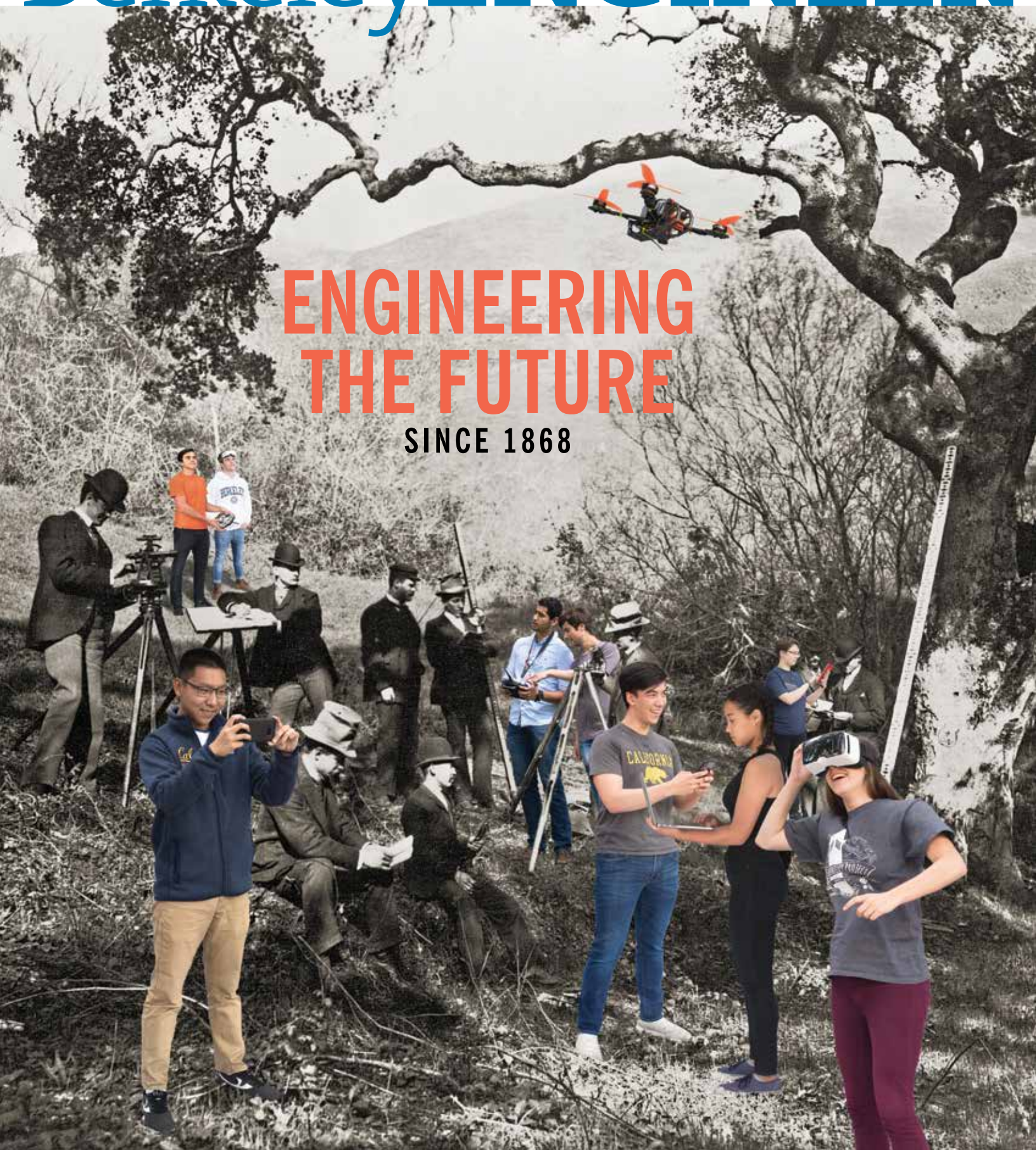
College of Engineering
University of California, Berkeley
Spring 2018
Volume 13

Universities and the digital transformation of society

Out of the GAIT
Digital health tech

Solar cruiser
CalSol's new ride

Berkeley ENGINEER



Leading our students toward a new future of work

For the past decade, I have had the great privilege of serving as dean for one of the top engineering colleges in the nation. During this time, I have had a ringside seat to the tremendous growth at Berkeley Engineering during a transformative time in our society.

The world looks markedly different now than it did when I first assumed the deanship in 2007. The time is coming when we may be driving along the road and turn to see that the vehicle next to us doesn't have a human being behind the wheel. In these not-too-distant scenarios, humans will be living and working closely with robots.

Automation and artificial intelligence are revolutionizing nearly every sector of our society and altering the landscape of our future workforce.

The future of work was on my mind as I looked out at our graduating engineering students at commencement a few weeks ago. As many traditional jobs are transformed by automation, we in academia need to prepare our students for the jobs of the future.

As many traditional jobs are transformed by automation, we need to prepare our students for the jobs of the future.

We have made huge strides toward this goal by bringing in a blend of technology, entrepreneurship and design into our instruction, and by offering a professional master's of engineering degree as well as the Management, Entrepreneurship, & Technology dual degree program with the Haas School of Business.

Our faculty members are already collaborating with researchers and scholars from business, law and other disciplines to ensure that our students not only survive in these changing times, but thrive.

Going forward, we will need to expand the college's offerings in career enhancement for those already in the workforce, with pedagogy combining new technology innovation with design and entrepreneurship. A successful exemplar that we could build on is our popular four-month-long Engineering Leadership Professional Program.

This year, Berkeley Engineering is celebrating 150 years of successfully sending our best and brightest graduates out into the world. I am excited for the next 150 years of innovation and entrepreneurship, and I am eager to explore new challenges as I return full-time to teaching and research as an engineering faculty member and as director of the Blum Center for Developing Economies.

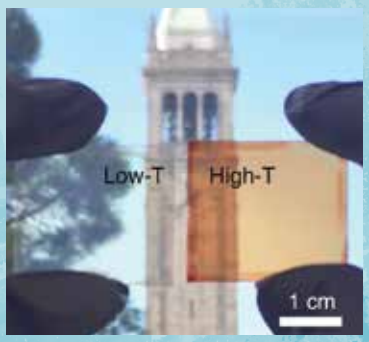
I end with a heartfelt thank you to the entire Berkeley Engineering community for making my time as dean so rewarding and inspiring. It has been a true honor.

—*S. Shankar Sastry*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING
DIRECTOR, BLUM CENTER FOR DEVELOPING ECONOMIES

Dean Shankar Sastry with Gary May (M.S.'88, Ph.D.'91 EECS), UC Davis chancellor and featured speaker at Berkeley Engineering's graduate student commencement.

in this issue

BerkeleyENGINEER SPRING 2018



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Peg Skorpinski

MICROPROCESSORS

Patterson wins Turing Award

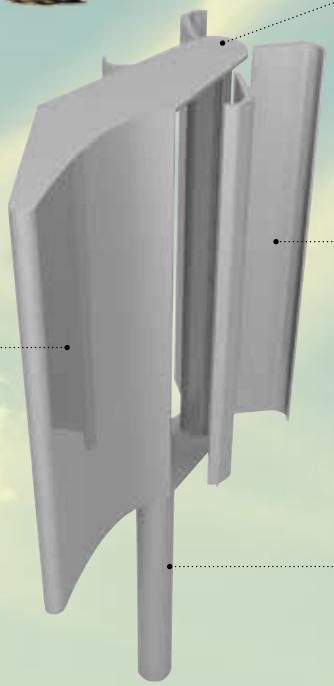
David Patterson, professor emeritus of electrical engineering and computer sciences, was named co-winner of the prestigious A.M. Turing Award — often called the Nobel Prize of computing — along with John Hennessy, former president of Stanford University. They were honored for their pioneering work on reduced instruction set computer microprocessors, which has proved foundational to computer architecture as well as to mobile and Internet of Things technologies.

"UC Berkeley is among the leading universities with Turing laureates among its faculty and alumni, so my share of this award is really recognition of my good fortune of having built my career here," said Patterson. "It has been a privilege to collaborate for four decades with the wonderful students and faculty of UC Berkeley just as the university celebrates its 150th birthday."

ENERGY

Redesigning wind power

Marin County is home to high winds and hawks. Its headlands, abutting the Pacific Ocean, make it a great location to harvest wind, but the county has strict regulations discouraging traditional, horizontal wind turbines — in part because they are so deadly for raptors. For the past three years, teams of Master of Engineering students have been working with county officials to devise a new, efficient wind turbine that would meet Marin's regulations and create a local and sustainable renewable energy source. For the past year, **Austin Campbell, Ali Elashri, Erica Horton** and **Chahal Neema,** all mechanical engineering students (with a blend of interests in energy systems and product design), have been working with mechanical engineering professors **Alice Agogino** and **Philip Marcus** and with industry advisor Tom Flynn, from the Claremont-based company California Energy and Power, to design a low-slung turbine that operates vertically, rather than horizontally. Not only does their design spare the birds, but it operates with less noise and is better adapted to turbulent erratic wind flow. The design is also modular, so it can be stacked in towers larger than are currently permitted in Marin.



Camo
The entire setup can be painted to blend in with surrounding landscapes. Coils of wire prevent birds from perching on top.

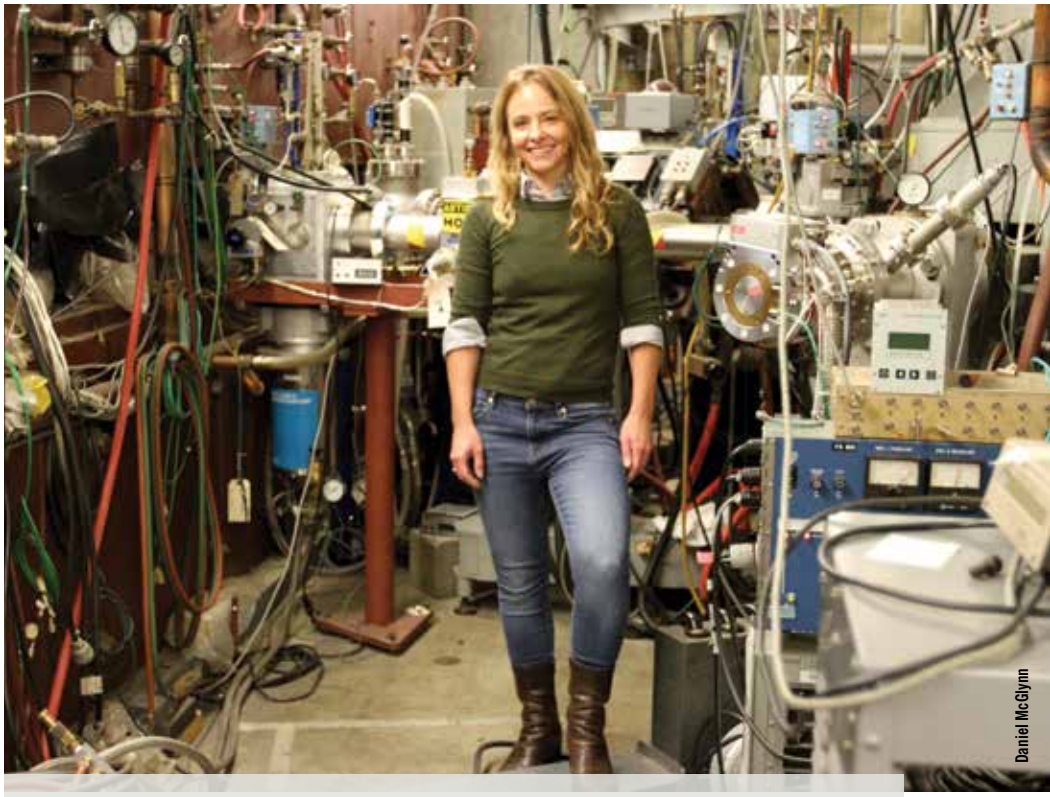
Blades
The blades, which are 25 feet tall, are able to manage turbulent airflow and operate quietly due to their drag-based design.

Concentrator
The scoop-like concentrator funnels the wind across the blades, which increases energy output (a single unit is capable of producing two kilowatts when modeled) and protects birds from flying into the turbine's blades.

Tower
The 15-foot tower keeps the turbine lower to the ground than traditional turbines; current Marin County regulations encourage the entire setup to stay under 40 feet tall.

Q+A on nuclear nonproliferation

Bethany Lyles Goldblum (M.S.'05,Ph.D.'07 NE) is executive director of the Berkeley-based Nuclear Science and Security Consortium. She also leads the university's Nuclear Policy Working Group and is involved with various aspects of nuclear security research, ranging from online war games to building new technologies to aid in the detection of nuclear threats.



Daniel McGlynn

Bethany Lyles Goldblum inside Berkeley Lab's 88-inch Cyclotron. Goldblum uses neutrons emitted from the Cyclotron to test a detector design with eventual applications in neutron imaging cameras and other nuclear threat sensors.

As an engineer, how did you get interested in nuclear security issues?

While I was getting my Ph.D. in nuclear engineering at Berkeley, I got a fellowship to attend a bootcamp at UC San Diego called Public Policy and Nuclear Threats. That experience was really powerful. I came out of it wanting to shape nuclear security policy and that has continued to remain a big part of my work. I am now the director of that program.

What is the Nuclear Science and Security Consortium (NSSC)?

The NSSC was founded in 2011 and is funded by the National Nuclear Security Administration. The program, which is headquartered at Berkeley, is a multi-institution initiative composed of eight universities and five national labs. The overarching goal of the NSSC is to address nuclear security and nonproliferation challenges while training students for future leadership roles and to break down some of the traditional boundaries between technical and policy disciplines. The proliferation detection landscape is only getting more complicated as more states, like North Korea, are finding pathways toward nuclear weapons. What we'll need in the future are experts who have backgrounds in a wide range of topics, such as building proliferation-resistant technologies, or who are capable of taking on nuclear forensics investigations to identify where nuclear material is coming from.

You also lead the Nuclear Policy Working Group.

I started the Nuclear Policy Working Group as a series of seminar-type gatherings with a few Berkeley students interested in nuclear security. Since then, the group has grown and morphed into a hybrid class, club and research group. We usually do a deep dive on a single research question over the course of a year. Last year we looked at alternative proliferation pathways. This year, we're exploring the impact of emerging technologies on situational awareness and potential implications for nuclear crisis and stability.

How are you tracking changes in nuclear security threats?

I've joined war-gaming exercises at Lawrence Livermore National Laboratory to explore different nuclear threat scenarios. We also use online gaming platforms to simulate different nuclear weapons deterrence strategies, and to try to understand how those strategies might change if adversaries have access to other kinds of weapons.

What does your fundamental research look like?

In addition to my other work, I've also designed a method to measure the light emitted from organic scintillators when exposed to neutrons of a given energy. We built a detector array to measure neutrons produced at Berkeley Lab's 88-Inch Cyclotron. The data will help us design and operate future neutron imaging cameras and other nuclear threat detectors.

NUCLEAR INNOVATION BOOTCAMP
IMAGINE NUCLEAR

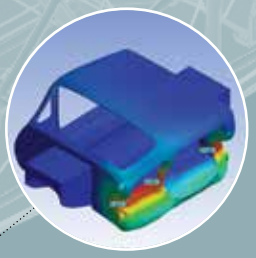
Founded by nuclear engineering professor **Rachel Slaybaugh,** and now in its third year, the Nuclear Innovation Bootcamp offers an opportunity for current students and professionals to come together for two weeks during the summer to think about the challenges of innovating the nuclear energy sector. Hosted at Berkeley, the bootcamp curriculum is developed in collaboration with other university and industry partners. Discussions and projects focus on nuclear innovation startups, and teams develop and pitch ideas at the end of the two-week program.

WEB EXTRA > nuclearbootcamp.berkeley.edu

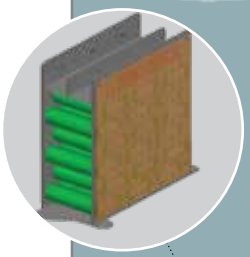
CALSOL TEAM

Solar cruiser

After winning the Formula Sun Grand Prix last summer, CalSol, the university's solar vehicle team, has decided it's time for a fresh ride. Their new car, called Tachyon, is a departure from previous versions. Instead of a single passenger, challenger-class car, of which the team has made eight versions since the mid-1990s, Tachyon will compete in the cruiser class and be able to hold four passengers. "One of our core values as an organization is member enrichment," said engineering physics major and CalSol member **Andre He.** "And this is a big challenge and learning opportunity. We are doing a lot of things that we haven't done before." Besides entirely redesigning the body — the structural chassis will be a composite monocoque, replacing the previous aluminum frames — the team has also invested significant time designing and building all of the control systems. In order to get Tachyon ready for next year's big races across the globe, including the World Solar Challenge, the team has been collaborating with industry partners, such as Ford and GM, as well as other university-based solar vehicle teams.



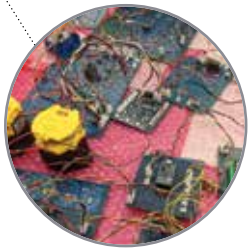
PAYLOAD
Like previous versions, the new car will be judged on speed and distance during competitions. But this car will also be evaluated on people-miles traveled, which is why the four-seater design helps.



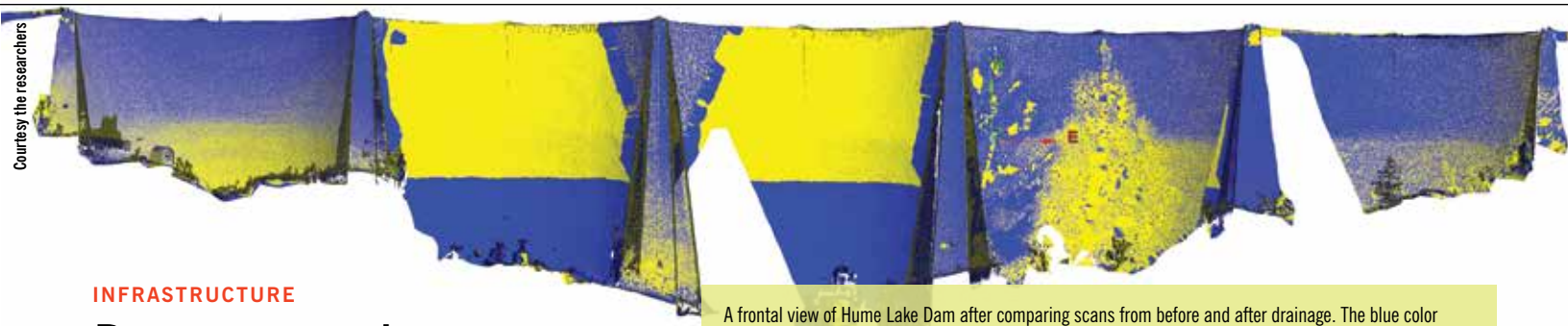
POWER
The new car is powered by a battery pack that is three times larger than its predecessor; it's charged by a solar array that is integrated into the body and can be adjusted to track the sun.

All images courtesy CalSol

BODY WORK
Made from carbon fiber overlaid on an aluminum honeycomb core to help with aerodynamics and save on weight, the shell of the car is also its structural frame.



CONTROL
Under the hood, the team has rebuilt all of the vehicle's electronics and control systems.



Courtesy the researchers

A frontal view of Hume Lake Dam after comparing scans from before and after drainage. The blue color shows where the dam moved toward the reservoir, and the yellow color shows where it moved downstream.

INFRASTRUCTURE

Dam scanning

The Hume Lake Dam, which sits in the Sierra Nevada about 50 miles east of Fresno, was built in 1908 as the world's first multiple-arch reinforced concrete dam. It's one of 1,400 aging dams in California. With last year's failure of the overrun spillway at the much larger (and more recently constructed) Oroville Dam, interest in assessing the state's aging infrastructure has taken on a renewed urgency.

To accurately evaluate the health of the Hume Lake Dam, civil and environmental engineering (CEE) professor **Robert Kayen** has been gathering data about the structure with the assistance of CEE undergraduate students **Tamika Bassman** and **Katherine Cheng.**

"We used a terrestrial laser system called lidar [light detection and ranging] to scan the surface of the dam. The first thing we learned was that the dam is in very good shape," Kayen said. "It was much stiffer in the response to water pressure against the face of the dam than expected."

"The other thing we learned," he continued, "which was a big surprise, was that when the dam reservoir was full, we expected the pressure to push the dam downstream, to cause a rotation downstream. In fact, what happened was that the dam tilted slightly upstream between one and four millimeters, which led us to go hunt for the error."

Bassman and Cheng were tasked with investigating the unexpected result. The team decided to use the Berkeley campus landscape to test measuring techniques and figure out the most accurate way to manage their data from the Hume Lake site.

To get scans of the campus, Bassman and Cheng loaded a cart with roughly 100 pounds of laser equipment and made their way to the top of campus buildings (including the Campanile) to capture the university's various views and angles. In all, they made 25 individual scans of campus, collecting millions of data points that they stitched with software into a 3-D model. Collection of the campus data helped the team devise a registration system using white circular reflectors, like the kind used on traffic signs. "We tested just picking points to take measurements, or measuring from reflector to reflector," Cheng said. "We found that reflectors had a lower error."

"We realized that we could get the best measurements from reflector-to-reflector distances between the control and the actual dam," Kayen said. "We learned that here on campus, not up there."

FINTECH

Blockchain comes to campus

Even to the most casual observer, the past year has been filled with all kinds of news about cryptocurrencies and blockchain. From dramatic market booms and busts, to regulatory rumors and Congressional hearings, blockchain has become all the rage.

Blockchain is also becoming popular on campus. The student group Blockchain at Berkeley, which started as a bitcoin interest group in 2014, has grown into a movement of sorts. Students interested in engineering, business and technology law are working on consulting projects; the group counts corporations like Airbus, Qualcomm and BMW as clients. And they are building startups, including the decentralized social media platform Sapien, which raised $12 million in funding in two hours through an initial coin offering.

Many of Blockchain at Berkeley's 300 participants are focused on educating other students. The club has also organized high-level conferences and hosts a popular meet-up that is open to the larger community. "Students have the potential to change the trajectory of this industry," said **Anthony DiPrinzio,** a political economy major and head of consulting and business development for Blockchain at Berkeley. "We are actually making a tangible mark on this space."

Anthony Mercado

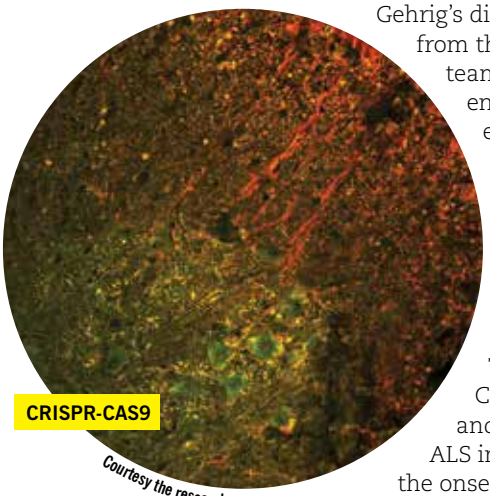
Blockchain at Berkeley hosted the university's first women in blockchain conference, she(256), in April. One of the main goals of the day-long event was to highlight the leading work of women in the blockchain space. **Dawn Song,** professor of electrical engineering and computer sciences, was one of the conference's featured speakers on blockchain research.

HEALTH

Curing diseases with CRISPR

Most strategies for treating genetic diseases focus on managing signs and symptoms, not on altering the gene itself. But recently, Berkeley Engineering researchers have successfully used CRISPR-Cas9 technology — a gene editing tool developed by Jennifer Doudna, professor of molecular and cell biology and of chemistry at Berkeley, and Emmanuelle Charpentier — to advance innovative cures for several formidable diseases:

AMYOTROPHIC LATERAL SCLEROSIS (ALS)

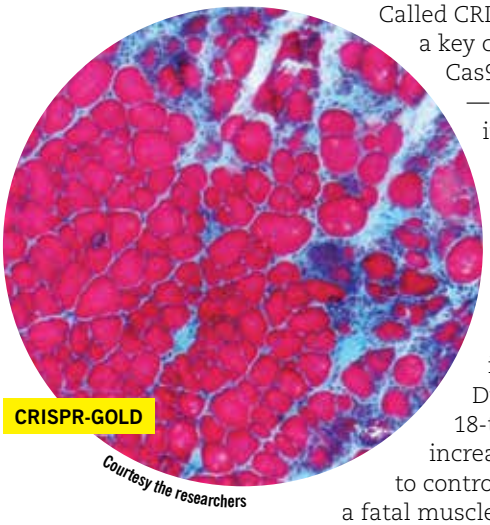


CRISPR-CAS9

Courtesy the researchers

In the United States each year, about 6,000 people are diagnosed with amyotrophic lateral sclerosis (ALS) — also called Lou Gehrig's disease — with a life expectancy of 2–5 years from the time of diagnosis. But research from a team led by **David Schaffer,** professor of bioengineering and chemical and biomolecular engineering, may lead to new therapies and an eventual cure for the disease. Using CRISPR-Cas9 gene editing, the scientists disabled a defective gene that causes ALS in mice, significantly increasing their lifespan. The team used a benign virus to ferry a gene encoding the Cas9 protein into motor neurons in the spinal cord. There, the gene was translated into the Cas9 protein, a molecular scissors that cut and disabled the mutant gene responsible for ALS in the mice. Not only did the therapy delay the onset of the disease, it also extended the lifespan of the mice by 25 percent.

DUCHENNE MUSCULAR DYSTROPHY



CRISPR-GOLD

Courtesy the researchers

Researchers from the laboratories of Berkeley bioengineering professors **Niren Murthy** and **Irina Conboy** have developed a new way to deliver CRISPR-Cas9 gene-editing technology inside cells. Called CRISPR-Gold because gold nanoparticles are a key component, their technique can deliver Cas9 — the protein that binds and cuts DNA — along with guide RNA and donor DNA into the cells of a living organism to fix a gene mutation. Viruses are commonly used to deliver CRISPR-Cas9 into cells, but that approach can have complications; CRISPR-Gold does not need viruses and repairs DNA mutations through a process called homology-directed repair. In their study, the researchers showed that a single injection of CRISPR-Gold into mice with Duchenne muscular dystrophy led to an 18-times-higher correction rate and a two-fold increase in a strength and agility test compared to control groups. Duchenne muscular dystrophy, a fatal muscle-wasting disease, affects 1 in 3,500 boys, with 20,000 new cases diagnosed each year worldwide.

DEEP LEARNING

Robot's play

To learn about their world, children play with toys, moving and manipulating objects without any sort of training. Now, researchers led by **Sergey Levine,** assistant professor of electrical engineering and computer sciences and member of the Berkeley Artificial Intelligence Research Lab, have developed technology that enables robots to do the same: manipulate objects they have never encountered before by building on previous play and observations. Using this technology, called visual foresight, the robots can predict what their cameras will see if they perform a particular sequence of movements. Although these predictions extend only several seconds into the future, they are enough to allow the robot to move objects around on a table without disturbing obstacles. Crucially, the robot can perform these tasks without any help from humans or prior knowledge about physics, its environment or the objects. Through this, the robot builds a predictive model of the world, which it uses when it encounters new objects. In the future, this technology could produce more intelligent robotic assistants in homes and help self-driving cars anticipate events on the road.

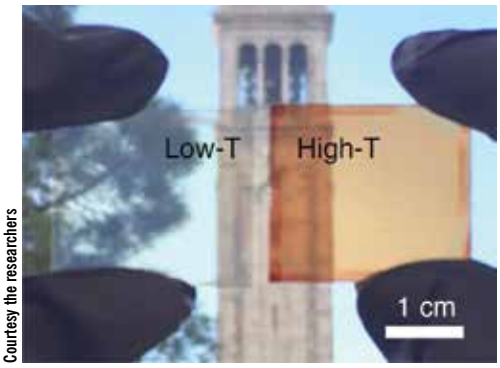
SEMICONDUCTORS

"Invisible" displays

New research from the lab of **Ali Javey,** professor of electrical engineering and computer sciences, may lead to the development of "invisible" or vanishing displays — or even futuristic applications such as light-emitting tattoos. The researchers created a proof-of-concept device, using a monolayer semiconductor just three atoms thick, which is bright when turned on but becomes fully transparent when turned off. The advance builds on previous research from the lab published in 2015, which explained how monolayer semiconductors could produce bright light. Their latest work overcomes what had been major obstacles in utilizing LED technology on monolayer semiconductors, and allows researchers to keep the thickness small but the width and length large, creating a high intensity of light. The team will now be working to improve the efficiency of the technology.

ENERGY

Solar power windows

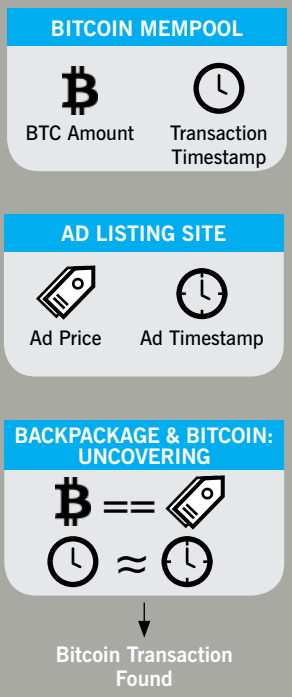


Courtesy the researchers

Imagine windows that could automatically tint darker on a sunny day to block heat while also generating electricity. An invention from a research team led by **Peidong Yang,** a professor with appointments in materials science and engineering and chemistry, could lead to this type of power-producing smart window for buildings, cars and display screens. The scientists altered the chemical structure of perovskite, a versatile material that already rivals silicon-based solar cells, so that the material turns from transparent to opaque when heated and also converts sunlight into electricity. While the sunlight conversion efficiency of the material — an inorganic halide perovskite with added cesium, lead, iodine and bromine — is still low, and the transition from transparent window to opaque solar cell requires heating the window to the boiling point of water, Yang and his group are already at work on versions that work at lower temperatures and with higher conversion efficiency.

CRIMINOLOGY

Fighting human trafficking



Human traffickers commonly post online ads selling sex, but they are often difficult for law enforcement to trace. Now, Berkeley computer science Ph.D. candidate **Rebecca Portnoff,** working with researchers from UC San Diego and New York University, has developed the first automated techniques to link ads to bitcoin, the leading payment method for online sex ads, and potentially identify those ads tied to human trafficking rings. The research team's approach used two novel algorithms. The first is a machine-learning algorithm that identifies separate ads for different sex workers that share a single author, a potential sign of a trafficking ring. The second algorithm takes publicly available information from bitcoin and compares payment timestamps with timestamps of the ads' appearance. The researchers tested these techniques on a sampling of 10,000 real sex ads and reported an 89 percent true-positive rate for grouping ads by author — significantly more accurate than current algorithms — as well as a high rate of linking ads to bitcoin transactions. The researchers plan to work with law enforcement and nonprofit organizations to further refine their analysis.

ADAPTED FROM ARTICLES BY BRETT ISRAEL AND ROBERT SANDERS, UC BERKELEY OFFICE OF PUBLIC AFFAIRS

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Universities and Transformation

BY S. SHANKAR SASTRY

Our smartphones have apps that help us navigate traffic, find public transportation or book rides in cabs. The "sharing" economy is enabling us to change how we find hotel rooms when we travel, and how we get loans or fund new businesses. These are just a few examples of how our daily lives have undergone a digital transformation that is bringing us a dizzying array of new choices as well as launching new business models.

Transportation and travel are just two of many sectors that are going through this radical transformation. For example, in healthcare, personal medical records and genomic data are already digital. Now, with the monitoring of people by wearable and implanted devices that remotely monitor pulse, blood chemistry, hormone levels, blood pressure, temperature, EMG and even EEG, we can provide levels of personalized medicine that were unimaginable even a few years ago.

Another example is in retail, where Amazon is digitally transforming how we shop. Enel, the world's largest electric power utility, is using the Internet of Things (IoT), predictive maintenance and fraud detection to drive new levels of reliability, cost efficiency and clean energy in Europe. Oil and gas operators are using predictive maintenance to monitor production assets and predict and prevent device failures from submersible oil pumps on offshore oil rigs. Manufacturers like Caterpillar are using IoT systems to lower inventory, production and delivery costs. Driving these changes is the confluence of the following technology trends: IoT, machine learning and artificial intelligence (AI), and cloud computing.

Driven by the dynamics of Moore's Law, a thriving multi-trillion information technology industry has created an Information Age that was foretold in 1973 by Harvard sociologist Daniel Bell. In the next 10 years, according to industry estimates, value chains will be sensorized: more than 70 billion sensors will have been installed across all sectors to provide unprecedented volumes of data that can be inexpensively stored and

The Digital of Society

We're in a whole new space. Industry is moving quickly – sometimes too quickly – and the government is left trying to catch up with policy and regulations.

This is why universities need to step in. We have expertise in the implications for the fast-moving changes taking place, and we can inform policy as the technology rolls out.

processed, enabling the utilization of computer-intensive machine-learning algorithms. AI is rapidly growing, and even though it is still in its relative infancy, it is poised to make major new advances.

The trifecta of IoT, AI and cloud computing offers a vision of digital transformation that is literally changing business models, services and how we live.

How Universities Can Help

While the term digital transformation is a concept that is increasingly appearing on corporate board agendas, it is our responsibility in academia to ensure that we continue to grow the seed corn for continued innovation in AI, IoT and computing. Indeed, in addition to cloud computing, we will need to provide new solutions for high-performance computing at the edges to allow the kind of massive computations that are needed to power the analytics that are at the heart of this transformation.

Never has there been a greater need for user-inspired basic research. In addition, there are important public good and social justice issues that need to be addressed: privacy, pricing, societal, legal and economic issues are at the forefront. For instance, it is important that pricing of new services not be regressive, or that other derived information not result in the inadvertent disclosure of private information.

On the public policy front, as Joan Walker, professor of civil and environmental engineering, says, we need to move away from an era where infrastructure policy was set by state and local governments exclusively. We are entering an era where intelligent information infrastructure is a shared public-private partnership.

At the same time, we will need to address the job churn being created by this transformation. For example, Uber and Lyft have created an entirely new mode of transportation using IoT and the cloud. These companies have disrupted traditional taxi and limo industries. Their impact has been felt as several traditional cab

companies have declared bankruptcy, resulting in a glut of city-issued taxi medallions. This scenario is being played out in multiple job sectors.

It is our mission in the university to take the lead in providing lifelong learning solutions and refreshers to enable our workforce to both keep current and also seek new opportunities. Our menu of professional masters courses and short courses, like the Engineering Leadership Professional Program, need to be expanded to address these needs.

Then, of course, there are legal issues associated with the regulation of robotic systems working in close proximity with humans. A few years ago, we relegated robots exclusively to jobs that were considered dull, dirty and dangerous. However, this is no longer the case, as we see in factory automation, drone delivery systems or self-driving cars. The questions of how we endow self-driving cars with the ability to make decisions are certainly upon us with the investigations of recent accidents involving driverless cars.

Can AI be made safer? Claire Tomlin, professor of electrical engineering and computer sciences, has begun the study of verifiable and safe AI to provide guarantees of how well humans and robots can work together based on developing human cognitive models. On the policy front, Tomlin is working with the Federal Aviation Administration, NASA and other certification authorities to designate airways in the sky to enable commercial drone operations.

"We're in a whole new space," says Walker. "Industry is moving quickly — sometimes too quickly — and the government is left trying to catch up with policy and regulations. This is why universities need to step in. We have expertise in the implications for the fast-moving changes taking place, and we can inform policy as the technology rolls out."

The Berkeley DNA

There are many reasons why Berkeley is well-poised as a leader in this regard. Not only is this campus at the forefront of research in IoT, AI and societal scale systems, it hosts world-class departments in economics, business, public policy, neuroscience, cognitive science and more. Berkeley's thriving interdisciplinary ecosystem is a key to the success of this public university.

Faculty from economics and the Haas School of Business have been working hand in hand with technologists at the very forefront of the theory of mechanism design to offer new services that will benefit the public at large, not just a select few.

In another example, in the Health@Home initiative, industrial engineers and bioengineers are partnering with campus colleagues from economics, business, public health and policy to build a sustainable model of healthcare infrastructure. The goal is to reduce hospital visits with new tools for monitoring, screening and care to be used at home (or work, or school), but to do so without jeopardizing the sensitive personal data collected and stored in this system.

Never has there been a greater need for user-inspired basic research... there are important public good and social justice issues that need to be addressed.

The goal is to invent the future in a way that supports the healthy development of our societies and economies in an age of intelligent tools.

We house one of the world's most comprehensive research groups in AI and machine learning, and they are brought together in the Berkeley Artificial Intelligence Research Lab where researchers tackle issues of privacy, cybersecurity and resilience alongside the development of new deep learning algorithms that allow robots to master skills via trial and error.

Earlier this year, the National Science Foundation granted $10 million to Berkeley for the Real-Time Intelligent Secure Explainable Lab, or RISELab, to build AI decision systems to address the challenges inherent when artificial intelligence plays an increasingly central role in healthcare, transportation, business and other aspects of our lives.

There is no doubt that new automation needs to work closely with humans, and it needs to have models of human cognition and decision-making built in and that work collaboratively. As Tomlin says, "Not only will we need to have robots working with humans, but we will also need to embed humans in the midst of automation with provably correct outcomes."

"The real question is not whether this will transform our society and culture, but how it will do so," adds Ken Goldberg, professor and chair of industrial engineering and operations research. "And what are the human consequences in these rapid changes?"

Those are the types of hard questions being addressed through an initiative led by Goldberg called the People and Robots Initiative at CITRIS, the Center for Information Technology Research in the Interest of Society, as well as a new interdisciplinary group, Work and Intelligent Tools and Systems, or WITS.

The goal of these groups is to invent the future in a way that supports the healthy development of our societies and economies in an age of intelligent tools. The organizers include researchers from engineering, data science, economics, sociology and political science.

The benefits of digital transformation are breathtaking: A 2015 McKinsey Global Institute report estimates that the value that industries and governments will create from IoT Digital Transformation will range from $3 trillion to $11 trillion per year in 2025.

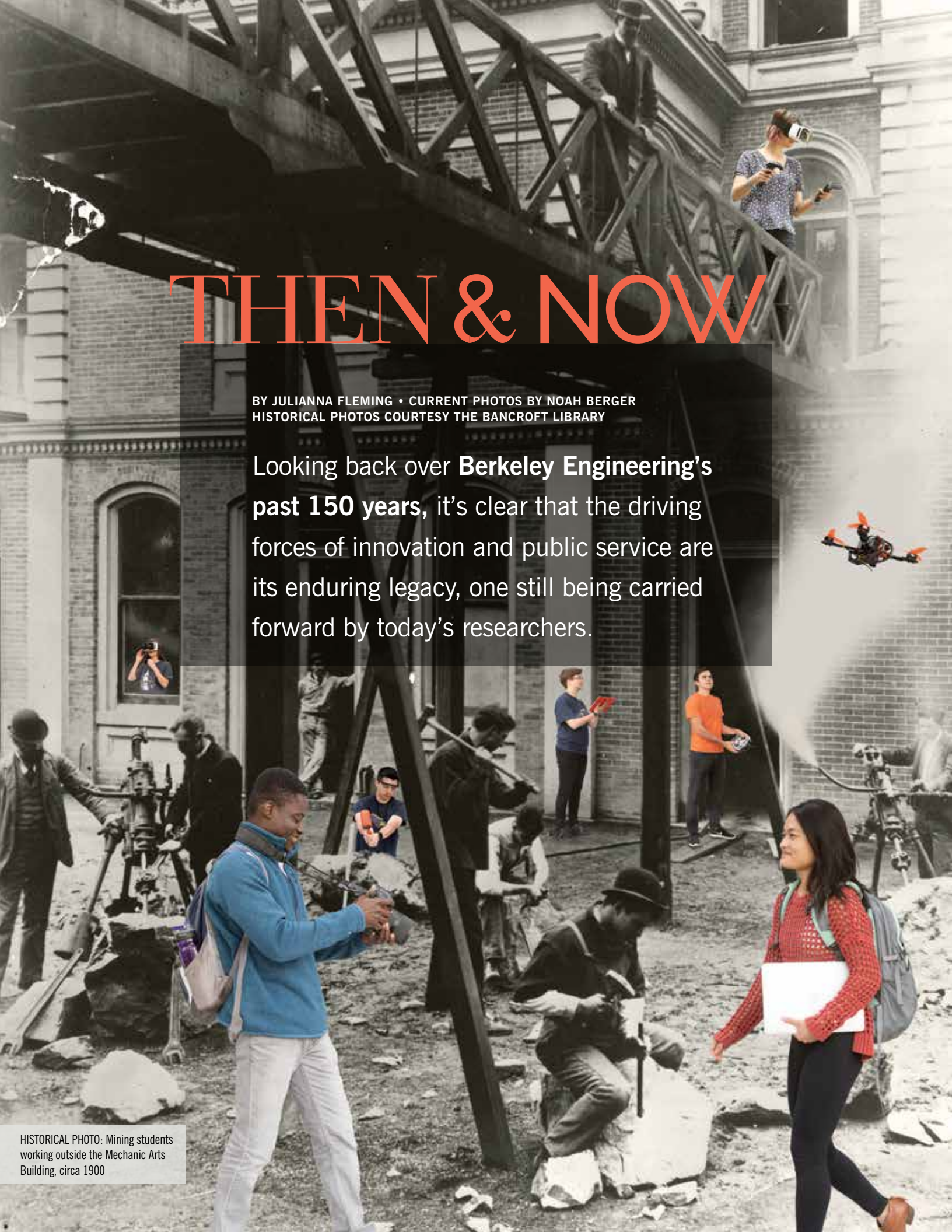
Our challenge going forward is to meld these new technologies with economic, business, legal, behavioral and many other tools and advances to design a society we will be glad to live in, even in the face of dramatic changes in how we work and live. This indeed will be our mantra going forward in Inventing the Future. BE

S. Shankar Sastry is the dean of the College of Engineering, Roy W. Carlson professor of engineering and director of the Blum Center for Developing Economies.

THEN & NOW

BY JULIANNA FLEMING • CURRENT PHOTOS BY NOAH BERGER
HISTORICAL PHOTOS COURTESY THE BANCROFT LIBRARY

Looking back over **Berkeley Engineering's past 150 years,** it's clear that the driving forces of innovation and public service are its enduring legacy, one still being carried forward by today's researchers.



HISTORICAL PHOTO: Mining students working outside the Mechanic Arts Building, circa 1900

CONSTRUCTION

Many of today's high-rise buildings, long-span bridges and dams were strongly influenced by Berkeley-generated research on concrete, the most widely-used construction material in the world. These advances were made possible by the vision of civil engineering professor and concrete researcher **Raymond Davis,** who in the 1920s grew the Engineering Materials Laboratory into the preeminent facility for construction research. Perhaps the most legendary researcher from the lab was **T.Y. Lin,** professor of civil engineering from 1946–76, who perfected the use of prestressed concrete, profoundly changing the history of building construction. He greatly simplified the design process for using the material, which quickly became integrated into structural engineering projects worldwide.

Fast forward to the 21st century, where civil and environmental engineering professor **Claudia Ostertag** is researching ways to make concrete more durable and sustainable. She has developed concrete composites than can mitigate damage in concrete structures, controlling cracking from the micro to the macroscale. Under testing, concrete structures that utilize these composites have shown exceptional resistance to cracking, outperforming conventional concrete structures.

BIOMECHANICS

After World War II, there was a major push by injured veterans for upgraded prosthetics. It was during this time that mechanical engineering professor **Charles "Chuck" Radcliffe** — who interrupted his own studies at Berkeley to serve in the U.S. Navy during the war — began his legendary research in prosthetic biomechanics and limb design. Working out of the Biomechanics Laboratory, originally established by civil engineering professor **Howard Eberhart,** a fellow pioneer in the research and development of artificial limbs, Radcliffe designed components that dramatically improved the performance, comfort, stability and control of lower-limb prosthetics. His research on gait cycle biomechanics remains relevant to today's designers.

Berkeley researchers continue to develop advanced prosthetics and exoskeletal devices, but now the study of biomechanics also happens at the cellular and molecular level. Called mechanobiology, this cutting-edge science investigates how cell shape, structure and environment affect the body, including the development of diseases. For over a decade, bioengineering professor **Sanjay Kumar** has looked at the mechanobiological regulation of cells in the brain, including cancer cells in glioblastoma, the most common and aggressive form of brain cancer. Having identified mechanical and other biophysical signals that influence the growth and motility of cancer cells, he is developing technologies to manipulate these signaling systems, making this a promising research area for future therapies.

HISTORICAL PHOTO: McLaughlin Hall and the Mechanical and Electrical Engineering Building, date unknown

MATERIALS

When Hearst Memorial Mining Building opened in 1907, mining was critical to the young state of California. With its smelters, rock crushers, drilling rigs and fume hoods, the building showcased turn-of-the-20th-century mining technology. Eventually, mining made way for materials testing and research. This drew researchers such as **Earl Parker,** professor of metallurgy, who came to Berkeley in 1944 to determine why the steel in Liberty Ships — built to carry supplies during World War II — was cracking. He became a major contributor to research on defects and dislocations, paving the way for the development of new steel alloys and other materials with exceptional strength and resistance to fractures.

Now, materials science professors **Kristin Persson** and **Gerbrand Ceder** are creating materials, atom by atom, through a technique called high-throughput computational materials design. In 2011, Persson launched the Materials Project, creating an open-access database for computed materials. Today, the project catalogs the basic properties of nearly 70,000 inorganic compounds, as well as the properties of hundreds of thousands of other materials and millions of associated computed properties. Materials research has historically been a long and costly process, but through the Materials Project, scientists can quickly identify the most promising combinations to develop the materials of tomorrow.

ELECTRICITY

When **Clarence Cory** became the university's first professor of mining and electrical engineering in 1892, the electric light and power industry was barely a decade old. After first working to supply light and power for the entire campus, Cory developed technology to support California's growing need for electricity, which was largely dependent on remote hydroelectric plants located in the Sierra Nevada. Recognizing the value of electricity to industry as well as the public, he pursued research that substantially improved the efficiency and range of long-distance power transmission lines that brought electricity to coastal cities.

The focus of modern energy research has shifted to renewable energy systems, in order to reduce carbon emissions. But before utilities can rely on renewables on a broad scale, energy storage issues must be solved to cope with the intermittent nature of these power sources. Now, electrical engineering and computer sciences professor **Seth Sanders** has created the technology behind the world's first utility-scale, multi-hour flywheel energy storage device. With this advancement, solar panels and wind farms can become dependable resources for large-sized energy grids.

WATER

California's population was a mere 1.8 million residents in 1905, when **Charles Gilman Hyde** joined Berkeley's civil engineering faculty. But he had the foresight to create environmental engineering practices that supported health and ecology, even as the state's population soared. Known as the "Dean of Sanitary Engineering of the West," Hyde developed Berkeley's world-renowned sanitary engineering program with the assistance of civil engineering professor **Wilfred Langelier,** a noted chemist. Hyde worked with Langelier to pioneer science-based water treatment technologies — which were integrated into the curriculum as well as adopted by water treatment plants worldwide — and was a major contributor to many of the state's high-profile water projects.

Today, as California's population approaches 40 million, civil and environmental engineering professor **David Sedlak** is advancing water treatment technologies that are cost-effective and sustainable. The co-director of the Berkeley Water Center, Sedlak is pursuing several approaches for creating water infrastructure for the next century, including designing open water wetlands. These manmade, lined pools of shallow water act as natural filters, using sunlight to break down chemicals and contaminants, and have proven more effective than other types of constructed wetlands at decontaminating water. With climate change and an increasingly crowded planet, this could be one of the pivotal technologies for ensuring a safe water supply in the future.

Out of the GAIT

A new undergraduate fellowship focuses on impact by building digital health technology

BY DANIEL MCGLYNN
PHOTOS BY GOLNAZ SHAHMIRZADI

Mechanical engineering student Tanisha Randhawa holding a prototype of an insole that can measure key gait indicators.

Tanisha Randhawa is a fourth-year mechanical engineering student, and right now she has a storyboard outlining a mobile phone app laid out in front of her. Two members of the university community, both in their seventies, sit across the table from her at the downtown Berkeley offices of the university's Osher Lifelong Learning Institute, OLLI@Berkeley (OLLI).

Randhawa is the technical lead on a project called GAIT, a collaboration between OLLI and the Fung Fellowship. She's collecting feedback about a planned hardware and mobile phone app prototype that will track metrics like stride velocity and stride length — key data points for assessing gait, which is a major indicator of mobility.

She's hoping to get some guidance, asking questions like, "If we are talking about speed, would you prefer miles per hour, or steps per hour?"

This small focus group is one of a handful that Randhawa and her GAIT teammates will be holding over the course of the semester to glean valuable insight about what would make the app useful to the target demographic — aging adults. The OLLI focus group participants steer Randhawa away from calling anything "lifetime data." They are also opposed to any kind of alert that might be construed as medical advice. "At my age, I don't need anything telling me what to do," says one of the interviewees. They are not much for bells and whistles, alerts or badges; instead, they just want the information displayed in a clear way.

Randhawa is taking notes, modifying the storyboards, which she will use to report back to her team: Anna Bloom (molecular and cell biology major), Lydia Chen (nutrition) and Michelle Sou (public health), who are also conducting interviews and helping to create GAIT's technology.

"I liked the idea that we would be working in groups," says Randhawa, "and with classmates who are not engineers. I'm with engineers all day, and I feel like engineers have a certain way of thinking. We love technology and innovation, but you get a different perspective when we are working with people from different majors."

The Fung Fellowship's cross-disciplinary nature is well suited to that broader view, Randhawa says. "I thought this was perfect because in mechanical engineering you can take some classes that are in biotechnology implant design or prosthetic design, but not necessarily public health, where you can think about the bigger picture."

As the semester unfolds, other Fung Fellow teams are also working along the fringes of health and wellness and digital technology. Some fellows are using virtual reality in the classroom to get kids more physical activity during the school day. One group is trying to figure out how to use blockchain to protect, manage and maybe monetize personal health data, while another is using augmented reality to relieve anxiety in pediatric cancer patients. There are projects, like GAIT, that are undertaken with outside organizations or companies, while others are self-directed groups looking to answer questions or further explore concepts that have come up during the two-year fellowship.

The Fung Fellowship for Wellness and Technology Innovations, which began in late 2016 with its first group of 45 undergraduates, is supported by Coleman Fung (B.S.'87 IEOR), the entrepreneur and founder of Blue Goji, a wellness technology company focused on the gamification of fitness (using immersive gaming and virtual reality technology). The program is run collaboratively between the College of Engineering and the School of Public Health. Operationally, the fellowship is headquartered at the Fung Institute for Engineering Leadership.

Jaspal Sandhu (Ph.D.'08 ME) is the program's faculty director. He uses his vantage at the intersection of engineering, public health and human-centered design — he is a founder and managing partner at an Oakland-based design agency called Gobee, and he has been teaching a design course at the School of Public Health since 2011 — to develop curriculum and lead instruction for the fellowship.

Earlier, during an info session for prospective fellows, he said: "This is a team-based experience. We have no shortage of smart people, but we are not just looking for smart people. We are looking for people with a purpose. We want people who are at their core trying to change the world and their professions. Everything else can be taught."

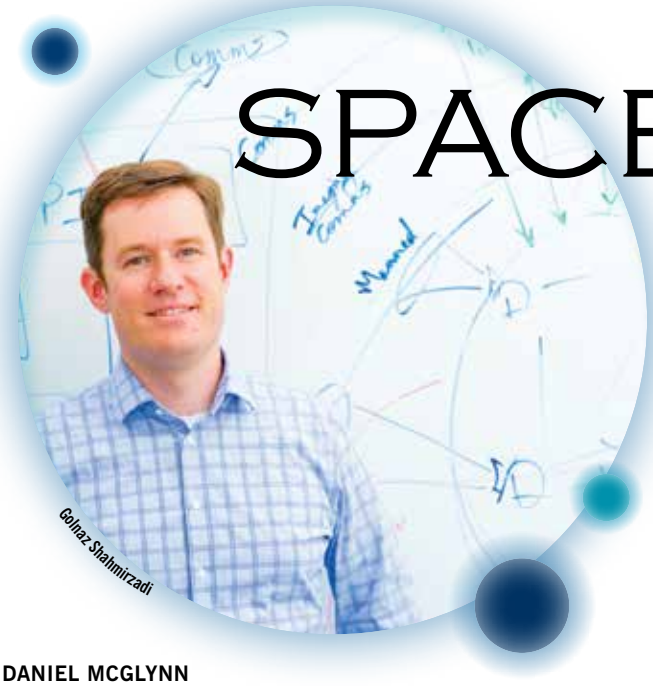
Last spring, before Randhawa and her team started working on GAIT, a handful of companies and organizations pitched ideas to the Fung Fellows. Their goal was to get students to sign on for a year to develop a technology solution to a health problem that they identified.

OLLI Director Susan Hoffman conceived the project based on insight gleaned from research presented at a global conference on aging. She was also inspired after noticing gait changes in a family member. "Falls in older adults are a public health issue, and gait dysfunction is a contributing factor" explains OLLI research associate Cheryl Brewster. "Research also shows that problems with gait are a bellwether for cognitive issues."

With Brewster's mentorship and the support of the Fung Fellowship's staff, Randhawa and her teammates developed a system to monitor gait. After receiving feedback from interviews, the team created five prototype devices that could be embedded with sensors. "The sensors record different aspects of data like stride length, stride velocity and stance width," says Randhawa. It's going to be coupled with a mobile application that will show you your stats.

In the future, the GAIT team hopes to have a prototype of their device and app built and tested by OLLI participants. While anyone with an aging loved one can understand the market demand for a product like the one Randhawa and her team are building, they are not out to commercialize their work or spin out a company. Instead, they are building something that tracks gait in aging people because they want to learn more about the interplay between technology and health. Or, as Randhawa said, it's always been about the bigger picture. BE

SPACE MAPPING


Golnaz Shahmirzadi

BY DANIEL MCGLYNN

As soon as Sputnik launched in 1957, the challenges facing a young spacefaring civilization started to show. Not everything that was shot into orbit came back down. At first it was a rocket body or two. By now, decades of missions and more than 6,000 satellite deployments later, there are hundreds of thousands of space debris fragments circling the Earth on orbital currents.

The ever-growing debris field is raising concerns about the viability of future space missions. Since the debris is moving at such high speeds, flying fragments contain grenade-like energy.

Space debris could even become a self-perpetuating problem: A major collision could destroy a satellite, spawning more debris, and thus more collisions, until the resulting debris cloud wipes out an entire satellite constellation, or a manned space station, or anything else in low Earth orbit. And it's not just astronauts or satellite operators that are at risk. Earth-dwellers are becoming increasingly reliant upon space-based communications for everything from space-based Wi-Fi to precision warfare targeting.

In 2009, the corpse of a Russian Cosmos satellite collided with a still active Iridium communications satellite. Both were destroyed, resulting in a plume of new fragments — including, according to the Congressional Research Service, 2,100 pieces that are larger than 10 centimeters.

That 10-centimeter size is significant because debris that large — about the diameter of a softball — can be tracked using existing technology. Anything smaller, which potentially includes hundreds of thousands of fragments, is basically invisible to today's tracking infrastructure, which is controlled by the Department of Defense.

That's where LeoLabs, a new Menlo Park-based company, comes in.

"In low Earth orbit, things can be moving at 17,000 miles an hour, so you need a ground-based service to monitor where everything is and then predict ahead," says LeoLabs co-founder Dan Ceperley (M.S.'05, Ph.D.'08 EECS). "The cool thing, from a technology standpoint, is that you are predicting ahead about 100 revolutions, so you have to have a lot of really good data to make those predictions and then constantly refine them."

Instead of the stereotypical big dish radar, the LeoLabs version is a fixed trough with no moving parts. It looks somewhat like a metal-clad half pipe. Called a phase array, the radar is designed to listen for radio waves using 100 specially tuned antennas.

The radar technology is based on an earlier design that fellow LeoLabs co-founders Michael Nicolls and John Buonocore built for the National Science Foundation in Alaska. The initial radar was designed to study the ionosphere (part of the upper atmosphere where significant solar radiation interactions take place).

And then came the bycatch, and the idea for LeoLabs. "When they turned it on, they were getting all of this ionosphere data — it was the first radar of its kind — but they were also getting satellite data," Ceperley says.

With a few measurements and some computation, the LeoLabs team can map paths and figure out if dangerous chunks of space debris are on a collision course with satellites or other spacecraft. Satellite operators can then purchase access to the data, giving them the ability to make adjustments to flight paths based on the hazards identified in the calculations from LeoLabs.

In addition to full coverage of low Earth orbit, this year LeoLabs is working toward increasing the resolution of their radar in hopes of capturing finer-grained space debris. "We are building toward a next generation of radar that will track things down to two centimeters in size," Ceperley says. "So suddenly the number of objects we are tracking goes from 13,000 to 250,000."


A new phase array radar installation that LeoLabs built at the Midland Spaceport in Midland, Texas.

courtesy LeoLabs

Professors **Pieter Abbeel** and **Michael Jordan,** experts in machine learning, have been appointed as joint faculty in industrial engineering and operations research in addition to their appointments in electrical engineering and computer sciences.

Rebecca Abergel has joined the Department of Nuclear Engineering as an assistant professor. She is a world-renowned scientist in actinide chemistry as well as the expanding research field of actinide biology.

Electrical engineering and computer sciences professors **Ana Arias, Chunlei Liu** and **Michael Lustig** are part of a research team developing a functional magnetic resonance imaging (fMRI) scanner that will provide the highest resolution images of the brain ever obtained. Using a new $13.43 million BRAIN Initiative grant from the National Institutes of Health, they plan to build the NexGen 7T by 2019.

Mark Asta, professor of materials science and engineering, became the new Materials Sciences Division Director at Lawrence Berkeley National Laboratory. He stepped down as chair of the materials science and engineering department in order to begin the new position.

Ruzena Bajcsy, professor of electrical engineering and computer sciences, has won a John Scott Award, bestowed since 1834 by the city of Philadelphia on those who have improved "the comfort, welfare and happiness of mankind." She was honored for her contributions to robotics and engineering science.

Undergraduate students **Ash Bhat** of interdisciplinary studies and **Rohan Phadte** of electrical engineering and computer sciences have launched a Google Chrome browser extension that can help spot fake Twitter accounts. Botcheck.me uses advanced machine learning to detect and tag posts from political propaganda bots.

Gabrielle Boisramé (M.S.'12, Ph.D.'16 CEE) published "A Tale of Two Fires: How Wildfires Can Both Help and Harm our Water Supply" on the California WaterBlog in December.

Matthew Brueckmann (B.S.'15 ME) returned to campus last summer to share his engineering expertise with PREP students and give them a guided tour of California's Great America amusement park in Santa Clara. He works for The Nassal Company, which specializes in themed environment design for rides or attractions at amusement parks, zoos and museums.

Anca Dragan, assistant professor of electrical engineering and computer sciences, landed a spot on the *MIT Tech Review's* "35 Innovators Under 35" list for her work in distilling complicated or vague human behavior into simple mathematical models that robots can understand.

Max Fratoni (M.S.'07, Ph.D.'08 NE), professor of nuclear engineering, was awarded the American Nuclear Society's Early Career Reactor Physicist Award.

Robert Full, professor of electrical engineering and computer sciences and of integrative biology, was awarded a Howard Hughes Medical Institute Professorship, which comes with a $1 million grant to develop innovative classes. He plans to teach students how to design products for humans based on biological innovations made by plants and animals.

Allen Goldstein, professor of civil and environmental engineering and of environmental science, has been awarded a prestigious research grant from the Humboldt Foundation, which promotes collaborative research with German scientists.

Shafi Goldwasser (M.S.'81, Ph.D.'84 CS), a Turing Award-winning computer scientist, became the new director of the Simons Institute for the Theory of Computing, replacing founding director **Richard Karp.** An expert in cryptography and complexity theory, she also joined the electrical engineering and computer sciences faculty.

Michael Hemati (M.T.M.'14 BioE), senior R&D engineer at Theranova, has been named one of Medtech's Rising Stars of 2017. He currently leads medical device startup Handl Medical and was one of the founders of SmartDerm, a startup founded to commercialize an M.T.M. project.

Bioengineering professor **Amy Herr** and electrical engineering and computer sciences professor **Scott Shenker** were among the inaugural winners of the Berkeley Visionary Awards, an honor created by the Berkeley Chamber of Commerce to recognize innovative leaders in the city whose work is creating an economic impact.

Randy Katz (M.S.'78, Ph.D.'80 EECS), electrical engineering and computer sciences professor, has been appointed vice chancellor for research at Berkeley. Last year, he was inducted into the Silicon Valley Engineering Hall of Fame for his groundbreaking research, national service and "exemplary mentorship and teaching."

New National Academy of Engineering member

The National Academy of Engineering elected electrical engineering and computer sciences professor **Constance Chang-Hasnain** to its ranks in February. A nano-optoelectronics expert, she was cited for her contributions to wavelength tunable diode lasers and multi-wavelength laser arrays. The selection brings the number of active and emeriti Berkeley Engineering faculty members in the academy to 74. The recognition is considered one of the highest professional honors accorded an engineer working in the United States.

PHOTO BY NOAH BERGER

Branko Kerkez (M.S.'08, Ph.D.'12 CEE; M.S.'12 EECS) and **Dan Work** (M.S.'07, Ph.D.'10 CEE) were selected as National Academy of Engineering Gilbreth Lecturers and will make presentations on their research at the annual meeting. Kerkez, an assistant professor at the University of Michigan, and Work, an associate professor at Vanderbilt University, were also named to *Connected World's* list of 2018 M2M Pioneers, which recognizes top technology leaders under the age of 40.

Ronald Ketchum (B.S.'75 EECS) has established the Ronald E. and Harold E. Ketchum EECS Scholarship, supporting exceptional undergraduate students in the EECS Department. "Berkeley Engineering taught me perseverance, discipline and how to work hard to achieve your dreams," he said. "As a student with limited resources, I was able to overcome obstacles and work my way toward a successful career. I am hopeful that this endowment will support future generations of talented, driven Berkeley engineers."

Kunwoo Lee (Ph.D.'16 BioE) and **Siddarth Satish** (M.T.M.'11 BioE) have been named to the 2018 *Forbes* "30 Under 30" list. Lee, a former student in professor Niren Murthy's lab and founder of the startup GenEdit, developed a way to deliver muscular dystrophy-curing CRISPR edits to the body using nanoparticles (see page 6). Satish is the founder and CEO of Gauss Surgical, a company that has developed technology to monitor blood loss in the operating room.

Ann Lee-Karlon (B.S.'89 BioE) has been elected to the AIMBE College of Fellows Class of 2018. A senior vice president at Genentech, she was recognized for "outstanding leadership in successful drug development and business operations in Genentech and for enhancing diversity of future BME leaders."

Civil and environmental engineering professor **Shaofan Li** was selected to receive a 2017 International Association for Computational Mechanics Fellows Award.

Professors **Tsu-Jae King Liu** and **Eli Yablonovitch** of electrical engineering and computer sciences were named fellows of the National Academy of Inventors, an organization that champions the societal benefits of university research.

Warren "Woody" Hoburg (M.S.'11, Ph.D.'13 EECS) had an eventful 2017. Not only was he selected for NASA's 2017 Astronaut Candidate Class, he also was recognized as *R&D Magazine's* 2017 Inventor of the Year for his achievements in drone technology. Prior to joining NASA, he was an assistant professor of aeronautics and astronautics at MIT, where he led a team that devised a lightweight and inexpensive unpiloted aerial vehicle (UAV) that could stay airborne for more than five days. Currently under development for the Air Force, this technology could be used to provide critical communications support for regions impacted by a natural disaster, among other applications.

PHOTO COURTESY NASA

Berkeley's grand prize for lab safety has been awarded to **Lane Martin** (M.S.'06, Ph.D.'08 MSE), associate professor of materials science and engineering, plus lab safety coordinators **Arvind Dasgupta** and **Margaret McCarter** and their research colleagues in the Prometheus Group.

Teresa Meng (M.S.'84, Ph.D.'88 EECS) delivered a keynote address at the International Solid State Circuits Conference. In her speech, "Winning the game in a male-dominated industry," she spoke candidly about pervasive gender discrimination as well as her own experiences with sexism throughout her career. Meng, the co-founder of Ahteros Communications and the first female professor in electrical engineering at Stanford, also offered practical advice and encouragement to audience members.

A team of four Berkeley graduate students — including **Eric Munsing** of civil and environmental engineering, **Allen Tang** of electrical engineering and computer sciences and **Sören Künzel** and **Jake Soloff** of statistics — won first place and a $100,000 prize in the final round of the Data Open, a yearlong series of data analysis competitions.

Ashley Muspratt (M.S.'05 CEE, Ph.D.'09 Energy and Resources Group) is the founder and CEO of Pivot, a six-year-old company offering an alternative to the infrastructure-intensive Western model of sanitation for large cities in parts of Africa, Asia and Latin America. Last summer, she was a development engineering fellow at the Blum Center for Developing Economies.

Negah Nafisi (M.S.'16 CEE) recently co-founded Easel, a company that connects artists and buyers in commissioning original artwork. Showcasing a range of mediums and styles, Easel's website aims to help artists manage the business side of commissions.

Joshua Nixon (B.S.'16 BioE) has co-founded a startup, Terramino Foods, with **Kimberlie Le,** a fellow graduate of the Alternative Meat Lab at the Sutardja Center for Entrepreneurship and Technology. The company, which uses fungi and algae to create alternatives to seafood, has launched a salmon alternative line of products, which they plan to start selling to restaurants by the end of the year.

Mechanical engineering assistant professor **Grace O'Connell** has received a CAREER Award from the National Science Foundation as a part of its Faculty Early Career Development Program.

Introducing FEMTech

Even though STEM classes are increasingly popular among undergraduate students, the balance of students is still overwhelmingly male in many of these courses. But FEMTech, Berkeley's first interdisciplinary tech club for women and underrepresented students, aims to provide support for those interested in the tech world, regardless of their major or experience level. "It's easy to say 'It's not for me, I'm not going to do this,'" said **Emily Orosco Nuñez,** club vice president and a third-year cognitive science major. "But with a group like FEMTech, it becomes 'Yes, it's hard, but keep with it.' Having a support system is really important."

FEMTech offers tutoring sessions, robotics workshops, speaker series and professional development workshops; this spring, members launched a DeCal class on web development aimed at students with little to no coding experience. But the group isn't just for newbies. With about half of its members coming from computer science and engineering majors, the club provides opportunities for engineers and non-engineers alike to collaborate and network. "FEMTech is for all majors," said **Lisanne van Engelen,** club president and a third-year electrical engineering and computer sciences student. "We need different ideas from those who are not in traditional tech majors but can still contribute to the tech field."

PHOTO BY JULIANNA FLEMING

Prasad Raghavendra, associate professor of electrical engineering and computer sciences, was honored by the National Academy of Sciences, sharing the inaugural Michael and Sheila Held Prize with David Steurer of ETH Zurich, for "revolutionary contributions to the understanding of optimization and complexity in computer science, work that has relevance for solving the most difficult and intractable of computing problems."

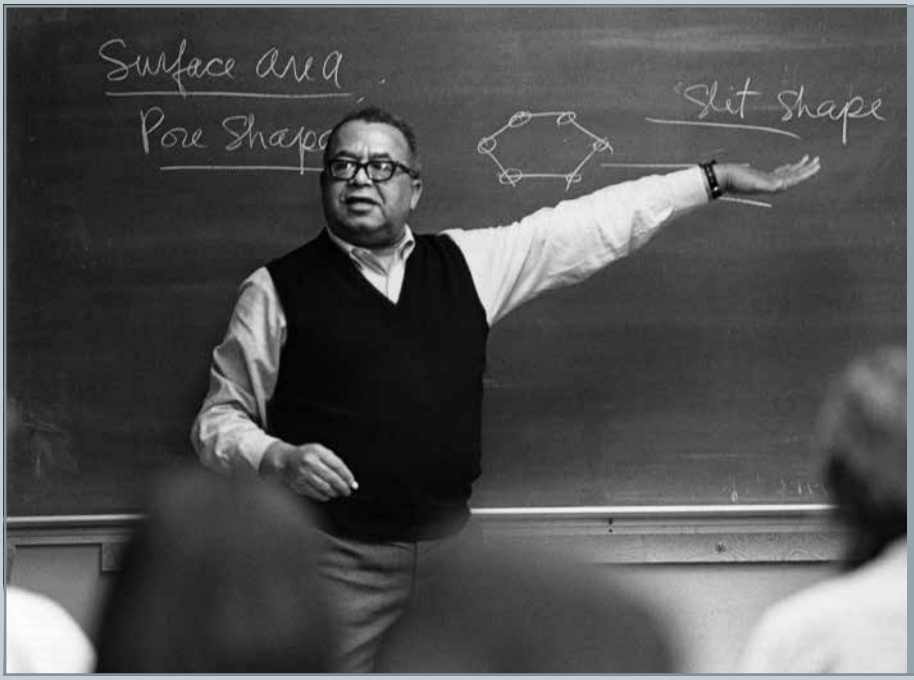
Rama Ranganathan (B.S.'85 BioE), professor of biochemistry and molecular biology at the University of Chicago, will lead their new Center for Physics of Evolving Systems, which spans the Division of the Biological Sciences and the Institute for Molecular Engineering.

Boris Rubinsky, professor of mechanical engineering, will be honored at the Eighth World Conference of Biomechanics in Dublin, Ireland, as well as the Symposium on Innovations in Bioengineering Technologies in the Service of Humanity and Society in Tel Aviv, Israel.

Civil and environmental engineering professor and California PATH program manager **Alexander Skabardonis** has been awarded the Traffic Simulation Lifetime Achievement Award by the Transportation Research Board.

Mark Velednitsky, graduate student in industrial engineering and operations research, has reduced the 28-page proof for the classic operations research challenge known as the "traveling salesman problem" to just a few lines. He initially worked on the proof as a homework problem.

Bioengineering professor **Michael Yartsev** has been awarded the prestigious 2017 Packard Fellowship for Science and Engineering to pursue research into how brains develop the ability to acquire language.



Robert "Pete" Bragg Jr., materials science and engineering professor emeritus, died in October at the age of 98. A passionate researcher, he established himself as a leading expert in X-ray crystallography, X-ray diffraction and the electronic properties of carbon materials. When he joined the Berkeley faculty in 1969, he was the only African-American in the materials science and engineering department — where he served as department chair from 1978–81 — and one of six African-American faculty members on campus. He remained deeply committed to science as well as to diversity, fighting for the increased hiring of minority faculty and overseeing key diversity programs. Among his many honors, he was awarded a Fulbright Fellowship and was a fellow of the National Society of Black Physicists.

PHOTO BY BRUCE COOK

Stephen Mahin (B.S.'68, M.S.'70, Ph.D.'74 CE), professor emeritus of civil and environmental engineering, died in February at the age of 71. He joined the Berkeley faculty in 1977 and was a popular teacher, mentor and colleague. An expert in earthquake engineering, he pioneered the development of hybrid testing techniques that integrated physical testing with computer simulations, and he was known worldwide for his wide-ranging contributions to seismic research. He served as chair of the Structural Engineering, Mechanics and Materials (SEMM) program from 1990–93, director of the Pacific Earthquake Engineering Research Center (PEER) from 2009–15, and founding director of the Computational Modeling and Simulations Center (SimCenter) in 2016. He was inducted into the American Society of Civil Engineers' Hall of Fame in 2012.

Kent Bingham (B.S.'58 CE) died in March at the age of 82. He was the chief structural engineer for the Walt Disney Company, including projects at Epcot, Tokyo Disneyland and California Adventure. He also worked on the King Kong and Earthquake attractions at Universal Studios, the sinking pirate ship for Treasure Island Hotel and Casino, the Las Vegas monorail system, the trolley for the Grove in Los Angeles and a prototype tram system for the San Diego Wild Animal Park. Over the last decade, he shifted his focus to alternative energy sources, working on advanced technologies for water, energy and transportation.

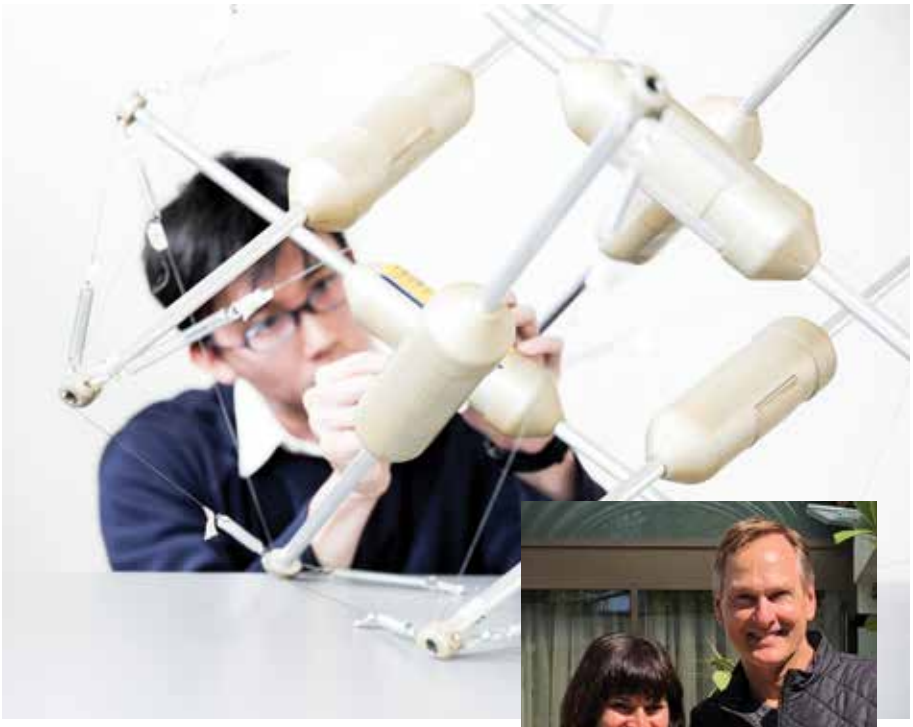
Sam Blackman (M.S.'99 EECS) died in August at the age of 41. He was the co-founder and CEO of AWS Elemental, a software company that delivers internet video to consumer devices. A tech visionary, he worked at Silicon Graphics, Intel and Pixelworks before forming Elemental Technologies — one of Portland, Oregon's biggest startup successes — which was acquired by Amazon Web Services in 2015.

Joseph Kaplan (B.S.'48 CE) died in February at the age of 92. A German native who immigrated to the United States in 1938, he founded and managed his own construction company, Joseph Kaplan Inc., for 49 years. He was also an active volunteer with the American Society of Civil Engineers, the National Society of Professional Engineers, the Construction Safety Institute and the Cal Alumni Association, among other organizations, and received numerous awards for his outstanding service.

Frank Kreith (B.S.'45 ME) died in January at the age of 95. Born in Austria, he fled during the Holocaust and eventually came to Berkeley to study engineering. After graduating, he worked at NASA's Jet Propulsion Laboratory, then taught at Berkeley and Lehigh University before joining the faculty at the University of Colorado at Boulder. A solar energy and sustainability expert, he also led a research branch of the Solar Energy Research Institute and advised lawmakers on energy and environmental issues.

Lotfi Zadeh, professor emeritus and world-renowned computer scientist, died in September at the age of 96. A native of Azerbaijan, he joined the faculty of the electrical engineering department at Berkeley in 1959 and was department chair from 1963–68. His work focused on linear systems and automata theory, and his textbook with Charles Desoer laid the foundation for the modern approach to systems analysis and control. In 1965, he authored his seminal paper on fuzzy sets, or fuzzy logic, which initiated a new direction that led to a vast literature and a rapidly-growing number of applications, ranging from consumer products to subway trains and decision-support systems. He was an IEEE fellow, National Academy of Engineering member and received more than 50 awards for his work.

PHOTO BY AARON WALBURG



Golnaz Shahmirzadi

Berkeley Engineering graduate students will benefit from the generous support of David and Irene Tyler, pictured right.

A lasting legacy

Growing up in the Bay Area, David Tyler (B.S.'81 ME) had always dreamed of attending Berkeley. Inspired by his mother, who taught him to aim high and never give up, he enrolled at Berkeley in 1977 and later became the first of eight siblings to graduate from college.

At Cal, he learned to appreciate the rewards of working hard as an engineering student, something he has carried with him over the course of his accomplished career. Last year, David and his wife, Irene, decided to establish the Tyler Family Fellowship as a meaningful way to honor his experience at Berkeley and leave a legacy that will transform lives.

"Establishing the Tyler Family Fellowship has enabled us to leverage the benefits we received at Cal to help future generations of students," says David. "If you're able, know that giving back to Cal will bring tremendous pride and joy."

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