was, until recently, considered naturally occurring and harmless to humans and ecosystems—however, when river water goes through a drinking water treatment plant, any bromide present combines with organic matter and chemical disinfectants (like chlorine), creating disinfection by-products (DBPs). DBPs are associated with reproductive and developmental health effects and cancer.

CEE's Duquesne Light Company Professor Jeanne VanBriesen and Ph.D. student Kelly Good are using many different sources of bromide information to estimate the amount of bromide entering the Allegheny River basin from coal-fired power plants.

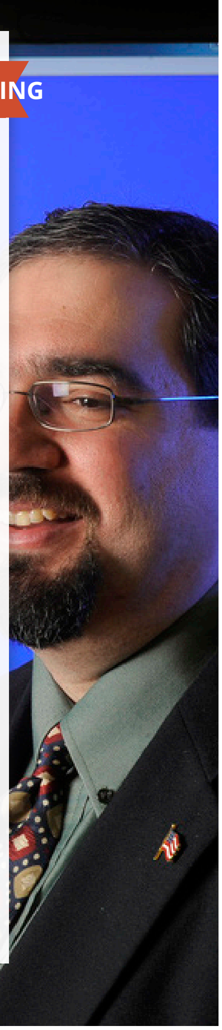
ELECTRICAL & COMPUTER ENGINEERING

When a criminal's face is caught on camera, law enforcement has a huge advantage—that's why many criminals wear masks, covering everything except their eyes. However, ongoing work in the CyLab Biometrics Center has shown that a person's face can be "hallucinated" based solely on their eye-region.

Marios Savvides, director of the CyLab Biometrics Center and a professor of ECE, and his student Felix Juefei Xu, a Ph.D. student in ECE, authored a study on this topic that was recently awarded "Best Student Paper" at the IEEE 8th International Conference on Biometrics: Theory, Applications, and Systems. The tool uses a machine learning algorithm that sweeps through millions of different face images and learns correlations between the eye region and the full face.

"Law enforcement would love to have these types of tools to use in in challenging crime cases," says Savvides. "This would fill a huge technology gap in this area."

To ensure that relevant emergency infor



ENGINEERING & PUBLIC POLICY

From April 21 – 22, 2017, over the weekend of CMU's annual Spring Carnival, EPP will be commemorating 40 years as a department with a 40th Anniversary Celebration. Friends and colleagues of EPP are invited to explore the department's many accomplishments and to recognize the individuals who have contributed to EPP's success. The event will include keynotes and presentations exploring energy, environment, information and communication technology, and other engineering and public policy issues across the last 40 years. The weekend will conclude with an invitation-only event at Phipps Conservatory & Botanical Gardens. Happy anniversary, EPP!

Learn more about this event by going to www.cmu.edu/epp/40th/.

MATERIALS SCIENCE & ENGINEERING

Deepoo Kumar, a MSE doctoral candidate studying with Professor Chris Pistorius, won the First Place Award in the Materials Photography Contest, a competition supported by the TMS Foundation.

As the recipient of the First Place Award, Deepoo was given a certificate, a first place ribbon, and $300. His photograph was on display in the TMS Member Welcome Center, located in the San Diego Convention Center, Ballroom 6 Lobby, during the TMS 2017 Annual Meeting in San Diego.

News of his award was posted online in conjunction with the conference and was announced in the TMS 2017 Daily Newsletter, as well as in posts to TMS social media. In addition, there will be future exposure in JOM, TMS e-News, and Student e-News.
tion," traditionally used by mineralogists and crystallographers to study the formation of

MECHANICAL ENGINEERING

MechE Assistant Professor Ryan Sullivan has developed a way to isolate individual particles, in order to study the way they interact with the atmosphere. The aerosol optical tweezers, a tool that traps a single particle in a laser beam, uses a laser that induces a Raman vibrational spectrum, allowing a spectrometer to collect real-time information every second about the particle as it evolves. The researchers can then throw materials at the droplet and observe how it changes: does it grow? Does the morphology, or shape, of the particle change? Do all the components mix together, or exist in separate phases?

Knowing what's at the interface of each individual particle is key to understanding how the particle, individually or in tandem with other particles, impacts the environment.
currently have access to the Innovent, but the College of Engineering envisions being able to

EXPERTS CONVERGE TO DISCUSS THE

FUTURE OF COMPUTER MEMORY

The Data Systems Storage Center, in conjunction with the Materials Science and Engineering and Electrical and Computer Engineering Departments, recently hosted the 16th Annual IEEE Non-volatile Memory Technology Symposium (NVMTS) at Carnegie Mellon University.

BY ???

The NVMTS is an international forum for exchanging information on technological advances in non-volatile memory among researchers from both academia and industry. Professors Jimmy Zhu (ECE) and Vincent Sokalski (MSE) organized the event, which included presentations on the most pressing topics underpinning modern computer memory technology.

Non-volatile memory, which refers to computer memory that retains information without a power source, holds great promise for future high-performance, energy-efficient computing. For example, it has the potential to drastically reduce the energy consumed by super computers, which could enable the widespread use of these machines. Non-volatile memory also has energy-saving applications for very small devices such as wearable or implantable technology, which could further extend their health monitoring capabilities.

Currently, these devices use volatile memory. This means that most of the energy expended by the devices is necessary simply to preserve information loaded in their memory—not to actually perform tasks or record new information. If these devices were to one day use non-volatile memory, energy would not be wasted on retaining information when the device's computer is sitting idle. Also, if the power is turned off or temporarily lost, the computer can be restarted without requiring any significant startup time or energy expenditure to reload lost information.

Non-volatile memory still faces significant technological challenges, and researchers such as those at the NVMTS are working together to come up with new solutions to push this field forward. Non-volatile memory is currently too slow and requires too much energy to make its way into mainstream computers or other electronic devices (such as smartphones).

To make the technology more feasible, researchers right here at Carnegie Mellon and across the globe are working together to discover new materials or schemes to improve the speed and efficiency of non-volatile memory. ■

WHAT IS NON-VOLATILE MEMORY?

NON-VOLATILE MEMORY, WHICH REFERS TO COMPUTER MEMORY THAT RETAINS INFORMATION WITHOUT A POWER SOURCE, HOLDS GREAT PROMISE FOR FUTURE HIGH-PERFORMANCE, ENERGY-EFFICIENT COMPUTING. FOR EXAMPLE, IT HAS THE POTENTIAL TO DRASTICALLY REDUCE THE ENERGY CONSUMED BY SUPER COMPUTERS, WHICH COULD ENABLE THE WIDESPREAD USE OF THESE MACHINES. NON-VOLATILE MEMORY ALSO HAS ENERGY-SAVING APPLICATIONS FOR VERY SMALL DEVICES SUCH AS WEARABLE OR IMPLANTABLE TECHNOLOGY, WHICH COULD FURTHER EXTEND THEIR HEALTH MONITORING CAPABILITIES.

NEWEST AAAS FELLOWS

The Council of the American Association for the Advancement of Science (AAAS) elected James H. Garrett, Jr., and Vijayakumar Bhagavatula to the rank of AAAS Fellow.

Each year, the Council recognizes individuals whose "efforts on behalf of the advancement of science or its applications are scientifically or socially distinguished."

The Council honored Garrett, dean of the College of Engineering, for his contributions to the field of computing and civil engineering, especially for his pioneering work on intelligent civil infrastructure and ability to foster an interdisciplinary academic culture. As the dean of the college, he demonstrates an unprecedented commitment to integrating engineering, arts, business and other disciplines to produce creative and technically strong engineers equipped to pioneer solutions to global challenges. Throughout his research career, he has investigated how sensors and data analytics can enhance the adaptability and efficiency of our cities and buildings. Garrett aims to give our built infrastructure the ability to detect and report problems it is experiencing so that it can be managed in a more proactive and cost-effective manner.

Bhagavatula, the U.A. and Helen Whitaker Professor in Electrical and Computer Engineering, was elected by the Council for his contributions to the field of pattern recognition, particularly for his creation of the theory and application of correlation filters for object recognition. Bhagavatula and his students develop spatial frequency-domain methods that can correlate live biometric signatures and stored templates when biometric signatures vary in appearance. In addition to his research on pattern recognition, Bhagavatula studies computer vision for autonomous driving, signal processing for two-dimensional magnetic recording (TDMR), and coding for flash memory systems.

The American Association for the Advancement of Science is the world's largest multidisciplinary scientific society, with individual members in more than 91 countries. AAAS publishes cutting-edge research in Science, a renowned peer-review journal.

EARLY CAREER PROFESSORSHIPS

On February 15, 2017, the College of Engineering awarded two professorships to honor and support Byron Yu and Jeffrey Weldon for their research and academic accomplishments.

BY DANIEL TKACIK

GERARD G. ELIA CAREER DEVELOPMENT PROFESSORSHIP

Electrical & Computer Engineering and Biomedical Engineering Associate Professor Byron Yu was awarded the Gerard G. Elia Career Development Professorship. Yu's research, which is at the intersection of neuroscience and engineering, seeks to understand how networks of neurons give rise to brain function. Potential outcomes of his work include brain-computer interfaces to assist disabled patients.

This professorship is given in honor of Dr. Gerard Elia (B.S., M.S., Ph.D. MechE '72, '73, '77). Dr. Elia's parents, Benjamin and Rose M. Elia, established the Gerard G. Elia Career Development Professorship in Engineering in 1996 in memory of their son, who sadly passed away in 1995. The career development chair was established to reward the accomplishments of an assistant or associate faculty member in the College of Engineering and to promote the scholar's future development.

SATHAYE FAMILY FOUNDATION EARLY CAREER PROFESSORSHIP

Electrical and Computer Engineering Associate Professor Jeffrey Weldon received the Sathaye Family Foundation Early Career Professorship. Weldon's research focuses on novel nanoscale device and circuit design for next-generation integrated circuits. His doctoral research in the area of RF CMOS integrated circuits has been widely adopted by industry and is frequently cited in journals and conferences. His postdoctoral research on the carbon nanotube radio was extensively covered by the popular and scientific press, including Scientific American.

Shirish and Archana Sathaye, personally and through the Sathaye Family Foundation, established the endowed Sathaye Family Foundation Career Development Professorship to support a non-tenured, junior faulty member in the Department of Electrical and Computer Engineering (ECE).

Archana and Shirish Sathaye are engaged and committed alumni. Archana's (ECE '93) career has spanned industry, academia, and non-profits. In addition to serving as a member of the ECE Alumni Council, she is the President of the Sathaye Family Foundation, a Member of the Board of Directors of The Tech Museum of Innovation, and serves on the board of multiple non-profits. Shirish (ECE '93), who serves as a member of the College of Engineering Dean's Advocacy Council and the ECE Alumni Council, joined Khosla Ventures as a General Partner after a decade of investment experience at Matrix Partners, and a long career at several technology companies. His current areas of investment focus are wireless and wireline networking, clean tech, and cloud-based software, storage and systems.

$16.5 MILLION TO ADVANCE DATA SCIENCE AND ENGINEERING

Electrical and Computer Engineering (ECE) Professor José Moura; his wife and Computer Science Professor Manuela Veloso; ECE Adjunct Professor Aleksandar Kavčić; and his wife, Dr. Sofija Kavčić, have jointly donated $16.5 million to Carnegie Mellon to support education and research in data science and engineering.

This strategic gift was made possible by Moura's and Alek Kavčić's pioneering research which has made its way into more than 3 billion computers.

In the early 1990's, Moura and Alek Kavčić, who was a Ph.D. student then, set out to accurately recover bits from storage disk drives of the future. They patented a detector that would safely and accurately extract recorded data from disk drives in the future. In the early 2000s, recording technology changed to perpendicular recording, and their detector algorithm invention became a must-have technology. It is estimated that the disk drives in 60 percent of computers made in the last 15 years contain this detector technology.

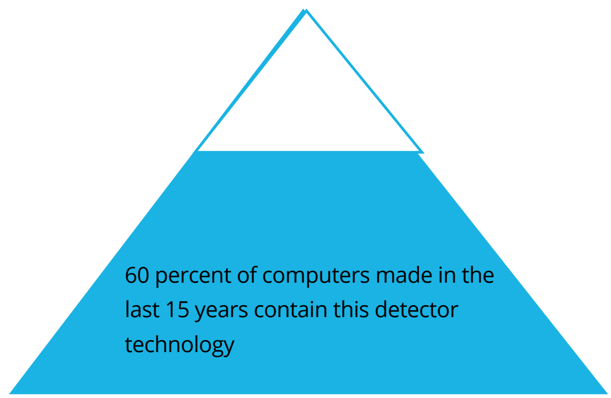
"We live in a society awash with data," Moura said. "With its exceptionally talented faculty and students, CMU has an opportunity to lead the nation in finding the new solutions to acquire, store, access, transmit and intelligently process these data, so we can have better health care, better education, better business solutions, better engineering and more fulfilling jobs.

"The result of my work with José is testimony to the excellent opportunities available to students at CMU," Alek Kavčić said. "This gift will enhance that experience for many more students, researchers and faculty members while expanding knowledge and ensuring new discoveries in data storage."

To draw upon the full capacity of the university, the gift will connect engineers and quantitative scientists from the College of Engineering, School of Computer Science and Department of Statistics with domain experts across CMU. It will provide Presidential Fellowships and Scholarships to students, foster course development and research, establish chaired professorships in the Department of Electrical and Computer Engineering, and support activities in the Data Storage Systems Center (DSSC.)

"I am truly grateful to José, Manuela, Alek and Sofija for their impressively generous gift to further the college's and CMU's efforts in data science and engineering," Garrett said.

GRAPHIC SHOWING PERCENTAGE OF COMPUTERS USING JOSE AND ALEK'S TECHNOLOGY WILL GO HERE



"THE RESULT OF MY WORK WITH JOSÉ IS TESTIMONY TO THE EXCELLENT OPPORTUNITIES AVAILABLE TO STUDENTS AT CMU. THIS GIFT WILL ENHANCE THAT EXPERIENCE FOR MANY MORE STUDENTS, RESEARCHERS AND FACULTY MEMBERS WHILE EXPANDING KNOWLEDGE AND ENSURING NEW DISCOVERIES IN DATA STORAGE."

ALEK KAVČIĆ

Rajkumar Named Fellow of NAI

Raj Rajkumar, the George Westinghouse Professor of Electrical and Computer Engineering at Carnegie Mellon University, has been named a 2016 Fellow of the National Academy of Inventors (NAI).

Nominated by their peers, NAI Fellows must be named an inventor on at least one patent and be affiliated with a university, government or nonprofit research institute, or other academic entity. The NAI Fellows Program represents more than 757 inventors worldwide and nearly 26,000 patents. Rajkumar, an internationally reputed researcher in embedded real-time systems, cyber-physical systems, operating systems and wireless sensor networks, holds three patents and founded Ottomatika, a startup that commercialized his research on intelligent software for self-driving vehicles. Ottomatika was acquired by Delphi Automotive in 2016.

An expert in autonomous vehicle research, Rajkumar helped Carnegie Mellon become a research hub for driverless technology. He is director of two U.S. Department of Transportation National University Transportation centers (UTC), including Mobility21 and the Technologies for Safe and Efficient Transportation National UTC on Safety. He is co-director of the GM-CMU Connected and Autonomous Driving Collaborative Research Lab and director of Metro21, a center related to smart cities.

Rajkumar joins five other Carnegie Mellon faculty members who are also NAI Fellows: President Subra Suresh, Jay Whitacre, Krzysztof Matyjaszewski, José F. Moura, and Raj Reddy.

Sensors To Innovate Elder Care

Civil and Environmental Engineering Assistant Professor Hae Young Noh has received a $500,000 Faculty Early Career Development Program (CAREER) grant from the National Science Foundation to study how sensor technology can be used to enable “smart buildings” to locate and identify specific inhabitants and to use the vibrations of their movements within the building to classify their activity.

The project, titled “Structures as sensors: elder activity level monitoring through structural vibrations,” aims to use buildings themselves as activity sensors by passively sensing the floor vibration caused by footsteps, and then using advanced sparse-signal approximation to assign those footsteps to specific individuals. The project focuses primarily on the application of this technology in elder care.

“Elder care facilities aim to maintain or improve quality of life and independence of elders while reducing costs and capacity needs for care-professionals,” Noh states in the award’s abstract. “One key to achieving this goal is to understand the activities of each occupant.”

To achieve this goal, Noh will first install vibration sensors in three different elder care facilities, and through detailed vibrational analysis, extract individual persons’ footstep vibration signals. From there, she will use that information to localize those footstep signals by dynamically fusing multiple sources of frequency information, all the while improving the model’s accuracy by iteratively fusing location information and signal separation.

This will allow elder care facilities to non-invasively monitor its patients’ health and activity through the use of simple vibration sensors, as well as locate portions of the building that may provide unsafe footing for occupants.

The NSF CAREER Program is a foundation-wide initiative, offering prestigious awards to encourage faculty early in their careers to serve as role models in research and education, and to build the foundation for a lifetime of leadership in their field.

Researcher Receives Air Force Grant

B. Reeja Jayan, assistant professor of mechanical engineering, has been awarded a Young Investigator Research Program grant from the Air Force Office of Scientific Research. Jayan will receive a three-year, $360,000 grant for studying electromagnetic fields in materials synthesis.

Jayan leads a multidisciplinary lab focused on molecular scale engineering of everyday materials like plastics and glass. Jayan and her colleagues work to uncover new behaviors and properties of materials that could lead to developments in areas like energy and sensing.

"We give existing materials another look with new tools, along with discovering new materials. It's sort of our lab's motto—give all materials a second look," Jayan explains.

The grant will help Jayan focus on ceramic materials. Jayan will use low temperatures with electromagnetic fields instead of high temperatures to grow and crystallize ceramics, a process that could help the Air Force develop new technologies in science and engineering.

The Young Investigator Research Program is open to scientists and engineers at research institutions across the United States who have received a doctorate or equivalent degrees in the last five years and show exceptional ability and promise for conducting basic research.

Jayan, who has a courtesy appointment in Materials Science and Engineering, is also a 2016-2017 Wimmer Faculty Fellow at Carnegie Mellon. As a fellow, she is developing online games to engage students and impart practical training that is not always possible in a classroom.

Dean's 2017 Early Career Fellows

The 2017 Dean's Early Career Fellowships have been awarded to four young professors for groundbreaking work in their fields. The fellowships are given to untenured faculty who are nominated by their department heads and selected by the College of Engineering's Review Committee. These awards will provide up to three years of funding to advance the recipients' work.

Steven Chase

ASSISTANT PROFESSOR IN BIOMEDICAL ENGINEERING AND THE CENTER FOR NEURAL BASIS OF COGNITION

Steven Chase has research interests in information representation in neural systems, brain-computer interfaces, neural signal processing, and learning, adaptation, and motor control. In 2016, Chase was awarded the National Science Foundation Faculty Early Career Development (CAREER) Award to discover the link between the neural reorganization and skill learning.

Deanna Matthews

ASSISTANT TEACHING PROFESSOR AND ASSOCIATE DEPARTMENT HEAD FOR UNDERGRADUATE AFFAIRS IN ENGINEERING AND PUBLIC POLICY (EPP)

Deanna Matthews is actively searching, exploring, and implementing mechanisms to improve the EPP student experience. As advisor and administrator for the undergraduate program, she has led the effort to evaluate and redesign the EPP double-major curriculum.

Meagan Mauter

ASSISTANT PROFESSOR IN ENGINEERING AND PUBLIC POLICY AND CIVIL AND ENVIRONMENTAL ENGINEERING

Meagan Mauter runs the Water and Energy Efficiency for the Environment (WE3) Lab. Her research explores all aspects of water technology: materials development, technology assessment, water usage, and water policy. She has lectured extensively and received many awards in her areas of specialization.

Albert Presto

ASSISTANT RESEARCH PROFESSOR OF MECHANICAL ENGINEERING

Albert Presto researches and implements new methods to better understand air pollution in urban environments. He developed the "Breathemobile," a traveling laboratory designed to map and monitor air quality in the Pittsburgh region and to increase public awareness of the harmful impacts of air pollution.

PLAYING WITH FIRE

BY EMILY DURHAM

Ph.D. student David Sapiro studies swords and the science behind blacksmithing

IN THE LAB, David Sapiro studies the properties of corrosion in austenitic stainless steels. But in his garage, you'll often find him leaning over a blacksmith's anvil, hammering hot steel bars into new shapes, crafting tools and blades from molten metals.

When one thinks of science, one rarely thinks of fire or hammering, but Sapiro, who is pursuing his doctorate at Carnegie Mellon University in Materials Science and Engineering, blacksmiths in his spare time. Blacksmithing, or the creation of objects made from heated wrought iron or steel, is a trade not often associated with academia, but when designing and crafting many of his own tools—tongs, power hammers, chisels, and the like—Sapiro improves his creations by applying the science behind the metals to his hands-on hobby.

"In undergrad, I studied pure chemistry, and I also did blacksmithing on the side, so now I'm combining them with corrosion and metallurgy," says Sapiro. "Corrosion is very much electrochemistry and studying individual atoms and molecules, very upper level science. But then the metal breaks, and I have to look at the fracture surface and say, was this a ductile fracture or a brittle fracture, and why did it break like that? That's stuff I can do in my garage."

Austenitic stainless steels, the most corrosion-resistant types of steel, are used in silverware, tubing, and other common household objects. Though they are resistant to corrosion, austenitic stainless steels still have their Achilles' heels: salt water.

"Austenitic stainless steels don't just rust like normal steel—they corrode in salt water and they can actually crack. So I'm working on trying to figure out when they do that, why they do that, and questions like that," says Sapiro.

How a metal corrodes and breaks is all tied into blacksmithing, Sapiro explains. To see if a particular steel would be good to use when forging a knife, for example, you take it, heat it up, quench it, see if it's hardenable, and then hit it with a hammer. And then, depending on how it breaks, it's either good or bad for that use.

"And that's why I like the research I'm doing and metallurgy in general," says Sapiro. "Because you can get really nitty-gritty on the science, but you can also just go to your garage and use that science, hands-on."

Sapiro doesn't only make tools—he makes swords, using authentic blacksmithing techniques. Sapiro has forged several different types of swords in his garage: a pata (an Indian sword fashioned with a gauntlet around the fist traditionally shaped like an animal's head), a falchion (a broad, single-edged sword), and a khopesh (the first sword ever made, an Egyptian sickle-shaped sword that evolved from the battleax). Currently, he is working with a group of other Carnegie Mellon students to forge a traditional Viking battleax.

What do swords have to do with academia? It turns out that TMS, one of the largest materials science conferences in the world, has recently incorporated an alternating bladesmithing competition and symposium into its annual proceedings. Sapiro entered the inaugural competition in 2015 with his creations—individually and in teams—and presented his findings at the symposium in 2016. He even published an article on the casting of his khopesh, "Fabrication of a Bronze Age sword using ancient techniques," in TMS's scientific journal, JOM. And come February, he'll be competing in TMS 2017's bladesmithing competition again, with his brand new flamberge (a wave-bladed sword).

So, whatever your interest may be, there is most certainly a science that can deepen your knowledge and augment your pastime. A perfect blend of technical and tangible, Sapiro is living the dream—working with his hands and pursuing a career studying the science behind his passion. ■

Mobility for All

BY CATHERINE GRAHAM

Self-driving car technology promises to change not just how we travel, but who is able to travel. The mobility of non-driving populations, for example, could increase up to 14%, according to Corey Harper, a civil and environmental engineering Ph.D. student and lead author of award-winning paper "Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions."

In December 2016, this article was selected for an Elsevier Atlas Award. Each month, Elsevier, a leading publisher of over 1,800 academic journals, recognizes research that could significantly impact people's lives around the world. The article, which appeared in Transportation Research Part C: Emerging Technologies in November 2016, was co-authored by civil and environmental engineering professors Chris Hendrickson and Constantine Samaras, and engineering and public policy Ph.D. student Sonia Mangones.

The idea for the reseach came about after Harper and his collaborators reviewed existing literature about self-driving cars and realized there wasn't much published on how this technology would affect non-driving populations or those who have trouble traveling independently.

"This is technology that promises mobility, but if so, how will it actually increase the travel of populations that could benefit from vehicle automation? If we don't explore these things, our transportation systems will have trouble providing efficient service to these people," explains Harper.

The researchers looked at data from the 2009 National Household Transportation Survey to understand travel characteristics of three groups: non-drivers, elderly drivers, and drivers with a self-reported medical condition.

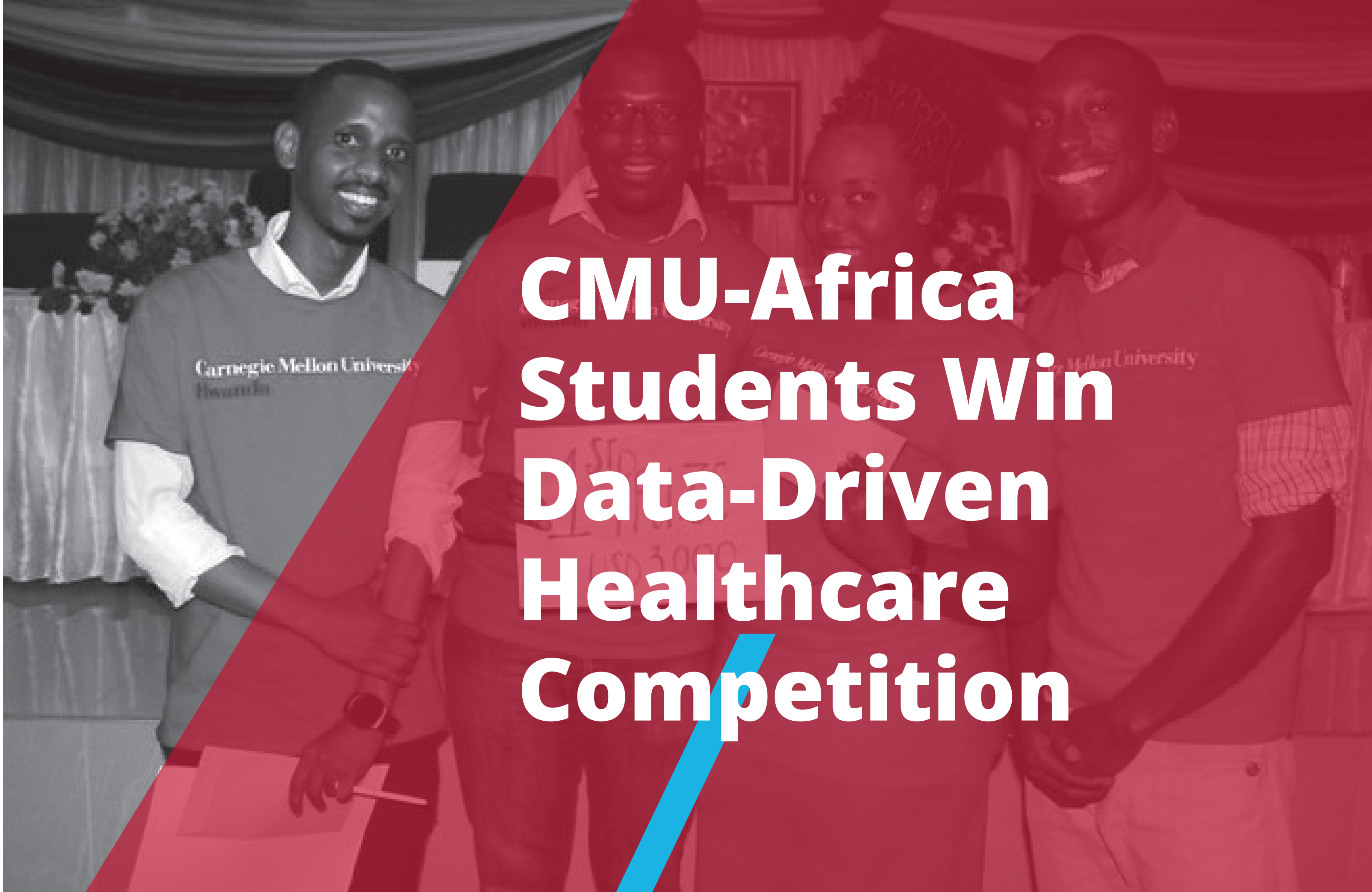
To estimate potential increases in vehicle miles traveled (VMT), they assumed that self-driving cars would allow elderly drivers, who may want to travel more but are limited by age, to increase their VMT to match that of a young adult.

Based on their analysis, the team found that when they combined the three groups, VMT could increase by as much as 14% or 295 billion miles, with elderly females (who stop driving substantially earlier than their male counterparts) and non-drivers making up most of the increase.

The study suggests that self-driving technology could significantly help underserved populations that currently rely on relatives, public transportation, or other assistance to travel. "With self-driving cars, things like age and disability will not be as much as a prohibitive factor when it comes to owning and operating a vehicle," says Harper.

Harper, who spent last summer working alongside some of the nation's top safety researchers at the National Highway Traffic Safety Administration (NHTSA) in Washington, DC, has deep interest in improving the current transportation system for everyone.

"I think the next step is to look at the travel needs of these populations with a finer scope if we want to address larger mobility issues," says Harper. "This paper deals with the demand side of self-driving cars, and I think what's next for us is to think about the supply side of this demand— What technologies do we need to put in cars, and how can we encourage these underserved populations to travel?" ■



CMU-Africa Students Win Data-Driven Healthcare Competition

IN JANUARY 2017, Carnegie Mellon University Africa students won first prize in the Nelson Mandela African Institute of Science and Technology's Africa Grand Challenge competition in Arusha, Tanzania.

The theme of the competition was "The Impact of Digital Technologies on Healthcare Systems," and it attracted master's and Ph.D. students from different centers of excellence across the African continent. CMU-Africa was represented by students pursuing their Master of Science in Information Technology–Batanda Kayondo, Aimable Rema, Renee Kabagamba and Aline Gasana.

The team was challenged to develop a healthcare solution for Africa using data analytics. They first identified a problem in Rwanda, which is that while many hospitals have long queues of incoming patients and the doctor-to-patient ratio is low, most of the cases could be handled quickly through simple first aid methods.

The team developed a system that would enable healthcare workers stationed around the country to receive emergency calls. These workers could identify the cases that can be solved through first aid, and those that instead require more extensive medical attention. The workers then could forward the cases that required additional attention to a hospital. This system would include training healthcare workers on first aid and would create employment opportunities for secondary school graduates.

The students won first prize for this system, which demonstrates how digital sensors, big data and analytics, robotics and mobile cell phones can be integrated into solutions that will significantly increase the capability to provide low-cost, reliable and effective transportation services in support of healthcare in Africa.

In addition to winning first prize, the challenge afforded the CMU-Africa team opportunities to network with key players in the industry, such as Merck Pharmaceuticals–a principal sponsor of the Africa Grand Challenge. ■

> THE BIGGEST TAKEAWAY FROM THE COMPETITION WAS THAT IT REINFORCED THE NEED FOR TECH INDUSTRIES TO CRAFT SOLUTIONS BASED ON THE NEEDS OF THE END USERS, AND TO FIND A WAY TO INVOLVE THEM IN THE DECISION-MAKING PROCESS.
> **BATANDA KAYONDO**

30 Under 30 Times 3

For three Carnegie Mellon Engineering alumni who already have an impressive record of accomplishments, they have a new title to add to their lists: "Forbes 30 Under 30."

As the CEO and co-founder of water filtration startup Rorus Inc., Civil and Environmental Engineering/Biomedical Engineering alumna **CORINNE CLINCH**, along with co-founder Uriel Eisen, has been named to Forbes' 30 Under 30 list in the Social Entrepreneurs category.

Clinch founded Rorus in 2014, while completing her master's degree in biomedical engineering. At the heart of the company is the Rorus Core, a modular water filter cartridge that uses nanotechnology to produce enough drinkable water for a family of six for up to six months by removing waterborne viruses, protozoa, and bacteria. The Rorus Core is the first of its kind—a rapid, gravity-fed filter that uses nanotechnology to filter dirty water, rather than chemical filtration.

In addition to their newest honor, Clinch and Rorus have received a laundry list of accolades since 2014.

"I'm so thankful for the honor and the opportunity Forbes 30 Under 30 gives Rorus to keep working at making the simplest, safest water filters," Clinch says. "Uriel and I wouldn't be where we are without our amazing team members, past and present, and we're looking forward to growing the team this year!"

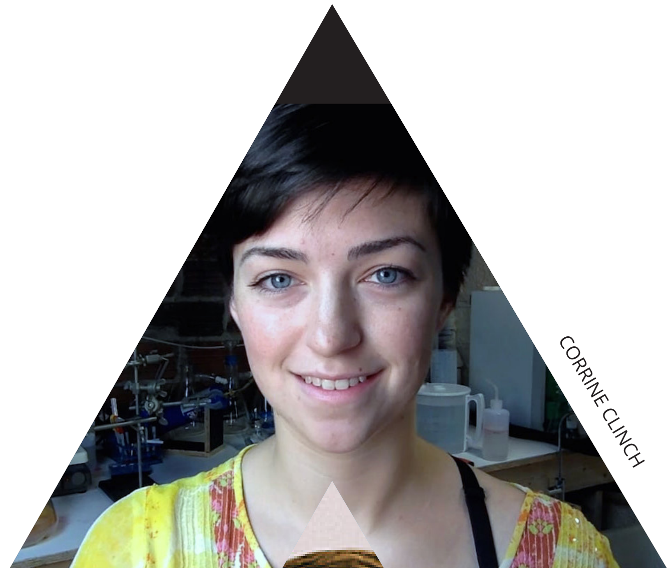
While a Mechanical Engineering student, **THOMAS HEALY** founded three startup companies. One was Hyliion—a company that hybridizes tractor-trailers by installing an intelligent electric drive axle on the trailer. This feat earned him the title "Forbes 30 Under 30" in the Energy category.

Hyliion is revolutionizing the industry by using a regenerative braking device to capture wasted energy and reduce fuel use by 30%. Healy's experience with a car that showed the wasted energy, coupled with his hobby of racecar driving, in which cars are shipped across the country in tractor-trailers, led him to consider applying the hybrid system to trucks.

The company took third place at the Rice Business Plan Competition in 2015, won the U.S. Department of Energy's National Clean Energy Business Plan Competition, as well as accolades from Wells Fargo and Shell Technology Ventures, with a current total of 18 awards and recognitions. The company is planning to start commercial production this year.

PABLO SANCHEZ SANTAEUFEMIA holds a dual master's degree in Engineering and Technology Innovation Management and Mechanical Engineering. Although an engineer by trade, he is an entrepreneur by nature and founded Bridge for Billions, an online incubation platform that connects early-stage startups with training and mentors. Though based in Spain, his work around the globe landed him on Forbes 30 Under 30 Europe Social Entrepreneurs list.

The company was founded on the statement, "Enablers of progress and agents for change." They bring business creation tools to entrepreneurs around the world because they focus on empowerment, robust collaboration, and believe geography is not a barrier. Bridge for Billions was founded on the belief that if you contribute your skills and resources to empower others you will enable change.

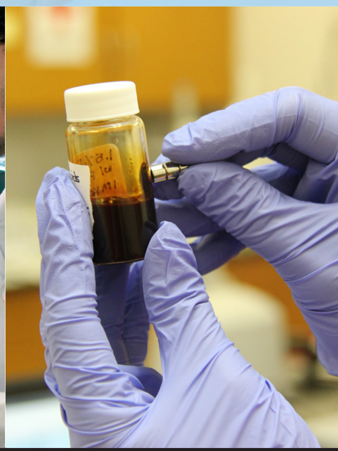


CORRINE CLINCH

THOMAS HEALY

PABLO SANCHEZ SANTAEUFEMIA

DAN STREYLE
(CIVE 75)



Give strategically, Support generously.

DAN STREYLE (CIVE 75) sets his focus on the future. As the lead project engineer, he facilitated the building of the University of Phoenix Stadium, where the Arizona Cardinals play. He created an impressive structure that will stand the test of time. At Carnegie Mellon, Dan created a lasting legacy through a gift in his estate plan that will benefit undergraduate engineering research, spurring innovation for generations to come.

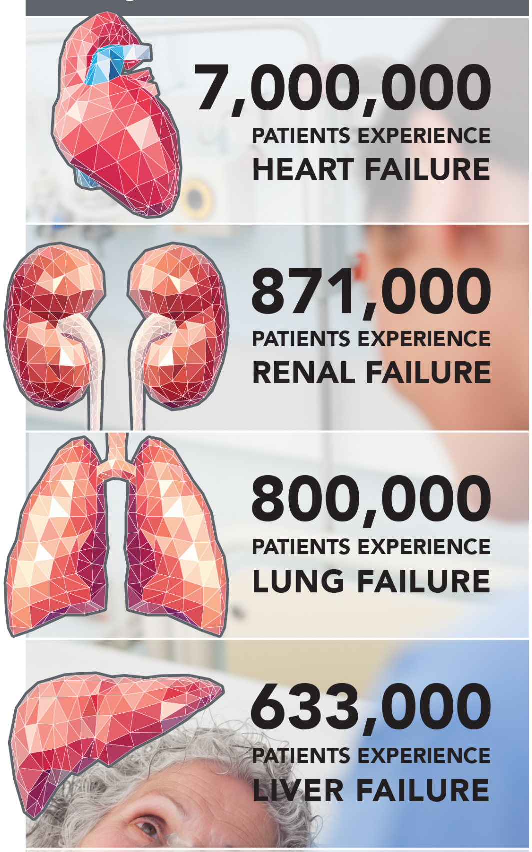
Learn how easy it is to achieve your philanthropic vision through a planned gift. Contact the Office of Gift Planning today at 412.268.5346, askjoebull@andrew.cmu.edu or visit giftplanning.cmu.edu.

Carnegie Mellon University
College of Engineering

Bioengineered Organs
CONSTRUCTING LONGER LIFE

ENGINEERING THE NEXT GENERATION OF REPLACEMENT HUMAN ORGANS

Each year in the United States:



THE MAJORITY OF THESE PATIENTS ARE NOT PUT ON THE ORGAN TRANSPLANT WAITING LIST AND WILL NEVER BE CONSIDERED FOR A TRANSPLANT BECAUSE THERE AREN'T ENOUGH NATURAL HUMAN ORGANS AVAILABLE.

What are biohybrid organs?

Biohybrid organs are a new generation of long-term replacement human organ engineered from a combination of bioprinted cellular and synthetic materials. This life-saving technology has the potential to eliminate the current organ transplant waiting lists.

OUR GOAL IS TO SAVE LIVES BY INCREASING THE AMOUNT OF ORGANS AVAILABLE TO PATIENTS IN NEED.

How will biohybrid organs help?

Collaborative research at Carnegie Mellon University in 3-D printing, tissue engineering, biomaterials, cellular mechanics, and artificial organs can support or replace diseased organs. These biohybrid organs can improve survival rates for the million of patients with end-stage organ failure in the United States.

Learn about the next generation of replacement human organs, visit **bme.cmu.edu**

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WHY I AM A HACKER

BY DANIEL TKACIK

Headlines about hacking, involving our phones, email – you name the system or device — have presented the public with a negative view on the term "hacking," correlating the act with mischievous or even criminal activity. However, most hackers are not criminals, maintains David Brumley, the director of Carnegie Mellon's CyLab Security and Privacy Institute. Hackers are, he argues, curious and imaginative professionals who seek a deep understanding of how something works. Here are a few hackers from CyLab explaining why they hack.

Tyler Nighswander

B.S. CS AND PHYSICS '13 AND MEMBER OF THE PLAID PARLIAMENT OF PWNING

Although hacking is about computer security, I see it as a way to really understand how things work. I've always been interested in taking things apart and understanding them, and in many ways, I view hacking as the epitome of that for computers. To be able to reverse engineer a system and find vulnerabilities, you need to understand not just how something was supposed to work,

Yuan Tian

PH.D. STUDENT IN ELECTRICAL AND COMPUTER ENGINEERING

We investigate how things might go wrong to have a deep understanding of the system so that we can build security schemes. We hack because we care about security, and we want to protect people from potential threats by identifying problems systematically. We are not the kind of hackers that just hack systems

Robert Xiao

PH.D. STUDENT IN COMPUTER SCIENCE AND A MEMBER OF THE PLAID PARLIAMENT OF PWNING

Perhaps the simplest answer is that I hack to learn — it's a fantastic opportunity to learn more about the world of cybersecurity, with the aim of understanding complex computer systems. With better understanding of the security challenges we face, I can develop more secure systems and help colleagues improve their computer security.

David Brumley

DIRECTOR OF CYLAB, PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING AND FACULTY ADVISOR TO THE PLAID PARLIAMENT OF PWNING

"Hacking is like solving a puzzle. The person who solves it often gains a better understanding of the program than its creator."