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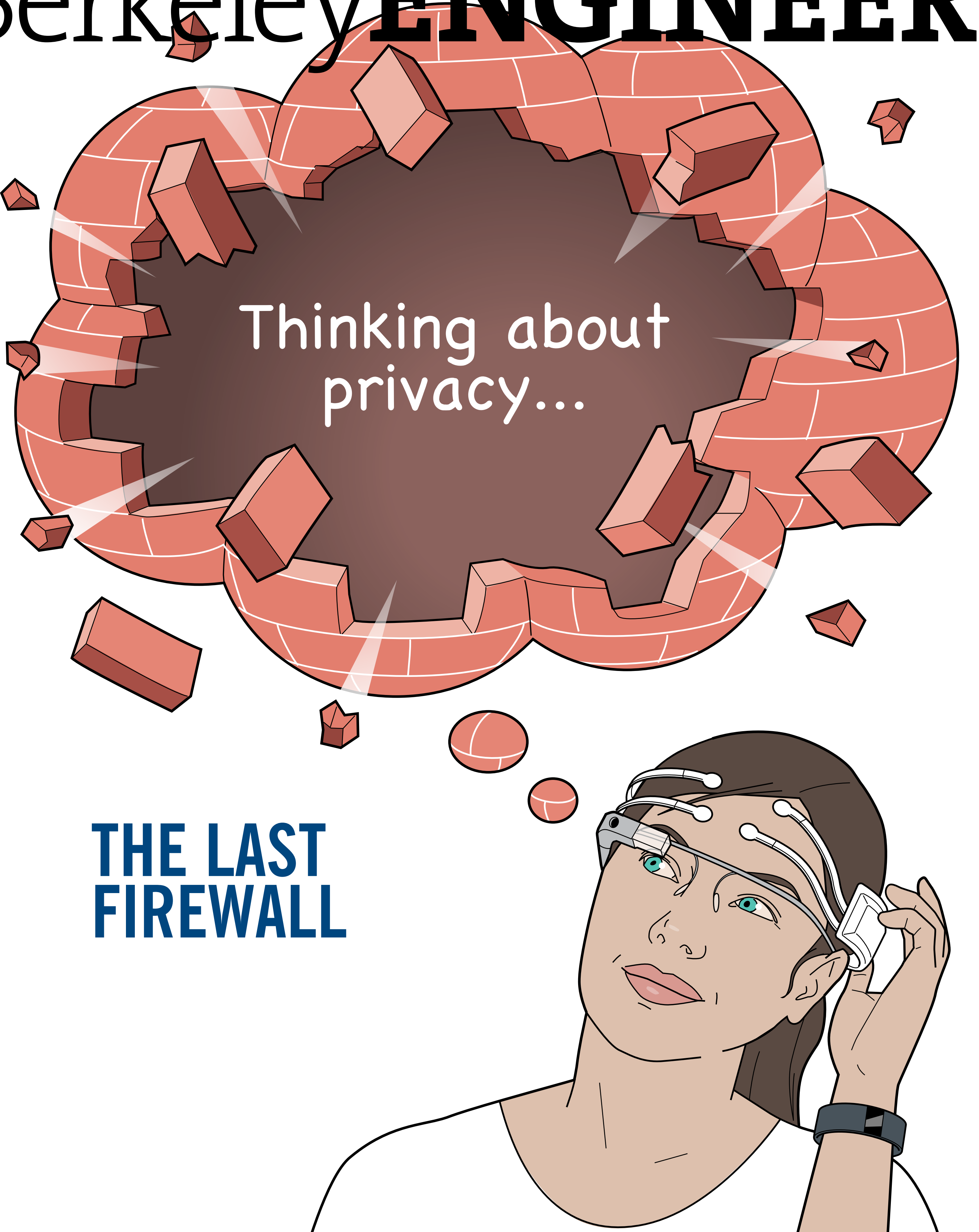

THE LAST FIREWALL

Made-to-order engineering education

"I'm not an engineer because I like following procedures. I'm an engineer because of those moments of stuckness, and because of the creativity and imagination it takes to become unstuck."

Kate Rakelly's words, spoken at the Jacobs Hall groundbreaking celebration on April 12, show us another side of engineering education—one that embraces open-ended thinking as well as logic. As Kate, an EECS undergraduate, puts it, "Sometimes after a very long time, the 'aha' moment comes, usually when you least expect it—when you realize which assumption was wrong, or how to frame the problem in a different way."

Students choose engineering to design and build solutions for the big problems confronting society: mobile devices to permit better and cheaper health care; data analytics for more efficient energy use; resilient cyber-physical infrastructure for improved public safety. When they choose Berkeley, the world's best public engineering school, we owe it to them to provide them with a deep understanding of people, technology and society.

We offer our students integrative design experiences throughout their time here at Berkeley—projects that begin with studying end-user needs and lead to harvesting emerging technologies to design, build and launch new products and services.

By tackling complex design challenges early on, our students become motivated to seek out the fundamentals of theory, technology and tools. This is the core premise of our new Jacobs Institute for Design Innovation. In Jacobs Hall, the institute's future home, our students will immerse themselves in the entire design ecosystem. They'll do this in multi-disciplinary teams, thus benefiting from various perspectives and becoming better communicators and leaders.

By tackling complex design challenges early on, our students become motivated to seek out the fundamentals of theory, technology and tools.

At the same time, our professors are doing more coaching and mentoring in small groups, thereby providing a more customized and student-centric learning experience.

As Sally Thompson of CEE illustrates, "Students in my hydrology class were really struggling. So I modified the class using a blog platform. One team, for example, explored how seasonal variations in rainfall posed challenges to California water management. Students shared their work with each other and offered peer feedback. Their blogs were vibrant, visually appealing and fun—and great résumé material."

In this context-based approach, we are matching the traditional depth and rigor of a Berkeley Engineering education with experiential and collaborative problem-solving, relying on real-world scenarios. We think this is the best leadership education we can offer our students as they master the integrated set of skills they will need to design and build our future.

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

Paul Jacobs, whose lead gift helped launch the Jacobs Institute for Design Innovation, joined student speakers Eric Mica, Kate Rakelly and Lavanya Jawaharlal for the April 12 groundbreaking celebration for Jacobs Hall, to open fall 2015.

Noah Berger

in this issue

Peter Mountain

MORE >

> TRANSCENDENCE IMAGE (above): Johnny Depp as Will Caster in Alcon Entertainment's sci-fi thriller "Transcendence," a Warner Bros. Pictures release. © 2014 Alcon Entertainment, LLC. All rights reserved.

> COVER ILLUSTRATION JASON LEE

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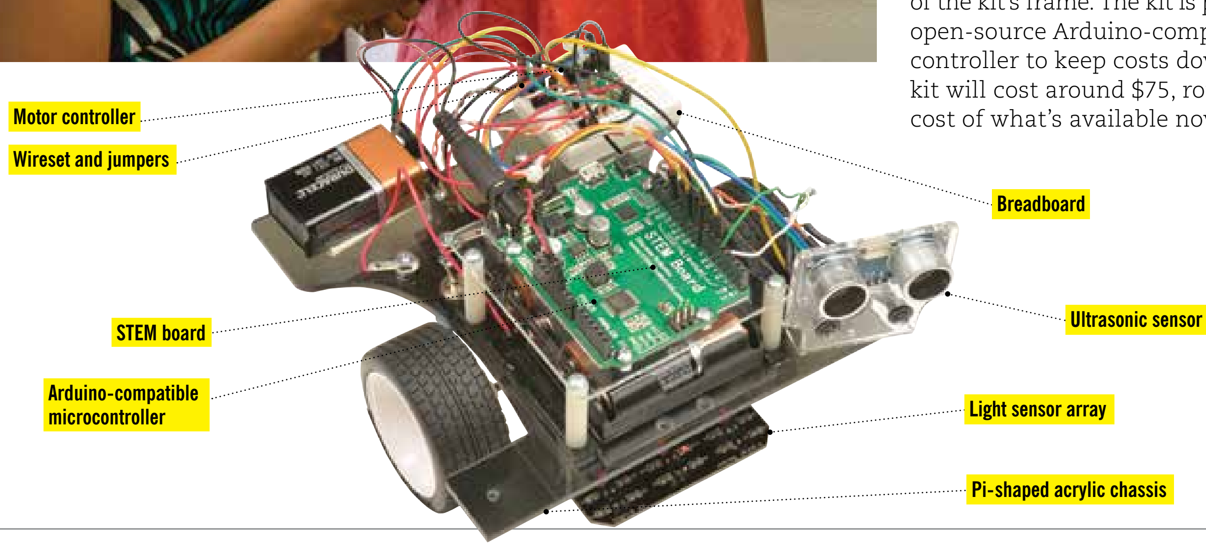
Courtesy STEM Center

DIY KIT

Bot on a budget

In 2011, mechanical engineering student **Lavanya Jawaharlal** (right), with her sister Melissa, co-founded STEM Center USA to increase access to science, technology, engineering and math (STEM) fields. Early on they decided to use robotics as a way to get high schoolers and college students hooked on STEM concepts, but they kept running into a problem: off-the-shelf robotics kits were either too simple or too complicated—and they were always expensive.

This inspired them to develop their own robot kit called the Pi-Bot. Its namesake is the Greek letter, which is also the shape of the kit's frame. The kit is powered by an open-source Arduino-compatible micro-controller to keep costs down. A Pi-Bot kit will cost around $75, roughly half the cost of what's available now.



COMMENTS

Friends, followers and readers: Thanks for your comments. Here is a recent sampling.

Re: "Jacobs gift launches design institute," *Berkeley Engineer,* fall 2013
As an ME alum, I'm delighted to hear that Berkeley is enthusiastically embracing hands-on engineering education. However, it's hardly new. As **Alice Agogino** is well aware, we dedicated the hands-on Integrated Teaching and Learning Laboratory at the University of Colorado, Boulder in 1997, and I was fortunate to serve as co-director until I retired several years ago. The interdisciplinary aspects of the program have been a great success—particularly the first-year course, in which teams learn engineering design experientially to create projects to showcase at a design expo each semester. And having helped create the hands-on ITL laboratory, I am fortunate to have access to such wonderful high-tech tools as laser cutters, 3D printers, CNC machinery, etc., for my own design projects in my retirement. Keep up the good work!
—Lawrence E. Carlson, M.S.'68, D.Eng.'71 ME, via e-mail

Re: "Applying the right pressure," *Innovations,* November 2013
Congratulations to the LifeWrap team, whose dedication to providing solutions to those who need help, without a primary profit motive, is most highly laudable. This device has the same favorable attributes as the iconic safety pin: tremendous application potential, cheap to manufacture and simple to use.
—Ernst Valfer, B.S.'50, M.S.'52, Ph.D.'65 IEOR, via *Innovations*

Re: "Jacobs gift launches design institute," *Berkeley Engineer,* fall 2013
Your piece about Sara Beckman and new design courses sounds really great. I worked for the General Electric Company for 36 years, starting out in their Creative Engineering Program. We used Alex Osborn's book, *Your Creative Power,* to get the creative juices flowing—you might want to check it out.
—Howard T. Vaum, M.S.'49 ME, via e-mail

HOW DO I FIND OUT MORE?
Find links to source articles, news details and expanded coverage through the college website at **coe.berkeley.edu/berkeleyengineer-links.**

FORENSICS

Moonshadow

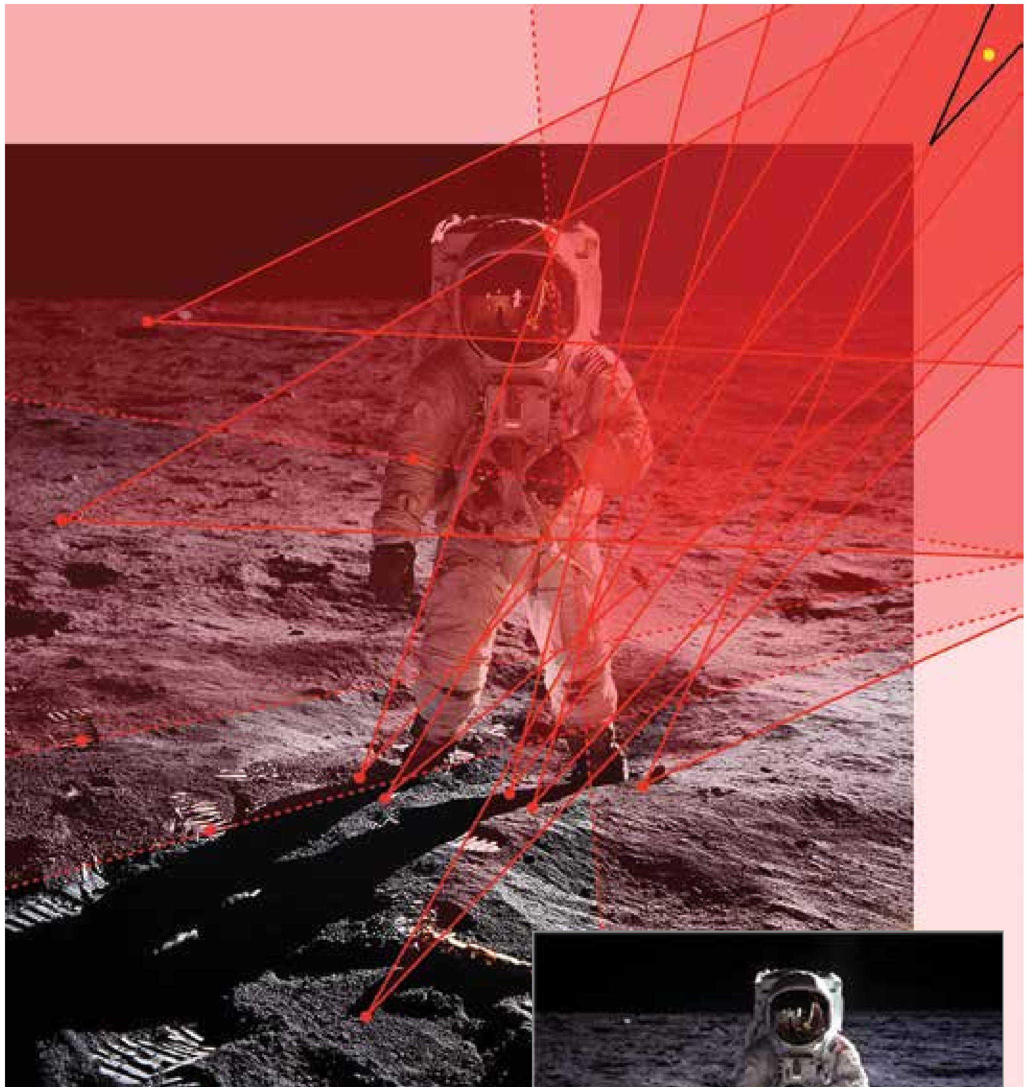
Computer science professor **James O'Brien** began tinkering with code while in elementary school—thanks to his father, who let him play text-based adventure games online. During one game, he rewrote the code to get past a pesky dragon.

That curiosity and experimentation eventually landed O'Brien a career in computer graphics. Not only has he helped develop methods for creating realistic simulations of material fracturing and explosions used in movie and video game special effects, but he also helped design a technique for detecting altered photographs.

"The widespread use of tools like Photoshop makes it easier than ever to manipulate photographs and makes the public less trustful of photographic reality," says O'Brien. "Faked photographs have real-world consequences."

He cites one of many possible examples: a 2004 photographic mash-up that implied then-presidential candidate John Kerry attended the same 1960s anti-Vietnam War event as activist-actor Jane Fonda.

"How many votes did that cost him, even after the manipulation was exposed?" asks O'Brien.



Original image copyright 1969, NASA. Annotated image by Kee, O'Brien and Farid, 2012

To uncover such manipulations, the team developed a photo forensics tool for analyzing shadow inconsistencies. It assumes a single point light source, such as a table lamp, or as in this iconic 1969 moon-landing photograph, the sun, which casts harsh shadows on the uneven lunar surface.

SUDOKU STRATEGY

Their technique creates a set of imaginary lines, or cones, extending from points in a photograph's various shadows—in this case, those cast by the astronaut or on the astronaut—through the shadow-casting parts of the figure and onto the implied light source. If all the imaginary lines or cones connect from their shadow origin points to the same light source, that is significant evidence that the photograph was not manipulated.

O'Brien likens it to a Sudoku puzzle in which the requirement that each line has the same sum creates a set of constraints for solving the puzzle.

In the same way, if it can be shown that one shadow in the photograph does not link to the same light source as the other shadows, then the image doesn't add up. That means it's nearly certain that someone manipulated the photograph.

"While any one specific method for detecting manipulation can be fooled," says O'Brien, "our goal is to gradually build up a whole toolkit to test all aspects of the photograph."

SHOOTING THE MOON: James O'Brien, professor of computer science, uses this iconic 1969 moon-landing photograph to demonstrate a photo forensics tool he helped develop. The tool determines whether a photograph has been altered by analyzing its shadows for light source inconsistencies.

SCI-FI

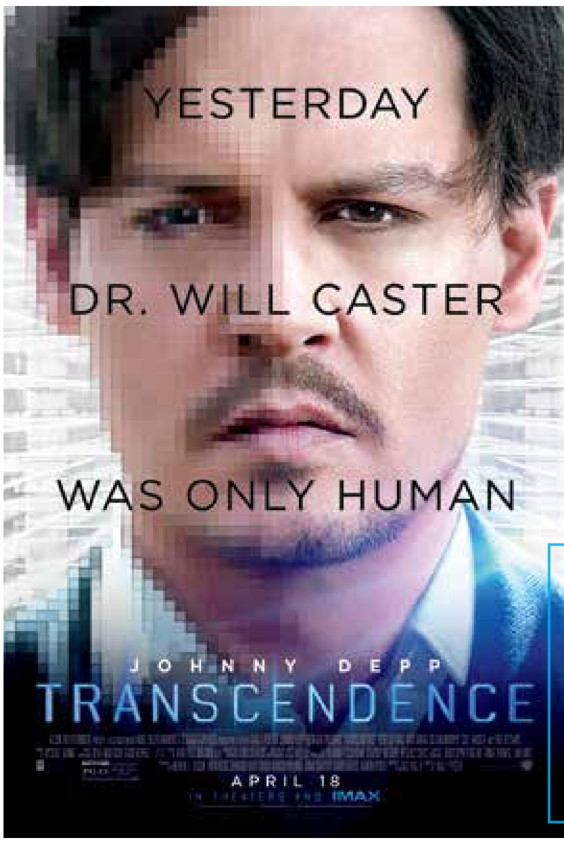
Art imitates academia

More than 200 people packed a campus auditorium in early April for a Q&A and screening of segments of the film *Transcendence,* a sci-fi thriller directed by Wally Pfister, an Academy Award-winning cinematographer. Pfister answered questions about Berkeley's role in the film, along with professors **Jose Carmena** and **Michel Maharbiz** of electrical engineering and computer sciences.

On screen, the actor Johnny Depp plays the role of an artificial intelligence scientist, Will Caster, whose brain is uploaded to a quantum computer.

During production, Maharbiz and Carmena provided Pfister with a primer in neural engineering and the potential connections between human and computer brains. They discussed the most recent advances in nanotechnology and organic-synthetic interfaces, as well as projections for what could be possible in the next 20 to 50 years. Not only did the researchers pore over the script line-by-line, they also flew down to Los Angeles to meet with Pfister and his team on set.

Beyond the science, the film also heavily references Berkeley, including shots of the Campanile.



Travis Massey

Jose Carmena

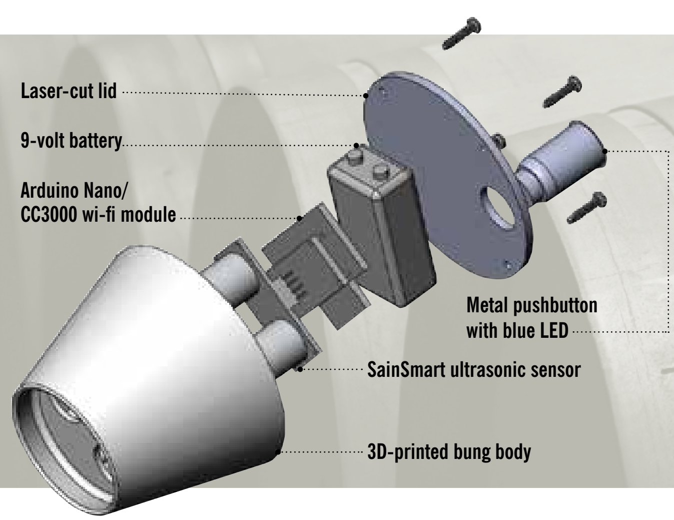
Michel Maharbiz

"What is consciousness?" asked Carmena at the campus screening. "We actually don't really know what it is, or how to define it. We cannot measure it. All we can do is to describe our own subjective experience."

SMART DEVICES

Optimal distillation

In the hands-on Interactive Device Design course co-taught by mechanical engineering professor **Paul Wright** and electrical engineering and computer sciences professor **Björn Hartmann,** undergraduate students compete to come up with the best solutions to real-world problems. Last fall, winning team members **Justin Kay, Carson Schultz, Claire Tuna** and **Matthew Visco** researched the distillery business to design an elegant solution to an age-old challenge.



Q+A on L.A. seismic study

Jack Moehle, professor of civil engineering at Berkeley since 1980, recently wrapped up a seven-year National Science Foundation survey of unreinforced concrete buildings in Los Angeles, which could be potentially vulnerable in severe earthquakes. Named to the National Academy of Engineering this year, Moehle talked to *Berkeley Engineer* about the seismic study and its impact.

Daniel McGlynn

Berkeley Engineer: ***What was the purpose of this NSF study?***

Moehle: There are approximately 22,000 older concrete buildings in California that do not meet the seismic standards of today. There's not enough money to fix all of them. We wanted to find ways to pick out the killers from this lineup of older buildings. If you target the buildings most likely to be dangerous, it will become a manageable problem.

Why Los Angeles?

Los Angeles is in a highly active seismic zone with a sizeable population of concrete buildings built before 1976. The Southern California Earthquake Center there has conducted ground-motion studies, so we had a good idea of what the seismicity was, what some scenario earthquakes would look like, and how they might affect buildings there.

How was the study conducted?

We developed the inventory from existing public records, refined by using satellite imagery and field surveys. We conducted laboratory tests of typical building components and deployed findings in computer software for simulating how buildings react to earthquake shaking. By combining the inventory and simulation models, we were able to identify how many buildings may be at risk, as well as how selective seismic strengthening could reduce loss of life and property damage.

Why was it important to release the data to the city of L.A.?

All of us were interested in getting the data into the city's hands, because what broader impact could there be than if Los Angeles starts a mitigation program to save thousands of lives?

The* Los Angeles Times *asked for the data last summer; why wait before releasing it?

The university has to protect the rights of its researchers to develop data, and to keep it private and confidential until the research is done. We were also concerned that people could misinterpret the data. This is not a list of buildings that are going to collapse, but rather a list of buildings that, as a class, have a higher risk than other buildings. We have not done any individual building studies.

What was the reaction when the* L.A. Times *ran a front-page story using study data?

I started getting calls from people worrying about whether the building they were living in was dangerous. My general advice was to gather information so that they could make informed decisions. What type of building construction is it? When was it built? Have there been engineering evaluations of seismic safety?

Is it unusual for an engineering study to be thrust into the public policy arena?

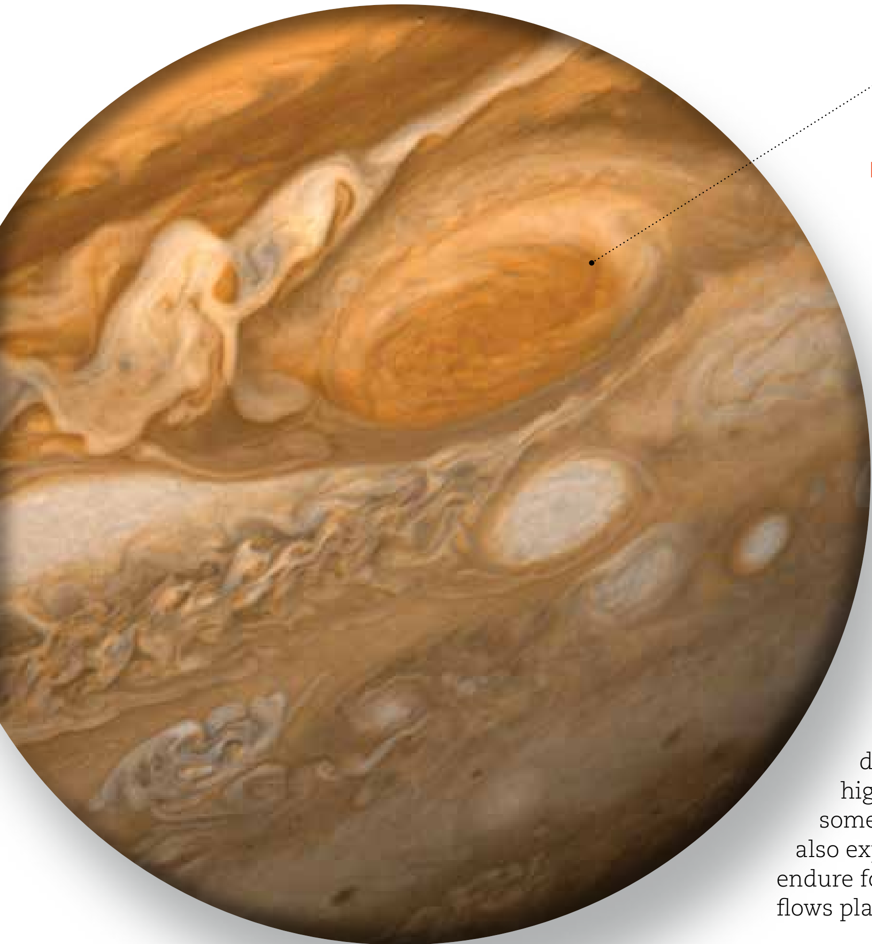
We've been interested for a long time in translating engineering metrics into public action, so this is not a totally unexpected result. I'm thrilled with what's going on, because we might actually make a huge difference in seismic safety in California. The steps along the way may have been a little nerve-racking, but if our study creates the impetus for a city to take action, it will be a crowning achievement.

PROBLEM Distilleries in the U.S. are required by law to track the volume in every barrel as it ages. Wineries can minimize oxygenation by topping barrels off when they lose about a liter of liquid. The measurement method commonly used throughout the industry today is by hand—a time-consuming and inefficient process.

SOLUTION The team designed a sensing prototype that, when placed in the bunghole atop a barrel, automatically measures the distance to the surface of the liquid. The LED light indicates that the measurement is being sent to a wireless web server and converted to volume. Through a website, the user can set measurement intervals and monitor readings.

RESULT The team estimates that replacing a standard bung with an electronic Büng could save distilleries about 160 hours of labor per 700 barrels each year. They are applying for a provisional patent for the device.

The Büng is shaped like a traditional cork, with added holes for an ultrasonic sensor on the bottom and a button for forcing a manual reading on top.



PHYSICS

By Jupiter

Probably the most distinctive characteristic of Jupiter is the Great Red Spot, a gigantic storm that was first observed in its atmosphere over 400 years ago. Scientists have struggled to understand why the Red Spot—about two to three times the size of Earth—has persisted for so long. But recent work from **Philip Marcus,** professor of mechanical engineering, in collaboration with **Pedram Hassanzadeh** (Ph.D.'13 ME), may explain the Red Spot's longevity. The team built a high-resolution, fully three-dimensional model and learned that vertical flows transport hot and cold gases to the storm's center, helping restore its energy. In addition, the model predicted a radial flow that draws in winds from high speed jet streams; the vortex may absorb some smaller vortices as well. Their work might also explain why oceanic vortices here on Earth can endure for years, as well as identify the role vertical flows play in the formation of stars and planets.

COMPUTING

Out for a spin

Semiconductor-based transistors, the on-off switches that direct electricity flow and form a computer's nervous system, consume greater chunks of power at increasingly hotter temperatures as processing speeds grow. A decade of research shows that magnets might be an alternative because they require far less energy when switching. However, the power needed to generate the magnetic field has negated much of the energy savings. But new work by Berkeley researchers could transform modern electronics by making nanomagnetic switches a viable replacement for the conventional transistors found in all computers. The researchers exploited a so-called Spin Hall effect by using nanomagnets placed on top of tantalum wire and then sending a current through the metal. When the current is sent through tantalum's atomic core, the metal's physical properties naturally sort the electrons to opposing sides based on their direction of spin. This creates the polarization to switch magnets in a logic circuit without needing a magnetic field. Electrical engineering and computer sciences professor **Sayeef Salahuddin,** graduate student **Debanjan Bhowmik** and **Long You,** a research scholar, co-authored the study.

Daniel McGlynn

Electrical engineering and computer sciences professor **Sayeef Salahuddin**

HEALTH

About a bone

Along with gray hair and wrinkles, aging also brings with it more fragile bones. Now researchers have learned that the natural bone aging process can be hastened by a deficiency in vitamin D. Working with colleagues from the University Medical Center in Hamburg, Germany, the Berkeley team—led by **Robert Ritchie,** professor of materials science and engineering—analyzed bone samples and measured their resistance to cracking. Their testing showed that vitamin D deficiency increased cracking by 22 to 31 percent. Upon further examination of samples from vitamin D-deficient subjects, the scientists found sections of heavily mineralized bone, which resembles older and more brittle bone, underneath new, non-mineralized bone surfaces. Surrounded by collagen, these mineralized sections were separated from the cells that could remodel them, which further accelerated the aging process. The researchers hope their work will eventually lead to more effective ways to prevent or treat fractures in patients with a vitamin D deficiency.

STEM CELLS

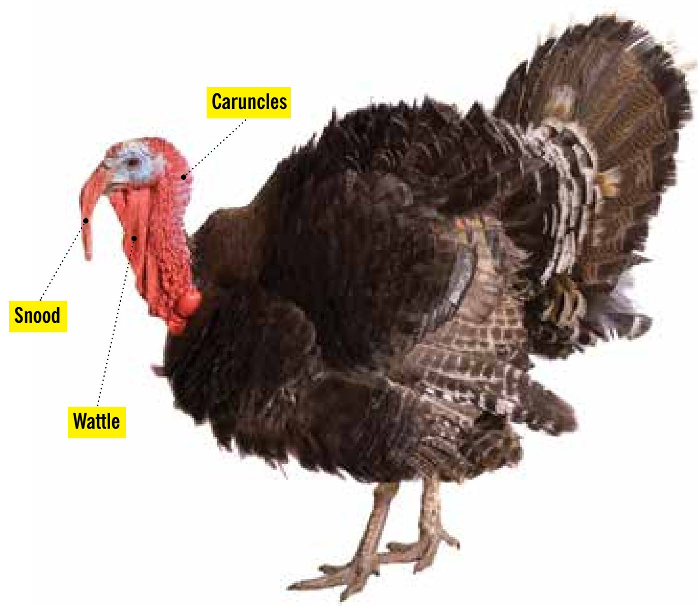
Reprogrammed

Eight years ago, scientists first developed a process to reprogram adult cells into embryonic-like stem cells that can develop into any type of body tissue. These induced pluripotent stem cells have since become a research mainstay in regenerative medicine, disease modeling and drug screening. The current technique uses a virus to introduce gene-altering proteins into mature cells, but scientists have been hoping to improve the quality and consistency of the process. Now, a team of Berkeley scientists, including bioengineering professor **Song Li, Timothy Downing** (Ph.D.'13 BioE) and graduate student **Jennifer Soto,** has shown that physical cues can replace certain chemicals when nudging mature cells back to a pluripotent stage. The researchers grew fibroblasts—cells taken from human skin and mouse ears—on surfaces with parallel grooves. After two weeks, the researchers found a four-fold increase in the number of cells that reverted to an embryonic-like state, compared with cells grown on a flat surface. Growing cells in scaffolds of nanofibers aligned in parallel had similar effects.

BIOSENSORS

True colors

Some may think of turkeys as good for just Thanksgiving dinner, but Berkeley bioengineers found inspiration in the birds for a new type of biosensor that changes color when exposed to chemical vapors. Turkey skin, as it turns out, can shift from red to blue and white, thanks to bundles of collagen that are interspersed with a dense array of blood vessels. Spacing between these collagen fibers changes when the blood vessels swell or contract, which, in turn, affects the way the light waves are scattered and alters the colors we see on the bird's head. The researchers, led by bioengineering professor **Seung-Wuk Lee,** found a way to get benign viruses—with a shape that closely resembles collagen fibers—to self-assemble into patterns that could be easily fine-tuned. Like collagen fibers, these nanostructures expanded and contracted, resulting in color changes. When exposed to a range of volatile organic compounds, the biosensors swelled rapidly, resulting in specific color patterns that distinguished the different chemicals tested. "Our system is convenient, and it is cheap to make," says Lee. "We also showed that this technology can be adapted so that smartphones can help analyze the color fingerprint of the target chemical. In the future, we could potentially use this same technology to create a breath test to detect cancer and other diseases."



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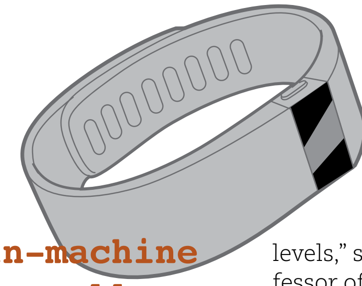
THE LAST FIREWALL

STORY BY
GORDY SLACK

PHOTOS BY
NOAH BERGER

ILLUSTRATIONS BY
JASON LEE



Implantable medical devices, brain-machine interfaces and wearable technology all present intensifying privacy and security challenges. Better to build security into such devices rather than trying to layer it over them later.

We've been transferring the contents of our minds into technology for thousands of years. Clay tablets and cave paintings helped us record our stories and where we buried our bones. More recently, we've begun externalizing gigabytes-worth of our most essential memories, capacities and experiences into smart devices. At the same time, those devices are growing ever smaller and are getting ever closer to our bodies: we're beginning to wear Google Glass on our faces, Fitbits on our wrists, insulin pumps on our hips and soon glucose-measuring contact lenses on our eyeballs.

But our self-extending, IT-heavy devices are no longer merely near or on us. They are making their way into us. Pacemakers, defibrillators and cochlear implants are now in wide use, and smart prosthetics, brain-machine interfaces and deep-brain-stimulation devices are becoming so. Each of these mechanisms generates and transmits a stream of data that may be life-supporting and supremely personal.

"When we put chips inside the body, the game changes," says professor of electrical engineering and computer sciences Jan Rabaey. He and a team of Berkeley engineers are working with surgeons at UC San Francisco on a new generation of implantable devices that can both read data directly from the brain and deliver signals back. One such tool records electrical activity through sensors implanted deep within the brain, analyzes it in real-time and delivers therapeutic doses of electrical stimulation when and where it can best mitigate neurological and psychiatric disorders. Some conditions that may be studied and treated with such a device are Parkinson's disease, essential tremor and treatment-resistant obsessive-compulsive disorder. The potential of such a device to tailor therapeutic treatments to individual patients is tremendous, says Rabaey.

As tiny wireless transmitters beam data between implanted chips in the brain and then out of the brain to be analyzed and converted into action by an external interrogator, signals can be vulnerable to exposure and, potentially, manipulation. Most researchers aren't thinking about security and privacy yet. They are focused more narrowly on the technological hurtles of converting biological signals, like neuronal activity, into something a machine can read and work with, says Rabaey. Perhaps understandably so. But Rabaey is acutely aware of the security and privacy threats implicit in such technology, and he is trying to get the attention of his colleagues.

"Right now," says Rabaey, "we're working on the very edge of what is even possible. If we can get these brain-phase-reading machines to work, that's amazing. Most of us are just not focused on security and privacy. Those seem like problems for the future." Maybe so, he adds, but the future is quickly hurtling this way.

Whether or not proliferation of brain-implanted devices will entirely "change the game," as Rabaey says (Miguel Nicolelis, a neuroscientist at Duke University, suggests our merging with our machines constitutes a speciation event), it will certainly raise serious security and privacy issues.

"We're creeping around in human thought, not just tracking human glucose levels," says Robert Knight, Berkeley professor of neuroscience and director of the Knight Cognitive Neuroscience Research Laboratory.

Knight says, "If you're designing a car, you don't want to have to figure out how to add a bumper and an airbag after the rest of the thing is done. Safety features should be part of the primary design."

Hacks come in many varieties, says Dawn Song, professor of electrical engineering and computer sciences and winner of a 2011 MacArthur Fellowship. In 2012, she and several colleagues published a study showing how they could secretly glean personal information (such as important numbers and home location) from the users of commercially available EEG headsets. The headsets, which read the signature electrical discharges emitted by different kinds of brain activity, cost between $100 and $300 and are increasingly popular among gamers, those practicing memory exercises and as interface drivers for other kinds of computer applications. The two most popular manufacturers, Neurosky and Emotiv, have thousands of units in the market and predict the number will soon reach into the millions.

Song and her colleagues studied 36 undergraduates who engaged in various interactive exercises while wearing the EEG headsets. They were shown a series of seemingly random photographs while their brain activity was observed. Without the students' knowledge, their brains were being plumbed for hints about such information as memorized PIN numbers, the locations of their homes and whether or not they recognized various faces.

The headsets read electrical discharges from the firing of billions of neurons throughout a brain. However, those signals are getting filtered through brain tissue and skull, and since each electrode is capturing the combined firings of so many neurons, the signals generated are both very rough and weak, says Knight. "You cannot do anything like read a person's mind by watching an EEG," he says. "And you never will be able to."

But if you can observe how the EEG responds to certain images while simultaneously observing the brain's response, you can infer things about the subject's relationship to the images, says Song. In particular, Song's team was interested in the characteristic spike in electrical activity that follows about 300 milliseconds after the subject sees something recognizable and significant, a relationship known as the P300 recognition response.

Song and her colleagues showed their subjects a sequence of images and numbers and looked for P300 signals. After showing many anonymous faces, the experimenters flashed an image of President Barack Obama, evoking a P300 response. After viewing a series of maps, subjects were shown a map of their own neighborhood, which catalyzed a P300 recognition response. Showing 10 maps, the researchers could guess which of them contained the subject's own neighborhood with about 60 percent accuracy. When the subjects memorized a four-digit PIN and were then flashed a random series of numbers, Song and her colleagues were able to guess, with an accuracy of about 35 percent, which of the numbers started the PIN series.

That's remarkable, but it is hardly good enough to enable malicious observers to glean social security numbers from the brains of users. Unless, Song says, the users are employing the headsets over long periods, observing many relationships and zeroing in on certain meaningful combinations. That's not impossible, says Song, if EEG headset users played online games that allowed the game's designers to control the images and to observe the brain-wave data associated with it. The user might think they were just playing an innocent game, while they were actually revealing personal information. That scenario becomes more plausible since the headset manufacturers publish application programming interfaces that allow third-party developers to write games and other apps that employ the devices.

> The purpose of the experiment, Song says, was to assess whether this kind of brain-machine interface could potentially pose privacy threats to users. Her conclusion: "Yes. Absolutely."
>
> *Dawn Song* • PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES

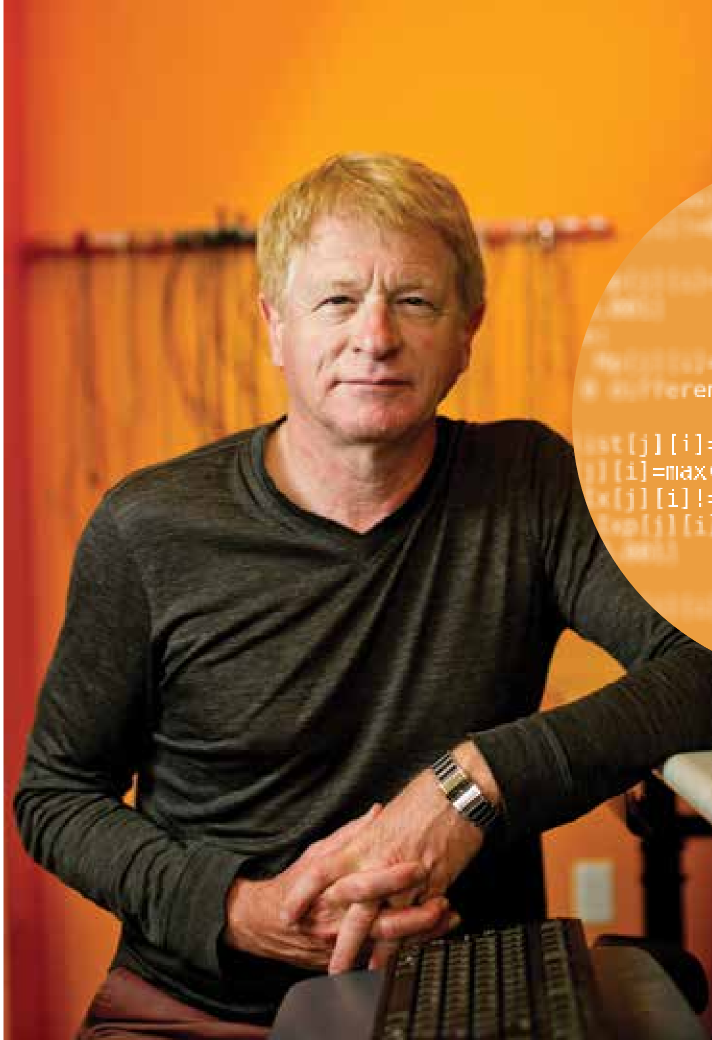
"The attacker doesn't even need to break into anything," Song says. "He simply hides the attack in an EEG-headset-driven app, a game say, that the user downloads and plays. The game knows what the user is looking at and gets the brain signal readings at the same time."

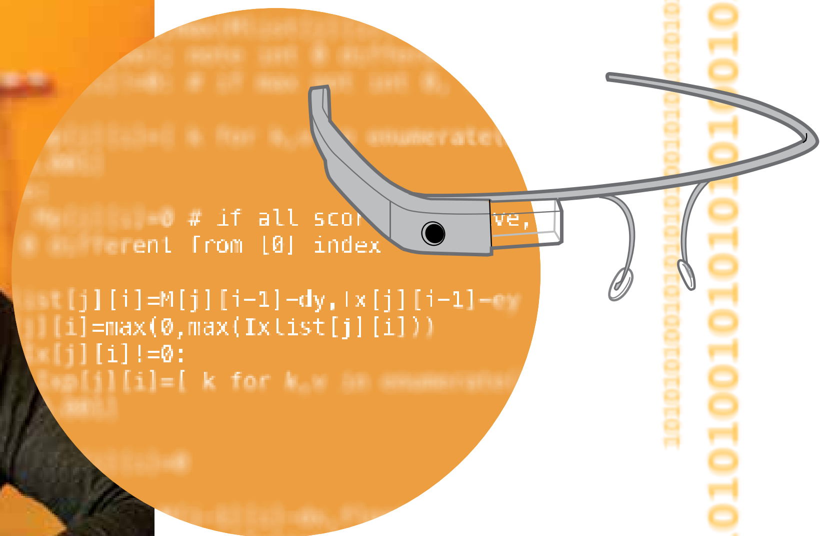
The purpose of the experiment, Song says, was to assess whether this kind of brain-machine interface (BMI) could potentially pose privacy threats to users. Her conclusion: "Yes. Absolutely."

Knight, who collaborates with Song on some EEG projects, agrees. His own startup company invented an impressive EEG headset that was sold to the Nielsen Company last year for neuromarketing—monitoring the brain while watching TV. Those headsets have their processors and storage built into the headset itself, but can also stream encrypted data wirelessly.

Even if the headsets weren't encrypted, there is no chance cyber pirates will be reading hapless minds any time soon, he says. "You can't even identify an individual based just on their EEG signals. It's very rough data." Yet he agrees with Song and Rabaey that when it comes to brain-machine interfaces, whether they are taking readings from inside or outside the skull, it is none too early to start taking the issues of privacy, security and safety to heart.

Speaking of hearts, they may also need guarding. Several years ago, University of Michigan computer scientist Kevin Fu showed that it was possible to crack the encryption code of common defibrillators and pacemakers. The devices, which can be wirelessly adjusted, also transmit a stream of data so that doctors can monitor patients. Fu and his colleagues were able to break the code and flip the switch on the defibrillator (potentially deadly for





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Jan Rabaey • PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES

its user) to adjust the pacemaker (also potentially lethal) and to eavesdrop on the data stream.

"Once you get into this device, you not only have all the medical information in it, but defibrillators are powerful stimulating devices," says Rabaey. "If you can pirate remote control of a stimulating device, all hell breaks loose."

Of course, the implantable cortical neuromodulation tool that Rabaey is working on (with faculty colleagues Elad Alon, Jose Carmena and Michel Maharbiz) is a stimulating device as well. Losing control of it to a malicious agent could likewise give a hacker lethal control.

"What can you do about it?" asks Rabaey. First, to prevent jamming and denial of service attacks, "you create a failsafe mode," he says. If ever the device loses its link or detects that it is under attack, it should go offline and lock into a safe mode. And it should only be unlockable when a key code is transmitted to the user from a clinic or device administrator. If anyone tries to manipulate the device into doing something irregular, it goes offline.

Another approach, put forth by MIT professor Dina Katabi, is to conceal wireless transmissions between BMI components in a fog of static that is far louder than the signal itself. Each component would have the code that could subtract the loud noise, leaving behind the weak but meaningful signal. "Unless they have the code, it would be basically impossible for an intruder to sort the signal from the overwhelming noise," says Rabaey.

"Security should be built from the ground up," says Rabaey. Very often it is layered on later, from the top down. But if you start when you are still designing the physical layer of transmission, he says, you can build things into the die that make it really hard to spoof it, or change it. For instance, "If every chip had a unique number generator as part of its central design—you cannot change it, there is no software that allows you to mess around with that—that would be a big first step that you could start building from. You would always know if another device was pretending to be you," he says.

"It always helps to throw a little randomness into the code, too," he says. "If a wireless link is predictable, it's always going to be much easier to read."

Rabaey thinks such read-write devices are going to enhance human life and promote health for both disabled patients and eventually for healthy people, too. He imagines each of us having what he calls a personal "human Intranet," linking each person's sensors and devices together into their own medical, entertainment and educational network, which would require a powerful "personal firewall" to be secure.

"It is time to start thinking about this now," Rabaey says, "while we are still building the physical layer. Or we can just add security later, but by then it will be too late to do right." BE

Water 4.0

ENVISIONING A DIFFERENT TOMORROW

Civil and environmental engineering professor **David Sedlak's** new book, *Water 4.0: The Past, Present and Future of the World's Most Vital Resource* (Yale University Press, 2014), calls for major changes in urban water systems. "If they want to realize the full benefits of conservation, water utilities will have to accept the idea that they are no longer in the business of selling water," says Sedlak. "Rather, they are stewards of a limited resource." An excerpt follows.

David Sedlak
Civil and environmental engineering professor

Daniel McGlynn

Ever since the Romans pioneered Water 1.0, centralization has been the big idea behind urban water systems. In fact, this original design principle has been so potent that each of the subsequent upgrades was built on its foundation. Starting with the addition of filtration and chlorine disinfection on the front end of water distribution systems (Water 2.0), and continuing to the installation of biological wastewater treatment on the sewer end (Water 3.0) and beyond, modern water infrastructure is still guided by its original blueprint of ancient Roman-style aqueducts and sewers.

Centralized urban water systems are presently under considerable stress from a variety of overlapping factors. Increases in population density, changing precipitation patterns, competition for water resources and recognition of the need to leave more water in streams to protect aquatic habitats are driving a movement toward formerly unusable water sources, such as seawater and wastewater effluent, for our next drinking-water supply projects. Coincident with these changes, concerns about chlorine disinfection byproducts, endocrine-disrupting chemicals and pollution of surface waters with nutrients are causing us to rethink our ideas

about water and wastewater treatment. And a deeper awareness of the damage caused by stormwater runoff is leading to a new focus on urban drainage systems. But coming up with the money needed to expand the water supply portfolio, improve treatment efficiencies, and fix urban drainage systems at the same time that our long-neglected pipe networks and treatment plants are reaching the ends of their design lifetimes is a tall order.

Not surprisingly, most cities appear to be on the path of least resistance, sticking with the centralized systems that have served them so well. In essence, they are doubling down on bets that their existing systems are up to the coming challenges. This approach means that utility managers will do their best to meet growing water demands by expanding imported water systems. When the conventional mode of expansion is no longer possible, they'll turn to reverse osmosis membranes to convert sewage effluent or seawater into drinking water. To maintain the network of decaying water and sewer pipes and to reduce the frequency of combined sewer overflows, they will dig up the streets and build gigantic underground tunnels to keep excess runoff out of their treatment plants. And to pay for all of these new projects, they will turn to their customers, raising monthly bills at rates that are just low enough to avoid a serious backlash.

I am pretty confident that this approach will work in most places—at least in the short term. Money will keep the water flowing, but it won't always be pretty. Examples of the coming problems that will be faced are evident in Indianapolis, where homeowners can expect to pay an extra hundred dollars per month to cover the construction of new stormwater-bypass tunnels; in Southern California, where more political fights and rising bills are on the way as plans to expand potable water reuse programs advance; and in Perth, where citizens are absorbing the sticker shock of new desalination plants built to compensate for the effects of climate change on the local precipitation pattern. Painful decisions about urban water systems will be further complicated by uncertainty surrounding the effects of climate change on precipitation patterns and the unlikely prospect of significant new government investments in water infrastructure. In light of all of these factors, there is no way of knowing when the cycle of crises and expenditures will end.

In recognition of the problems associated with our current approach, some people have advocated for something different. They assert that the answer to our water problems can be found in the adoption of practices that reduce the amount of water passing through urban water systems. This belief grew out of the observation that water conservation can forestall the need to develop new water supplies. Conservation also saves energy and helps growing cities avoid costly investments in expanding the capacity of their sewage treatment plants.

The idea of reducing water use as a way of controlling runaway increases in water bills and simultaneously minimizing damage to the environment is intuitively appealing and often results in immediate economic benefits for utilities. Investing in efficiency should be a lot more effective than mindlessly plowing more money into the expansion of existing water systems. Unfortunately, urban water systems and the institutions that support them have evolved in ways that ultimately restrict the ability of conservation and related efficiency measures to solve our most pressing problems.

The first factor that prevents conservation from being a panacea is that water utilities have a limited number of tools they can use to change the behavior of their customers. The tools they do possess—namely, raising the price of water and offering rebates to offset the costs of installing water-saving devices—are often inadequate when it comes to achieving the full potential of conservation. If a utility really wants to reduce water consumption, these approaches will only go so far; serious conservation will require a fundamental change in public attitudes about the value of water and the role that water utilities play in determining how it can be used. Unfortunately, such changes tend to be unpopular with politically powerful constituencies such as real estate developers, libertarians, and members of anti-tax groups, who bristle at the idea of regulations that restrict personal liberties and increase the costs of home ownership.

Talented water utility managers are sometimes able to navigate the political process to bring about the necessary policy changes, especially if there is already an awareness in the community of the consequences of impending water shortages. But water utility managers are rarely at the top of the political hierarchy. When it is time to balance the goals of water conservation against economic development, political philosophy, and the desire of elected officials to please their constituents, these managers often find themselves unable to implement the kinds of changes needed to support their desired water-saving policies. Faced with the uncertainties of the political process, utility managers find it easier to return to more politically safe solutions involving backhoes, pipes, and concrete.

Engineering

In a new course, "Engineering, the Environment
is challenging his students to build more just and
rethinking the role engineers play in social issues.

STORY BY DANIEL MCGLYNN • PHOTOS BY NOAH BERGER

A COUPLE OF YEARS after studying mechanical engineering at the University of Michigan, Khalid Kadir was living in France trying to make it as a professional road bike racer. But the itinerant life as a cycling journeyman in the late 1990s was grueling, and he started looking for what was next.

So Kadir moved to California when a friend offered him a job at a Silicon Valley startup. Not long after, he decided to return to school. He was interested in international development work and thought that engineering was a good way to stay out of the fray of politics that bog down other well-meaning professions. "I became an engineer because I just wanted to do good," Kadir says. In 2001, he enrolled in Berkeley's master's program in environmental engineering and began studying with CEE professor Kara Nelson, who specializes in drinking water and sanitation systems in developing countries.

On the heels of completing his master's degree, while driving cross-country, Kadir stopped at a pay phone in Utah to call Nelson to ask how he did on his comprehensive exam. Nelson said he had done extremely well and asked him if he wanted to come back for a Ph.D. And he did.

Over the next few years, Kadir became an expert in using natural systems, ponds specifically, to manage wastewater as a development strategy. But he kept coming back to a nagging question: wastewater treatment ponds are relatively simple to build and maintain compared to other systems, but they don't get built in places that need them the most. Meanwhile, the problems of waterborne illness and disease persist. He wanted to know why. Kadir started taking courses beyond his doctoral requirements—courses in social theory, water policy, international development and economics.

Despite his earlier aversion to politics, Kadir came to understand that engineering projects, while framed in a technical context, relate directly to political currents, namely social structures like power and privilege. Building wastewater treatment ponds, he learned, isn't strictly about technology; it has more to do with land ownership and access.

"Technical experts draw a box around a technical problem. We call it a control volume," Kadir says. "We have inputs and outputs and we deal with what's inside the box. So when we draw the box around water in the Central Valley that contains nitrate, we don't look at undocumented laborers, we don't look at substandard housing, we don't look at that larger picture because that's not what our training tells us to do. We are there to deal with nitrate in drinking water. I started unpacking that in my own work and started asking about the bigger picture."

In order to get more on-the-ground experience and to study wastewater systems in another context, Kadir spent 2007 in Morocco as a Fulbright scholar. When he returned to Berkeley in 2008, he tried his hand at teaching as a graduate student instructor in the Global Poverty and Practice minor. During his last semester in spring 2010, Kadir was invited to a faculty meeting and was asked to be the lead lecturer for a global poverty course in the fall. Each semester his teaching load increases. "Teaching has forced me to keep my game up. I've read more in three-and-a-half years of teaching than in all my grad years," Kadir says.

Now Kadir occupies a unique position at the university: a lecturer with a strong technical background teaching largely non-engineering students. But that is changing: Kadir was recently named a Chancellor's Public Scholar, an appointment through American Cultures Engaged Scholarship (ACES), a university-wide program designed to bring community engagement and diverse perspectives into the classroom. He was then given the task of developing a course that teaches social justice concepts to engineering students.

"Certain people are stuck living on the margins. The forces that drove them to live on the margins are the places where we can apply engineering," Kadir says. "How do we make engineering part of larger solutions and not just technology pieces that we throw in and leave?"

KADIR'S NEW COURSE, "Engineering, the Environment and Society," is open to all university students, but most are engineers. In addition to reading environmental justice scholars and hearing from expert guest lecturers, the class also critiques case studies outlining the connection between design and placement of infrastructure projects and the impact on communities.

By exposing students to these concepts now, the goal is to create professionals better equipped to tackle large social problems and to understand their ethical responsibilities as technical experts. "Critical thinking just doesn't happen in courses where you are trying to figure out problems using mathematics or physics," says Oscar Dubón, the college's associate dean for equity and inclusion and an early advocate of the new course. "A lot of engineering problems involve complex or unclear social, political and economic issues. Providing students an opportunity to explore that is important."

One big draw for students in the class is the opportunity to work with community partners on actual engineering projects.

social justice

and Society," Khalid Kadir
equitable systems by

As the course unfolds, half of the class opts to work in teams of four or five with nonprofit organizations on active community-based projects. The projects include data analysis of air quality issues in a West Oakland neighborhood, working with partners in Richmond's Iron Triangle neighborhood to study and map areas affected by chronic storm flooding and trying to treat and reduce nitrate-laced drinking water in the Central Valley.

"Without exception, every community partner we talk to sees helping students learn this stuff as a priority," Kadir says. "They want engineers out there who think about these things."

Derek Hitchcock, an ecologist focused on urban watershed issues with the Richmond-based Watershed Project, is one of those community partners. Hitchcock is working with a student team on developing educational materials about low-impact development strategies, such as rainwater catchment and stormwater management that he can use to train his staff and community members.

The Watershed Project recently built a water-retaining bioswale along the Richmond Greenway, a public path and open space reclaimed from historic railroad use. The benefits of the project are hidden underground—that's why Hitchcock also asked the student team to build a portable demonstration model of how the bioswale works, so that the process is visible to community members.

Hitchcock has been working at the intersection of ecology and engineering for years and is excited to see engineering students exposed to community work early in their training. "It allows students to see how anything they design and build in the future will impact communities," he says. "Projects can have a positive or negative impact. So it is a good opportunity for them to understand that they can make the world more livable and not just build things that are structurally sound."

Two other student teams are involved with water projects in California farmworker communities. "The students realize nitrate in the water is a very serious problem, and you have to attack the problem from all angles," says Shen Huang, a technical analyst with the Community Water Center (CWC), an organization working on nitrate contamination in drinking water in the Central Valley. Huang is an MIT-trained mechanical engineer with a background in community-based development.

The students working with CWC visit families in the unincorporated farming town of Monson, between Fresno and Bakersfield, to test the effectiveness of home-based water filters. Nitrate contamination is a byproduct of industrial agriculture and most California farmworker communities that get their drinking water from private wells are dealing with some level of exposure. There is clear evidence that high nitrate levels in drinking water are connected to cancer, birth defects and blue baby syndrome.

In Monson, students visit families when drawing samples for their filter tests. While in the homes, students get the chance to better understand some of the challenges related to purchasing and maintaining their off-the-shelf reverse-osmosis filters. "It's like stepping out of the book and actually being in the story," Huang says.

While access to engineering expertise for some of California's marginalized communities is a big theme of the class, an undercurrent of the course is the idea of access to engineering as a profession for students interested in pursuing community development work.

"I didn't even know about engineering until I got here," says Areidy Beltran, a fourth-year earth and planetary science major who is working with the Community Water Project. She attributes her participation in the class, in part, to her interest in pursuing civil engineering in graduate school. "My main interest is developing sustainable and simple technologies to improve environmental conditions for underrepresented minorities in the U.S., as well as for people abroad without sufficient resources," she says. "This class puts it all together—it gives examples but also includes the science."

Beltran is the first member of her family to attend college. She says the introduction to the social justice concepts that apply to her as a first-generation student and also as a scientist have been eye-opening. After one lecture about power and privilege in the U.S., she remembers thinking, "I was a statistic on the board. I can actually talk about experiences based on those statistics. It is weird to see other people learning about you when you are the subject sitting in class—it was really interesting to see that."

Kadir looks forward to the end of the class, when students submit reflective essays on their own positions of power, privilege and developing sense of professional ethics. He also wants to see the course assessments to figure out how the vision aligns with actual learning outcomes.

"I hold these different fields in my hands, and that can be challenging at times. I see myself as a translator because I end up in between these places where people speak different languages," Kadir says, referring to the separation between the technical and the political. "But essentially, that's what teaching is at some level." BE

Introducing (ES)²

Berkeley requires all undergraduates to take at least one American Cultures (AC) course. There are hundreds of American Cultures courses to choose from across the university.

In 2011, the American Cultures program expanded with the American Cultures Engaged Scholars (ACES) program.

The latest ACES course is "Engineering, the Environment and Society," also the first American Cultures course offered by the College of Engineering. "Through the ACES program, students have the opportunity to engage communities in real engineering issues around water quality and air quality, so that is phenomenal," says Oscar Dubón, the college's associate dean for equity and inclusion.

Most of the class consists of first-year engineering undergraduates who are part of a new program called Engineering Scholars=Engaged Scholars, or (ES)², which is funded by the GM Foundation. The (ES)² program is intended to attract talented students from diverse backgrounds to the college through community engagement.


Daniel McGlynn

2010+

Christopher Ategeka (B.S.'11, M.S.'12 ME) was named to *Forbes'* "30 Under 30" list of social entrepreneurs in 2014. Ategeka was recognized for founding CA Bikes, an organization in rural Uganda that produces bicycles and wheelchairs to facilitate transport to health care services and schools (see *Forefront,* fall 2011).

Lorenzo Einaudi (M.Eng.'12 IEOR) is moving back to the U.S. from Chile to work on a greenfield project, a new seamless pipe manufacturing facility, in Houston.

Thomas Emery (M.Eng.'13 ME) moved to Ann Arbor, Michigan last summer to work as a calibration engineer for General Motors, writing software for various features in automobiles. "I am loving the job so far," he says, "because I am rarely at my desk and mostly out in the car."

Guillermo Garcia (Ph.D.'12 ME) co-founded Heliotrope Technologies to develop new materials and manufacturing processes for electrochromic devices, such as energy-saving smart windows. Garcia has co-authored six articles for journals, including *Nano Letters* and *Advanced Optical Materials.*

David Kalinowski (M.Eng.'13 IEOR) is working on the supply chain at Tesla Motors and offers this career advice: "You should love and believe in what your company is doing—that is what is keeping me at Tesla."

Viraj Kulkarni (M.Eng.'12 EECS) returned to India and got married. He and his wife have founded Algokraft Engineering, a big data software and technology company.

Daniel Lee (M.Eng.'13 MSE) is working at the Jet Propulsion Laboratory and creating his own show on the gaming website, twitch.tv, on the side.

Zhou Lin (M.Eng.'12 ME) is working with a bank in China to finance engineering projects, focusing on energy-related projects from coal and natural gas to wind and solar.

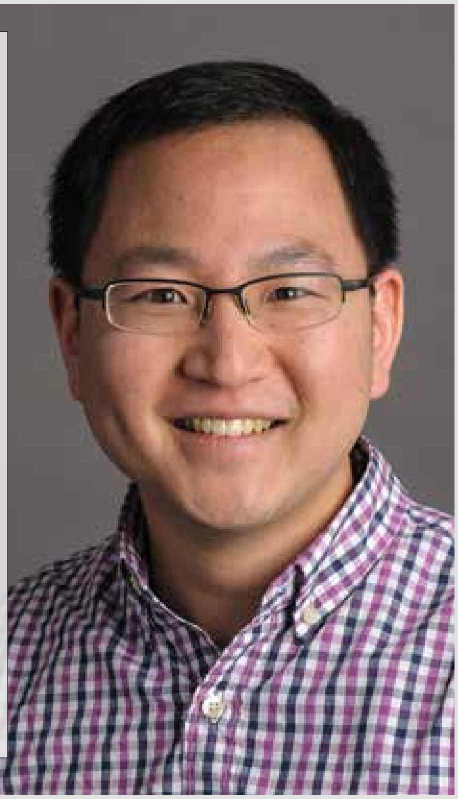
Eric Mai (M.S.'10 CEE) and **Jerry Jariyasunant** (Ph.D.'11 CEE) received CNN's "Top 10 Inventions" award for their product, Automatic, a device that pulls data about engine conditions and driving habits from dashboard computers. It can also remember where your car is parked. The product made Apple's top holiday gift list in 2013, and Fast Company called it a "visionary gadget that makes any driver more fuel-efficient." While at Berkeley, the pair also collaborated on "BayTripper," an app for real-time public transportation information.

Grace Yayun Wang (M.Eng.'13 IEOR) is running an organization called Consulting Incubation Network, which helps undergraduate and graduate students get into the consulting industry through training, mock interviews and one-on-one mentoring.

Memorial Stadium goes Kabam

Michael Li (B.S. '01 EECS) is the founder and general manager of Kabam, one of the world's leading creators of free-to-play web and mobile games. Li attributes part of the company's origins to his time as a Berkeley student; in Engineering 110, a venture design course, he wrote the business plan that would later become the underpinnings of Kabam. In the fall of 2013, Kabam pledged $28 million over 15 years to purchase the naming rights to the remodeled Memorial Stadium, the largest college field naming rights deal in the country. As part of the deal, the gaming company will also provide student scholarships and internship opportunities, and offer game day tickets to 500 veterans and their families every season. "This is a great Cal story," says Sandy Barbour, the university's athletic director.

STORY BY DANIEL MCGLYNN • PHOTO COURTESY KABAM



2000+

Soyoung (Sue) Ahn (M.S.'01, Ph.D.'05 CEE) joined the faculty at the University of Wisconsin, Madison as an assistant professor of civil and environmental engineering in 2006 and is now an associate professor. Her research interests are in traffic flow theory and operations, intelligent transportation systems applications and traffic operation impacts on environment and safety.

Kushal Chakrabarti (B.S.'04 EECS) has returned from a year off after launching Vittana, a micro-lending non-profit organization (see *Berkeley Engineer,* spring 2012). After travelling 100,000 miles over five continents, he offers these newfound bits of wisdom: 1) "People are the same everywhere: Moms worry, boys try to impress girls and everyone just wants to be seen"; 2) "Never try to bribe a Bangladeshi border guard"; and 3) "Smile, even—especially—if you don't feel like it."

Greg Lukina (B.S.'05, M.S.'06 CEE) has joined David Lyng Real Estate as director of business development. Previously, he was a senior manager with Cahill Contractors in San Francisco.

Juan Carlos Muñoz (M.S.'01, Ph.D.'02 CEE), associate professor of transport engineering at the Pontifica Universidad Católica de Chile, serves as associate dean of academic affairs in the school of engineering. In 2003, Muñoz served as advisor to the Minister of Transport and Telecommunications for Transantiago, the most ambitious transport reform undertaken by a developing country, according to the World Resources Institute. Last fall, Muñoz announced the successful implementation of a low-cost design to improve traffic patterns at a notoriously congested transfer station, which increased station capacity by 15 percent.

Ehsan Saadat (B.S.'06 BioE) provided medical care for Boston Marathon bombing victims last year as a third-year resident in orthopedic surgery at Harvard Medical School. Saadat studied orthopedics at the UCSF School of Medicine and says, "Every day in the operating room, orthopedics lets me dovetail my knowledge of biology and engineering with human anatomy."

Nima Shomali (B.S.'08 ME) recently spent a year in Afghanistan helping to rebuild the country's economy in his role as a senior strategy and innovation consultant for IBM. Shomali earned an MBA at NYU and is also an alumnus of the London Business School. He worked in investment management at Goldman Sachs, designed jet engines for the F22 Raptor and F35 joint strike fighter planes for Pratt and Whitney and designed satellites and ground-based observatories for NASA as part of Berkeley's Space Sciences Laboratory. He also supervises a sanitation project in southern Honduras with the state health ministry and Save the Children.

SEND YOUR CLASS NOTES to **berkeleyengineer@coe.berkeley.edu,** or mail to *Berkeley Engineer*, UC Berkeley College of Engineering, McLaughlin Hall #1704, Berkeley, CA 94720-1704.

Tundra scientist

Geophysicist **Susan Hubbard** (Ph.D.'98 CEE) leads a research team from the Lawrence Berkeley National Laboratory in Barrow, Alaska—the northernmost city in North America—as part of the 10-year Next-Generation Ecosystem Experiment (NGEE). The NGEE is a collaboration between scientists and engineers who are trying to better understand changes in the Arctic tundra, so that they can improve climate predictions. Hubbard studies the structure beneath the subsurface to detect thawing that could lead to the release of greenhouse gasses from organic matter trapped below ground. Despite below-freezing temperatures and the threat of polar bears, Hubbard sends this report back from the field: "The data have been gorgeous. There is so much good energy. So it's very, very fun."

BARROW OWL PHOTO: ROY KALTSCHMIDT/LAWRENCE BERKELEY NATIONAL LABORATORY

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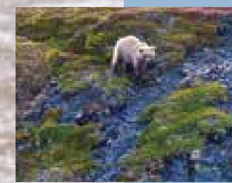


1990+

Robert Bertini (Ph.D.'99 CEE) is a professor of civil and environmental engineering at Portland State University, where he directs the Portland Sustainable Transport Lab and chairs the transportation research board committee on traffic flow theory. Recipient of a National Science Foundation CAREER award, Bertini has also served as deputy administrator of research and innovative technology at the U.S. Department of Transportation and was a visiting professor at Delft University of Technology in the Netherlands.

Gary Fedder (Ph.D.'94 EECS) has been named associate dean for research in engineering at Carnegie Mellon University. Fedder's research interests are in MEMS, specifically in design, fabrication and control of sensor- and actuator-based systems. He will continue to direct the Institute for Complex Engineering Systems, which fosters multidisciplinary research and relationships between the university, government and industry.

Kara Kockelman (B.S.'91, M.S.'96, Ph.D.'98 CE) is a professor of transportation engineering at the University of Texas at Austin. She was named a "World's Top 100 Young Innovator" by MIT's *Technology Review* in 2002 and received two American Society of Civil Engineers awards, in 2007 and 2010. In 2008, she was named "Woman of the Year" by Women in Transportation Science, Heart of Texas chapter.

Sunil Kulkarni (B.S.'93 ME) studied law at UC Hastings, was a litigation partner at Morrison & Foerster and served as senior counsel for the University of California. Last August, Governor Brown appointed him to a judgeship at the Santa Clara County Superior Court. According to the South Asian Bar Association of Northern California, he will be the first South Asian American judge ever appointed in Northern California.

1980+

Scott Ashford (M.S.'86, Ph.D.'94 CE) was appointed dean of Oregon State University's College of Engineering. A faculty member at OSU since 2007, Ashford has held the position of the Kearney Professor of Engineering and chaired the School of Civil and Construction Engineering.

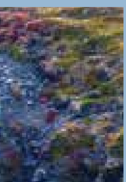
Carlos Banchik (M.S.'87 ME) is the founder of Innova Technologies, a leading engineering firm specializing in monorail and people-mover transit. Innova has worked on such projects as the Las Vegas Monorail and the Hoover Dam Bypass Bridge. Banchik is the president of the International Monorail Association.

Tzu-Yin Chiu (Ph.D.'83 EE), CEO of the Semiconductor Manufacturing International Corporation, and **Mark Liu** (M.S.'80, Ph.D.'83 EE), president and co-CEO of the Taiwan Semiconductor Manufacturing Company, received 2013 distinguished alumni awards for electrical engineering from the Department of Electrical Engineering and Computer Sciences.

Sue Holl (Ph.D.'80 MSE) has been a member of the engineering faculty at Sacramento State University since 1980. Now material sciences department chair, Holl has helped establish the Society for Manufacturing Engineers and the American Institute of Aeronautics and Astronautics at the college. Last year she was asked to deliver the Livingston Faculty Lecture, a distinction given to faculty members who go above and beyond general teaching requirements. A teacher for over 33 years, Holl says, "It is odd to decide what you want to do for the rest of your life at age 20 and still love it, but I do. I never get sick of teaching."

Michael Luby (Ph.D.'83 CS), vice president of technology at Qualcomm, and **Yoky Matsuoka** (B.S.'93 CS), vice president of technology at Nest, received 2013 distinguished alumni awards for computer science from the Department of Electrical Engineering and Computer Sciences.

Timothy D. Sands (B.S.'80, M.S.'81, Ph.D.'84 MSE) was appointed the 16th president of Virginia Tech, effective June 2014. Sands began his career at Lawrence Berkeley National Laboratory in 1984 and later returned to campus as a professor in materials science and engineering. Sands moved on to Purdue University as executive vice president for academic affairs and provost. He also served as acting president in fall 2012, launched Purdue's online teaching



Hitting the ground with sledgehammers generates measurable seismic waves that can reveal whether or not the deeper permafrost layers are frozen.

Hubbard uses a variety of above- and below-ground data to study complex relationships between land surface, active layer and permafrost.

The researchers use geophysical tools—seismic, radar and electrical—to determine what's beneath the ground, while cameras suspended from kites collect high-resolution aerial photos of the landscape.

Hubbard's team measures the subsurface with ground penetrating radar, which sends electro-magnetic waves into the ground that bounce off the interface between sublayers. The measurements are taken by pulling radar-equipped sleds across the Arctic tundra, either on foot or behind a snowmobile.

platform and oversaw efforts that resulted in the highest first-to-second year retention and four-year graduation rates in Purdue's history.

Ken Sasaki (B.S.'87, M.Eng.'89 CE) has been reappointed to the California Building Standards Commission, where he has served since 2012. Sasaki is a principal at Wiss Janney Elstner Associates Inc.

Daniel L. Wade (B.S.'89 CE) is the new director of the San Francisco Public Utilities Commission's $4.6 billion Water System Improvement Program (WSIP), where he will oversee four geographic regions with 16 projects under construction. Wade earned his M.S. in civil and geotechnical engineering at Virginia Tech and became vice president for dams and hydropower services for the wet infrastructure firm MWH America before joining WSIP. He serves on the board of directors of the U.S. Society on Dams.

1970+

Charles H. Ballard (M.S.'74 EECS) was elected vice president of the Pennsylvania School Boards Association.

CLASS OF 2013: Last October, the Department of Civil and Environmental Engineering inducted eight civil engineering alumni—including academicians, founders of engineering firms and an official of the Smithsonian Institution—into the CEE Academy of Distinguished Alumni.

Left to right: Gregory Fenves, Jefferson Hilliard, John Koon, Brenda Myers Bohlke, Ashraf Habibullah and George Tchobanoglous. Not pictured: Wayne Clough and J. Michael Duncan.

PHOTO CREDIT SLAVA BLAZER

Ballard has served on the board for the East Penn School District for more than 18 years, a district that serves over 8,000 students in the Emmaus, Pennsylvania region.

Ebrahim Nana (B.S.'73 IEOR) is the president of NanaWall Systems, a company that produces environmentally friendly glass walls that absorb sound, retain heat and protect against harsh weather conditions. NanaWalls were used in the renovation of Berkeley's Memorial Stadium; at the VIP level, 175 feet of NanaWalls allow an unobstructed view of the home side and a panorama of the Bay Area.

1960+

Anil K. Chopra (M.S.'63, Ph.D.'66 CE), Johnson Professor of structural engineering at Berkeley, received the 2013 Normal Medal, the oldest and most highly prized award of the American Society of Civil Engineers (ASCE) for his paper, "Earthquake Analysis of Arch Dams: Factors to be Considered," published in ASCE's *Journal of Structural Engineering.* This is Chopra's fourth Normal Medal—a rare distinction in itself.

Mahesh Desai (M.S.'66 ME) has worked in a variety of engineering fields for the last 48 years, including nuclear power, disk drives, tandem servers and integrated defense systems. He now runs a consulting business in San Jose.

Charles Markee (B.S.'60 EE), author of the young adult novel, *Irish the Demon Slayer,* has released a sequel in his Otherworld Tales series entitled *Demon Invasion.* After retiring from his engineering career in 2001, Markee says this venture into writing has been an exciting change from his last technical position in Silicon Valley.

1950+

B.J. Barden (B.S.'53 ME) spent two years in the U.S. Army at the Benicia Arsenal, accelerating his path to U.S. citizenship before joining IBM in San Jose in 1956. He then transferred to the New York headquarters, where he stayed for 10 years. An early retirement in 1987 allowed him and his wife, Marie, to return to the Bay Area and travel the world. When at home in San Francisco, Barden volunteers as a docent at the Hyde Street Pier and San Francisco Maritime National Historical Park.

Farewell

This winter, the college lost three professors who came to campus as undergraduates in the 1940s:

- **Frank E. Hauser** (B.S.'48 ME, M.S.'50 MSE, Ph.D.'57 ME), professor emeritus of mechanical engineering, died in November at age 89. A member of the Berkeley faculty for 36 years, Hauser researched plastic deformation and causes for fatigue and fracture in materials. He also served as an expert witness for court cases involving metallurgical engineering. In addition to membership in the American Society of Metals and the American Association for the Advancement of Science, Hauser was a lifelong member of the Sierra Club.

- **Charles W. Radcliffe** (B.A.S.'45, B.S.'47, M.S.'50, D.Eng.'56 ME) died in December at age 91. Radcliffe served in the U.S. Navy during World War II. In 1956, he joined Berkeley's mechanical engineering faculty. Radcliffe was a member of the International Society for Prosthetics and Orthotics, traveling the world to deliver lectures. He invented the 4-bar Radcliffe knee and SACH (solid ankle cushion heel) foot and worked with medical colleagues to improve techniques for fitting artificial legs.

- **Jack Washburn** (B.S.'49, M.S.'50, Ph.D.'54 Metallurgy), professor emeritus of materials science and engineering, died in October at age 92. Washburn served in the U.S. Navy during World War II. He joined the Berkeley faculty soon after graduation and was a principal investigator in the materials science division of Lawrence Berkeley National Laboratory. His research focused on materials properties, dislocations and ion implantation semiconductors. Washburn received the Berkeley Citation in 1996.

Bruce Del Mar (B.S.'37 ME) died in February at age 100. Del Mar worked at Douglas Aircraft, where his most significant contribution was his patented method for pressurizing commercial aircraft cabins. In 1952, he started his own aviation and defense company, where he developed tools used in weapons training for the U.S. military and NATO. Del Mar then switched from aerospace engineering to developing ambulatory heart monitoring. His company, Del Mar Avionics, became the leading producer of medical devices worldwide and led the transition from hardware-intensive analysis devices to sophisticated software-based systems. Several of Del Mar's inventions are on display at the Smithsonian Institution's National History and Air and Space museums in Washington, D.C.

Philip T. Gardner (B.S.'40 ME) died in September at age 95. Gardner shipped out with the Merchant Marines to the Pacific and Indian Oceans during World War II, then returned to Los Angeles after the war to begin a 34-year career with the Consolidated Vultee Aircraft Corporation. Gardner designed equipment used in drilling oil and gas wells for the National Supply Company and was an aircraft design engineer for Lockheed Aircraft. He later developed and tested the country's first intercontinental ballistic missile.

Mark Ketchum (M.S.'77, Ph.D.'86 CE) died in February at age 60. A prominent Bay Area bridge designer and structural engineer, Ketchum co-founded the engineering firm OPAC in 1992. He has been internationally recognized for engineering projects and bridges throughout the world, including the pedestrian crossing over Interstate 80 in Berkeley.

Bhaskar Thapa (Ph.D.'94 CEE), a lead designer of the Caldecott Tunnel's fourth bore, had worked on the project for eight years before his death in June at age 49. At the ribbon-cutting ceremony in November, Thapa was recognized posthumously for his contributions to the project, and his family received a standing ovation. "Bhaskar enjoyed seeing the fruits of his labors when the tunneling and final lining were completed for this challenging project," said Michael McRae, principal with Jacobs Associates, the engineering firm working on the tunnel. "He was incredibly proud of this achievement, and we often spoke about the pride he would feel when driving his two boys and wife through the tunnel."

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Berkeley engineers Julie Haduong, BioE '14, and José Carrillo, EECS '14, love a good challenge—so they've teamed up to co-chair this year's Senior Class Gift campaign. Their goal? Break the record set by the Class of 2013 by inspiring at least 484 of their classmates to make a gift to the Berkeley Engineering Fund before graduation.

Julie and José's proud work captures the spirit of giving back that makes Berkeley Engineering what it is today.

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