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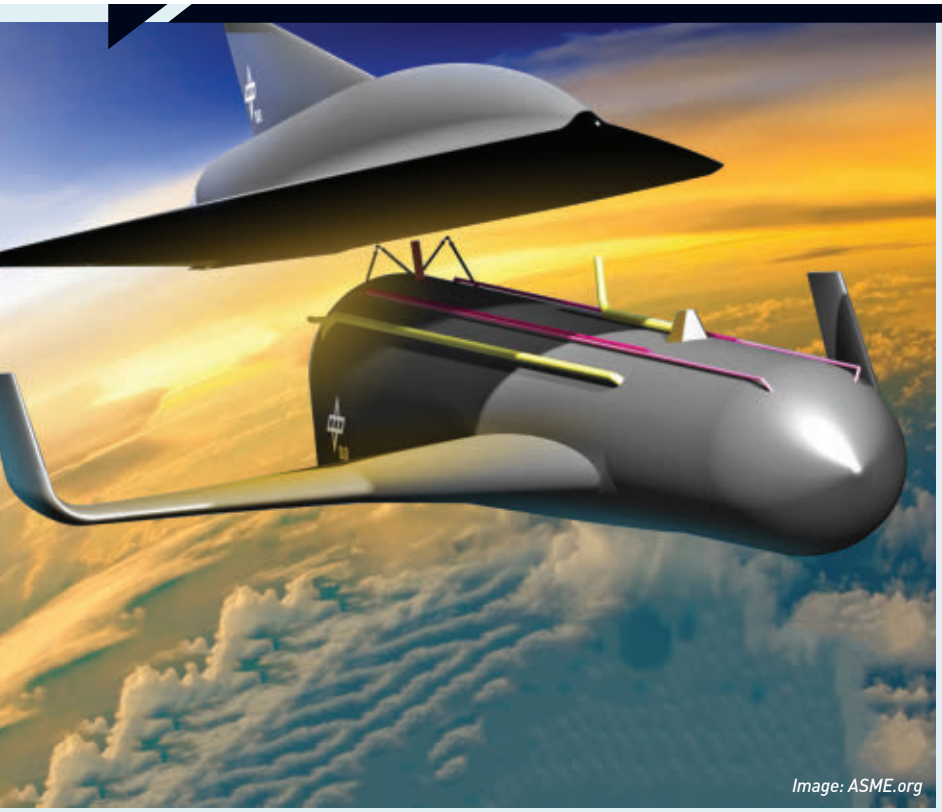


Image: ASME.org

CERAMICS MAKE HYPERSONIC FLIGHT A POSSIBILITY

FOR HYPERSONIC FLIGHT to become a reality, new incredibly strong materials are needed. A group of researchers at the University of Manchester have created something that will leave hypersonic nose cones and leading edges intact. It's an ultra-high temperature ceramic, or a UHTC, mated with a carbon-carbon composite.

Image: ASME.org

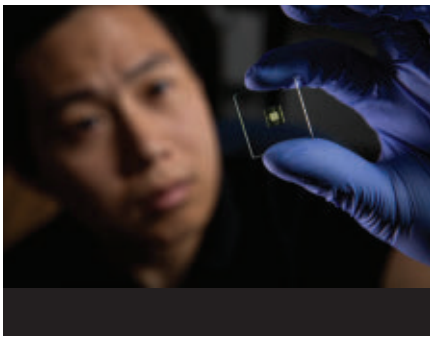
ROBOT TEACHERS TRANSFORM EDUCATION

Robots and artificial intelligence are changing the landscape for educators. Believing that AI is another step to personalized learning, a Georgia Tech professor successfully used an AI-backed "robot teaching assistant" based on IBM's Watson system for classroom work.

For these articles and other content, visit asme.org.

REGIME CHANGE IN 3-D-PRINTED MICROFLUIDICS

ENGINEERS AND CHEMISTS from Brigham Young University in Provo, Utah, have broken through a major barrier to the wider use of 3-D-printed microfluidics. With a customized printer and resin, the researchers were the first to fabricate a lab-on-a-chip with 3-D-printed features small enough to fall within the "true" microfluidic regime below 100 micrometers.



POWER FROM A SECOND SKIN

RESEARCHERS HAVE DEVELOPED an elastomer membrane to harvest energy from the human body's daily movements. The thin, stretchy material is called STENG, for "skin-like triboelectric nanogenerator."

NEXT MONTH ON ASME.ORG

PODCAST: DRIVING DOWN SOLAR POWER COSTS

Marie K. Mapes of the Department of Energy's Solar Energy Technologies Office talks about the SunShot program, a national effort to drive down the cost of solar power.

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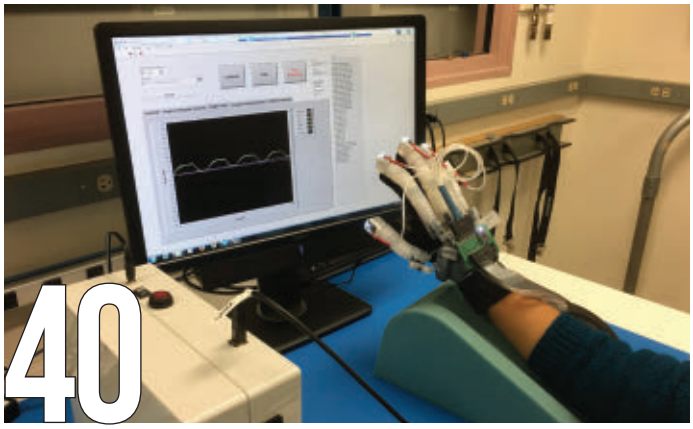

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Give me the place to stand, and I shall move the earth
—Archimedes

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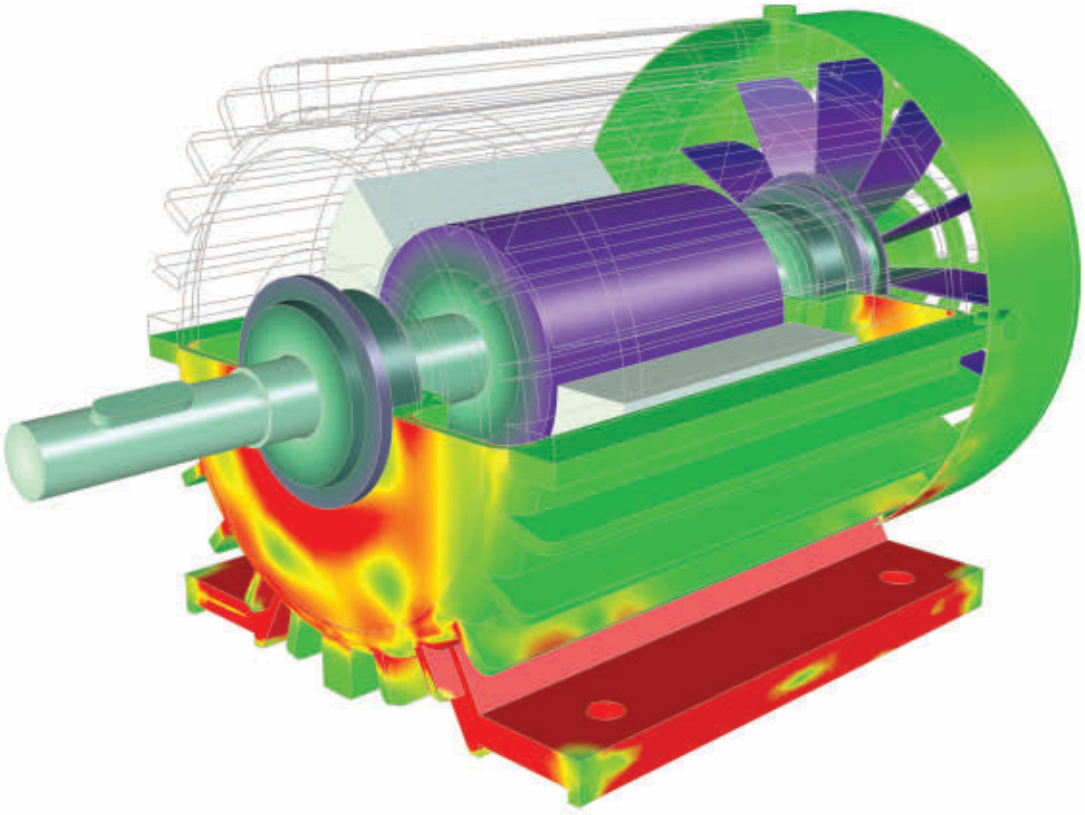

Visualization of the von Mises stress distribution in the housing of an induction motor by accounting for electromechanical effects.

In the 19th century, two scientists separately invented the AC induction motor. Today, it's a common component in robotics. How did we get here and how can modern-day engineers continue to improve the design?

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John G. Falcioni
Editor-in-Chief

E-FEST PUSHES GLOBAL BORDERS

Since he joined ASME back in 1999, Marcelino Guedes F.M. Gomes, the proud but affable president assessor at Petrobras Transporte S.A., has implored, prodded, and cajoled ASME to increase its presence in his native Brazil. Last year, he took matters into his own hands.

Sensing there was an opportunity to hold one of ASME's hugely successful E-Fest programs in Brazil, Marcelino (who, with traditional Brazilian informality, goes by his first name) mobilized staff at Petrobras to put his home country's best foot forward. He also organized a large web of university engineering professors from the Brazilian Society of Mechanical Sciences and Engineering, and commandeered an enthusiastic group of college engineering students from Universidade Federal do Rio de Janeiro.

Engineering students from the Universidade Federal do Rio de Janeiro. Far right is Marcelino Guedes F.M. Gomes.

Marcelino's efforts paid off. When ASME's selection committee—which included me—visited last fall, the presentations wowed us. As a result, ASME awarded hosting privileges for the continent's first E-Fest to Rio de Janeiro.

The Rio event (July 27–29) will be one of the four E-Fests held worldwide this year. The first one, E-Fest Asia Pacific, will be held next month, March 16–18, at the Delhi Technological University in India. E-Fest West will open March 23 and run through the 25th at the Fairplex grounds in Pomona, Calif., and E-Fest East will be held April 13–15 at Penn State University in State College, Pa.

E-Fests (efests.asme.org) bring together students from around the world to college campuses and other regional sites for a weekend of engineering competitions, music, activities, giveaways, networking, career development, and job fairs. The program began in 2017, with three inaugural events; two in the U.S. and one in India.

Pulling off E-Fests successfully takes a combined effort of ASME volunteers, especially a large number of hardworking student volunteers, backed by a community of strong corporate supporters and staff members.

"ASME is a great brand and we are so excited that Rio was selected as the site of the first E-Fest in South America," said Jay Carreiro, the commercial officer of the U.S. Consulate General Rio de Janeiro, who has dubbed the event, the "Engineering Olympics." The Consulate office played an important role in ASME's selection process, offering to help through outreach to sponsors, local media, and government officials.

"We see this event as one more step in the approximation between ASME and Brazil. It could well be the watershed we have been waiting for in bringing ASME closer to Brazil," Marcelino said proudly. ME

FEEDBACK

What should engineering students know about the profession while in school that you wish you knew when you attended? Email me.

falcionij@asme.org

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Introduction to Uncertainty Quantification for Engineers

Date: Feb. 22nd, 2018

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LETTERS & COMMENTS

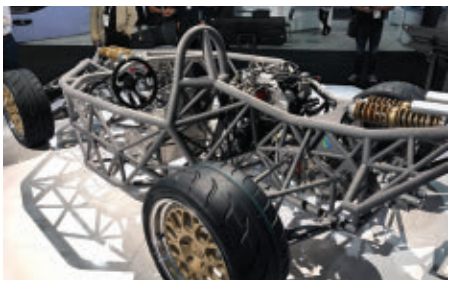
OCTOBER 2017

Reader Simmons is less than impressed with AI design work.

> A reader extols engineering prior to science. And in a comment, how best to expand engineering education in Maine.

BLIND SPOT

To the Editor: With any engineering design work done using a program, the final design is only as good as the programmers and the end users. For an example of this, take a look at the La Bandita Speedster that was depicted in the October 2017 issue ("AI and The Future of Machine Design," by Ahmed K. Noor).



A rear-end collision would direct the force of the impact through the tubular frame and right into close proximity to the back of the drivers head. It's a great illustration of why artificial intelligence will never replace actual intelligence.

John Simmons, *Buena Vista, Colo.*

ENGINEERING BEFORE SCIENCE

To the Editor: When people try to make distinctions among "engineering science," "engineering practice," and "engineering technology," we at times encounter the term "engineering" being defined as "the application of scientific principles."

I was looking into this recently, and I was interested to discover that the term *engineering* precedes *science* by several centuries. "Science" was coined in 1834

COMMENT

PRIORITIZING INVESTMENT FOR ENGINEERING EDUCATION

Many baby boomers are reaching or even exceeding their retirement age. That means plenty of companies urgently need to hire new engineers to replace their retired or soon to be retired colleagues. Of course, in addition to replacements for retirees, even more engineers would be needed if new research and development projects are to be accomplished.

The situation in Maine is worth considering. How can the state best benefit from prioritizing investments in engineering education at the undergraduate level?

Currently, in the University of Maine System (UMS), the University of Maine offers eleven undergraduate engineering and engineering technology programs. In comparison, the University of Southern Maine (USM) in its Gorham campus offers two engineering programs: mechanical engineering and electrical engineering, both of which are accredited by the Accreditation Board for Engineering and Technology. If Maine is going to address the need for educating more engineers, the leadership of the university system needs to determine which campus of the UMS has the potential for growing engineering programs and what engineering programs are most needed.

As to the first question, USM has a strong potential for offering more than the current two engineering programs. Its Gorham campus is close to a good collection of industries in southern Maine and the greater Portland area, which makes it a perfect place for harboring more engineering programs.

Regarding the engineering programs that are needed, according to data released by the American Society of Engineering Education among the 106,658 graduates of engineering programs in the country in 2015, a total of 59,691, or 56 percent, graduated from the four most popular engineering programs. These are mechanical engineering (25,436 graduates), civil engineering (11,900 graduates), electrical engineering (11,385 graduates), and computer science (inside engineering, 10,970 graduates). Among these four most popular and needed engineering programs, two are not offered at USM. They are civil engineering and computer science (inside engineering).

The significant synergy between mechanical engineering and civil engineering on one hand and between electrical engineering and computer engineering on the other hand greatly simplifies offering the mentioned new programs. Offering these programs at USM will have significant positive impact on the number of engineers who are trained by the University of Maine System.

by William Whewell, then Master of Trinity College, Cambridge. Before that date, the term generally used to refer to the works of Newton and his fellow investigators, was "natural philosophy."

That term embraced not only the narrow mathematic-based definition of science adopted by scholars from that date on, but included the knowledge possessed by a sadly neglected ancestor to engineering: the craftsman. Bear in mind that in 1834 when the word *science* was coined, the Industrial Revolution was in full swing.

That revolution was not led by collegiate "scientists" but by craftsmen such as John Smeaton, James Watt, and Robert Stephenson. In the early United States, it was largely self-educated innovators like George Henry Corliss—a storekeeper and major contributor to steam engine design—and Squire Whipple, who with one year of liberal arts college education led the country in bridge construction and wrote the first correct textbook on structural analysis, who made the largest impact.

As Francis Bacon said, "There is little concurrence between learning and wisdom."

Douglas L. Marriott, *South Lebanon, Ohio*

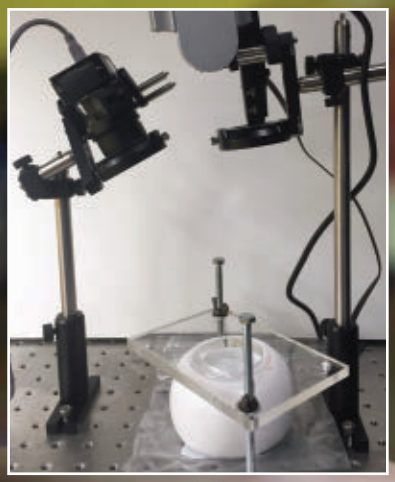
Finally, expanding engineering programs at USM may result in fruitful collaborations as well as healthy competitions among the UMS engineering programs. Such interactions should be encouraged as they provide students with great opportunities in their engineering education. It's healthy competition that increases efficiency.

Offering each type of engineering programs only in one location across the state cannot be helpful in attracting engineering students. It limits the number of prospective students' options and leads to reduced number of engineering students and graduates in Maine. If we believe that more engineers are needed in Maine we should expand offering the most favorite engineering programs across the state. **ME**

MEHRDAAD GHORASHI, P.E., is an associate professor of mechanical engineering at the University of Southern Maine in Gorham.

The ideas expressed do not necessarily represent the views of the University of Southern Maine or the University of Maine System.

FEEDBACK Send us your letters and comments via hard copy or e-mail memag@asme.org (subject line "Letters and Comments"). Please include full name, address and phone number. We reserve the right to edit for clarity, style, and length. We regret that unpublished letters cannot be acknowledged or returned.



Researchers tested their system by imaging a compressed model breast using a camera (inset left) and a laser projector (inset right).
Image: Carnegie Mellon

HAND-HELD CANCER SCANNER

RESEARCHERS DEVELOP AN INEXPENSIVE, NONINVASIVE MEANS TO MONITOR LESIONS

Breast cancer can best be treated when it's detected early. But the equipment doctors use to detect and monitor suspicious legions on the breast is invasive, large, and expensive. Jana Kainerstorfer, assistant professor of biomedical engineering at Carnegie Mellon University in Pittsburgh, and doctoral student Constance Robbins are developing a hand-held device to noninvasively check how lesions change over time.

"The goal is to develop an inexpensive, noninvasive yet quantitative monitor of the physical and physiological characteristics of a breast lump that could be used in both the doctor's office and by the woman at home," Kainerstorfer said.

The researchers developed a device that uses near-infrared light to optically image the tissues. "Malignant tumors contain greater water concentration and less lipid concentration than surrounding tissue and [have] a high concentration of blood vessels," Kainerstorfer said. "These changes can be monitored optically, based on near-infrared light interaction with tissue."

Adding optical imagery expanded the work of James Antaki, a professor of biomedical engineering, and Molly Blank, a 2016 Carnegie Mellon graduate now at the University of Washington's department of bioengineering. Blank's hand-held device compared a lesion

to the surrounding tissue, creating a topographic image that can be examined for the size, shape, stiffness, and location of the deformation.

Carnegie Mellon's researchers developed spatial frequency domain imaging, which offered two-dimensional images in an inexpensive, portable system.

"The light source is a projector and the camera can be a cellphone camera, [so] the depth penetration is limited to the superficial tissue layers," Kainerstorfer said. "[However], we are compressing tissue such that the imaging depth does not create an obstacle."

Blank said the optical innovation was important for younger women who have denser breast tissue. "I'm excited to see the ongoing integration of the new optical system with the previous mechanical one," she said in a school press release.

The researchers developed breast

The system can send the near-infrared images to a smartphone.
Image: Carnegie Mellon

cancer mimicking models ("optical phantoms") to display the effectiveness of the imaging. The researchers settled on flexible polydimethylsiloxane with ink and titanium dioxide standing in as scattering and absorption agents.

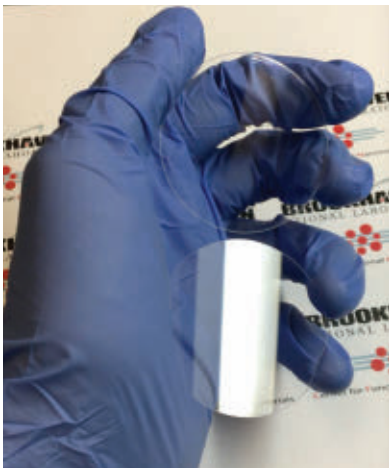
"We demonstrated that we can image lesions, even deep inside the phantoms when compression was applied," Kainerstorfer said. "That was proof of concept."

Kainerstorfer said they plan on human testing of the device sometime in the next six months. **ME**

NEIL COHEN is a writer based in Ramsey, N.J.

GLASS WITH NO GLARE

Eliminating glare and surface reflections from glass might prove to be better done as an inside job, according to scientists at the Brookhaven National Laboratory on Long Island. Researchers at the lab's Center for Functional Nanomaterials have demonstrated a way to reduce both to nearly zero, making the glass nearly invisible.



Compared to regular glass, nanotextured glass is virtually glare-free.
Photo: CFN

Glare and reflection are caused by light refracting or bending when it goes from one material to another, such as from air to glass. The CFN has demonstrated how nanoscale features gradually change the refractive index, eliminating those effects. Nanotextured glass has proven to be anti-reflective over a broad wavelength range, from all visible light and the near-infrared spectrum, and all viewing angles. That'll mean less squinting when using a laptop on a sunny day.

According to CFN director Charles Black, the project started as a way to make solar energy more efficient and convertible in a cell or capturing device.

"Typically, these kind of things are encapsulated with glass or plastic, so minimizing light reflections is what led us down the pathway to trying to make ultratransparent glass," Black said. "The approach we've taken to nanostructure the glass is an idea that's been around for quite some time."

The glass surface is textured via a process called "self-assembly," the ability of certain materials to spontaneously form ordered arrangements. In this case, a block co-polymer material provided a template to etch the glass surface with a collection of nanoscaled cone-shaped structures with sharp tips, a shape that's optimal to eliminating surface reflections. The surface nanotextures mimic structures from nature, such as the light-trapping posts in a moth's eyes that keep it safe from predators.

"The best thing is that you don't need a separate coating layer to reduce glare, and the nanotextured surfaces outperform any coating material available today," said former Brookhaven Lab postdoctoral researcher Andreas Liapis, who co-authored the online paper with Black about the findings.

In addition to improving the user experience for consumer electronics, Black said nanotextured surfaces make energy conversion by solar cells more efficient by minimizing the sunlight lost from reflection. Another possible use for the tech is replacing the damage-prone, anti-reflective coatings used in powerful pulse lasers, such as the ones that manufacture medical devices and aerospace components.

Black said Brookhaven has shown what's possible with nanotextured materials, and the lab is looking for partners to turn it into reality.

"Our business is to do basic science, it's not to manufacture things," Black said. "We believe that our world would be better if these materials existed. It will be up to us to work together with someone who is expert in manufacturing to explore how we might get there." **ME**

Anupam Sharma is scanning wings to find out what makes owls so stealthy. *Photo: Christopher Gannon/Iowa State University*

A DESIGN AS QUIET AS AN OWL

Owls, particularly barn owls, are alone among birds in being almost completely silent in both gliding and flapping flight.

"From an engineer's perspective, the owl's silent flight shouldn't be possible," said William Devenport, a professor of aerospace and ocean engineering at Virginia Tech. "Because, if you look at the owl wing, it's covered in edges, and each of those edges should radiate noise."

Figuring out how owls' wings allow for soundless flight could help engineers quiet jet engines, airplane wings, drones, wind turbines, and even home appliances like hair dryers. Iowa State University and Virginia Tech researchers are working together on owl wing studies to determine just what makes the owls' flight soundless.

To learn exactly how owls' wings manipulate air flow, turbulence, and pressure to produce silent flight, Anupam Sharma, an Iowa State assistant professor of aerospace engineering, is scanning owl wings, creating digital models and running complex simulations.

Three features of the owl wings come together to allow the birds to flap and glide with such quiet stealth: a soft, pliable, comb-like structure at the leading edge of the wing; feathers at the

Printed blades take cues from owl wings. *Photo: Christopher Gannon/Iowa State University*

trailing edge of the wing that end in a pliable and porous fringe, with the comb-like structure; and a downy coat of hairs that form a canopy on the flight feathers.

So far, Sharma and his team have been investigating the first two features to determine how they affect noise. The team has done numerical simulation to investigate every part of the flow field over the front end of the wing to understand what's going on in time and space.

Those simulations showed that, far from increasing unsteady pressure, the wing's leading edge reduces unsteady pressure in the airflow over the wing. The noise produced during flight is proportional to unsteady pressure.

"The leading [edge] is not straight, it's jagged to reduce unsteady lift at the leading edge, which is somewhat akin to how supersonic flight uses a delta [triangle-shaped] wing," Sharma said. To understand that, think of air turbulence as blobs of cohesive structures. "One blob will hit one portion of the wing and the jagged structure breaks it apart, breaks it off up from the rest of the blobs," he said.

This breaks up the pressure of the airflow, and the noise it causes.

Sharma's team is working with Virginia

continued on p.17 »

RUBBER, HEAL THYSELF

Pulling to the side of the road to change a flat tire could become a thing of the past, thanks to researchers who developed a new type of rubber that's as tough as natural rubber yet self-healing.

Liheng Cai, a postdoctorate fellow at Harvard who will be an assistant professor this spring at the University of Virginia, said the project was inspired by how living organisms heal themselves after damage.

Other Harvard researchers had developed self-healing hydrogels, which rely on water for the reversible bonds that promote mending. Creating self-healing dry materials such as rubber presented more of a challenge, since its polymers are connected by permanent, covalent bonds that are strong but won't reconnect when broken.

"The idea I came up with is to find a way to integrate both strong covalent bonds and weak, reversible bonds into a single dry rubber," Cai said.

One obstacle came with the concept of blending both kinds of bonds. Cai said covalent and reversible "do not like to mix with each other." The solution came from mixing on a microscopic scale with a "molecular rope," a randomly branched polymer which can form both types of bonds.

Cai said the breakthrough arrived when "we saw a transparent liquid of randomly branched polymers before crosslinking them to form a solid network," creating the tough, self-healing rubber.

The hybrid rubber doesn't crack but develops "crazes," similar to cracks but connected by fibrous strands. Any stress gets redistributed so there is no localized point that would break. The stress gets released, and the material goes back to its original form. A punctured tire made from the rubber would heal enough to continue driving.

Cai said self-healing rubber has the potential for use not only in tires, but gloves, medical devices, stretchable electronics and soft robotics. **ME**

"IT'S KIND OF LIKE CRASH TESTING A CAR. You stress the fuel right up to its design or well beyond to understand how it behaves in adverse conditions. In this way we can assure ourselves the fuel will perform in a safe way during abnormal situations."

John Bumgardner, director of transient testing at the Idaho National Laboratory, on subjecting nuclear fuel to extreme conditions, quoted by the Idaho Falls Post Register *on November 15, 2017.*

Footbridges can connect isolated villages to economic opportunities.
Photo: Bridges to Prosperity

BUILDING FOOTBRIDGES TO IMPROVE RURAL ECONOMIES

Bridges provide safe and convenient connections between communities and the services they need. Unfortunately, in many developing countries, bridges and other infrastructure are often in poor condition or nonexistent.

The creation of new bridge crossings could link the world's rural and underserved communities in developing countries to vital services, such as education, healthcare, and new employment opportunities.

One organization at the forefront of building bridges in developing communities is Bridges to Prosperity (B2P).

"On a household level, the effect of a bridge is considerable," said Alissa Smith, Director of Engagement for B2P. "On a community level, it is enormous."

Smith's statement is backed up by research. In 2013, Bridges to Prosperity and economists at the University of Notre Dame in South Bend, Ind., partnered to examine the potential of footbridges to create economic returns. Their three-year randomized, controlled trial in rural Nicaragua found that a footbridge resulted in a 30 percent increase in household income and a 56 percent increase in agricultural yields of staple corn crops. The study also found that bridges increased investments back into the community, represented by a 69 percent increase in spending on agricultural goods like fertilizers and pesticides.

A bridge also appeared to decrease the perception of risk. The likelihood of a household experiencing involuntary rationing of food staples during floods in communities without a bridge reaches nearly 50 percent, but drops to just 2 percent in communities with a bridge.

This kind of data gathering is not new to B2P.

"Bridges to Prosperity has invested over the last two years in key systems that will allow us to better serve isolated communities," Smith said. "These systems utilize technology and newly developed software to create a comprehensive database that links project management, volunteer, and donor information, in-field assessment, and evaluation data collection so that B2P's staff can more efficiently diagnose and address challenges, identify trends in engagement or impact, and communicate across departments, program countries, and end-user communities."

Smith said the organization has worked with Salesforce developer Tact to integrate these systems. They will launch mobile data collection devices and an SMS survey program in all B2P program countries by 2019.

Engineering new bridges in developing countries can have a dramatic impact on the people living there. Bridge construction can improve the local economy and quality of life by providing a safer and quicker means of transportation.

The benefits of such projects aren't going unnoticed.

"We continue to explore, through our new Lean Data Program which utilizes SMS surveys to assess the impact of a footbridge on individual end-users, the influence of footbridges on access to schools, health clinics and hospitals, and employment," Smith said. ME

KAYLA MATTHEWS is a contributor to Engineering for Change. For more articles on global development visit www.engineeringforchange.org.

LET THERE BE DARK

Venetian blinds have a certain film noir appeal, but few household fixtures are more of a pain to clean. Stanford University researchers have developed a window that may one day put an end this domestic frustration.

The prototype pane, about 4 square inches, blocks light through the movement of a copper solution over a sheet of indium tin oxide modified with platinum nanoparticles. When transparent, the window is clear and allows about 80 percent of surrounding natural light to pass through. When dark, the transmission of light drops to below 5 percent. It only takes about 30 seconds to change from transparent to dark or vice versa.

Existing smart windows are made of materials, such as tungsten oxide, that change color when charged with electricity. But these materials tend to be expensive, have a blue tint, can take more than 20 minutes to dim, and become less opaque over time.

Once materials science and engineering professor Michael McGehee hit upon the idea in collaboration with chemist Christopher Barile, the rest was surprisingly easy. "I had the concept of plating metal and using it to block light, and Chris got all the chemistry to work." McGehee said the window technology can innovate lighting in rooms, automobiles, even sunglasses, and has the potential to save about 20 percent in heating and cooling costs.

The researchers have filed a patent and entered into discussions with glass manufacturers and other potential partners. Developed commercially, McGehee said, the windows could operate with a switch, knob, or by automation. The thicker the metal, the more light will be blocked, he explained. Tinting will be determined by controlling the amount of plating.

The researchers switched the windows on and off more than 5,000 times and saw no degradation in the transmission of light, but further testing is needed in real-world conditions to gauge the effect of things like high temperature and prolonged exposure to sunlight.

McGeehee said the work is in an important but under-investigated area, so there's a lot to keep his team motivated. In fact, McGehee had an odd response from his colleagues in the ivory tower. "It was hard for other professors I work with to understand: 'Why windows?' " ME

HEAD IN THE STARS, WORK ON THE GROUND

Engineers working on **global health challenges** can get valuable assistance from **the space program.**

I am a professional emailer. So my day job hasn't typically included jumping off 10 meter platforms into wave pools, or being flipped over in a sinking helicopter simulator in the dark, or fighting blinding fires and freezing floods. Or, perhaps even harder, sewing fabric cuffs or moving marbles from one table to another with Dixie cups and rubber bands.

But at least I nailed the Etch-a-Sketch challenge.

Throughout last spring, I was a candidate for the Canadian Astronaut Selection, which meant I was challenged and tested from nearly 4,000 applicants to a final public 17 finalists. Eventually, the Canadian Space Agency got wise to me, and today my new friends Josh and Jenni are training in Houston as Canada's latest astronauts.

When I applied for the astronaut job, it wasn't to walk away from the challenges inherent in global development, but to amplify the impact of engineering. The International Space Station can be a unique platform for addressing chronic challenges on Earth.

Many astronauts return home deeply transformed by a sense of our interconnectedness with the rest of humanity and with our fragile planet. Former astronauts Ron Garan, Nicole Stott, Leland Melvin, and Anousheh Ansari noted their shared experiences of seeing the Earth from orbit at the recent launch of the Constellation Foundation, with a vision that, "Profound collaboration is the key to making what seems impossible possible."

By engaging research partners in developing countries, for instance, space agencies can ground-truth Earth observation data, then leverage their orbiting assets toward environmental impact monitoring and response. More ambitiously, through the development of sustainable life support systems that can operate for long-duration space flights, engineers can exchange in a multi-direction technology transfer with others working to address similar challenges here on Earth.

I was not the only Canadian astronaut candidate thinking about embracing high-tech aerospace tools to tackle critical planetary health challenges. Another candidate, Sara Spangelo, founded a small-satellite company, Swarm Technologies, which will soon reach the most remote places on Earth with affordable connectivity.

Our team at Portland State is working with Sara's to provide global, cost-effective environmental monitoring of critical resources. Today, we are remotely monitoring the water supplies for over a million people in Ethiopia and Kenya. With Sara's help, we'll be able to monitor over five million people's water supply in the next year, linking this critical data to water service providers and regional water resource management authorities.

Working with the USAID, NASA's SERVIR program, and the Kenya-based Regional Centre for Mapping of Resources for Development, a consortium of 20 African countries, we are also using our sensor data to ground-truth satellite-based remote sensing data and extend our impact into regional water management.

The aerospace and global health worlds continue to collide. The Planetary Health Alliance, a convening concept coined by the Rockefeller Foundation and *The Lancet* medical journal, connects climate change science to the practical impacts on people. The warming planet, declining biodiversity, shortages of arable land and freshwater are impacting all of us—though some are feeling these effects more quickly.

Where our teams operate in the African Great Rift Valley, which extends from Tanzania through Ethiopia, drought has been a historic way of life. But now, it's persistent and critical.

While some Americans still scoff at climate change, Ethiopians and Kenyans live with the early impacts every day. Space-based monitoring of the changing climate and its impact can help decision-makers act to ameliorate some of the worst effects on people taking the brunt of global warming.

None of this replaces the work being done on the ground, but a different viewpoint is always helpful—even when the perspective is from Earth's orbit. ME

EVAN THOMAS is an associate professor of public health and mechanical engineering at Portland State University and Oregon Health & Science University.

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A DESIGN AS QUIET AS AN OWL

Tech researchers to understand the role the hairs on the wings play in quieting noise. The hairs initially rise almost perpendicular to the feather surface but then bend over in the flow direction to form the canopy with interlocking barbs at the their tops.

The hairs aid in reducing trailing noise. When a blade like the ones on a wind turbine slices through the air, the sharp edge at the back of the blade converts the air's turbulence into sound waves, Sharma said. Virginia Tech researchers found the canopy of the owl wing's surface pushes off the noisy flow.

"The impact of hairs and the canopy is to take the blobs and move them away from the wing's surface; then, the noise production mechanism weakens," he said. "Unsteady pressure depends how close turbulence is to surface and trailing edge; you want to get the eddies to be moved away from the trailing edge."

After Virginia Tech researchers simulated and optimized the canopy structure, they created a 3-D-printed, plastic attachment consisting of small finlets that can be attached to blades, such as those within airplane engines or the rotating blades of wind turbines.

The finlet invention may be retrofitted to an existing blade and wing designs and used in conjunction with other noise-reduction strategies to achieve even greater noise suppression, Sharma said.

"The add-ons could be useful in wind turbines," he said. "They seem silent, but even the small amount of noise they make in quiet surroundings becomes source of annoyance." Local laws make it difficult for manufacturer to place turbines unless they have means to reduce noise, Sharma added.

Researchers continue to study the back part of the owl wings to find even more methods to quiet all types of fan blades and airplane wings.

Just imagine, one day you'll be watching a plane land and may not even hear the jet engine. Or you'll hike through an area with wind turbines and not hear that eerie hum. That's something that might be worth listening for. ME

JEAN THILMANY is an independent writer. For more articles on manufacturing and design visit ASME.org.

Q&A
FRANK BLASE

AS CHIEF EXECUTIVE OFFICER of igus GmbH, Frank Blase established reinforced plastic Energy Chain Systems and injection molded polymer bearings as two distinct product groups of igus and set up a network of sales engineers. This revolutionized the company, linking seemingly unrelated products and creating functionally advanced, yet affordable polymer components and assemblies. The company now has more than 3,500 employees in Germany and through 35 subsidiary companies around the world.

ME: In terms of efficiency and organization, you have one of the most impressive manufacturing facilities I've seen. What's this attributed to?

F.B: People. We like to keep every employee involved and engaged. I want to keep the small-company feeling we had when we started, and empower people to feel that each person can make a difference in the products we make.

ME: Your building has no igus sign outside. Why is that?

F.B: We are a very large company, and our building is impressive, but we started out very humbly. My father Günter started the company in 1964 in a garage. As a company, we have grown, and I owe a lot of that growth to America. But we remain family owned. We want to be a good neighbor here in Cologne (Germany). We don't want to show off.

ME: Tell me about the unique design of the building internally and also about those pods on the roof.

F.B: Our building was designed by the architectural firm of Nicholas Grimshaw. It's a modular mechanical system where we can change the configuration of virtually every workspace in the plant. This is our factory, our warehouse, our office, and our testing facility. The pods are large roof domes that bring natural light in and help with ventilation.

ME: You said you owe a lot of the growth in igus to America. Why is that?

F.B: I went to the U.S. in 1978, when my parents' company was doing €500,000 in sales worldwide. Now we do €700 million per year. I was very lucky to attend Texas Christian University and it opened my mind to think big. In Germany, we are taught about tolerance but not about entrepreneurship. The education I received at TCU was incredible.

ME: Your products penetrate multiple industries and products, from 3-D printers to cranes. What does the future look like?

F.B: We are always looking to improve our products and to see how they can reshape existing technologies. For example, we are looking at offshore applications where our plastics may replace metal parts. But the next frontiers are the IoT and digital automation. This was invented for us.

ME: I want you to tell me about the unusual mechanical artwork in your lobby. Then please tell me why your desk sits on the factory floor.

F.B: The artwork is our igus constellation that shows the customer as the center of the universe. I don't want our employees to forget that. My office is where it belongs, because I want anyone who has something that can help us help our customers to tell me directly.

ME: You have a 10-year-old son. What do you hope he learns from you?

F.B: I want my son to see that he needs to remain humble as he grows up, but also to go after his dreams. The possibilities in life are right in front of us. I give credit to this generation for the passion they show. Finding that passion within myself was the greatest gift. **ME**

JOHN G. FALCIONI

FEEDING SOLAR PANELS TO FARMS

Farmers in Germany are showing new ways to make efficient use of farm land while meeting energy needs. They have placed solar panels over crops so their vast lands can generate both food and energy.

The concept is called agrophotovoltaics, and the idea is to make more efficient use of land. Farmers can meet their energy needs via the solar panels and make money through both crops and surplus energy.

Led by the Fraunhofer Institute for Solar Energy Systems ISE, the concept was tested with multiple crops including winter wheat, potatoes, celeriac, and clover grass.

Solar panels were placed in a southwest orientation in rows five meters above the crops. The panels were placed so the crops got uniform exposure to sunlight.

The results were promising. Under the shade of the solar panels, the yield of clover grass under the solar panel array was only 5.3 percent less, while the yield of potatoes, wheat and celeriac were between 18 to 19 percent less.

Even with the reduction in yield, the overall crop production could still be sold at a profit.

Over 12 months, the array could produce enough electricity for 62 four-person households. The energy also could be redirected into farming activity such as charging electric vehicles and processing harvested crops.

"Agrophotovoltaics has the potential to open up new space that is urgently needed for the photovoltaic expansion in Germany. At the same time APV can mitigate the conflicting interests between agriculture and open space PV systems for viable land," said Hans-Martin Henning, Institute Director of Fraunhofer ISE.

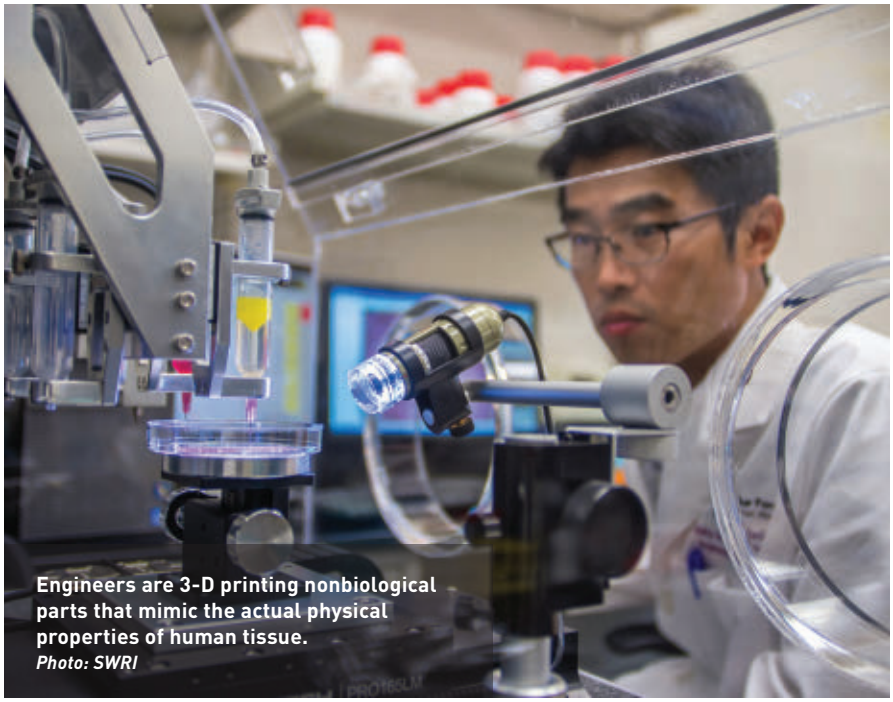
Henning also noted that market readiness for such a concept and photovoltaic systems of different sizes need to be tested. **ME**

BIG NUMBER

30 TWh

ANNUAL ELECTRICITY CONSUMPTION BY THE SERVERS SUPPORTING THE BITCOIN CURRENCY.

OVER THE PAST FEW YEARS, THE INTERNET-BASED CURRENCY known as Bitcoin has received a lot of attention. One of the lesser-known aspects of the so-called cryptocurrency is its power consumption. The computers that track transactions pull electricity off the global grid at a continuous 3.4 GW, or 30 TWh per year, according to the website Digiconomist. More startling, the electricity draw is 294 kWh per transaction, enough to power a typical U.S. household for 10 days. Digiconomist suggests alternative transaction clearing mechanisms may be less power-hungry, but Bitcoin is unable to support such sustainable algorithms.



Engineers are 3-D printing nonbiological parts that mimic the actual physical properties of human tissue.
Photo: SWRI

THE QUEST TO 3-D PRINT SURROGATE HUMAN TISSUE

Researchers at the Southwest Research Institute now are tackling the challenge of 3-D-printing nonbiological parts that mimic the actual physical properties of human tissue.

There is nothing new about using 3-D printers to make intricate anatomical copies of body parts. Surgeons use them to visualize what they will see and decide how to proceed before actual surgery. But it is quite another thing to 3-D print nonbiological parts that mimic the actual physical properties of human tissue. Researchers at the Southwest Research Institute now are tackling the challenge.

Beginning as a proof-of-concept project, mechanical engineer Travis Eliason used an off-the-shelf "hobby-type" printer and common printing materials to produce a surrogate of the hard bone and soft muscular tissue of the cervical spine. "The ultimate goal is to replace human surrogate material for research with a nonbiological, artificial object that represents some structure of the body," he said. "It would be reusable, and nonbiological-based so there are no safety concerns as with human tissue, and easy to use."

Research into musculoskeletal injury depends mostly on either human surrogates or cadavers. Both are pricey and in limited supply. Cadavers are widely used but present problems with procuring, storing, preparing, and disposing, all of which increase costs. Surrogates don't have those issues and using them eliminates any concerns about safety. But they are expensive and mostly produced for specific cases, making them unsuitable for multiple uses. Think crash dummies or models for CPR training. Perhaps most significantly, their sturdiness makes it difficult to accurately replicate specific actions of the human body.

Eliason was intrigued by the possibility of printing surrogate tissue while working on another additive manufacturing project. "This was all really very new for us," he said. "But I saw that I could manipulate the structural properties of an object, and I began to think, 'Could we use that ability to adjust the structural properties to matching biological properties?'"

Eliason chose the cervical spine simply because the institute had worked with the parts and had a wealth of data already available. But it wasn't easy to print, he said, because of the intricacies of the internal structure. "There's a lot of unsupported overhang [in vertebrae]. When you print you lay down material on top of what has been printed, so there was a lot of support material. That was difficult in getting it to print."

To match the material properties of cervical spine ligaments, he used three common printing materials: SemiFlex, NinjaFlex, and PolyFlex. Coupons—rectangular-shaped printed objects used to refine material and printing parameters—were tested in tension using an electromechanical test frame. The test results determined the optimum combination of material and printing settings to produce a structure mimicking ligament and disc properties of a cadaver.

Eliason said the test results were a good first step in eventually manufacturing tissue that mimics muscles and bone.

The test ligaments used in pure moment motion-segment testing behaved significantly stiffer than cadaver tissue. They were manufactured using three off-the-shelf flexible materials and a hobby-type printer, and still succeeded in validating proof of concept: By using multiple materials and varying print parameters and structure, surrogate ligaments can be printed that closely match material properties of cadaveric tissues. After printing the bone structures, the ligaments can be fitted to create functional anatomical structures that closely mimic biomechanical behavior of those from a cadaver.

The next steps are two-fold, Eliason said. The first is to use more advanced printers and software for the next phase. More advanced software is already available and printer technology is advancing quickly. He sees a lot of promise in polyjet printing, which spreads material similar to an ink-jet printer and cures the printed

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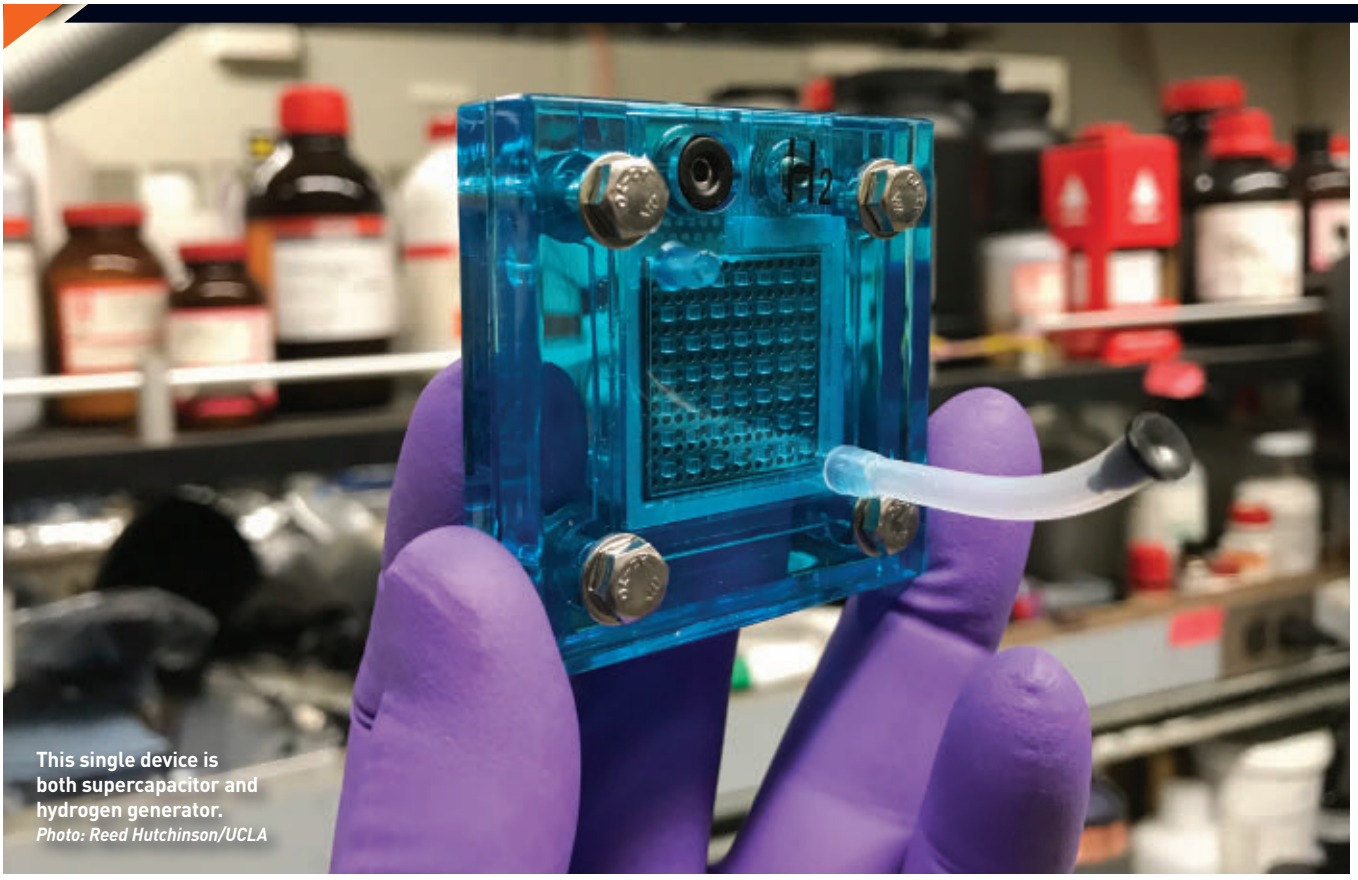


This single device is both supercapacitor and hydrogen generator.
Photo: Reed Hutchinson/UCLA

RETHINKING ENERGY STORAGE

SOLAR POWER PRODUCTION DROPS on cloudy days and at night when it is dark. To deliver solar energy whenever we need it, researchers are developing devices to store and release it on demand. This month, we examine two proof-of-concept devices that do just that. One converts solar power to electrical or chemical energy, while the other releases stored heat with a flash of light.

SOLAR STORAGE

THE LAB Kaner Lab, University of California, Los Angeles. Richard Kaner, director. Maher El-Kady, postdoctoral scholar.

OBJECTIVE Study conducting polymers and graphite, and use these and similar materials to store solar energy.

DEVELOPMENT Built a single solar-powered device that can use a supercapacitor to store solar electricity or split water into pure-burning hydrogen fuel.

University of California, Los Angeles, researchers have developed a prototype that uses solar energy to either charge a supercapacitor or produce hydrogen gas for fuel. Storing solar power as electrical energy or chemical energy typically requires two separate systems, one for each task, but this combines both functions into a single device.

Combining supercapacitor and water-splitting technology is an advance similar to bringing together phone, web browser, and camera to create a smartphone, said UCLA's Richard Kaner, whose lab pioneered the device.

Supercapacitors charge, store, and release energy differently than a battery. They charge rapidly, within seconds or minutes, and withstand hundreds of thousands more recharging cycles than a battery. On the downside, they store less energy than a battery of the same weight and provide power in a short burst rather than a constant stream. Engineers frequently use them to accelerate hybrid cars from a stop and to provide a surge of power in consumer products.

At the heart of this hybrid system is the nanoscale foamed iron-cobalt-nickel material on which it is based. It is a layered double hydroxide, a class of materials whose alternating anion and cation structure holds charges well. Maher El-Kady, a postdoctoral researcher in Kaner's lab, synthesized the material using a rapid, one-step electrodeposition process. The nano-

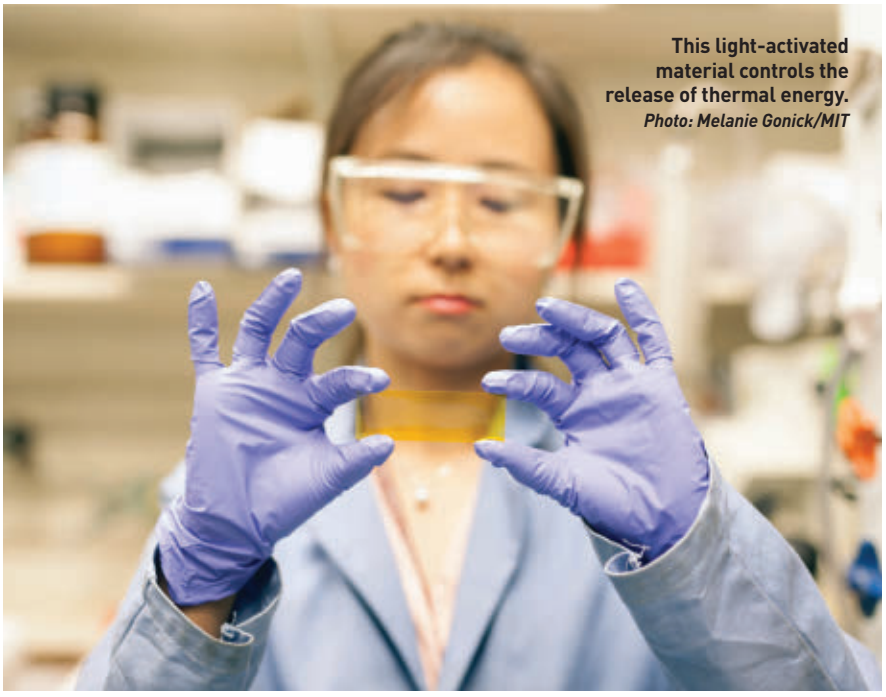
structure has a very high surface area:volume ratio, maximizing the amount of material available to store charge.

Layered double hydroxides also have another use: they catalyze such electrochemical reactions as splitting water into oxygen and hydrogen. El-Kady reasoned that the same nanostructure that improved the material's ability to store a charge might also enhance its ability to split water. When he found that it did, he decided to build a device that could take advantage of both its charge storage and catalytic capabilities.

To make a dual-function device, the researchers sandwiched the nanostructured electrode between an activated carbon electrode and a platinum electrode in a solution of potassium hydroxide. Then they wired two circuits. Each one connected the solar panel with the nanostructured electrode and either an activated carbon or a platinum electrode.

The circuit between the nanostructured electrode and the activated carbon electrode creates a supercapacitor that stores five times more charge than the best commercial device, El-Kady said. The nanostructured electrode also improved the water-splitting reaction's energy efficiency.

El-Kady sees the device as a gateway toward producing fully renewable hydrogen for transportation fuel. Currently, most of the world's hydrogen comes from reforming methane, which also produces carbon dioxide. ME



This light-activated material controls the release of thermal energy. *Photo: Melanie Gonick/MIT*

THERMAL BATTERY

THE LAB Grossman Group, Massachusetts Institute of Technology. Jeffrey Grossman, professor of environmental, materials, and mechanical engineering, director. Grace Han, postdoctoral scholar.

OBJECTIVE Apply nanomaterials, electronic, optoelectronic technology to renewable energy, water desalination, and other challenges.

DEVELOPMENT Added light-sensitive molecules to a phase change material to trigger the release of stored heat with a flash of light.

Sunlight is a common source of renewable energy worldwide. It warms water for households, while high-tech prisms concentrate light to melt salt to generate steam for electrical turbines day or night. Storing those hot liquids in insulated tanks retains thermal energy, but insulation is ideal. Eventually, the heat simply dissipates with time.

"I believe that designing new materials could allow us to store thermal energy and release it when needed," MIT's Jeffrey Grossman said.

His goal was a material that could store and release heat on demand, the way a battery does for electricity.

To design his new material, Grossman and his colleagues reexamined solid phase change materials. Extensively investigated in the 1970s, these solids turn liquid as they absorb heat and release a burst of heat as they cool and resolidify.

In order to make them behave more like a battery, Grossman needed to slow down their release of heat. To do this, Grossman and postdoctoral researcher Grace Han added light-sensitive molecular "switches" to a waxy phase-change material.

As Grossman and Han melted the mixture of switches and phase-change material, they flashed it with ultraviolet light. This caused the light-sensitive molecules to form kinks. These structures prevented the waxy material from resolidifying even when cooled below its normal phase transition temperature.

When Grossman and Han flashed the supercooled liquid with visible light, the molecular switches returned to their linear form. Only then did the wax begin to recrystallize, turning the mixture solid and releasing heat.

The proof-of-concept material has an energy density of about 200 Joules per gram, about as much as a lithium-ion battery. In lab tests, it was able to retain heat for days, Grossman said.

The lab is working with a company to incorporate it into their solar cook stoves to dry crops, cook at night, and provide space heating. The material can also capture and recycle waste heat from any process, ranging from industrial machinery and processes to vehicle engines, he said. ME

MELISSAE FELLET is a writer based in Missoula, Mont.

A NEW FRONTIER IN ENGINEERING

DANIEL S. GOLDIN, ADMINISTRATOR, NASA, WASHINGTON
SAMUEL L. VENNERI, CHIEF TECHNOLOGIST, NASA, WASHINGTON
AHMED K. NOOR, DIRECTOR OF THE CENTER FOR ADVANCED COMPUTATIONAL TECHNOLOGY, LANGLEY RESEARCH CENTER, HAMPTON, VA.

Three leaders at the U.S. space agency discuss how advanced engineering concepts would enable new air and space vehicles.

LOOKING BACK

Engineers were reexamining the space program when this article first appeared in February 1998.

Several design features will significantly affect aerospace systems. For example, a high degree of autonomy is emerging as a technological area of strategic importance to future missions. In addition to requiring revolutionary propulsion, an interstellar probe intended to travel past Pluto—to cite just one possibility—must be a "thinking," intelligent spacecraft. Such a probe will feature embedded sensors; actuators; an elaborate information-processing system; and intelligent software agents that can actively monitor a situation, exhibit intelligence by reasoning and responding to tasking, and work toward goals based on the current environment. Because the probe will be too far away, the time delays will be too great for the craft to be controlled from Earth. Moreover, the spacecraft will need to learn, adapt, and make decisions as it goes, and be self-diagnostic and self-repairing.

The development of such structures promises significant benefits closer to home. These intelligent systems will also be used in near-Earth craft and even vehicles operating in the Earth's atmosphere. They will allow for the safe reuse of future transportation systems with minimal maintenance and operational constraints, which translates into lower costs over the systems' operating life.

Another important design feature is the use of engineered multifunctional materials and structures. In addition to supporting loads, multifunctional structures use sensors to detect and evaluate loads or failure as well as interact with the surrounding electromagnetic environment. They are used for reducing the mass and volume of the aerospace system, lowering its manufacturing and maintenance costs, and improving its performance. Modularity—the use of modules to tailor vehicle capabilities to specific mission needs—will also be significant, as will miniaturization of subcomponents or of the entire vehicle.

Aerospace systems will also need to survive harsh environments. Large areas of air vehicles will be exposed simultaneously to extreme thermal and acoustic load levels (for example, airframe temperatures of 400 °F to 1,500 °F and noise levels up to 170 decibels). These state-of-the-art designs can easily weigh more than twice that of structures for nonextreme environments. Design-life requirements of future systems also far exceed those of current vehicles. Advanced materials and structural concepts will be needed for primary structures, leading edges and nose caps, cryotanks, and thermal protection systems to reduce their weight and cost as well as improve the reliability of these systems.

Furthermore, unlike current space missions, which require many people in mission control and in the back rooms, future outposts should be fully autonomous with only a skeleton crew in mission control. ME

A PIONEER RETURNS

While NASA leaders were sketching out a potential future in space, the space agency was readying a nod to the past. John H. Glenn—engineer, Marine aviator, Senator from Ohio, and the first American to orbit the Earth—was selected to fly aboard the Space Shuttle *Discovery* as a payload specialist. Nominally, the mission that October was designed to study the effects of weightlessness on the aging—Glenn was 77 at the time of his flight. Biometric readings of Glenn were taken before, during, and after the flight. (Another experiment was scrapped at the last minute.) Glenn's mission also gave NASA a much-needed promotional boost: Glenn appeared on multiple magazine covers and received a tickertape parade in New York City after the shuttle landed safely.

John Glenn is fitted for a space suit prior to his Space Shuttle mission in October 1998.
Image: NASA

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3-D PRINT SURROGATE HUMAN TISSUE

material with ultraviolet lights. "The benefit is that you can blend materials on the fly to get a whole spectrum of multiple properties," he said.

The second is more challenging: Develop new material to match structural and biomechanical properties of human tissue, an area of study with a limited amount of research to refer to, Eliason said.

"We've seen a lot of 3-D printing in the medical field to visualize body parts," he said. "But we've not seen anything to get the material properties correct. That's the difficult part, getting the correct biomedical behavior of soft tissue, so that it not only looks like a cervical spine but behaves like one."

Eliason thinks the key to advancing the project lies in material science and design of a new material beginning with the internal structure. "Some kind of metamaterial," he said.

SWRI researchers are intrigued by the design of a 3-D-printed door handle that does not have moving parts. The 3-D-printed metamaterial is a single block of metamaterial cell grids. The door lock transforms the rotary movement of the handle into the linear motion of the latch.

Developed by the Hasso-Plattner Institut in Potsdam, Germany, the system is based on shearing-wall technology. The key to the metamaterial mechanism is a specialized type of cell, "the only ability of which is to shear. Unlike the rigid cell, this shear cell is designed to deform when a force is applied, more specifically to shear, which allows for controlled directional movement," according to the institute.

"There's no moving parts," Eliason said. "You design cells to collapse under shear. Certain cells collapse so you get movement just by design."

That could be the way to design surrogate muscle tissue. The idea in mimicking a tendon is to design the same behavior in the microstructure of a printed part, holding tension but buckling under compression, with an interlocking or shear-collapsing structure.

That's still in the future. Researchers are looking for improvements in printer resolution to accommodate the microstructure needed to get the necessary behavior. Until then, cadaver tissue will remain the standard in surrogate tissues. ME

JOHN KOSOWATZ is senior editor at ASME.org. For more articles on biomedical engineering, visit www.aabme.org.

MODERNIZING THE WIND-UP TOY

In a world of battery-powered toys and games, wind-up toys feel nostalgic. There are still innovative uses for the wind-up mechanism, for example to charge batteries in high altitudes.

But a group of researchers in the United Kingdom and China are out to improve the centuries-old wind-up mechanism so toys can generate more kinetic energy and be in motion longer. They created a computational design tool that can arrange better mechanical assemblies and improve the run time of wind-up devices—in this case toys—compared to conventional assemblies.

"For the same input spring mechanism, our solutions lead to 1.5 to 2 times more travel distance for the designed toys against non-optimized versions," said Niloy Mitra, professor of geometry processing at University College London.

At the center of a wind-up device is a spring motor, which generates kinetic energy and gives momentum to a wind-up toy car for a car or a clock to operate. The motion is transferred via higher-pair joints and other parts inside the wind-up assembly.

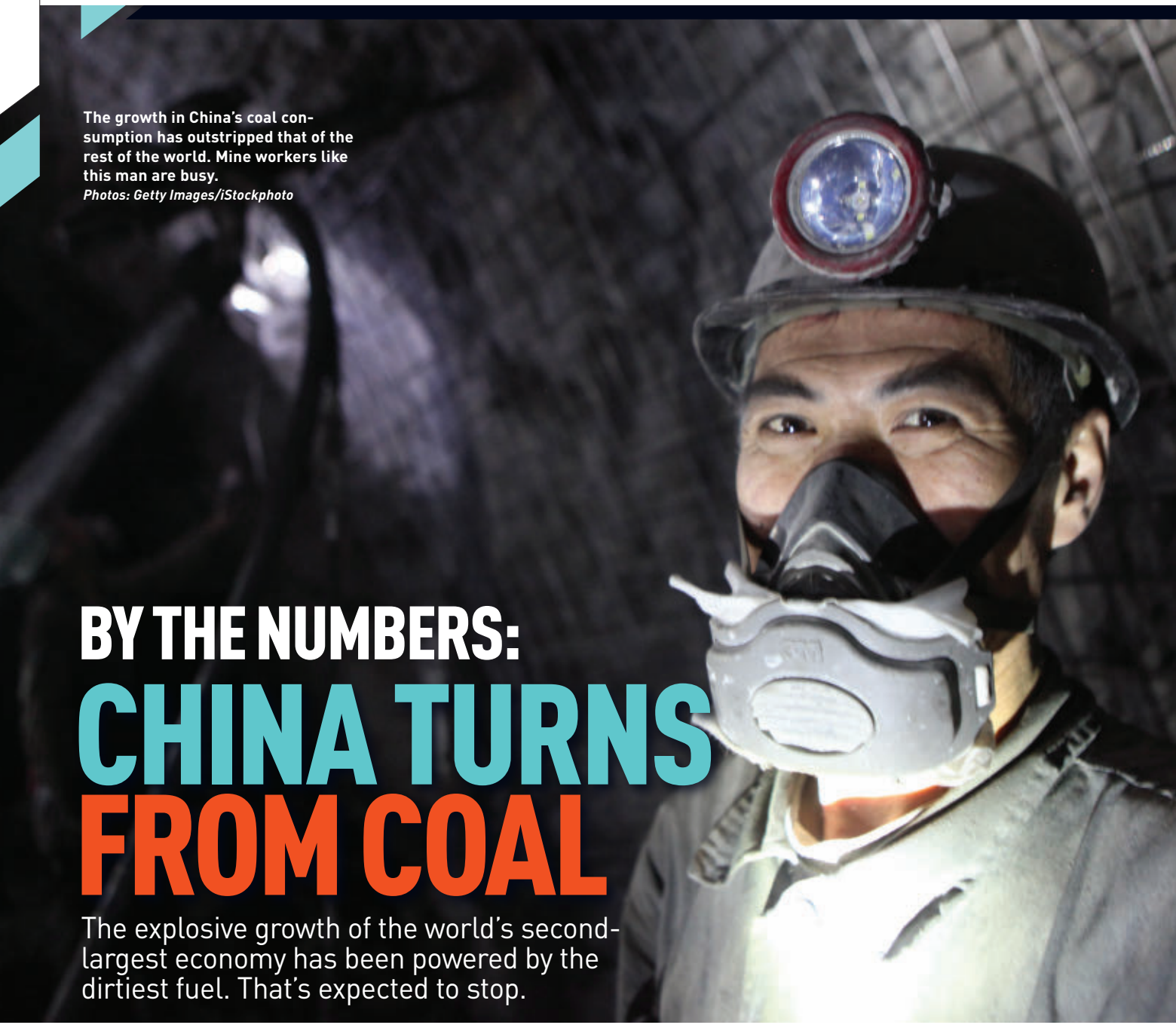
Designing such assemblies manually and keeping them compact for small toys can be complicated. So the researchers came up with a computational technique to automatically design efficient wind-up mechanisms that are compact, use fewer parts, and generate more motion.

The computational tool can be handy when creating wind-up toys using 3-D printing, for example. It mostly applies to wind-up toys, but could also help design electronic cars and even quadcopters, Mitra said.

The wind-up toy computational system has four components. The first is elemental mechanisms, which takes into account 11 common mechanisms used in wind-up toys, analyzes them, and models the geometry, kinematics and connections. Based on user input, the tool can create conceptual designs and compute the motion transfer between parts. That provides the basis to automatically construct an optimized wind-up design relative to the size of the device. Beyond a sleeker wind-up design, the goal is also to avoid collision of parts, reduce assembly complications, and if possible, to provide a more efficient design.

The researchers tested the computational tool against standard wind-up designs. The optimized designs were more compact, less complex, and used smaller mechanical parts. On the same amount of wind-up, the optimized toys ran longer than the non-optimized models. ME

AGAM SHAH



The growth in China's coal consumption has outstripped that of the rest of the world. Mine workers like this man are busy.
Photos: Getty Images/iStockphoto

BY THE NUMBERS: CHINA TURNS FROM COAL

The explosive growth of the world's second-largest economy has been powered by the dirtiest fuel. That's expected to stop.

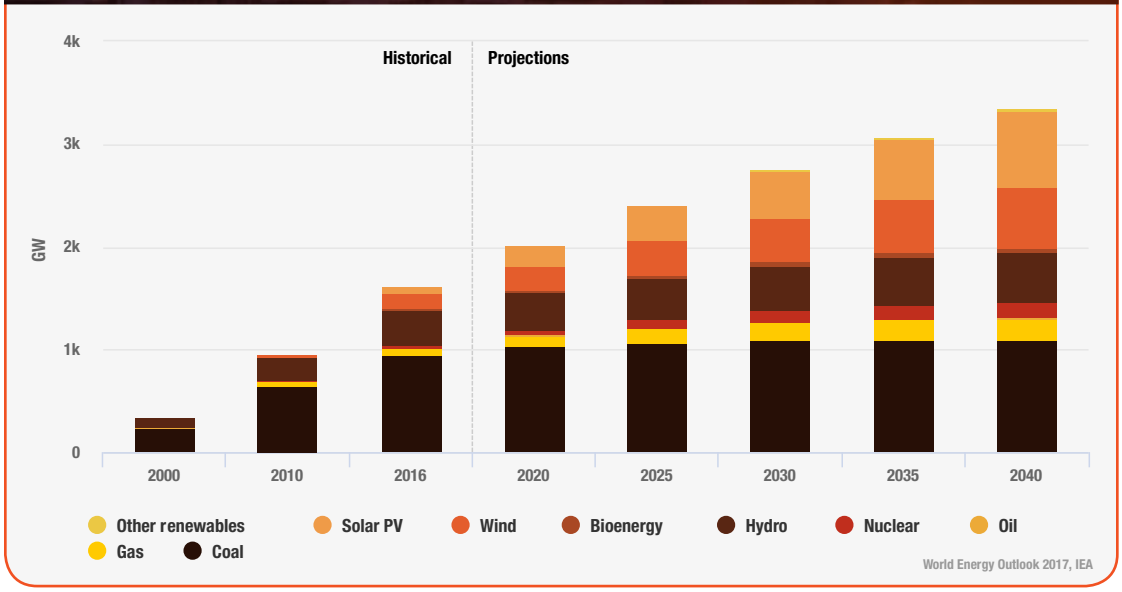
The global economic story of the past 30 years has been the growth of the People's Republic of China. Last year, according to data from the International Monetary Fund, China's nominal GDP was $11.9 trillion, second only to that of the United States. In 1989, China's nominal GDP was only $0.46 trillion.

All that new production needed electricity to power it, and for China, coal was the fuel of choice. As the International Energy Agency reported in its *World Energy Outlook 2017* in November, between 1990 and 2016, China increased its annual coal consumption by 2.03 billion tons; the rest of the world added only 152 million tons per year. With China's electricity demand forecast to increase to 9,230 TWh per year by 2040, from 5,320 TWh in 2016, carbon emissions and other power-related pollution would skyrocket unless something changed.

The IEA's *Outlook* sees new policies that would reduce the demand for coal in China and accelerate the use of natural gas and renewable energy sources such as wind and solar. Indeed, contrary to earlier fears, the IEA projects that China's coal demand actually peaked in 2013 and will decline by 15 percent between now and 2040.

Gas will take up a lot of the slack, according to the IEA. "China provides a quarter of the projected rise in global gas demand," the report states, "and its

INSTALLED ELECTRIC GENERATING CAPACITY IN CHINA, BY TECHNOLOGY



World Energy Outlook 2017, IEA

projected imports of 280 billion cubic meters in 2040 are second only to those of the European Union, making China a linchpin of global gas trade."

But the forecast increase in renewable power is breathtaking. By 2040, China's installed capacity for wind power plants is forecast to increase to 593 GW, from 149 GW in 2016. The rise in solar is even steeper, going from 77 GW to 783 GW. In fact, additions to wind, solar, hydroelectric, and biomass energy capacity are forecasted to account for 77 percent of China's total capacity increases between now and 2040, and will make up 57 percent of the nameplate capacity by then.

Or to put it another way, the amount of renewable electricity capacity expected to be added in China is far greater than the total coal power capacity today.

"China's choices will play a huge role in determining global trends, and could spark a faster clean energy transition," the report states. "The scale of China's clean energy deployment, technology exports, and outward investment makes it a key determinant of momentum behind the low-carbon transition."

In other words, China has grown to such a size that, when it changes the way it makes electricity, it changes the world all by itself. ME

JEFFREY WINTERS

NOT Too Far FROM THE TREE

Farmers are redesigning their orchards to make them easier for workers to pick. That makes them perfect for the first wave of robot harvesters.

BY JOHN H. TIBBETTS

More powerful computers, better sensors, and improved artificial intelligence promise to make machines competitive with human laborers for picking the apple harvest.
Photo: FF Robotics

Exhausted by his long days picking apples, Avi Kahani looked forward to his life as an outdated technology.

This was in the early 1980s, when Kahani managed his communal farm's orchards on Israeli hills overlooking Lebanon. Every year, kibbutz members pitched in to pick fruit. And each year, they raced to harvest the apples while they were ripe enough to command the highest prices.

Kahani, who would soon leave to study mechanical engineering, could already see the first wave of industrial robots sweeping through industry. If robots could replace workers in factories, he reasoned, why not laborers in orchards?

"We thought robots would be coming soon," Kahani said, laughing at the memory. "Unfortunately, apple-picking robots have taken a lot longer than we expected."

Today, Kahani is making that vision a reality. In 2013, Kahani and Gad Kober cofounded Israel-based FFRobotics, one of two companies racing to commercialize the world's first mechanical apple picker. Abundant Robotics, based in Hayward, Calif., is the other.

Attached to a slowly moving tractor, FFRobotics' arm needs only two degrees of freedom to pick most apples.
Photo: FF Robotics

FFRobotics' robot sits in the back of a human-driven truck. As it moves through the orchard, its four arms reach out to grasp apples in their three-pronged hands. Once they have the apple, the effectors rotate to snap it off the branch and then drop it in a container. The system could replace an army of pickers, and that is the point.

"What's driving robotics in fruit picking is the same in Israel, Europe, and the United States," Kahani, the company's CEO, said. "Seasonal workers are hard to find, and their wages are rising."

Each apple for the world's lucrative fresh market is still picked by hand. In the United States alone, 40,000 people labor in apple orchards and packing sheds each harvest season. Temporary migrant laborers make up about one-third of the peak-season labor force, arriving on H-2A guest visas. An unknown number of seasonal workers are undocumented.

This past year, as immigration—both legal and illegal—became a highly charged political issue, many farms and orchards had trouble finding enough seasonal workers. Without those workers, unpicked apples will rot on the branch.

"Growers feel powerless about the current labor market and guest worker system," said Karen Marie Lewis, a Washington State University tree fruit horticulturist. "The state of Washington is highly dependent on visa and immigration law, which can determine whether we get the full complement of our workforce."

Even before worker shortages, wages for seasonal workers were rising. The guest worker program requires growers to pay migrants the same prevailing wage they pay domestic laborers, which has been increasing, Lewis said. Between labor's rising cost and its uncertainty, growers are eager for feasible alternatives.

FFRobotics is developing that alternative. After three years of field-testing in Israeli orchards, Kahani and his colleagues plan to test their apple-picking robot on Washington's 2018 harvest, which runs from mid-August through mid-November. The state accounts for nearly three out of every five apples grown in the United States.

Fruit picking is hard, repetitive work, just the type of semi-skilled labor typically replaced by automation in manufacturing. But to perform their tasks reliably, factory robots need a highly structured environment. They require

precisely oriented parts delivered to specific locations, and consistent lighting, colors, and background conditions to avoid confusing their vision systems.

Traditional orchards are anything but that. Their canopy of leaves and branches presents a shifting collage of confounding light and shadow as the sun moves across the sky, altering the appearance of each apple. A robotic picker must distinguish a ripe fruit from less mature apples, and from tree limbs, branches, twigs, and leaves.

It must also do this under floodlights, since the only way for a grower to afford a robotic picker would be to run it 24/7.

There is little room for error. Apples are among the most easily bruised fruits. If a robotic picker misses and an apple falls, it may be ruined for the lucrative fresh market.

Fortunately, farmers have been making orchards robot-friendly for years—and they never even knew it.

MODERN ORCHARDS

A traditional apple tree has a thick trunk and branches that stick out randomly in every direction. The trunk and branches soak up a lot of water and energy before they get to the fruit.

So, geneticists developed dwarf varieties with narrower trunks and branches that deliver a greater percentage of water and nutrients to the apples. This produced more apples per acre.

Orchard managers train these dwarf varieties to make them more accessible. They prune and thin them to establish wide, shallow canopies in nearly vertical planes or V-shapes, so each apple grows within the reach of a human arm. They support weaker trunks with wood or concrete, and keep branches from sagging with wires and trellises.

They plant rows up to 1,800 feet long, so human pickers can move efficiently along their "fruit walls." These apple trees stick out about a foot from the trunk on each side of the row, with fewer limbs and shadows to hide or obscure fruit. This makes it easier for a laborer to identify, reach, and pick each apple.

"In Washington, we are building repeatable, predictable, and accessible canopies for human pickers and now we are primed for engineering solutions, including robotic harvesting," said Lewis. "A human-friendly orchard is a robot-friendly one."

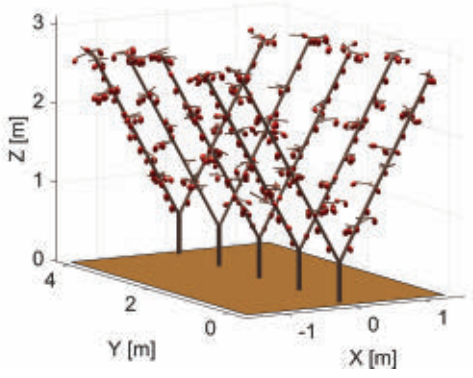
Modern orchard designs also allow engineers to build simpler apple-picking systems, added Amir Degani, founder of the Civil, Environmental, and Agricultural Robotics (CEAR) Lab at Technion-Israel Institute of Technology in Haifa. Degani advised with FFRobotics on developing its robotic arm.

"To harvest apples on a natural tree, a robot arm would require six to seven degrees of freedom, and that's too expensive," Degani said. "With a simpler tree, you can actually use a 3-degree-of-freedom robot that FFRobotics is using."

FFRobotics' multiple arms, for example, sit on a truck that moves slowly through the orchard, eliminating one degree of freedom. To reach an apple, an arm moves up-and-down and forward-and-back, two degrees of freedom. Once it grasps the fruit, the hand rotates (a third degree of freedom) to detach it from the tree.

FFRobotics' only challenger to date, Abundant Robotics, also deploys multiple robotic arms guided by algorithms and cameras. Each arm has a vacuum tube end-effector that sucks fruit off trees and drops them into bins.

Abundant, which spun out from the independent lab SRI in 2016, field-tested its robot in Washington and Australia in 2017. The company received $10 million in funding led by Google's investment arm in May 2017, bringing its total financial backing to $12 million.



Left, farmers train modern orchards to make apples more accessible to pickers. Right, an illustration of how a robot sees apples on a tree.

Photos: FF Robotics

The Washington Tree Fruit Research Commission was an early supporter of Abundant Robot's picker, providing $500,000 in seed funds. FFRobotics also has a proposal before the commission for funding.

"With or without that support, we will be in Washington in 2018," Kahani vowed.

Washington will be ready. A grower typically sets aside 5 percent of an orchard's acreage annually to plant new trees, which produce apples within three years. At that pace, transitioning an entire orchard to new canopies would require two decades. In Washington, however, some growers are moving faster.

"The industry is spending a boatload of money to plant new acres or transition older acreage to robot-ready canopies," Lewis said.

The combination of labor woes and successful robot tests have raised interest among orchard owners across the country, including Rod Farrow, who grows 28 apple varieties on Lamont Fruit Farm's 520 acres in Waterport, N.Y.

"Even a couple of years ago, we thought we would not see a commercial apple picker in our lifetimes, but things are moving very quickly," he said. "Robot systems can pick an apple and put it in a bin at an equivalent rate as our workforce with very little damage to the apples. I believe we will have a commercial version working in our own orchards in five years."

DEEP LEARNING

Before locating and grasping an apple, a robot picker must recognize it as one—despite variations in light, dust, wind, and a background of leaves and branches.

Most fruit-picking systems depend on deep learning software to recognize apples, said Manoj Karkee, an associate professor at Washington State University's Agricultural Automation and Robotics Lab. A deep learning model consists of interconnected layers of computation. It is a type of neural network, named because it is a simplified imitation of the human brain's system of neurons and synapses.

"Deep learning is the go-to method for working with these kinds of robotic fruit-picking problems," Karkee said. "It gives us so much accuracy and robustness in detecting and localizing objects in complex environments."

To train a deep learning network to recognize apples takes two things. The first is computing power, which arrived on the scene in the form of graphics processing units (GPUs) used to rapidly crunch numbers for realistic, rapidly changing video game displays. The second is examples of apples, which are readily available from Internet's vast trove of images and videos.

To understand how deep learning works, consider how Facebook tags friends in photographs. Its network's first computational layers might detect simple things like image elements, such as edges. The next layers might bring together these edges to form parts of faces—noses and eyes, for instance—and further layers might weave those features together to identify the person. Each successive layer of the model builds on the knowledge of the previous layers. The model learns how to recognize features—color, texture, shape—that the programmers tell it to look for.

FFRobotics trained its deep learning model similarly, feeding it labeled digital images of apples and tree backgrounds. The model learned by trial and error to correlate an apple's "face"—its specific color, shape and texture—with its corresponding image label. It then trained the model on images of tree trunks, branches, twigs, and leaves.

Over time, the model learned to get it right. When it consistently misidentified a blob of leaves as an apple (or vice versa), the programmers tweaked the algorithms until they were more likely to identify an apple accurately next time. Then they asked the model to identify features in unlabeled digital images that it had never seen before, refining the algorithms as they moved forward.

Even with this training, FFRobotics preps the robot before it enters an unfamiliar orchard.

"We always take a lot of pictures in the same orchard where the robot will pick," Kahani said. "When we go to Washington for field tests, we will take additional pictures in their orchards because even small changes—such as the angle of the sun from Israel to the Pacific Northwest—can change the model's results. Training the model is an ongoing process."

Not only do apple tree varieties and cultivation practices vary, but modern orchards often cultivate premium apples in shades of red, pink, green, and gold.

Abundant Robotics uses a vacuum effector to pull apples off the tree and deposit them in a container.
Photo: Abundant Robotics

"To gain maximum efficiency, you must train the system with pictures of the fruit variety in the orchard you want to pick," Kahani said. "Then we classify the apples based on the individual grower's criteria of apple size and color."

A member of the FFRobotics' team also scans each tree's critical points and junctions with an encoder, digitizing the tree. The data goes into Matlab to create a 3-D model of each tree.

The four-armed robot, which rides on a tractor driven by a human, uses a single camera to capture an image of an individual apple. The 3-D model identifies the fruit's location and orientation and differentiates the fruit from the rest of the tree based on the deep learning algorithm. A controller then directs the robotic arm to that location.

OPEN OR CLOSED

FFRobotics is still struggling with whether to go with open- or closed-loop controller. The open-loop system recognizes a specific fruit and sends the gripper to that location. If a strong wind moves the apple left or right, the gripper does not follow.

The closed-loop system tracks the movement of the fruit by distinctive points on the apple's face as guides and adjusts the arm as it moves closer to the apple. While closed-loop systems are more effective, they are also too expensive, Kahani said.

"From our experience, the open loop system with this robot and this gripper is working very well even in windy situations," Kahani said. "But we are thinking and working all the time to improve the system, so we may change it."

The three-fingered gripper at the end of the robotic arm has a single motor that grips the apple and rotates it about 90 degrees to detach it from the tree. The arm retracts several inches and drops the apple into a container.

The robot's vision system functions best when apples are clearly visible or only partially hidden. Apples blocked by branches would be too difficult to pick, so the robot leaves them for a human to pick later. The machine can pick 80 to 90 percent of a crop, depending on the tree design, said Kahani, shaving harvesting costs by about 25 percent.

"Even picking 70 percent of a crop would make it financially viable," said Karkee. "A manual crew may have to follow up by picking the other 30 percent, but that would take care of seasonal labor demands at harvest."

Because farmers would use an apple picker only 80 days per year, Kahani would like to adapt the mechanism to other fruits. He envisions rewriting the algorithm and reengineering the gripper for peaches or citrus fruits. The robot would then become a migrant laborer, working the fall harvest in the north and heading south for the winter harvest in winter.

Some humans are likely to join them, however, Farrow said. Robots, at least the early versions, cannot reach every apple and they are prone to breakdown.

"The federal guest worker program is a nightmare to work with, but if you give up those workers to use these robots, then those people aren't available to you anymore," Farrow said.

Farmers will still need laborers, but Farrow expects most growers to embrace robot pickers as they transition to new canopies. "Large operations that are already transitioning will adopt robots quickly. But you need at least couple hundred acres with the right canopy to justify making it work financially, and many operations aren't there yet."

Maybe not, but they are certainly a lot closer than they were when Kahani was picking apples as a young man. **ME**

JOHN H. TIBBETTS is a freelance writer based in Charleston, S.C.

The expressive face of RoboKind's Milo robot helps teach autistic children to recognize emotions on the faces of people around them.
Image: RoboKind

FACE TO FACE WITH AUTISM

Robots promise to change the way therapists help children and adults with autism–and pave the way for more social robots in the future. **ALAN S. BROWN**

Laurie Dickstein-Fischer discovered how robots might help autistic children at a robotics conference in Japan in 2009. She was pursuing a doctorate in school psychology, and attended the meeting with her husband, Gregory Fischer, a mechanical engineer creating surgical robots at Worcester Polytechnic Institute in Massachusetts.

In Japan, both were drawn to the displays of social robots, which used sensors and artificial intelligence to perceive and interact with people. Most were costly and, in Dickstein-Fischer's opinion, served no real purpose.

The exception was Paro, a furry seal-shaped robot that responded to its name and purred and vibrated when petted. Adults with dementia loved it and treated it like a pet. But unlike a living pet, it needed no care or feeding and never misbehaved.

At the meeting, Dickstein-Fischer met an American engineer who started talking about using robots for autism intervention. "He talked about autism as a pathology," she said. "I had worked with autistic students in Baltimore, and thought of them as people, not pathologies.

"But I came home thinking this was the next big thing, using robots to work with autistic children. I said to Greg, 'You're an engineer, I'm a psychologist. We could build a robot especially for autistic children from the ground up.'"

She envisioned a robot that looked like a child's stuffed animal, a penguin with large eyes and exaggerated features. Back at WPI, she and Fischer put together a group of students to build PABI, the Penguin for Autism Behavioral Intervention.

Around the same time, Carolyn Garver, who had directed the Autism Treatment Center in Dallas for 30 years, got a call from David Hanson, a well-known roboticist who had worked for Disney Imagineering.

"He said that he had a robot and thought it would have implications for autism," Garver recalled. She never heard of Hanson and knew nothing about robots, but invited him over. Hanson brought Milo, a robotic face to her office and cabled it to his laptop.

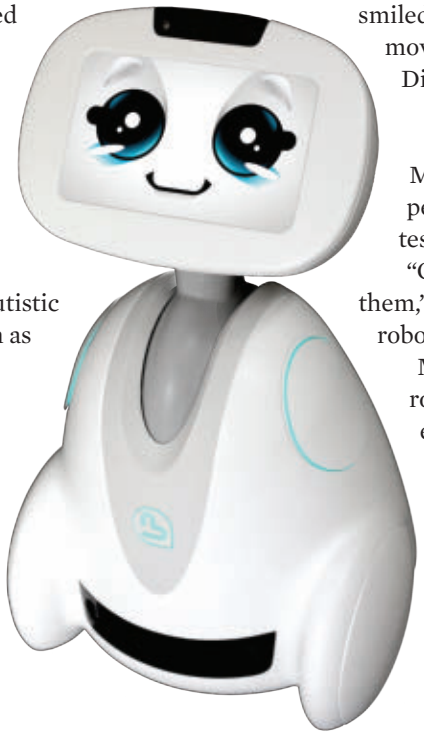
The face contained motors and flexible skin. It smiled, frowned, looked confused or angry, and moved like an animatronic character in a Disney theme park.

"The minute I saw it, I loved it," she said.

Hanson and his chief engineer, Richard Margolin, teamed with Garver to test how people with autism would respond. The tests confirmed Garver's enthusiasm.

"Children and adults were really taken by them," she said. "One person even asked the robot on a date."

Milo and PABI are as different as two robots can be. Margolin believes Milo's expressive face engages people, while Dickstein-Fischer thinks it might scare some people. Yet both robots can help teach autistic children and adults practical and social skills.



Blue Frog's Buddy robot is a social robot that parents can use to work with autistic children.

Photo: Blue Frog Robot Company

Margolin eventually bought Hanson's autism operation and renamed it RoboKind. He has begun selling Milo robots for autistic children. Meanwhile, PABI has moved through several design iterations, and Dickstein-Fischer is planning additional upgrades and tests.

Other autism robots are just reaching the market or are in development. Some, like Darwin-OP2 by Chung Hyuk Park, an assistant biomedical engineering professor at George Washington University, are humanoids. Others are less conventional, like Paris-based Leka's ball-mounted display, which uses AI to play games with autistic and developmentally challenged children. Several developers have adapted other social robots, such as Blue Frog's Buddy and SoftBank Robotics' Nao, for autism intervention.

The torrent of new autism robots is not surprising. Over the past 10 years, better processors, sensors, and AI algorithms have made social robots far more responsive. Autism therapy gives them a purpose—and offers a structure that suits their emerging skills. In many ways, autism therapy is a first step on the way to true social robots.

THE SPECTRUM

No one is certain how many people have autism. Recent estimates by the Centers for Disease Control and the more in-depth National Health Interview Survey estimate it is 1.5 to 2 percent of all children from three to 17 year old.

Autism is difficult to pin down because it expresses itself in many ways. Most autistic people struggle with social skills, from knowing when to shake hands to identifying when others are happy or sad. They find it difficult to communicate, control their emotions, and apply what they have learned to new situations. They often rebel at change.

The intensity of symptoms varies so widely, experts now call this condition autism spectrum disorder. More than one-third of people on the spectrum have severe autism, and are intellectually challenged or non-verbal. Others, such as actress Daryl Hannah and comedian Dan Ackroyd, have symptoms that are barely noticeable.

Most people with autism fall somewhere in the middle, and many of them have jobs, including accountants, laboratory technicians, and software programmers. A substantial percentage succeeded because interventions early in life helped them manage their behaviors. A child who learns how to decode the emotions on a face or respond appropriately in social situations will find it easier to fit into school and eventually the world.

Unfortunately, early intervention takes trained therapists and time. This makes it expensive. Most schools and parents cannot afford daily therapy.

Robots can help. They enable therapists to deliver treatment more effectively, and can prompt classroom teachers, aides, and parents with limited training through the steps needed to teach an autistic child a skill. This could make intensive therapy more accessible and affordable.

In fact, it was the potential of robots to reduce the cost of early interventions that initially drew Dickstein-Fischer to the field.

"When I was a teacher and school counselor in inner city Baltimore, where incomes averaged $17,000, I did not have the resources to serve all those children and neither did their parents," she said. "I thought that a $2,000 robot that schools could afford would make it possible to deliver those services."

The Milo robot works as a force muliplier, reinforcing skills taught by human teachers. ***Image: RoboKind***

Studies by Dickstein-Fischer and others show that robots can do this, and how they do it goes to the heart of the human-robot relationship.

ROBOTIC REINFORCEMENT

Autistic children struggle to pick up social clues that they might help them make sense of the world. As a result, therapists must teach them things that other children pick up naturally. This could be as simple as identifying an apple or when someone looks happy or sad.

The most common way to teach that skill involves placing three cards on the table. They might show an apple, an orange, and a pear. The therapist or teacher asks the child to point to the apple. If the child picks right, the teacher says, "Great job." If not, the teacher prompts the child to try again, trying to remain positive.

It sounds easy. But while the teacher is doing this, he or she is also measuring the child's progress by timing responses with a stopwatch, recording answers and prompts, and gathering and reshuffling the cards. All of this pulls the teacher's attention away from the child. Therapy mechanics, Dickstein-Fischer said, are a major cause of teacher and therapist burnout.

Autism robots can manage these mechanics automatically. They typically link with a tablet. As the child chooses the cards, the robot automatically records data more accurately than any human and immediately displays new cards.

"When we tested the robot, not only did the kids become

Paris-based Blue Frog applied lessons from service robots to Buddy, an autism-friendly social robot.
Image: Blue Frog Robot Company

more engaged, but we got an unexpected result—it cut the time needed to complete the therapy in half," Dickstein-Fischer said.

This is because the robot recorded the therapy data faster than the teacher could. It also freed the teacher to focus exclusively on the child.

"Pairing PABI with the tablet worked better than the tablet alone, and students and teachers were more on task," she said. "They were visibly happier, and there was more interaction between child and therapist."

The robots also prompted the children to stay focused.

"We have a video of a girl hugging PABI and rubbing its tummy," Dickstein-Fischer said. "We never saw that child interacting with a stuffed animal before. When she gets an answer right, the teacher praises her and PABI says, 'Great job,' and flaps its wings up and down. When it's wrong, it asks her to try again. For her, it's like getting reinforcement from a friend."

EMBODIED

Autism robots provoke those feelings because they have an embodied physical presence and they are responsive. They act as if they were alive. While most realize they are not really alive, studies by educators, roboticists, and psychologists show that people treat them very differently than computers or tablets. This is why people with dementia fight over who gets to hold the Paro seal, and why children want to hug PABI.

Autism robots build on that engagement. "They are very consistent, and do the same thing over and over without ever getting upset or having a bad day," Garver said. "For autistic children and adults, a robot is predictable and easier to deal with than other people."

Robots can also go beyond teaching facts to helping children deal with their feelings, recognize emotions in others, and navigate new social situations.

For example, Garver and Pamela Rollins, an associate professor at the University of Texas' Callier Center for Communication Disorders in Dallas, developed a curriculum to help autistic children calm down. This included teaching children how to identify when they were getting upset and a series of skills, like taking deep breaths, counting to 10, or squeezing a ball, to manage those feelings.

They also taught children to recognize the emotions of people around them.

"Autistic kids don't understand the perspectives of others," Garver said. "So, we showed Milo being happy, then asked them to pick out the happy person on the tablet and Milo would say, "Right," if they got it right. The display on Milo's chest might show someone smiling or even the child smiling. And all the time, there is a facilitator sitting there, encouraging and motivating them."

They used these skills on Milo to help children navigate social situations.

"Kids on spectrum will say, 'hello,' but not look at you or smile," Rollins explained. "Now, you and I know that before you talk to someone, you need their mutual attention, so you look at them, smile, and say 'hi.'

So, Rollins developed a series of social narratives, short stories and images Milo can show on its chest display, that describe a social situation, clues about how to identify the situation, and appropriate ways to respond.

"We teach this the way someone taught us math by describing skills like how to add or subtract," she said. "Icons on the robot's chest say and show that when you greet someone, you look at them, smile, and say, 'hi.'

"So, we describe the situation, then we show different children and adults looking, smiling, and saying hi on the tablet. Milo asks the children, 'Did my friends do it right?' The child with autism must discriminate if they did all the components.

"Milo never gets angry, it's always positive. If a child does something wrong, it says, 'Let's do it again.' And it seems to be working. About 30 percent of kids who were not making progress by other means are making progress with the robot," Rollins said.

BUILDOUT

Building Milo and PABI presented several challenges. First, they had to be rugged enough to stand up to kids.

Fischer encased PABI in spring steel ribs that pop back into shape when squeezed, surrounded by a soft, compliant stuffed animal body. He combined 3-D printed mechanical components with off-the-shelf hobby-type servos to pan and tilt the head and individual eyes. The wings use antagonistic pairs of cables to flex up and down or point, but, as Fischer noted, that's enough to give a high-five.

While Fischer does a lot of work in his lab, his home has become a museum of penguin prototypes. There's a 3-D printer and soldering station in the basement, offset by piles of fluffy fabric and opened pillows used for stuffing. A colleague from the university who sews costumes for theater stitches everything together, and Fischer and Dickstein-Fischer's two-year-old son helps with product testing.

Margolin spent years making Milo more robust and affordable in a lab that has its own combination of order and chaos. Along the way, he brought in a consultant who specialized in mechanical toys to recommend gearboxes, motors, and simplified control systems.

"It's not a pick-and-place robot, so we didn't need that kind of accuracy," Margolin said.

PABI's electronic and servo insides are guarded by spring steel ribs and a plush, stuffed exterior.
Photo: PABI

He also found other ways to shave costs. Milo uses stiff rather than bendable legs that give it a "Frankenstein" walk but simplify design and reduce problems with overheated motors and gearbox jams. But he also added spring-loaded safety clutches that keep the robot from exerting more than 2.5 lb of force.

Margolin spent most of his time on Milo's expressive face. "In terms of engagement, kids really like the face," he said. "We're actively teaching social and emotional skills, and autistic kids connect to it better than they do to an animated screen."

Margolin uses six servos, most of which move through arc, plus one linear motor driving a rack-and-pinion system to control facial movement. He molds the face with a custom-formulated polymer that curves and twists, aided by embedded hard points that tweak those motions to get the expressions exactly right.

While Milo and PABI are very different robots, Margolin and Fischer both want to build robots that adapt to individual children. They hope to do this by adding better sensors and algorithms.

Both are working on video cameras that track a child's eyes and bring them back on task when they wander. Both hope to use cameras and microphones to tell if a child is happy or sad, so they can respond appropriately.

"We are also looking at very low powered radar to monitor heart rate, breathing, and gestures," Margolin said. "When fused with data from video and voice, it will enable the robot to create a theory of mind about the child's emotional state and respond to that."

This is just the beginning, Fischer said. "One of the reasons I like the type of child training we do is that we almost want teachers to be robotic," he said. "It very structured, but maybe we can use this to learn what we need to get into a less structured environment.

"Maybe one day, instead of flashcards on a tablet, we'll have a bucket of toys that we spill out on the floor and the robot says, 'Touch the red dinosaur.'" ME

ALAN S. BROWN is senior editor at *Mechanical Engineering* magazine.

ROBO-REHAB

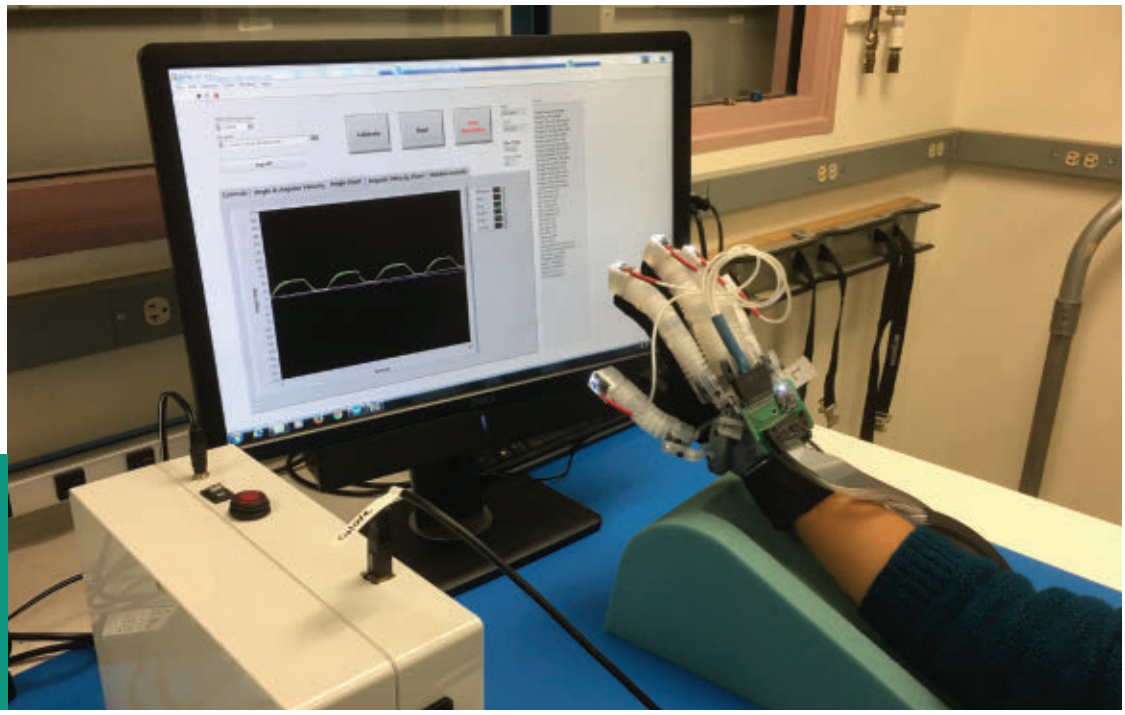
A soft robotic device being developed by researchers could give patients a quicker boost toward manipulating their fingers to hold and grasp items.

JOHN KOSOWATZ

EVERY YEAR IN THE US, 795,000 people fall victim to stroke, many of them with debilitating effect. Sometimes, the damage affects only a portion of a person's body, arms or legs, or speech. Often, it renders half of the body useless, limiting the patient's movement or control.

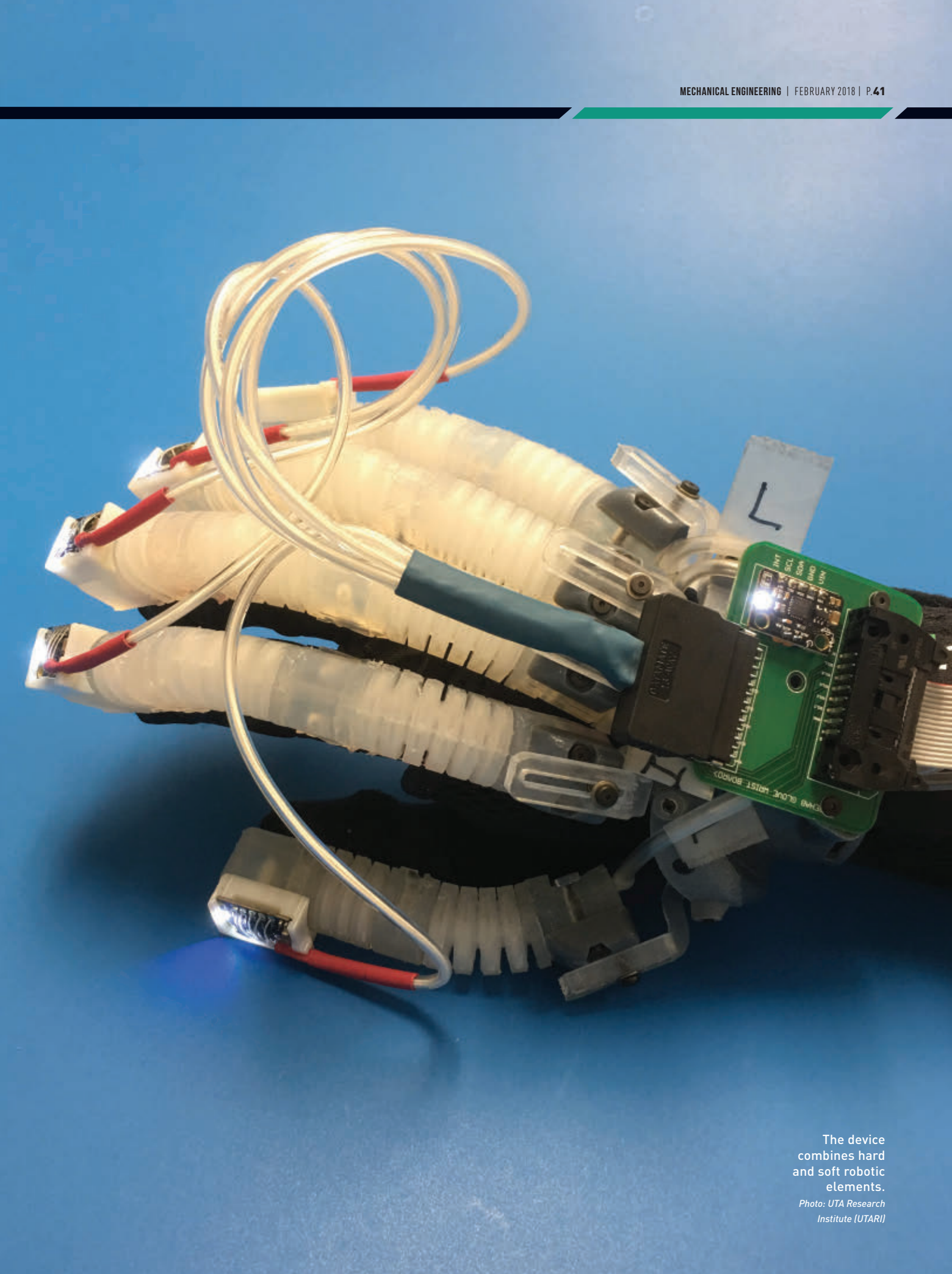
A patient's rehabilitation usually focuses on improving overall movement of arms and legs. But rehabilitating the extremities—hands and fingers—is often left for a later time. A soft robotic device being developed by researchers in Texas could change that pattern, giving patients a quicker boost in manipulating their fingers to hold and grasp items.

Rita M. Patterson, a professor of family medicine at the University of North Texas Health and Science Center, and Mahdi Haghshenas-Jaryani and Muthu Wijesundara at the University of Texas Arlington Research Center, are developing a soft robotic device for the hand, or more specifically, the fingers and thumbs.



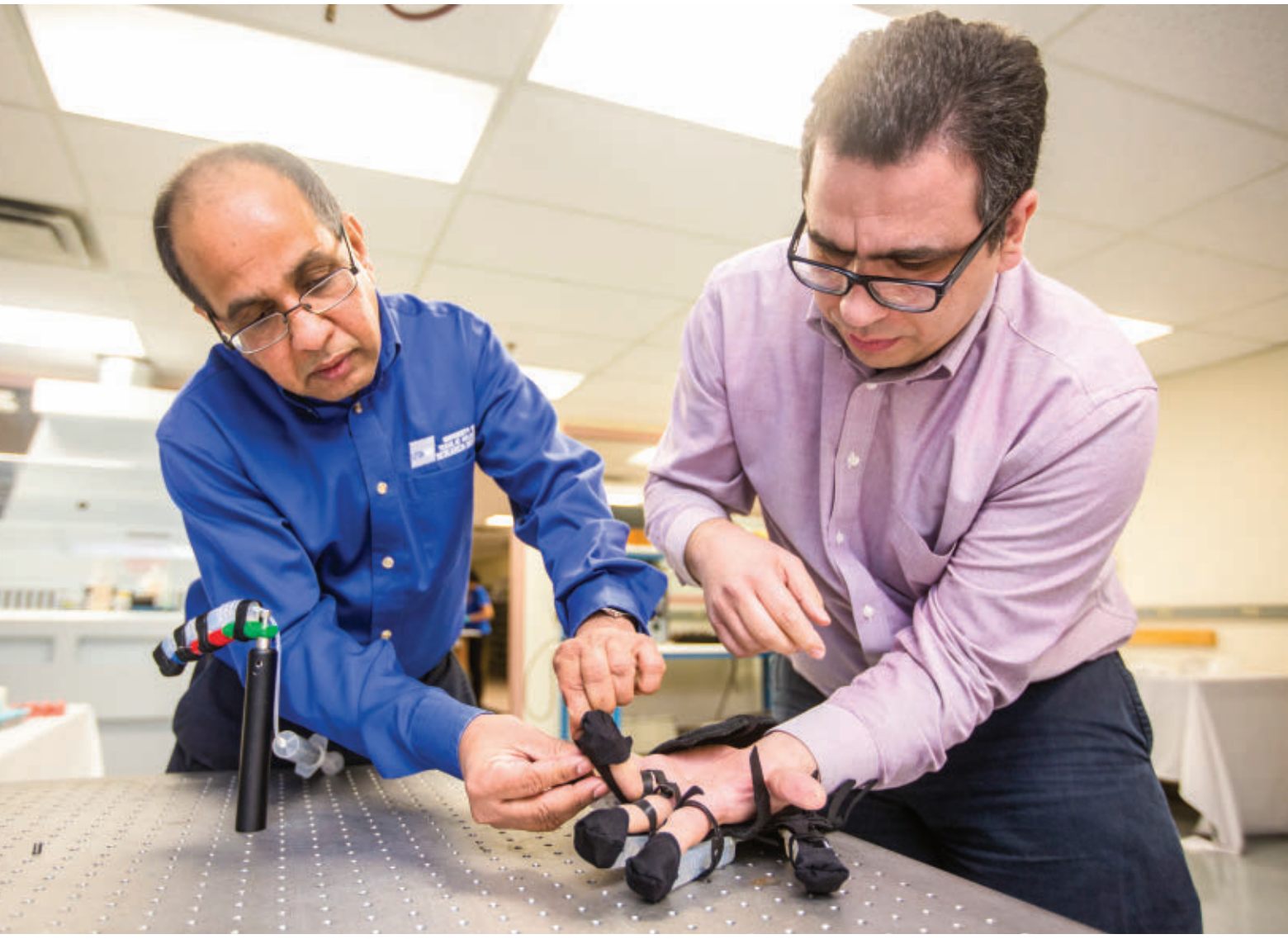
The device controls the level of force applied and sends data back for evaluation.

Photo: UTA Research Institute (UTARI)



The device combines hard and soft robotic elements.

Photo: UTA Research Institute (UTARI)



Actuator sections are placed over individual joints and connected through a glove.
Photo: UTA Research Institute (UTARI)

"We have not seen much in devices geared toward the hand," Wijesundara said, especially with hard robotic devices. "When you really look at hand devices, they are not very dexterous."

The specific anatomy, comprised of many small joints that produce complex motions, makes designing a hard robotic device difficult. Those available are rigid, mechanically complex, large, heavy, and costly. "There have been some successes, but the biggest limitation is providing a continuous bending motion," Wijesundara said of soft robotics.

Patterson's recent research uncovered 20 soft robotic devices for hands and fingers, but all are in early development phases and have limitations. She noted that over the last three years there has been a rapid increase in the development of devices for rehabilitative use. Most of those identified were continuous passive motion machines, which constantly move a joint through a controlled range of motions, and none are fully portable or operational without a technician. Most focused on flexion and/or extension of the index and middle fingers.

The team, which benefits from its members' previous manufacturing experience, is developing a device that combines hard and soft robotic elements. Using advances in laminating materials and working with compression molding and other fabrication techniques,

the team is combining the mechanics of hard robotics with soft robotics. The device relies on proprietary, bellow-type soft actuator sections that are placed over individual joints and connected through a soft and rigid hybrid structure, or glove. By attaching actuators to the joints, the device can control degrees of bending and the entire range of motion of flexion and extension, Wijesundara said.

Additionally, the device controls the level of force applied and sends data back for evaluation by a technician or therapist. The researchers say it will allow therapists to work with more people and to care for them remotely, providing portability and allowing patients to rehab without having to travel to an office.

One of the biggest design challenges is fitting the device to variable hand sizes. Eventually the team will produce the device in standard size gloves. Accommodating hand size differences within one standard size—small, medium, large—is problematic because actuators are placed on each joint of each digit of the hand. Placing them properly requires a stretchable frame to accommodate shortening or lengthening. That design differs from others that are currently being developed.

> **"THERE'S A DOZEN DIFFERENT PROBLEMS AND EACH REQUIRES A DIFFERENT REHAB MODE."**
>
> MAHDI HAGHSHENAS-JARYANI

One of those devices is a lightweight glove developed by engineers at Harvard University's Wyss Institute and currently being tested on patients. The Wyss glove uses a continuous tube structure of Kevlar and other materials over the length of the finger, while the Texas glove uses a soft and rigid hybrid structure to hold the actuators. Patterson said the hybrid structure allows the device to individually control each joint for "applying desired motion and force, through either mechanical design or independent actuation." The Wyss device relies on the interaction between the continuous tube and the finger, impacting the finger as a whole and not individual joints.

There are other differences, including motion. The Harvard glove has one-direction action motion while the Texas glove is bidirectional, using pressure and vacuum actuation for flexion and extension. The Texas device also has sensors to track finger motion and torque applied to all the joints, and measures quantifiable therapeutic parameters, such as range of motion, stiffness, and grip strength to monitor a patient's progress and therapy.

Knowing how much force to apply, however, can be difficult to gauge. The hand has its own feedback to the central nervous system, so applying too much pressure can produce a reflex reaction. "Finding that sweet spot between mechanical input parameters and what you're applying to the hand, you have to be careful not to elicit a reflex reaction in your own system," Patterson said.

And therein lies a more basic issue. The task of designing a robotic device for the hand and fingers must take into account the needs of a range of potential patients. But there have not been any meaningful studies to determine the differences, Patterson said. "Just knowing the actual resistance of a normal hand, from a child with cerebral palsy to an adult with a stroke, it's never been documented in literature," she said. "We don't know the specs of what we're designing for."

Fleshing out those specifications is another big part of the discovery phase. The team has tested the device on individual stroke patients. But the next phase involves improving the interface between the device and controls, and fine-tuning the system to meet the varying needs of patients. Clinical trials are still in the future.

"What does the therapist want to control?" Haghshenas-Jaryani asked. "There's a dozen different problems and each requires a different rehab mode." The team is confident the device will fill a large void and eventually help both therapists and patients.

Today's standard practices for hand rehabilitation require therapists to work one on one with patients, a time-consuming process that's often restricted by a lack of qualified therapists in some areas of the country.

"This can help the therapist as an extension or helper," she said. **ME**

JOHN KOSOWATZ is senior editor at ASME.org.

A NEW AGE OF RAIL

Reinvesting in freight railroads could be an infrastructure solution to multiple challenges.

MICHAEL E. WEBBER

Every decade or so, a futuristic transportation scheme captures the collective fancy. In the 1970s, it was magnetically levitated trains—maglevs—capable of shooting between cities at better than 300 miles per hour. In the 1990s, promoters of personal rapid transit were trying to drum up interest in automated minicars running on elevated tracks. Today, technologists breathlessly tout the Hyperloop, which (one day) will zip through evacuated tubes faster than the speed of sound.

All those technologies sound cool and might eventually prove useful.

Today, however, we have some pressing transportation challenges. Our roads and bridges are poorly maintained and their limited capacity promotes traffic congestion. Transportation is the leading source of carbon dioxide emissions and vehicle accidents kill more than 30,000 people every year.

Each of those problems are exacerbated by freight transportation on American highways. Freight is bigger than most people realize, moving about $50 billion worth of goods every single day in 2013. Trucks move 29 percent of the freight ton-miles, but are responsible for 77 percent of the sector's emissions. (Astonishingly, empty trucks account for about one-fifth of the truck miles traveled.) Between the rise of Walmart with its truck-based logistical system and the spread of internet-based retailers such as Amazon, highway freight tonnage has grown by 45 percent since 2000.

According to the U.S. Department of Transportation, the existing population of trucks on congested highways

already substantially impedes interstate commerce and projections suggest highway congestion will get much worse in the coming decades.

While the speed and flexibility of planes and cars has provided many benefits to society, the congested roads and airports signal they might be hitting their limits. Trucks are convenient because they enable flexible point-to-point operation, but they are relatively inefficient, dirty, dangerous, and destructive to our roads.

These facts and trends reveal that freight—the movement of goods rather than people—presents a worthwhile opportunity for a system-wide improvement.

Rather than waiting for some still-unrealized technological breakthrough, we should instead expand our national freight rail system.

Yes, rail.

ROAD AND RAIL

It would be easy to believe that freight rail's day has passed. From its peak a century ago at more than 250,000 miles of total network mileage, today there are fewer than 95,000 miles of track for Class I railroads, as rail lost market share for the movement of people and goods to air travel and the Interstate Highway System. From 1990 to 2013 alone, the U.S. population increased 28.2 percent while track miles decreased 28.6 percent, despite increases in shipping and freight movement.

That decline didn't just happen. It was a policy choice carried out over decades. Starting in the 1950s we prioritized the movement of goods by truck over rail, investing trillions of dollars into the interstate and national highway system. Today, the national freight transportation infrastructure has about $6 trillion in assets, with more than half that total locked up in highways. While private-sector trucks operate over public highways (making the Interstate Highway System effectively a subsidy by taxpayers to trucking companies), the freight railroads are almost entirely private.

Since bottoming out in the 1970s, financial restructuring enabled railroads to invest in better efficiency. Consequently, revenues and incomes have risen for decades despite the lower trackage available. As one assessment by the RAND Corporation noted, American railroads have become extremely efficient and productive, moving increasing volumes of freight over a shrinking infrastructure.

Rail moves 40 percent of freight as measured in ton-miles, but is responsible for only 8 percent of freight transportation carbon emissions. Even though both trucks and locomotives use the same fuel—diesel—railways emit less CO_2 per ton-mile of freight movement because rail is much more energy efficient than trucking. By one estimate, moving freight by rail instead of trucks can save up to 1,000 gallons of fuel per carload.

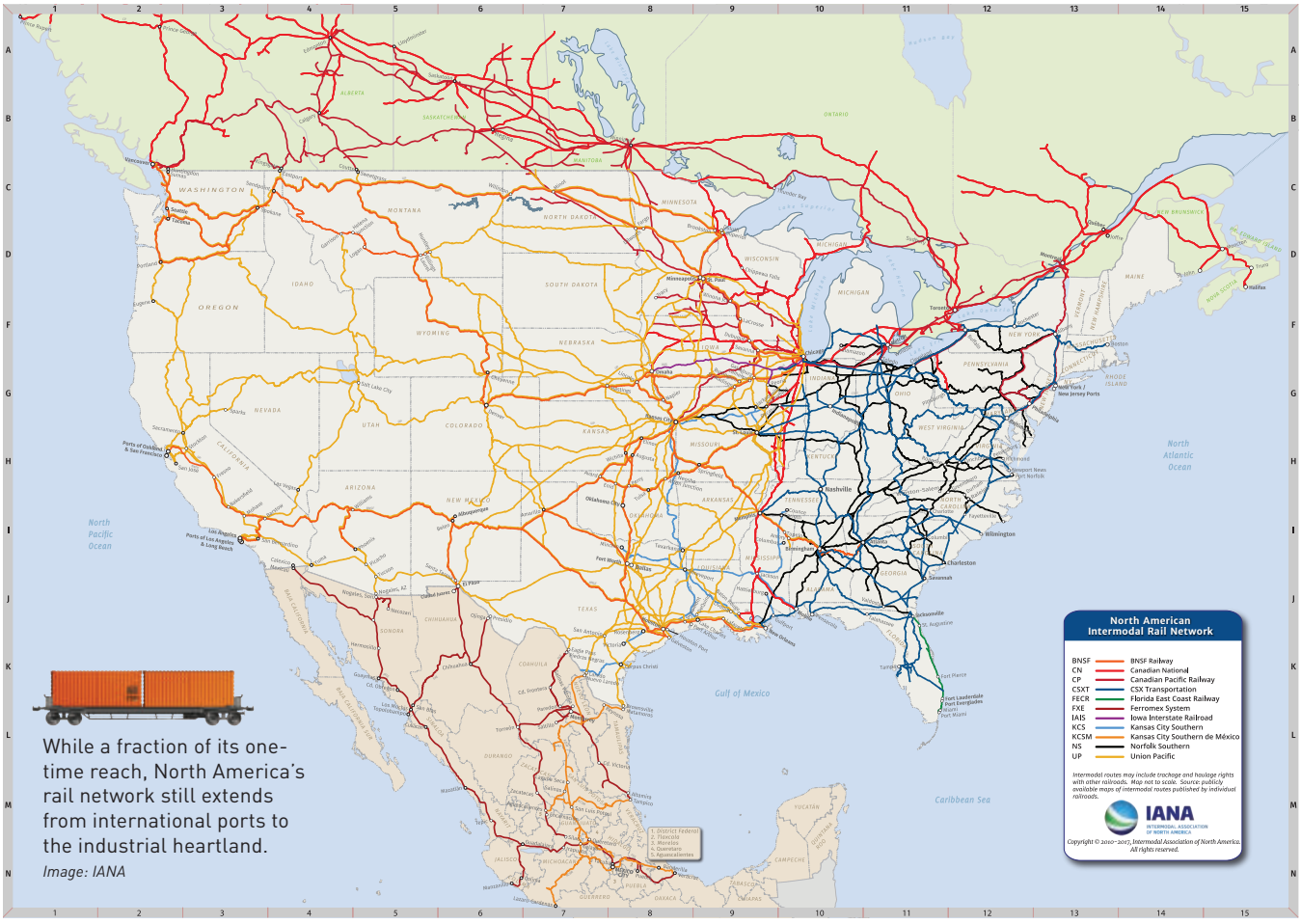
Moreover, freight rail has the potential to get cleaner—quicker—than trucks, ships, or planes. According to the Bureau of Transportation Statistics, the median age of the 25,000 locomotives in the United States is less than 13 years, so natural fleet turnover patterns offer a chance to integrate newer, cleaner versions. That means the rail fleet can be cleaned through investments in just tens of thousands of locomotives (compared with more than 10 million heavy-duty trucks on the roads today). For instance, switching locomotives to compressed natural gas could reduce emissions while leveraging an abundant and secure source of fuel.

To be sure, trucking is great for the last few miles when delivering goods (which is useful, as most of us do not live next to train tracks). But more than two-thirds of the ton-miles of freight travel more than 500 miles and the efficiency of rail transportation means that even if the route is longer than what is possible with point-to-point trucking, shipping by rail would still use far less energy.

Reviving freight rail could also yield benefits beyond just energy savings and emissions reductions. Transferring freight from trucks to rail will also be safer.

Freight transportation is responsible for approximately 100,000 injuries and 4,500 fatalities each year, and trucks are responsible for 95 percent of the injuries and 88 percent of those deaths. Most of the people killed by trucks are in passenger vehicles sharing the road with semis. A study in 2013 concluded that the additional risk of fatalities from heavy trucks is equivalent to a gas tax of $0.97 per gallon.

A fully loaded semi-tractor trailer does as much damage to highways and bridges as 1,000 passenger vehicles. *Photo: Getty*



While a fraction of its one-time reach, North America's rail network still extends from international ports to the industrial heartland.
Image: IANA

By contrast, rail transportation is responsible for about 4,000 injuries and 500 fatalities, the vast preponderance of which were from trespassers on the railroad right-of-way. Increasing the amount of rail traffic might increase those numbers, but it would be more than offset by the reduction in deaths and injuries on the road.

Not only will roads be safer, but they will also be in better condition. The Highway Trust Fund that provides money for maintenance and repairs goes broke every year because revenues (collected via a tax on gasoline and diesel fuel) haven't kept up with expenses. One way to provide the trust fund with enough money is to raise the gasoline tax, set at 18.4 cents per gallon since 1993, but that is unlikely in the modern political environment.

Another way is to reduce the wear and tear by removing the heaviest vehicles. Damage to roads scales with axle weight to the third power. So one 40-ton semi causes more than a thousand times the damage of a typical 4,000 pound car. As one seminal study noted, "For all practical purposes, structural damage to roads is caused by trucks and buses, not by cars."

Because of the governmental concern about the damage that heavy trucks can do to roads and bridges, significant effort and money is expended on vehicle weight enforcement. In 2013, there were just over 200 million weight enforcement activities for trucks, which identified about 400,000 violations, each of which puts our highway infrastructure at risk. By moving trucks off the road and onto rails, the rate of damage will decrease, reducing the risk of infrastructure failure and lowering maintenance costs.

Until recently, the freight railway network was being stressed on many routes by hauling of coal from fields in the western U.S. to power plants around the country. Coal trains are huge: 100 hopper cars that can each carry 100 tons, all pulled by six 3000 hp locomotives. In terms of

ton-miles, coal still comprises the single largest commodity moved by the freight rail system.

Coal's decline, displaced by cheaper, cleaner natural gas, wind, and solar power, opens up spare capacity in the rail system that could be used for moving other goods.

Those railroad right-of-ways from the western coal fields to the east also have potential as routes for alternative energy. Following up on the old idea of lining train tracks with wires and poles, we could couple rail lines with a national high-voltage direct current transmission network, spanning the heart of the windy Great Plains and sunny Southwest, thereby enabling better integration of renewables, cleaning up the power sector further. Since the best solar and wind resources are often far from major demand centers like large cities, developing a national grid that can easily move power around would be advantageous.

Coal still comprises the single largest commodity moved by rail, but with more electricity being fueled by gas and renewables, railroad capacity may soon be opened up.
Photo: Getty

We could even put those power lines underground to reduce their vulnerability to windstorms. Not only would a nationally coupled rail and powerline network reduce emissions and spawn more rural economic development, but it would also improve grid reliability.

Laying electricity along the tracks also opens up the door for electrified freight trains. Such trains are common in Europe and it may be simpler to electrify freight rail transportation than to build out the charging infrastructure for electric road vehicles.

SWITCHING TRACK

The vast preponderance of the rail system sprawls across the continent, so many of the economic benefits from a return to freight rail would accrue to rural areas. Since U.S. companies like GE make locomotives, accelerating the adoption of newer, cleaner models would also trigger an uptick in domestic manufacturing jobs and output. In addition, locomotive engineers make about 30 percent more per hour than truck drivers. Even the other jobs—rail yard engineers, signal and switch operators, conductors, and so forth—earn more than truck drivers. Those higher wages would have rippling economic benefits.

Given all these potential cross-cutting benefits of increasing the role of rail for freight transportation, how should we proceed?

One simple way to encourage the switch from road to rail is to put a price on carbon. A carbon tax would harness the efficiency of markets while sending a price signal that rewards the more energy-efficient and cleaner option of rail transportation.

Another approach—one that wouldn't also put motorists in the crosshairs—would be to raise money for road maintenance via a fee based on miles driven and vehicle weight. This would target the vehicles that do the most damage and stop the subsidy of heavy trucks by the drivers of small personal cars.

By more closely aligning the costs with the damage, trucking would lose some of its competitive advantage compared with rail.

While a carbon price and update to our highway tax model would likely encourage a lot of switching to rail for freight, increasing throughput (ton-miles) on rail without other improvements could degrade key performance metrics such as delivery time and reliability. Since many freight customers are very sensitive to those factors, commensurate investments have to be made in optimizing performance, double-tracking where possible, adding new tracks, and alleviating bottlenecks.

Expanding track miles is an obvious step forward, though not the only one. Adding more sidings or double-tracking at congested zones can facilitate operation of more trains

in different directions and allow trains operating at different speeds to more easily share the same track.

But just laying a bunch more track isn't enough.

As a pair of major studies by the RAND Corporation in 2008 and 2009 noted, increasing the national rail freight capacity will need a variety of strategies beyond direct infrastructure investments. Such measures include revised regulations, flexible pricing, deploying new technology, and implementing improved operating practices. For instance, operational enhancements to more efficiently use existing tracks might be just as important as building more miles of track, but those changes need to be informed by more detailed and extensive modeling to identify locations of bottlenecks and developing schemes that avoid them.

Another way to increase capacity while cleaning up the transportation sector is to increase and improve the fleet of locomotives. Incentives for rail companies to buy newer, cleaner, more efficient locomotives, would simultaneously clean up and expand capacity.

More routine and detailed inspections of rail systems can also improve safety and throughput by allowing heavier freight loads and faster train movement. The Automated Track Inspection Program exists partly for this purpose. But according to one assessment, it "does not conduct a comprehensive evaluation of the national rail network on an annual basis due to the limited number of surveying cars." Let's invest in more surveying cars and conduct those inspections more consistently, frequently, and comprehensively so that trains can move more efficiently.

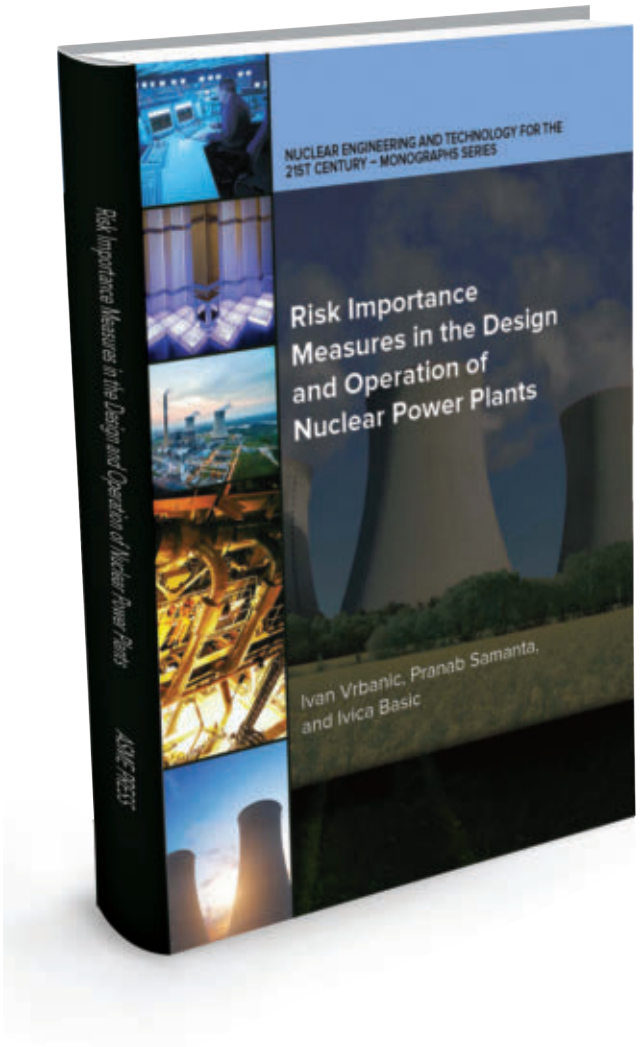
New concepts will inevitably capture the imagination. We owe it to ourselves to investigate them to see if they will work. But in the end an old idea—moving goods by rail—might be the modern innovation we need to reduce energy consumption and avoid CO_2 emissions while making roads less congested, safer, and more enjoyable for motorists. **ME**

MICHAEL E. WEBBER is the deputy director of the Energy Institute at the University of Texas at Austin. His book *Thirst for Power: Energy, Water, and Human Survival* was published by Yale University Press in 2016.

TO LEARN MORE

- "U.S. Freight System Modernization Necessary to Reduce Bottlenecks, Improve Security," June 9, 2009, https://www.rand.org/news/press/2009/06/09.html.
- Brian A. Weatherford, Henry H. Willis, and David S. Ortiz, "The State of U.S. Railroads: A Review of Capacity and Performance Data," RAND Corp., 2008.
- Richard Hillestad, Ben D. Van Roo, and Keenan D. Yoho, "Fast-Forward: Key Issues in Modernizing the U.S. Freight-Transportation System," RAND Corp., 2009.
- Bureau of Transportation Statistics, *Freight Facts and Figures 2015*, U.S. Department of Transportation, 2015.
- U.S. Department of Energy, *Transportation Energy Data Book*, 2016

Building more miles of track and repairing infrastructure such as bridges could add capacity, but adding sidings could unclog bottlenecks.
Image: Getty



FEATURED

RISK IMPORTANCE MEASURES IN THE DESIGN AND OPERATION OF NUCLEAR POWER PLANTS

IVAN VRBANIC, PRANAB SAMANTA, AND IVICA BASIC

ASME Press Books, 2 Park Avenue, New York, NY 10016-5990. 2017.

In using risk-informed approaches for ensuring safety of operating nuclear power plants, engineers must consider risk importance measures obtained from probabilistic risk assessments of the plants. Obtaining these measures in appropriate forms is helpful for decision makers and can facilitate the use of risk information. Vrbanic, Samanta, and Basic explore the concept of component-level importance measures that take into account different failure modes of the component, including common-cause failures. Some of the current practical applications of risk importance measures from the field of nuclear plant design and operation are also discussed. The monograph is the volume in the ASME Nuclear Engineering Division's series, *Nuclear Engineering and Technology for the 21st Century*.

150 PP. $99; ASME MEMBER $79. ISBN: 978-0-7918-6139-4

SMALL UNMANNED FIXED-WING AIRCRAFT DESIGN: A PRACTICAL APPROACH

Andrew J. Keane, András Sóbester, and James P. Scanlan
John Wiley & Sons, 111 River Street, Hoboken, NJ 07030-5774. 2018.

Today, the mental image for drones or unmanned aerial vehicles is of a highly maneuverable quadcopter. But as the authors of *Small Unmanned Fixed-wing Aircraft Design* point out, unmanned fixed-wing aircraft have been flying almost since the Wright Brothers took to the air. The authors, leaders of a UAV team at the University of Southampton, describe their work in developing small- to midsize fixed-wing drones, drawing heavily on the latest digital design and manufacturing methods and using off-the-shelf components as much as possible. The book is equal parts how-to guide, experimenter's notebook, and essay on the philosophy of design.

496 PP. $120. ISBN: 978-1-1194-0629-7

CLEAN MEAT: HOW GROWING MEAT WITHOUT ANIMALS WILL REVOLUTIONIZE DINNER AND THE WORLD

Paul Shapiro
Gallery Books, 1230 6th Ave, New York, NY 10020. 2018.

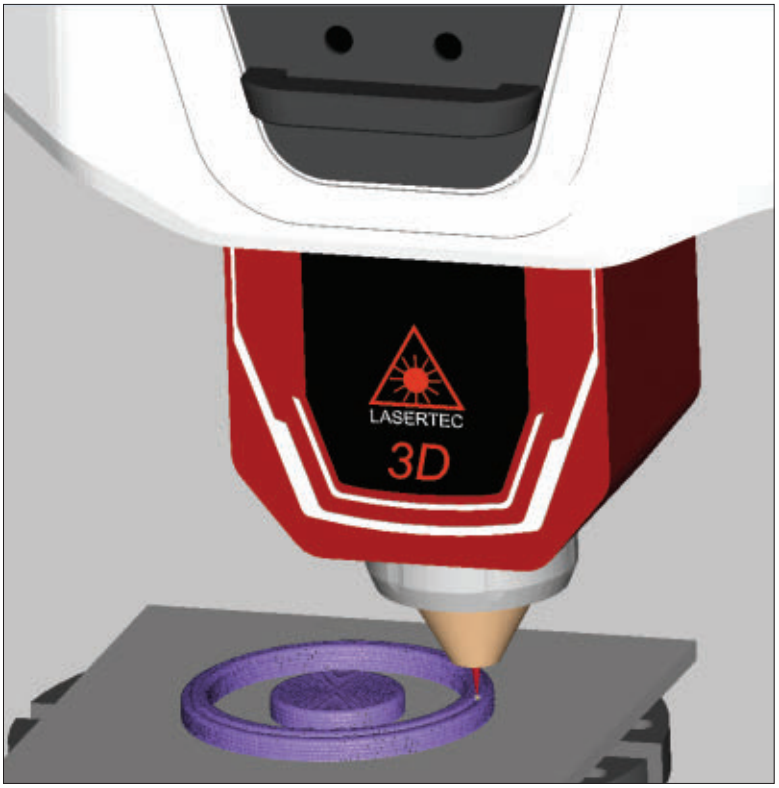
One of the frontiers of bioengineering is the scramble to create an alternative to farm-raised meat out of bioreactor-grown cells. The impetus for this effort comes from multiple directions—the hope that cultured meat would be healthier to eat, the recognition that present-day farm practices are ecologically damaging, the ethical concerns over raising animals in confinement—and Shapiro explores those ideas and others. He also profiles food-tech innovators and doesn't shy away from the corporate decision-making that ultimately may determine whether so-called clean meat leaps from the Petri dish to the bun.

256 PP. $26. ISBN: 978-1-5011-8908-1

CNC MACHINE SIMULATION

CGTECH, IRVINE, CALIF.

IN VERICUT 8.1, A NEW ADDITIVE manufacturing module has been employed, along with enhanced support for Force optimization, workpiece sectioning, an X-Caliper measurement tool, report template, and grinding and dressing operations. The module identifies potential problems that can occur when integrating additive methods. Force optimizes NC programs by analyzing cutting conditions such as force, chip thickness, and feed rate. The X-Caliper measuring tool identifies model thickness, length, and width dimensions. Revisions in the report template make creating a custom report easier. VERICUT can simulate the dynamic compensation needed while the dresser is used, even when the grinder is engaged with the part.



P&ID COLLABORATION,

SAN RAFAEL, CALIF.

Plant 3D 2018 simplifies the design process by helping customers easily produce piping and instrumentation diagrams, integrate them into a 3-D plant design model, and collaborate effectively. With a new cloud-based collaboration capability that leverages the Autodesk BIM 360 Team, using a built-in command, users simply upload a plant project to a BIM 360 folder and invite their teams. Check whether piping components in the P&ID are correctly mapped into the Piping Specification by linking the P&ID to piping specifications. Components not in the piping spec will be flagged out-of-spec and can be easily identified using the P&ID Painter feature.

MATERIALS TESTING

TA INSTRUMENTS, NEW CASTLE, DEL.

The WinTest 8.0 software package is a powerful user interface and controls platform for all TA ElectroForce products. The ElectroForce mechanical test instruments are used for fatigue, durability, and dynamic characterization of materials such as rubber, automotive components, biomaterials, and medical devices. This software provides data acquisition capabilities including a simplified setup process, auto configuration settings, and user-defined data sample rates. It also doubles the real-time control and data rate to a speed of 10 kHz, adds TuneIQ for torsion motors, and includes new application-specific add-on software modules.

ASSET MANAGEMENT

BUREAU VERITAS, NEUILLY-SUR-SEINE, FRANCE

Veristar AIM3D, based on the Dassault Systèmes 3DEXPERIENCE Platform, combines marine or offshore assets with smart data in a collaborative environment. Conceived to be used from the design stage through construction and throughout the operational life cycle to reflect and predict the condition of any asset, or fleet of assets, the solution supports risk-based inspection and condition-based maintenance approaches, providing asset management dashboards for individual ships, rigs, or facilities—or for entire fleets. It's designed to enable smarter decisions based on better visibility of actual asset condition and performance, reducing costs during operations and providing return-of-experience data to better inform design and construction..

VIDEO TRAINING SESSIONS

MECSOFT, IRVINE, CALIF.

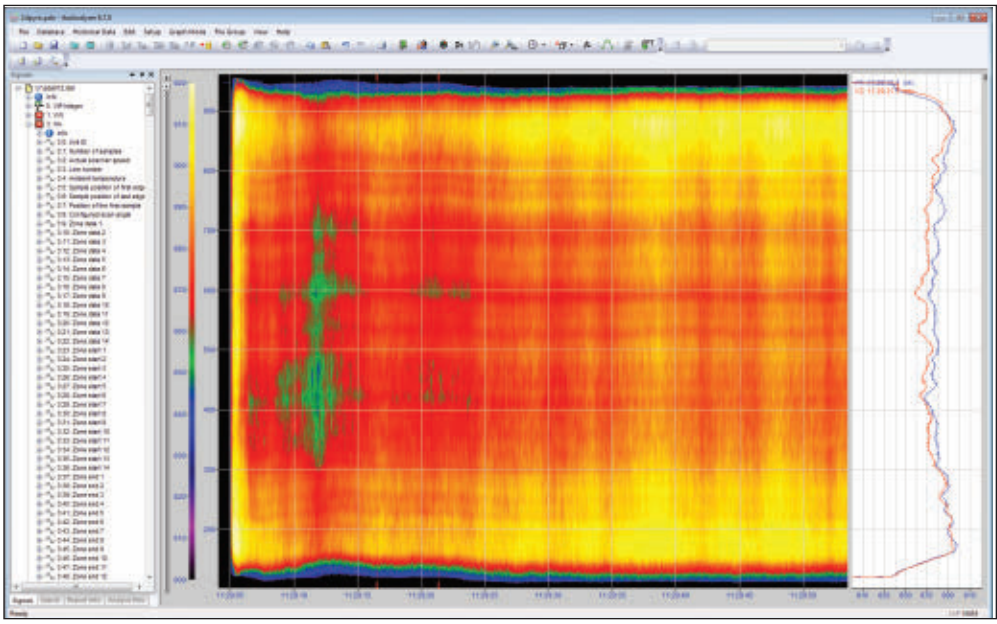
CAMJam 2017, the video training companion for MecSoft's VisualMILL, RhinoCAM, and VisualCAM for SOLIDWORKS milling modules, is the complete video archive of training sessions, more than 80 instructional videos covering the complete suite of MILL module functionality, conducted by the company's support staff. All training sessions are organized by content, indexed, and searchable. Included are a PDF document for organization and easy retrieval from the video library and all of the source part files referenced by the CAMJam video archive. Topics include the 2017 MILL User Interface; machine setup, stock, and indexed 5-axis setups; and many more.

SOFTWARE

LINE SCANNER INTERFACE

AMETEK LAND, SHEFFIELD, ENGLAND

This interface between ibaPDA systems and LANDSCAN LSP-HD infrared line scanners acquires temperature measurement data from steel strips in rolling mills. Developed by software company iba AG, ibaPDA is a powerful, PC-based acquisition and recording system for maintenance, process analysis, and quality control. The ibaPDA-Interface-LANDSCAN allows data from different sources to be available across the entire production process within the ibaPDA system. Highly visual data is displayed live, and users can view temperature measurement trends, product ID, scanning speed, environmental temperature, and position of the strip. This recorded measurement data also can be visualized in detail and analyzed with ibaAnalyzer, which is supplied free with the interface.



MULTIPHYSICS DESIGN ANALYSIS

IRONCAD, ATLANTA

Multiphysics for IronCAD (MPIC) provides fully coupled multiphysics for stress, thermal, electrostatic, and fluid analysis. Extended markup language data (XMD) technology for encapsulating model data provides easily expanding features for advanced XMD design analysis tools. Other innovations include a single-button control unit for flexible customization in different industries; moving-least-squares (MLS) FE tying that automatically detects the intended/unintended small gaps/overlap of parts in large assembly analysis without laborious geometry modifications; and analysis reports that have direct links for easy review. The automatic parts contact/impact analysis default setting helps CAD users solve general mechanical contact/impact problems. Analyses such as deep drawing or stamping springback problems now can be done using the default setting.

PRINT INSPECTION

METTLER TOLEDO, COLUMBUS, OHIO

CIVCore 11.5, featuring the WestPack Innovation Award 2017-winning Dot Print tool, gives manufacturers a method for inspecting inkjet and other dot matrix-style print. The software supports a wide range of hardware configurations and merges the client and server applications into a single application to significantly increase speed on all systems, particularly those using Mosaic inspection technology. An added benefit of this unification is simpler logging and error handling for easy diagnosis of problems. The Dot Print tool is specifically designed to help manufacturers verify the accuracy and quality of inkjet printing systems used to apply variable information such as the expiration date on food.

BIM COLLABORATION

ALLPLAN, MUNICH, GERMANY

The company's openBIM platform, bim+, includes an app for the iPad and the browser version's touch functionality, so it is available on every device. Task management with the Task Board has been optimized and the interface function improved for better control of 3-D models. A tool for system-independent and collaborative working in building information modeling (BIM) projects across all disciplines, bim+ is open for any software used in the construction industry via various formats such as IFC and BCF or the innovative API programming interface. The central coordination model forms the basis for

SUBMISSIONS

Submit electronic files of new products and images by e-mail to **memag@asme.org**. Use subject line "New Products." *ME* does not test or endorse the products described here.

interdisciplinary collaboration, as this is where all the relevant information is compiled and discrepancies become immediately visible.

AGILE PRODUCT DEVELOPMENT

ESTECO, TRIESTE, ITALY

VOLTA promises to take enterprise-engineering processes to a new, collaborative dimension as it protects a company's intellectual property and accelerates innovation processes. It expertly orchestrates simulation data and multidisciplinary business processes, enabling conscious decision-making and innovative product development. With its service-oriented architecture, VOLTA facilitates the sharing and reuse of enterprise engineering knowledge and provides all process stakeholders with a solid environment for distributed execution and access to key design data. In addition, VOLTA also provides an information structure that helps organizations manage engineering data related to product digital twins, resulting in quicker reactions to changes in scenarios or requirements.

DESKTOP CAD

IMSI DESIGN, NOVATO, CALIF.

TurboCAD Expert 2017, a 2-D/3-D CAD application for Windows desktop PCs, is for experienced 2-D/3-D CAD users familiar with AutoCAD or AutoCAD LT looking for a powerful alternative. It offers all of the two-dimensional drafting and design tools users require, with an optional AutoCAD-like 2-D drafting interface, complete with command line and dynamic input cursor, which simplifies the transition from AutoCAD. Advanced features include 2-D geometric and dimensional constraints, a collection of architectural design tools, 3-D surface modeling tools for mechanical design, photorealistic rendering features, database connectivity with customizable reporting, and support for dozens of industry standard CAD and graphic file formats.

3-D METROLOGY

INNOVMETRIC, QUEBEC, CANADA

PolyWorks 2017 delivers a control-centric reviewing workflow for all portable metrology and CNC CMM measurement specialists that need to share large metrology projects containing hundreds of dimensional and GD&T controls with colleagues, customers, and suppliers. Its unique approach to real-time collision analysis for more efficient CNC CMM project setups uses the new Control Reviewer in PolyWorks|Inspector or in the free PolyWorks|Viewer. Among the software platform's many features, measurement and manufacturing specialists can access a global list of dimensional controls sorted by characteristic index, for first-article inspection reports, and add custom controls to the global list of controls, for example, those measured using manual gauges.

PEDESTRIAN SIMULATION

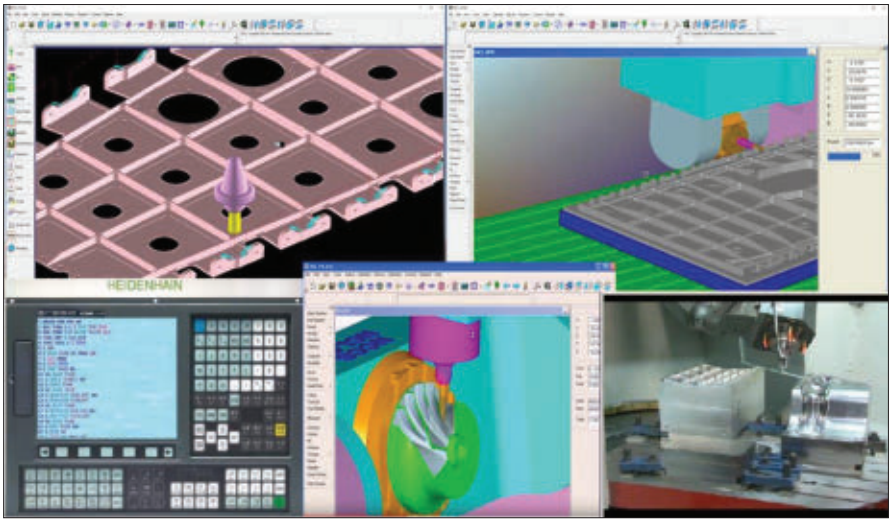
OASYS, NEWCASTLE UPON TYNE, U.K.

MassMotion 9.0, an advanced pedestrian simulation and crowd analysis tool used in urban infrastructure and transportation hubs globally, lets users build 3-D models and control agent behavior, testing and validating a wide range of scenarios. A BIM-compatible 3-D model, with object snap for even faster model building, supports "live" links between different levels and areas of complex structures, providing a window on the entire and continuous pedestrian flow. Agents don't just disappear from one area and pop up in another—you can follow them up the stairs and escalators, etc., where risks of congestion or obstruction are just as high.

MULTI-AXIS MACHINING

NCCS, IRVINE, CALIF.

NCL blends automated and user-controlled tool path generation techniques for reduced programming time. A combination of power, flexibility, and tool control are geared toward allowing users to quickly produce any part, reduce machine time, improve quality, and increase profits. NCL runs in the Windows 64-bit and 32-bit versions. The increased memory allocation of the 64-bit processing environment provides better performance and stability. In addition to a VoluMill roughing module, the NCL model has a STEP converter. NCL's features include user-friendly GUI Interface, optimized NC Code, total tool control designed for perfect results, flexibility, custom cut routines, and 2 ½- through 5-axis simultaneous motion.



COATING THICKNESS GAUGE

PAUL N. GARDNER COMPANY, POMPANO BEACH, FLA.

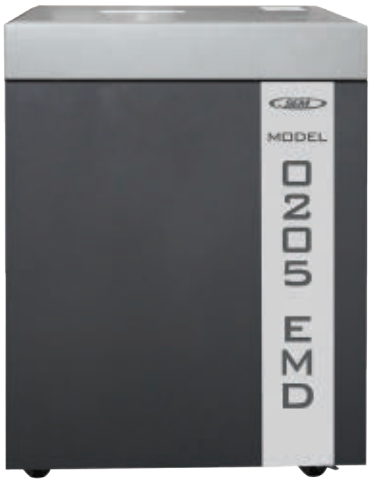
The handheld, factory-calibrated CMI155 and CMI157 measure the thickness of single-layer coatings or the total thickness of applied coatings on iron, steel, aluminum, and other ferrous and nonferrous metal substrates. With a probe foot designed for smooth surfaces and an extended measurement range, they are ideal metrology tools for paint and powder coaters, coating inspectors, automotive and aerospace finishers, and electroplating plants. Highlights include single-button operation; automatic substrate detection; integrated probe design; IP52 protection against dust and water; no operator training required; rapid inspection of paint, lacquer, and other protective coatings on metal substrates; dual technology that ensures the right measurement on contact; and reliable nondestructive analysis.

ELECTRONIC MEDIA SHREDDER

SEM, WESTBORO, MASS.

The SEM Model 0205EMD from Security Engineered Machinery destroys SSD (solid-state drives) media-containing devices to waste particles of 30 mm squared or less and meets DIN 66399 Standard E-4. Complete destruction is accomplished by patent-pending destruction shafts with pyramid-shaped elements through which the drives pass.

Electronic media as well as the data-carrying SSDs are crushed between two rotating shafts and fall into a collection container for simplified, hands-free collection of waste material. The SEM 0205EMD produces end waste that meets DIN standard E-3 when destroying only the SSD board and DIN standard E-4 when destroying entire systems including SSD drives, phones, and tablets with the boards included.



SERVO MOTOR

ALLIED MOTION TECHNOLOGIES, AMHERST, N.Y.

The HeiMotion Premium brushless AC servo motor comes in five metric frame sizes with rated torque from 0.12 up to 14.4 Nm and continuous shaft power from 50 W to 3.75 kW. It offers highly accurate torque ratings, energy efficiency, and a life span of 20,000+ hours. An innovative compressed winding technology allows for compact size and lower production costs. The series is configurable in thousands of combinations to fit virtually any application. It is engineered for use in machine tools, autonomous vehicles, robots, medical diagnostic equipment, and more. Standard flange sizes: 40, 60, 80, 100, and 130 mm; speed from 2,000 to 9,000 rpm; holding torque from 0.18 to 18.5 Nm; and winding voltage choices from 48 to 560 V.

SUBMISSIONS

Submit electronic files of new products and images by e-mail to **memag@asme.org**. Use subject line "New Products." *ME* does not test or endorse the products described here.

EMISSIONS REMOVAL

BINOMIC INDUSTRIES, MAHWAH, N.J.

The ScrubPac VentClean System is a package deal that promises to remove 99 percent of storage tank and rail car vent emissions caused by breathing and filling operations. VentClean handles single as well as multiple sources with large variations in venting rates. The scrubber system uses a triple-action scrubbing technology, is available in four model sizes to handle gas capacities from 0 to 1,500 acfm, and has two unique (Type 1 and Type 2) operating configurations. Type 1 is economically priced and configured to use water on a once-through basis. Type 2 incorporates a special circulation pump and uses water at a reduced-consumption rate, or a chemical reagent such as sodium hydroxide on a recirculated batch basis.

TOOL PRESETTING

HAIMER, IGENHAUSEN, GERMANY

A highlight of the company's portfolio of Microset tool presetting devices is the VIO linear series, with a linear drive for efficient and highly precise presetting of drilling, milling, and turning tools. The direct drive within the x- as well as z-axis offers the user dynamic positioning precision and reliability in even the largest tooling. HAIMER guarantees a very good price-performance ratio based on the machines' repeatability of +/- 2 µm, the high-speed linear drive that increases productivity, and a modular design to cover a wide spectrum of needs. Tools that weigh up to 160 kg and have a diameter and measuring length of up to 1000 mm can be measured.

ELECTRICAL CONDUCTIVITY MEASUREMENT

PAUL N. GARDNER, POMPANO BEACH, FLA.

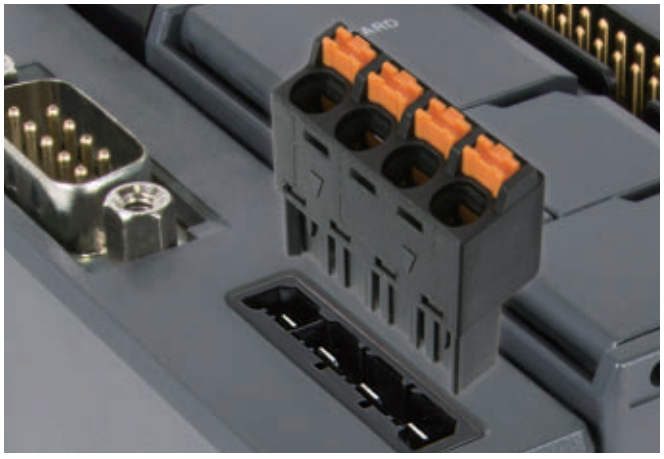
The SIGMASCOPE SMP350 determines the electrical conductivity of metals with precision and accuracy using the phase-sensitive eddy current method, which allows for contact-free determination of a substrate's electrical conductivity, even under paint or plastic coatings up to 500 µm thick. This method also minimizes the influence of surface roughness. It is effective in a wide range of measuring applications and fields, including quality assurance and sorting of raw materials; authenticating of coin alloys (e.g., specific conductivity of coins); assessing hardness and strength of heat-treated materials, inspecting for heat damage, material fatigue, and cracks; estimating the phosphorous content in copper; tracking precipitation processes, e.g., for Cu-Cr alloy; testing the homogeneity of alloys; and scrap metal sorting.

HARDWARE

3-D PRINTING PROTOTYPES

STRATASYS, EDEN PRAIRIE, MINN.

Inspired by advanced robotics, the Stratasys F123 Series empowers virtually any user, regardless of 3-D printing experience, to build durable and accurate prototypes using a range of functional FDM 3-D printing materials. A single printer addresses the complete prototyping workflow, from initial concept verification to design validation and final functional performance, to ensure product designs are thoroughly evaluated before manufacturing. Designed for office and classroom environments, most F123 Series operations are easily performed with a touchscreen user interface, the system can be used remotely from any networked computer, and build progress can be monitored from portable devices.



PLUGGABLE TERMINAL BLOCKS

DINKLE, STAFFORD, TEXAS

Harnessing a patented push-in design for connecting wires to their terminal blocks, the plug fits into its mating socket, which is usually attached to a printed circuit board through pins, and the wires connect to the socket in a system created to make traditional screw terminals more efficient and easier to use as well as to save space. Screw terminals take time to tighten properly, and there is always the danger of under-torqueing and loose connections, or over-torqueing and stripped screw threads. Connecting a solid wire with push-in-design takes only 3.6 seconds, a flexible wire just 4.1 seconds, and a flexible wire with a ferrule only 3.7 second. Pluggable terminal blocks are available in a wide variety of sizes and ratings.

ROTARY ENCODER

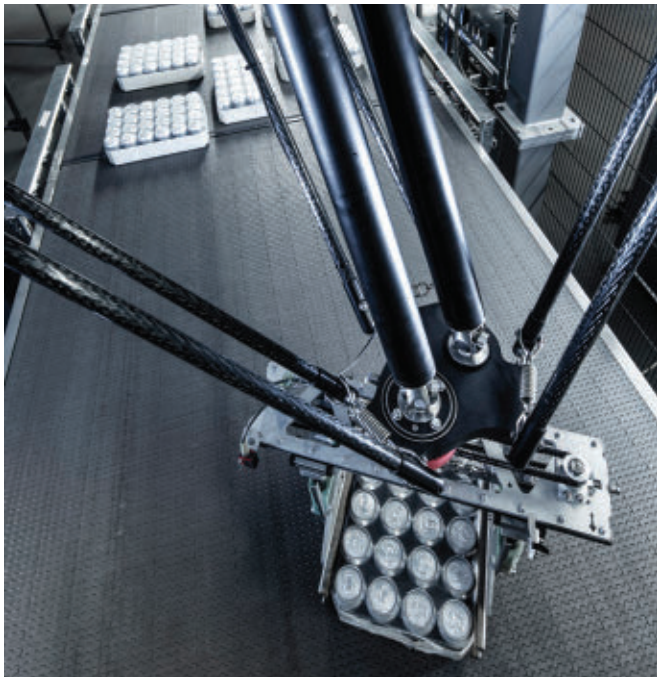
HEIDENHAIN, SCHAUMBURG, ILL.

The RENCO brand RCML15 rotary encoder, widely used for feedback in automated medical devices, is now commonly found in motors being made for blood pumps too. The encoder's slim and lightweight design combined with its reliability make it a popular go-to source for feedback in blood pump motors that operate within a multitude of medical devices such as hematology analyzers, which are automated systems that count leucocytes, red cells, and platelets in blood. Noted for its compact modular design without an integral bearing, special properties include a low profile at a height of only 8.9 mm, as well as its easy, self-centering mounting thanks to a patented slide lock mechanism. Through OPTO-ASIC technology, it offers the greatest functionality with the smallest possible dimensions.

PACKAGE CONVEYING

KHS, DORTMUND, GERMANY

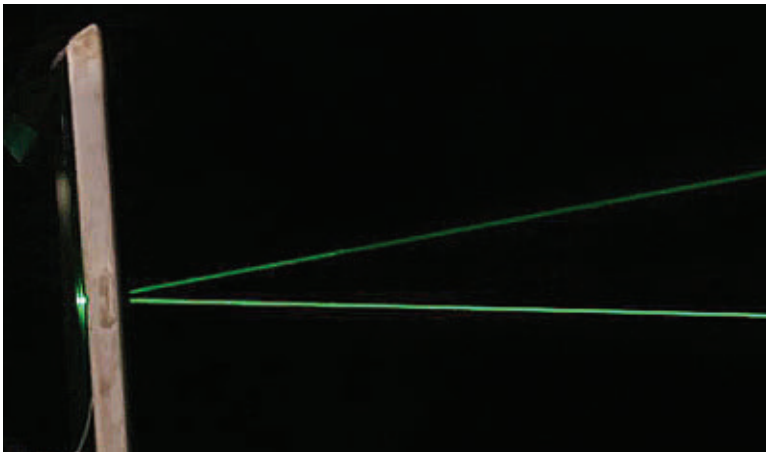
The flexible and compact InnoDry Block, with an integrated buffer system, is designed for accumulation-free, gentle pack conveying without the side guides otherwise required. This does away with the need for adjustment during format changeovers. Secondary and tertiary packaging innovations are also geared toward efficiency. Where two or more single machines can be compiled to form a compact block system, KHS InnoDry Block combines a packaging machine with a palletizer and has a handle dispenser integrated into the packer. This setup is made possible by especially flexible buffer areas and the use of a highly dynamic handling system for layer formation. Advantages include both shorter conveying segments and format changeover times.



PAINT-CURING OVEN LOGGER

PAUL N. GARDNER COMPANY, POMPANO BEACH, FLA.

The CurveX 3 Standard offers easy-to-use, high-quality temperature data logging for paint-curing ovens. Measurements, analysis levels, and report options are fully customizable to provide tailor-made information on the quality of curing processes. The data logger is fitted with a large full-color touch screen for easy menu-driven operation and quick display of measurement results. The logger has six channels and a memory of at least 8,000 measuring points per channel. The Ideal Finish Analysis data analysis software allows you to analyze the logged data and create detailed reports. An oven logger kit contains an insulation box with heat sink. Add the desired magnetic or clamp-type probes to make the kit complete.



LASER BEAM DEFLECTOR

METAMATERIAL TECHNOLOGIES, NOVA SCOTIA, CANADA

Metamaterial Technologies Inc. (MTI) Lamda Guard division's metaAIR provides vision protection against bright and intense laser lights. The flexible, optical metamaterial filter engineered to stop and deflect harmful laser beams aimed at aircraft can be adhered onto the inner surface of a cockpit windscreen. The laser beam is deflected off the filter before it reaches the inside of the cockpit. The large-scale optical filter covers an entire windscreen and blocks and deflects laser strikes, protecting pilots' vision from them during critical phases of flight. It does not affect nighttime vision as it is neutral in color and highly transparent. This filter can also be applied to protective eyewear, retractable visors, optical sensors, and almost any clear glass or plastic surface.

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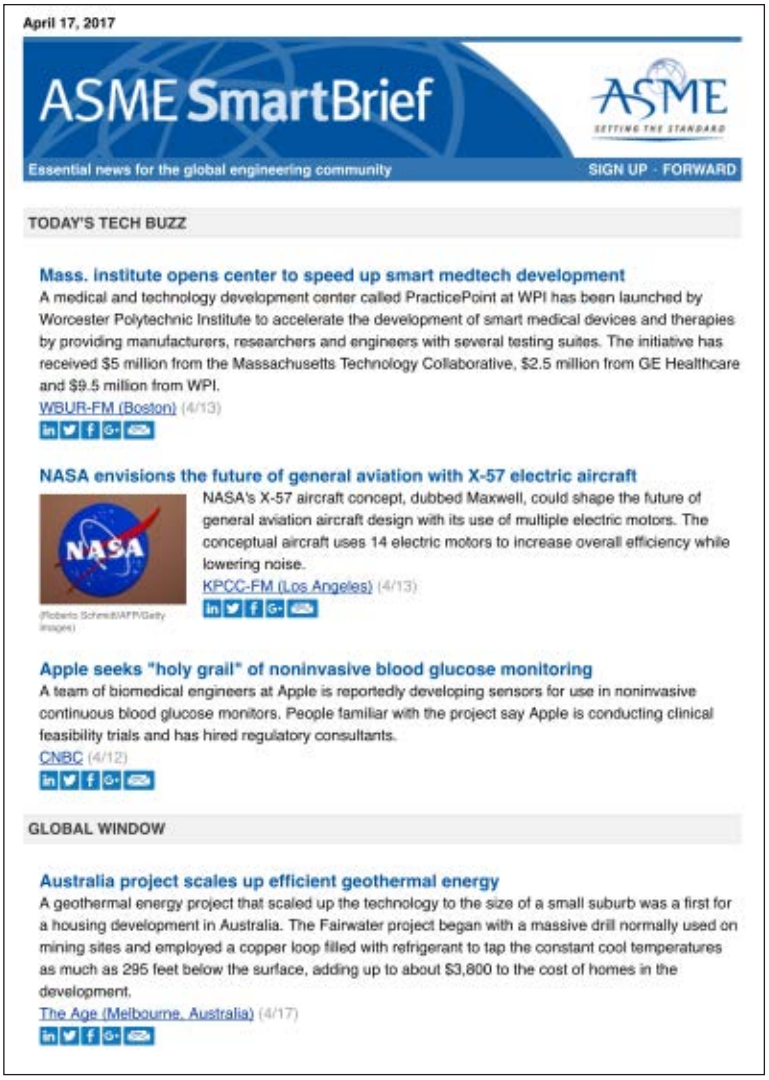

April 17, 2017

ASME SmartBrief

Essential news for the global engineering community — SIGN UP · FORWARD

TODAY'S TECH BUZZ

Mass. institute opens center to speed up smart medtech development

A medical and technology development center called PracticePoint at WPI has been launched by Worcester Polytechnic Institute to accelerate the development of smart medical devices and therapies by providing manufacturers, researchers and engineers with several testing suites. The initiative has received $5 million from the Massachusetts Technology Collaborative, $2.5 million from GE Healthcare and $9.5 million from WPI.

WBUR-FM (Boston) (4/13)

NASA envisions the future of general aviation with X-57 electric aircraft

NASA's X-57 aircraft concept, dubbed Maxwell, could shape the future of general aviation aircraft design with its use of multiple electric motors. The conceptual aircraft uses 14 electric motors to increase overall efficiency while lowering noise.

KPCC-FM (Los Angeles) (4/13)

Apple seeks "holy grail" of noninvasive blood glucose monitoring

A team of biomedical engineers at Apple is reportedly developing sensors for use in noninvasive continuous blood glucose monitors. People familiar with the project say Apple is conducting clinical feasibility trials and has hired regulatory consultants.

CNBC (4/12)

GLOBAL WINDOW

Australia project scales up efficient geothermal energy

A geothermal energy project that scaled up the technology to the size of a small suburb was a first for a housing development in Australia. The Fairwater project began with a massive drill normally used on mining sites and employed a copper loop filled with refrigerant to tap the constant cool temperatures as much as 295 feet below the surface, adding up to about $3,800 to the cost of homes in the development.

The Age (Melbourne, Australia) (4/17)

"It's about more than just awareness building. It has had a definite impact on how I do business. The information is so timely and far reaching that it helps me to think about innovation and development going forward."
— CEO

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— Engineer

"When I meet with clients I am better informed. I know things that [they] haven't heard yet, and it allows me to speak knowledgeably about a wide range of topics. It is a great confidence builder."
— President & CEO

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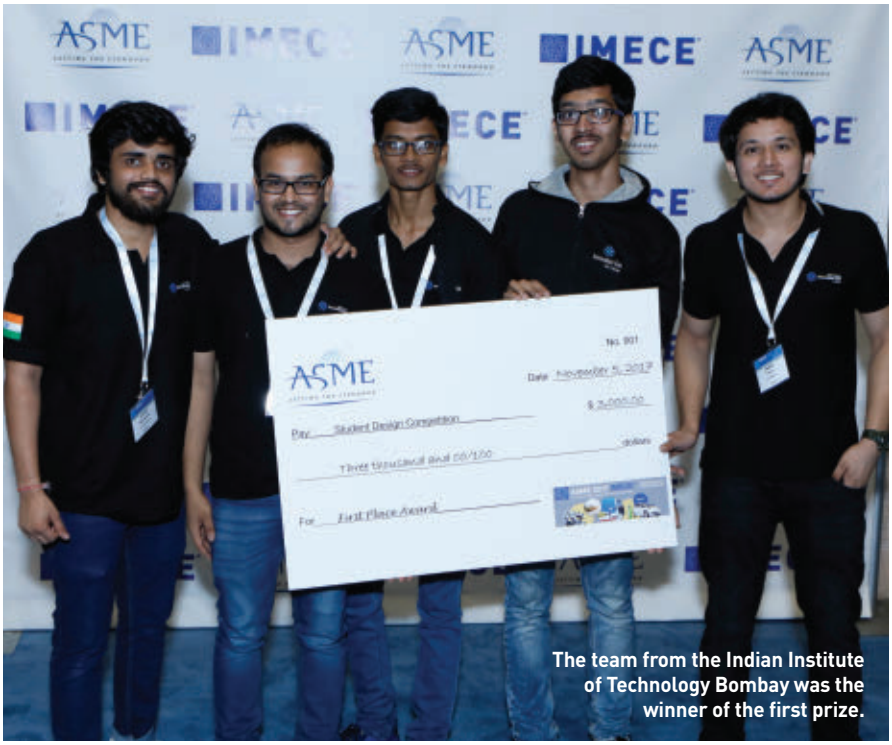
RECRUITMENT

NEXT MONTH IN MECHANICAL ENGINEERING

READY, SET, GO!

How engineering competitions are changing the way students learn.

ROBOT PENTATHLON CHALLENGES STUDENTS



The team from the Indian Institute of Technology Bombay was the winner of the first prize.

Hitting golf balls, scaling a set of sharp stair steps, and sprinting to the finish line—the 2017 ASME Student Design Competition Finals held Nov. 5, 2017, at the ASME International Mechanical Engineering Congress and Exposition (IMECE) in Tampa, Fla., had robots figuratively sweating through their paces. Teams of finalists who had competed earlier in the year at the ASME E-Fest regional Student Design Competition (SDC) events held in India and the United States were invited to compete in the SDC finals, a robotic pentathlon that featured five events.

One highlight of the competition's final round was the performance of the team from India Institute of Technology Bombay during the sprint event, in which the team's robot finished the 10-meter race in an amazing 4 seconds—far and away the fastest sprint performance of the day. The team, who also performed impressively in the competition's other events, was named the overall winner of the SDC finals, receiving the $3,000 first prize. The pentathlon also encompassed activities in which robots had to lift a weight as high as possible, propel a tennis ball across a room, climb a set of three steps, and hit a golf ball as far they could.

Two teams from the University of Mississippi, who had previously placed first and second at the competition at E-Fest East at Tennessee Tech University in April, rounded out the top three at the SDC finals when the scores were tallied. One of the teams, called Ole Miss Red, took home the $1,000 second-place prize at the finals at IMECE, while the other team, Ole Miss Blue, received the $500 third prize.

"As we look forward in planning Student Design Competition challenges, we want to fully maximize the opportunity presented by holding these competitions at ASME E-Fest events," said **Kevin Schmaltz**, chair of the ASME Student Design Competition Committee. The 2017 Robotic Pentathlon and recently announced 2018 SDC challenge, "Robot Football," aim to celebrate student design, creativity, and innovation. ME

NEW DEADLINE FOR ASME JOURNAL ISSUE ON MICROSCALE MEDICAL DEVICES

The ASME *Journal of Medical Devices* has extended the deadline to submit a paper for its "Special Issue on Microscale Medical Devices." The new deadline is March 1, 2018.

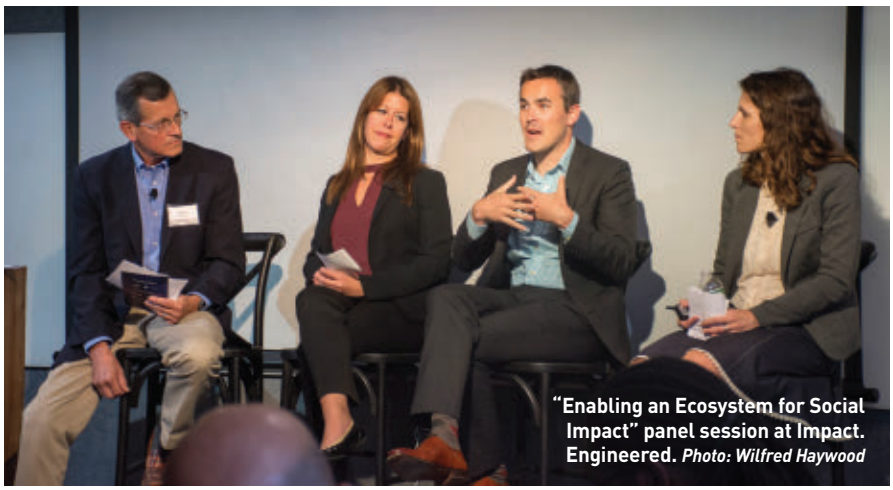
This special issue of the ASME *Journal of Medical Devices*, which was previously titled "Biomimetic Medical Devices: Microfluidics, MEMS, and NEMS," will highlight original research on the use of microscale devices for medical applications. Manuscripts being submitted for the special issue should describe new results from novel microfluidic, MEMS, NEMS, or other microscale devices. Reports on experimental or computational research are welcome.

Yaling Liu, associate professor of mechanical engineering and mechanics at Lehigh University, is the editor for the special issue, which will also focus on areas including lab-on-a-chip, organ-on-a-chip, biomimetics, medical devices, nanotechnology, disease diagnosis, drug screening and biosensing.

Papers should be submitted to the journal electronically by March 1, 2018, through the ASME Journals Digital Submission Site at http://journaltool.asme.org. The initial review of submissions will be completed by April 15, 2018, and the special issue will be published in September 2018. ME

INAUGURAL IMPACT. ENGINEERED HONORS SOCIAL INNOVATORS

ASME and Engineering for Change (E4C) recently launched Impact.Engineered, which calls attention to the innovations of industry, engineers, and entrepreneurs striving for social impact in underserved communities the world over. Several individuals and companies were recognized for their contributions to the technology for development arena during an evening reception at the inaugural event, which was held on October 18, 2017 at the Centre for Social Innovation in Manhattan.



"Enabling an Ecosystem for Social Impact" panel session at Impact. Engineered. *Photo: Wilfred Haywood*

Approximately 100 engineers, scientists, entrepreneurs, and makers from the public and private sectors attended the one-day forum, which featured programming focused on the future of engineering and highlighted the work of individuals and organizations who have consistently demonstrated a commitment to innovation, quality, rigor, sustainability, and social impact.

Two companies—D-REV and Sign-IO—were named the award winners in the "Hardware Trailblazer" category, which recognized excellence and innovation in the production of hardware solutions for emerging markets. D-REV, a San Francisco-based non-profit organization, designs, and produces affordable, quality medical devices for developing communities. The second award winner in the category, Sign-IO, was one of the grand-prize winners at the ASME Innovation Showcase (ISHOW) in Kenya, which was held in May.

Elaine Weidman-Grunewald, the chief sustainability and public affairs officer and head of sustainability and public affairs at Ericsson; **Mitchell Baker**, the executive chairwoman of the Mozilla Foundation and Mozilla Corporation; and **Linda Raftree**, an independent consultant and convener of the discussion forums Technology Salons and MERL Tech were honored by ASME and E4C with awards for "Women Leading in Technology and Impact."

In addition to the awards presentation, which took place at the conference's evening reception, the event included opportunities for attendees to hear from and connect with representatives from social enterprises, impact design firms and leading engineering firms, and to take part in panel discussions and workshops. ME

IMECE PLENARY FOCUSES ON FUTURE OF DIGITAL TWINS

Aaron Knobloch of GE was the plenary speaker.

Aaron Knobloch, senior scientist and program manager at General Electric Global Research Center, delivered his presentation, "When Machines Find Their Voice: The Industrial Internet of Things and Digital Twins," at the Closing Plenary Luncheon at the ASME 2017 International Mechanical Engineering Congress and Exposition (IMECE) in Tampa, Fla.

The nearly 700 attendees saw Knobloch's discussion, which focused on the concept of digital twins—complex physics-based models of equipment fed by continuous real-time sensor data—and how they are revolutionizing the maintenance and optimization of hardware. Much like the user profiles created on Amazon.com when visitors to the site make purchases, digital twin models enable companies like GE to create profiles of the equipment they sell to customers, such locomotives or jet engines, Knobloch said.

Driven by "huge changes in our connectivity, the performance of computing, and the cost of sensors and computing" during the past two decades, digital twin models offer hardware operators the opportunity to reduce maintenance costs and make overall operations more efficient, he said.

As an example, Knobloch pointed to electric utilities as operations that could reap the benefits of digital twins modeling. Airlines is another industry where it would be a natural fit, he said.

Knobloch also mentioned health care and athletics as areas where digital twins could have an impact, due to the reduction in cost of wearables. This technology would make it possible to "make predictions about sickness, or for athletes, optimized performance based on parameters that (can be measured) more easily because wearables are becoming cheaper," Knobloch said. ME

A demonstration of strength of the artificial muscle.

Images: Wyss Institute at Harvard University

BRAWNY ORIGAMI

Flexible sheets find strength in their folds.

We often link being strong with being unyielding, but when researchers at Harvard University and the Massachusetts Institute of Technology wanted to make their soft robots stronger, they found that folding well was the way to go.

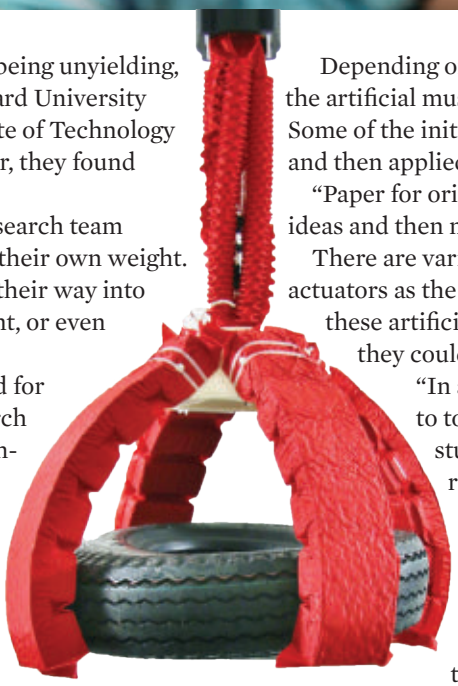
The origami-inspired actuators the research team designed can lift as much as 1,000 times their own weight. These artificial muscles could soon find their way into wearables electronics, surgical equipment, or even insect-like microbots.

"Anything that's foldable could be used for these actuators," said Daniel Vogt, research engineer at Harvard University's Wyss Institute, who was a co-author on a paper released about the actuators.

The researchers built artificial muscles using different flexible materials like paper, metal, and plastic sheets as a corrugated inner skeleton that could fold up into a specific shape. They encased the skeleton in a skin-like plastic casing, and when they applied a vacuum to the casing, air pressure would fold the flexible material into a much smaller volume.

In one example, a zig-zag sheet of plastic was placed in a gripper, and applying a vacuum caused the sheet to slowly fold upwards. In the process, the gripper could pull up the full weight of an automobile tire.

The researchers also programmed the artificial muscles to pick up bananas and bottles.



Depending on the skeleton's design, it is possible for the artificial muscles to shapeshift in multiple directions. Some of the initial origami designs were tested on paper and then applied to metal or plastic sheets, Vogt said.

"Paper for origami is often what allows us to try some ideas and then move on to other materials," Vogt said.

There are various potential applications for these actuators as the technology unfolds. For instance, since these artificial muscles are both strong and supple, they could find use in industrial settings.

"In a car factory you don't want your gripper to touch the car because it is very expensive stuff," said Shuguang Li, a postdoctoral researcher at MIT and another co-author of the paper.

"For this kind of application, you can use our soft gripper to manipulate a product that is fragile or expensive," said Li.

The researchers are adding the actuators to power gloves to supplement grip strength to those with muscle diseases.

Although the design is derived from origami, don't look for paper to start folding itself into cranes.

"Origami geometry looks beautiful, but when you make something for engineering use, it's a little overcomplex for the joints and connections. We borrowed the artificial muscle idea from origami geometry but we also simplified it," Li said. ME

AGAM SHAH

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