interface ®

Energy **Watch**

12

features:

departments:

8

30

**Printed with soy-based ink on paper
that is 30 percent post-consumer
waste, 55 percent recycled and
FSC-certified. CALIT2's Interface:**

SAVES 40 trees
 a year's worth of oxygen for 20 people

SAVES 17,128 gallons of water
enough for 1,016 eight-minute showers

**SAVES 28,560,000 BTUs of
 energy**
*power for the average household
for nearly four months*

**ELIMINATES 116 pounds
of waterborne pollutants**

**ELIMINATES 1,895 pounds
of solid waste**
*enough to fill more than
400 garbage cans*

**ELIMINATES 3,731 pounds
of greenhouse gas**

innovate | integrate | incubate | ignite

2

Picture
THIS

Anna Lynn Spitzer

COLLABORATION ADDS A COLORFUL, CAPTIVATING ENERGY CHANNEL TO YOUR TV OPTIONS

▼ PCMCIA CAR

HƎMI
IN 3

VIDEO L/MONO-AUDIO-R

AV IN 3

H/PΩ

3

Ahhh... finally home from another strenuous day at work. You're settled on the couch, a cold drink in one hand and the television remote in the other.

Before switching on the football game, a movie or the latest episode of "The Bachelor," though, what if, with a jab at the remote button, you could switch the channel to a colorful and easy-to-read review of your home's energy usage for the day, right there on your big-screen TV?

You might see that your air conditioner and appliance usage are normal but that your miscellaneous plug load consumption is way up. A quick trip into the study confirms the spike: a laptop plugged in and running, two phone chargers hanging from their outlets ... and oops, a desk lamp left burning all day.

A project underway at the CalPlug Center at CALIT2 is making this simple home energy monitor a reality. Called the Energy Channel, version 2 (EC 2.0), the user-friendly application is a collaboration with Southern California Edison that relays instant power usage – detailed energy information from a home's SmartConnect meter - to a TV display in 5-second increments. The goal: easy access to real-time information, increased awareness and, developers hope, a call to action.

Serv. Account: 2-932-1007-64
SMITH, JOHN

⚡ Energy Channel

10:00 AM
Tue March 21

80°
Irvine, CA

Last Week Energy Usage

Your Home: Apartment
2 bed, 2 bath

18%
15%
28%
39%

Avg. Similar Home in
Irvine, CA

28%
12%
25%
35%

Current Power Demand

NOW
2,045 w
DAILY PROJECTED
1,097 w

SO FAR TODAY
55 kWh
DAILY AVG.
125 kWh

30%
14%
21%
35%

Your Home		Avg. Similar Home	
Air Conditioning:	237.6 kWh	Air Conditioning:	199.2 kWh
Electrical Vehicle:	514.8 kWh	Electrical Vehicle:	415 kWh
Home Appliances:	369.6 kWh	Home Appliances:	581 kWh
Misc. Energy Use:	198 kWh	Misc. Energy Use:	464.8 kWh

Great job saving energy in home appliances. Try to schedule your laundry after 7 pm this Sunday.

■ Air Conditioning ■ Electrical Vehicle ■ Home Appliances ■ Miscellaneous Energy Use

Lower your bill: Enroll in a SCE DR program at https://www.sce.com/drp

---

"People still have a hard time accessing and understanding energy information," says Sergio Gago, CALIT2 information technology specialist and EC 2 .0 overseer. Even though all homes in Southern California now have smart meters, those meters send data to SoCal Edison servers only once each day, so even customers who log into online accounts are seeing data that are at least 24 hours old. "Research tells us that in order to educate people, you need to provide feedback as soon as possible."
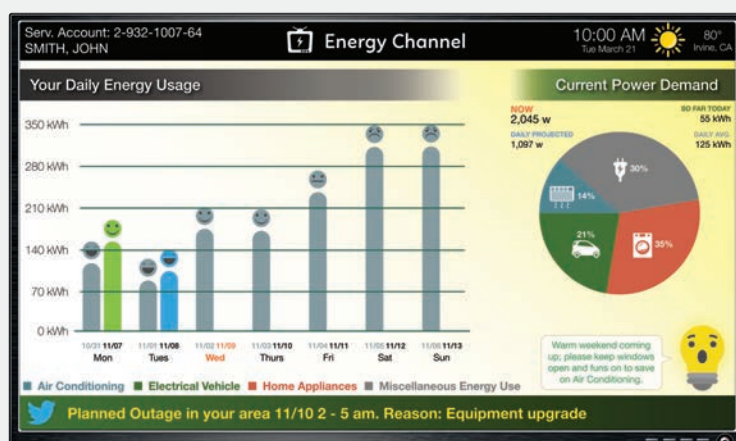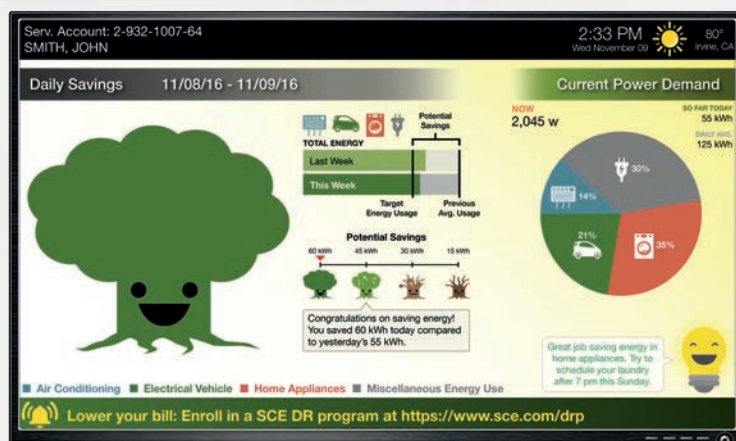
Research also shows that providing instantaneous feedback to consumers can reduce energy consumption by 5-15 percent.

Gago says that miscellaneous plug loads can be responsible for a big chunk of energy usage – as much or more than big-ticket items like air conditioning or heating. "People think AC uses a lot of energy but then they realize they are connecting appliances that can add up to twice the energy."

Where the average homeowner sees a large-screen TV on the living room wall, Gago and his research team saw an opportunity. Because the television is on for

Second screen (middle right):

Serv. Account: 2-932-1007-64
SMITH, JOHN
2:33 PM
Wed November 09
80°
Irvine, CA

Daily Savings   11/08/16 - 11/09/16

Current Power Demand

NOW 2,045 w
SO FAR TODAY 55 kWh
DAILY AVG. 125 kWh

Potential Savings
TOTAL ENERGY
Last Week
This Week
Target Energy Usage   Previous Avg. Usage

Potential Savings
60 kWh   45 kWh   30 kWh   15 kWh

Congratulations on saving energy! You saved 60 kWh today compared to yesterday's 55 kWh.

30%
14%
21%
35%

Great job saving energy in home appliances. Try to schedule your laundry after 7 pm this Sunday.

■ Air Conditioning ■ Electrical Vehicle ■ Home Appliances ■ Miscellaneous Energy Use

Lower your bill: Enroll in a SCE DR program at https://www.sce.com/drp

Third screen (bottom right):

Serv. Account: 2-932-1007-64
SMITH, JOHN
⚡ Energy Channel
10:00 AM
Tue March 21
80°
Irvine, CA

Your Daily Energy Usage

Current Power Demand

NOW 2,045 w
DAILY PROJECTED 1,097 w
SO FAR TODAY 55 kWh
DAILY AVG. 125 kWh

350 kWh
280 kWh
210 kWh
140 kWh
70 kWh
0 kWh

10/31 11/07 Mon | 11/01 11/08 Tues | 11/02 11/09 Wed | 11/03 11/10 Thurs | 11/04 11/11 Fri | 11/05 11/12 Sat | 11/06 11/13 Sun

30%
14%
21%
35%

Warm weekend coming up; please keep windows open and fans on to save on Air Conditioning.

■ Air Conditioning ■ Electrical Vehicle ■ Home Appliances ■ Miscellaneous Energy Use

Planned Outage in your area 11/10 2 - 5 am. Reason: Equipment upgrade

several hours a day in most American homes, and TV screens most often are the residences' largest displays, CalPlug researchers realized they could be the perfect interface for delivering easy-to-digest energy information.

SoCal Edison perceives real potential in the project. Its Emerging Technology Department approved funding and its Demonstration and Pilots Department is working hand-in-hand with CalPlug on app development. "Based on other behavioral programs that have been launched at SCE, it has been proven that consumer behavioral-based products help save energy," says Shamahrukh Marghoob, SCE product development project manager. "This particular research includes a TV channel and an app that helps residential customers be aware of their energy usage and how much money they can save if they change their energy-usage patterns. It also shows other relevant factors that are useful from the consumers' point of view."

Energy Channel started at CalPlug in 2013 as a collaboration with two sponsors: DirecTV and So Cal Edison. Researchers programmed the first version into a set-top box, but soon realized that approach constrained accessibility. "We wanted to keep the solution affordable for everyone," says Gago. "If you have to be a DirecTV

customer to get the channel, we didn't consider that available to everyone."

The team had a challenge or two to overcome, though, in order to implement EC version 2.0: TV screen as app interface. Smart meters communicate data through ZigBee, an inexpensive wireless language that connects Internet-of-Things devices to each other. TVs of the future most likely will have ZigBee capability but today's televisions – even the most app-oriented models – don't.

So researchers designed a workaround.

They loaded the energy channel onto a microcomputer and inserted it into a dongle, a small hardware connector. The 4.5-inch x 1.25- inch dongle resembles a flash drive and can be plugged into the TV's HDMI port. A ZigBee connector is then attached to the microcomputer stick, and voila!

Any television with an HDMI port can download the app and display a variety of colorful and compelling energy usage information. Not only does it draw nearly real-time data from the home's smart meter, but the plug-and-play app can display year-to-year comparisons of energy usage, drawing on the meters' three-year repository of stored information. "You can

compare how you're doing today with the same day last year," Gago says.

EC 2.0 is imaginative, engaging and easy enough for a child to understand. Four pages rotate every 30 seconds, each displaying a different view of the user's energy consumption. There's a current-demand pie chart that updates every five seconds, breaking down real-time usage by percentage into categories: HVAC, appliances, electric cars and miscellaneous plug loads.

There are daily and monthly usage comparisons, notification banners, a live SCE Twitter feed, charts that illustrate available energy savings and comparisons to similar homes, as well as tips based on household usage. There's even a personified tree, whose visage changes from lush, green and smiling to barren, brown and decidedly unhappy, depending on the resident's energy conservation efforts.

In addition to its smart-meter connection, EC 2.0 uses Wi-Fi to draw data from a number of sources: Zillow, SCE's Twitter feed and the Weather Channel. These

help the app compare similar houses in comparable neighborhoods, forecast weather-driven spikes in usage and offer SCE updates and energy-saving tips.

Machine learning algorithms allow the app to recognize normal patterns. If a consumer usually does laundry on Sunday afternoon and plugs in his electric car every night at 9 p.m., the app learns that. If a homeowner's TV is on every afternoon when her children come home from school, the app learns that, too. If an energy spike or other unusual event occurs at an unexpected time of day, a blinking light affixed to the television – regardless of what channel the viewer is watching – notifies the user, who can switch to the Energy Channel for specific details.

And, using crowdsourcing data, the app provides users with conservation goals based on neighbors' energy usage. "The app provides tailored feedback," Gago says. "It's going to provide you with the option to do better next time."

Also in development is a mobile version with all the capabilities of the TV app that can be stashed in a purse or pocket.

Future plans for the project include an effort to improve plug load disaggregation. Disaggregation, a "hot topic" in energy management, according to Gago, means figuring out which small appliances or electronics account for how much of each outlet's energy output. The plan entails gathering information from consumers in the app's startup menu. "We will ask our users to tell us what kind of appliances they have, what time they come home from work and other information. That will help us to define usage patterns," he says. "We believe if we're able to provide you with this level of disaggregation, even if it's not super-detailed on every single device, it will provide an overview [of each plug's activity]."

SCE, which funded the project with $250,000 over the last year, viewed a demonstration of the technology in March at company headquarters in Rosemead, Calif. Marghoob says Edison could invest in a consumer-ready version if it determines that the app is cost-effective and actually could provide energy savings.

She estimates that if only 10 percent of SCE's 100,000 customers tuned into EC 2.0, 13 million kilowatt hours of electricity could be saved annually. This is enough to power at least 1,000 additional homes, or, put another way, the equivalent of nearly $2 million annually in consumer savings.

SCE currently is investing billions of dollars to expand and prepare its electricity infrastructure for new distributed technologies, including solar, energy storage and electric vehicles, according to Gary Barsley, SCE emerging technology program manager. In addition, Barsley says, "We have active programs to assess and help accelerate market adoption of helpful new energy-related technologies for our customers and our grid. The Energy Channel 2.0 project…is a successful example of this."

SCE's Marghoob calls the collaboration between CalPlug and the utility company "very effective."

"That's why the project is more improved and advanced [than EC 1.0]," she says. "This is helping to produce a market-ready, consumer-friendly product that improves customer satisfaction and leverages existing SCE technology infrastructure to deliver cutting-edge technology for customers." *it*
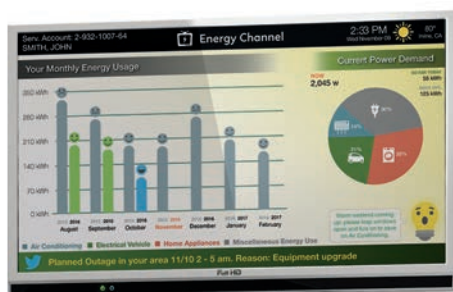
PASSIO
PROBLEM

8

A DEDICATED STARTUP IS PUTTING A SPIN ON PERS

NATE
SOLVERS

✒ William Diepenbrock
🎨 Sharon Henry

ONALIZED MEDICINE

What started as a challenge to UC Irvine students in an undergraduate bioengineering class has sparked a novel medical tool that could revolutionize how doctors treat injuries for patients with diabetes.

Bridging the gap between inspiration and action was something simple – collaboration among students, researchers and university agencies that help turn ideas into new business enterprises.

That collaboration spawned Syntr Health Technologies, which is developing a proprietary device based on the classroom challenge. The medical device could radically accelerate the healing of ulcerated foot wounds in diabetic patients – the kinds of wounds that can lead to life-threatening amputations.

"Our company is the result of an encompassing effort by multiple departments at UCI, working together to inspire innovation. Without that effort, I don't think any one of us would be where we are right now," Syntr Health Technologies CEO Ahmed Zobi says.

Zobi, 23, was a student in UCI Professor Michelle Khine's yearlong Bioengineering Innovation and Entrepreneurship (BioENGINE) course when his class project team was tasked with a challenge: Create a way to speed up processing of adipose tissues – what most of us would call fat. After accepting the task, Zobi had a brainstorm: he saw a way to radically speed the process and volume of fat processing, and with the collaboration and input of the engineering team, succeeded in the creation and validation of a prototype. It was so effective that Zobi and several colleagues were encouraged to continue developing the tool after the class ended.

They formed the heart of Syntr Health.

Guided by professors and university mentors, they also added a new member to the team – Chief Medical Officer
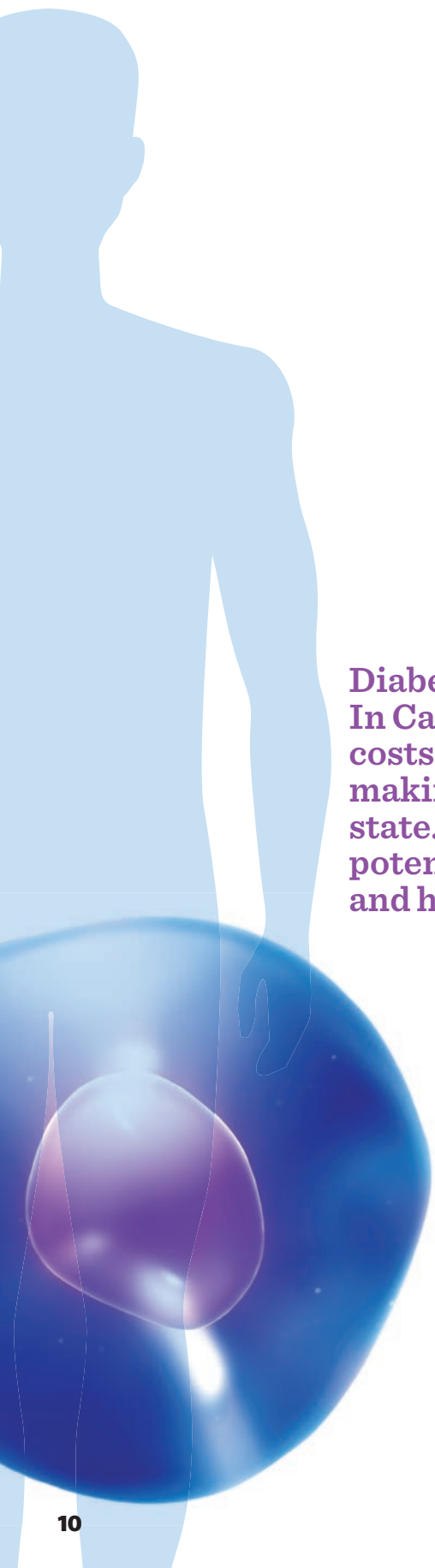
Derek Banyard, a surgeon-scientist in training whose research emphasis is optimizing the regenerative potential of human adipose tissue.

In just over a year, the team progressed through 10 design stages and five prototypes to create a tool that goes far beyond anyone's expectations.

In simple terms, the tool takes fat extracted through liposuction techniques and forces it through microchannels etched into an acrylic chip. The process enriches – and possibly reactivates – adult stem cells embedded in the fat. Often damaged and quiescent in diabetes patients, these awakened cells are injected into a diabetic patient's wound, where they jump-start healing.

> **Diabetes is a huge epidemic. In California alone, diabetes costs about $16 billion a year – making us the most expensive state. Our treatment holds the potential to slash those costs and help thousands of patients.**

Other researchers have devised similar approaches. But, unlike those, Syntr's automated tool can accomplish the entire task in less than 30 minutes, generates a much higher concentration of stem cells and does it all without applying chemicals to the fat. The result: a relatively simple and highly accessible outpatient treatment.

Banyard says the treatment has potential applications far beyond diabetes, but the company chose wound-healing as its focus because of the opportunity to make a tremendous impact on people's lives.

Nearly 30 million children and adults in the U.S. have diabetes – more than 9 percent of the population – and 1 in 10 health care dollars is spent treating diabetes and its complications, according to the American Diabetes Association.

Untreated, ulcerated wounds in diabetics can lead to amputation, which in turn can shorten the lifespan of patients.

"Diabetes is a huge epidemic. In California alone, diabetes costs about $16 billion a year – making us the most expensive state," Banyard says. "Our treatment holds the potential to slash those costs and help thousands of patients."

The road to commercialization is a long one, but along the way, the team has received support from several UCI programs.

First, there was the guidance from Khine, who connected Zobi with Jered Haun, a biomedical engineering assistant professor, who invented an earlier version of their tool. Haun now serves as a faculty adviser and consultant to the company.
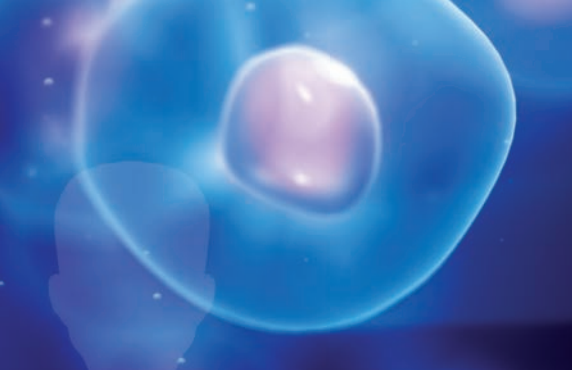
The university's Applied Innovation helped sponsor Khine's class (along with the Samueli School of Engineering and the nonprofit BioAccel) and now provides Syntr with space in a business incubator called The Cove just off the Irvine campus. The Cove has provided the team with medical and research support.

Syntr also worked with CALIT2. Team members attended CALIT2 lectures on organizing their business, and worked directly with several of the institute's entrepreneurial-minded engineers on aspects of their business.

"CALIT2 provided a great springboard and network for our efforts," Banyard says.

That springboard and network are essential for the company's current phase of development. Syntr is amid an intense

Manipulating stem cells to hasten healing

Syntr Health Technologies' patent-pending, CD-microfluidic device enables processing of a patient's own adipose tissue (body fat) to create a stem cell-enriched therapy that helps speed the healing of diabetic foot ulcers.

Here's an overview of the process:

Procedure time: under 30 minutes

1 A small amount of body fat is extracted from the patient.

2 Fat is transferred to microfluidic chip.

3 Chip spins in a centrifuge to expedite material flow. Process time is less than 10 minutes.

4 Processed stem cells are packaged into syringe barrel.

5 Patient's own processed stem cells are injected into the wound area.

Fat is the body's most abundant source of potent stem cells.

Stem cells respond to the pressure and shear force created by traveling through the microfluidic chip channels. These forces enrich stem cell populations critical to wound healing while increasing their activity.

Complications from diabetic foot ulcers are the leading cause of nontraumatic lower-limb amputations.

---

effort to acquire grants and investor funding that will allow it to demonstrate its tool's effectiveness through studies, further refine its tool and pursue federal approvals.

It's a complex and tricky task.

"We are right now in a constant grind of experimentation for improvement as well as applying for funding continuously," Banyard says.

First, there's the research.

Banyard leads that effort. He is preparing the groundwork for clinical studies that will authoritatively prove what early work appears to demonstrate – that Syntr's device actually reactivates the adult stem cells.

Here, another university organization plays a key role – the Center for Tissue Engineering in the Department of Plastic Surgery at UCI Medical Center. This is where human fat specimens are collected and the experimentation takes place.

"CTE's contribution of lab space and resources has been critical to the progress of the company," Banyard says.

Second, there's the patent.

The team is working on its patent application, with guidance from patent experts on staff at UCI. They expect to file in June – until then, key elements of their process will remain under wraps.

Third, there's the money.

Both the research and patent application require funding. But funding is also easier to get with research completed and patent applications filed. The company is up for several key grants that may come to fruition in the next few months.

Zobi and Chief Financial Officer Hugo Salas are hard at work pitching their company in investment competitions and for grants. The Cove has hosted several of these efforts, and CALIT2 and
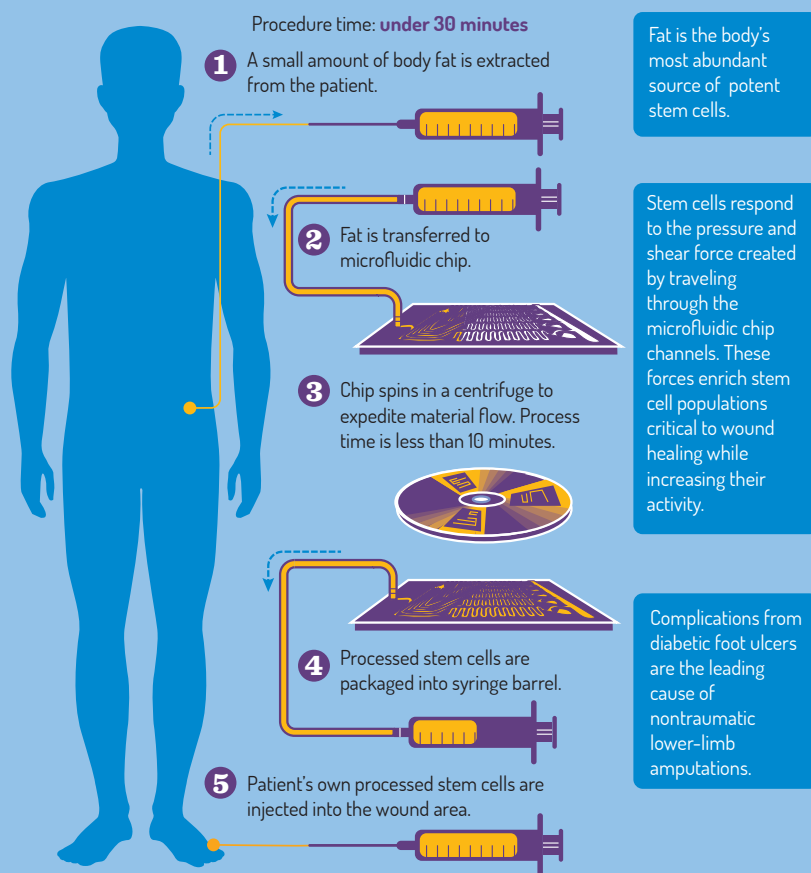
Applied Innovation support the students with business guidance.

Fourth, there's the device.

Chief Technical Officer Justin Stovner and Chief Operations Officer David Duarte are focused on the tool itself. They work on streamlining each generation of the tool. With each version, they develop new options for processing fat, and lay the groundwork for modifications that can adapt the tool to new ventures.

Finally, there's the government approval.

That is tied to testing, in part, but also hinges on determination by the FDA on whether the device is considered a type of minimal manipulation of human tissues. If that determination is made, then the device could be fast-tracked to approval. If not, the company still has other options for speedy approval

– including recognition of its significant potential to help diabetics.

"There are many new regulatory pathway approaches coming up this year," Zobi says. "We are learning as we go, but we know that with the support of UCI behind us, we can make a huge difference in many people's lives."

Khine is banking on Syntr.

The team embodies what she was shooting for when she revamped the senior design class to focus on entrepreneurship. In fact, Syntr's blending of medical and engineering specialties mirrors a new effort she is pursuing to expand class outcomes.

"They're exactly what we're shooting for," Khine says. "I've never seen such a passionate team before. They're really dedicated." *iit*

ENGINEERS DEVELOP POWERFUL MILLIMETER-WAVE SIGNAL GENERATOR THAT COULD REVOLUTIONIZE WIRELESS COMMUNICATION
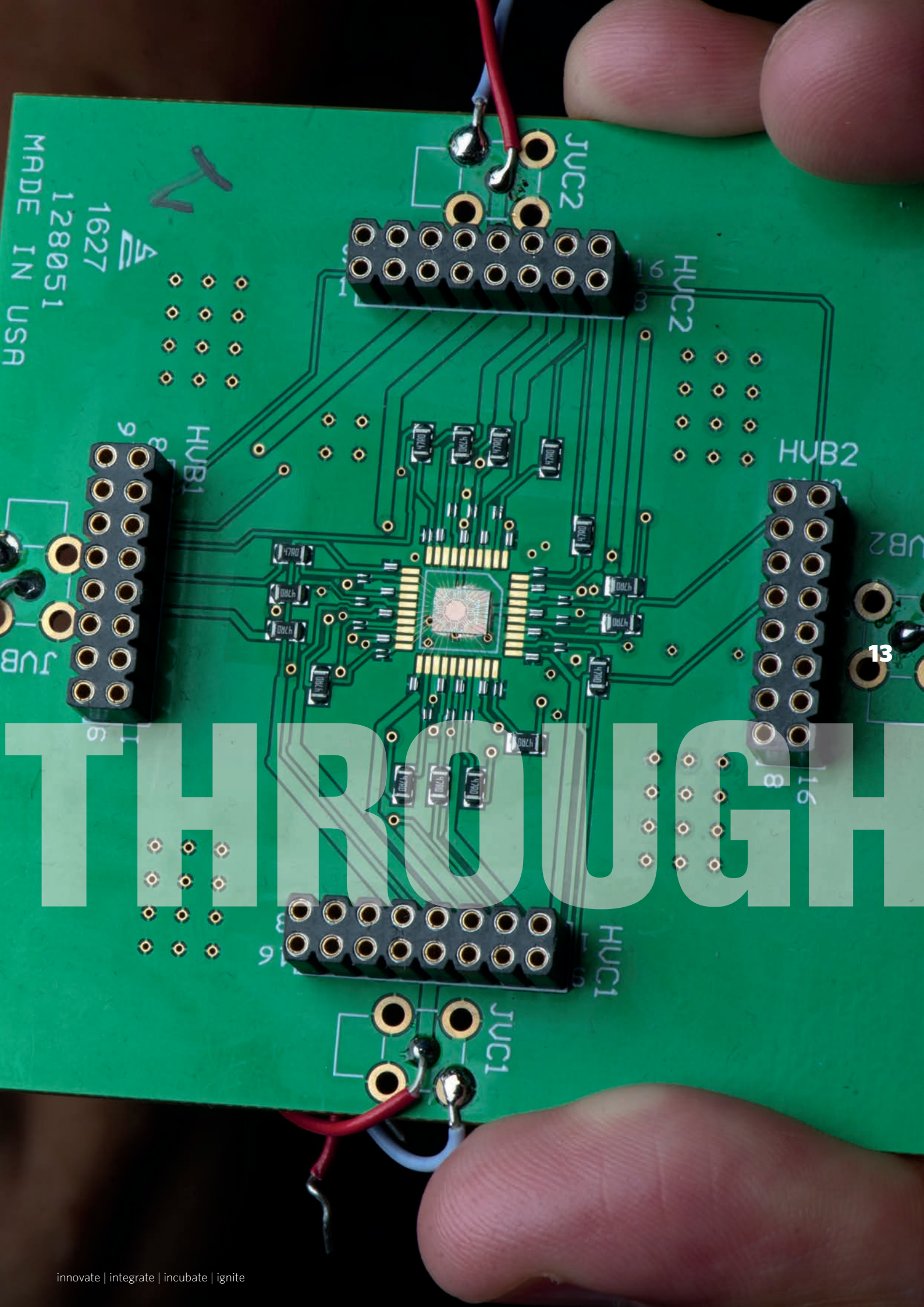
Radiator
BREAK

Brian Bell   Steve Zylius   Sharon Henry

THROUGH

13

Your doctor waves a hand-held scanner over your body and gets detailed, high-resolution images of your internal organs and tissues.

Using the same device, the physician then sends gigabytes of data instantly to a remote server and just as rapidly receives information to make a diagnosis.

Integrated circuit researchers at the University of California, Irvine have created a silicon microchip-based component that could make these and many other actions possible.

Known as a "radiator," the tiny gadget emits millimeter-wave signals in the G band (110 to 300 gigahertz). Waves of this frequency easily penetrate solid surfaces and provide extremely sharp resolution, enabling new, more effective methods of biomedical and security scanning and imaging. The chips also can perform a key role in point-to-point wireless communication.

UCI electrical engineering & computer science professor Payam Heydari (left) and grad student researcher Peyman Nazari have engineered a circularly polarized radiating element that could have widespread applications.

MAKING WAVES

Next-generation 5G wireless is expected to maximize signals in the millimeter-wave frequency band. This advancement will allow faster transmission of higher-quality video and multimedia content. The silicon microchip-based radiator can emit powerful millimeter-wave signals.

Tiny though it is, the Heydari lab's radiator chip boasts the highest power and efficiency of any device in its class, according to its creators.

WHAT IT IS

The **via stack** (segments of conductive material) is sandwiched between two **metal layers** on a **silicon base.**
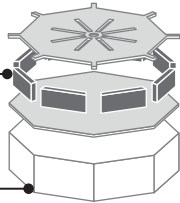
The layers create a container that collects and emits the **millimeter-wave** signal.

Container is encircled by a **delay loop**

with eight **amplifiers**

and eight **ports** to the container.

HOW IT WORKS

Signal is initiated
The startup signal is initiated from the fluctuation of the current (inherent thermal noise) within the delay loop circuit. No external startup signal source is required. ❶

Amplifier boosts power of the signal ❷
Signal travels along the delay loop.

Timing gaps ❸
Amplifier adds gaps to adjust timing. (The time it takes for a signal to make a complete loop determines its output frequency.)

Split signal ❹
Some of the signal travels through the port toward the center (container.)

signal route

❼ **Millimeter-wave output**
Radio waves are emitted in a **circularly polarized** manner.

Unlike linear polarization, circular polarization signals aren't lost due to misalignment in orientation (polarization) between transmitter and the receiver antennas.

Sustainable loop
At each segment, the amplifier boosts the signal and adjusts timing, resulting in a sustainable looping signal. ❻

❺ **Weakened signal**
The remaining signal moves along the loop to the next amplifier.

The peak of a **circularly polarized** electromagnetic wave makes a complete revolution during one period of the wave.
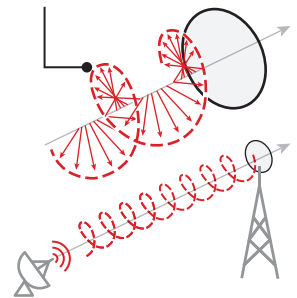
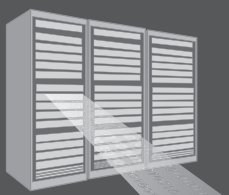Because **linear polarization** radiates along one plane...
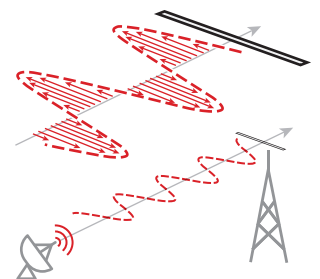
... misalignment is more likely.

POTENTIAL APPLICATIONS

Wave signals in the G band (110 to 300GHz) are able to transmit large chunks of data to a remote server and are powerful enough to penetrate solid surfaces and produce images with sharp resolution.

Point-to-point and short-range communications

Spectroscopy and remote sensing

Biomedical and security imaging

The UCI engineers who created the technology say tests in their lab have shown it to have the highest power and efficiency ever recorded in such a radiating element while exhibiting the lowest noise (interference from other sources of radiation).

UCI electrical engineering & computer science professor Payam Heydari is the lead investigator on the project.

"We're very excited about the successful design of this radiator because it represents a complete breakthrough," says Heydari, a 2017 IEEE Fellow. "We're offering an entirely new kind of physics, a new kind of device really. Our power and efficiency is an order of magnitude greater than other designs."

Through a process of trial and error, he and members of his UCI lab invented a tool that performs three crucial functions, he says. It combines power from multiple amplifiers, modulates that signal to a desired frequency setting and radiates it out in waves that are used to see, sense or communicate.

"By making a single device that provides a multitude of operations, we've gotten rid of all the interstage, highly inefficient systems found in other radiators, and as a result, we can achieve higher power output," Heydari says.

One of his lab's graduate students, Peyman Nazari, designed the device as an octagonal semiconductor chip with a unique cavity structure that allows for the emission of circularly polarized radiation. Most transmitters now generate linearly polarized signals, which can get "lost" when antennas and receivers are out of alignment. Emissions from one of the UCI radiators, if you could see them, would appear as tiny spinning tornados. Beams of this shape are particularly effective at penetrating solid objects and providing detailed pictures of what's inside.

Heydari says his group's invention will be particularly beneficial in biomedical applications, as it will give doctors a way to differentiate tumor masses from healthy tissue. It could also be used in genomic research, equipping scientists with an instrument that can be so precisely tuned as to enable the excitation, or lighting up, of individual proteins.

But the new radiator can do a lot more than facilitate scanning and imaging. According to Heydari, it could be the key that unlocks millimeter-wave transmission as part of the fifth-generation wireless standard now in development. In addition, the tiny yet powerful chips can be embedded virtually anywhere. The Internet of Things will rely heavily on machines, buildings and other infrastructure being equipped with sensors and antennas. Driverless vehicles will only be possible if cars and trucks can detect each other.

"By using this millimeter-wave technology, cars all of a sudden become super-smart processing systems," Heydari says. "Vehicles will be able to communicate with one another, and radar capabilities will be enhanced, greatly improving blind spot detection and collision avoidance."

His lab's radiator work is sponsored by the Samsung Advanced Institute of Technology's Global Research Outreach Program.

"By using this millimeter-wave technology, cars all of a sudden become super-smart processing systems. Vehicles will be able to communicate with one another, and radar capabilities will be enhanced, greatly improving blind spot detection and collision avoidance."
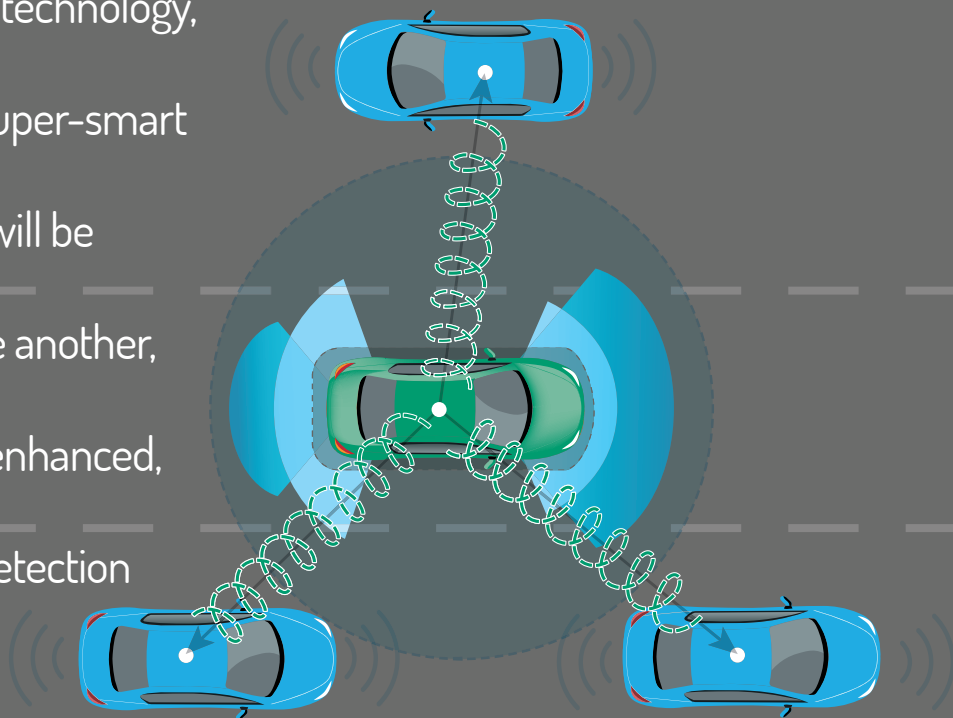
5G
AND THE FACTORIES OF THE FUTURE

→ HOW THE NEXT-GENERATION WIRELESS NETWORK WILL TRANSFORM ADVANCED MANUFACTURING

Wednesday, June 7, 2017

5:00 pm Registration

5:30 pm Presentations

7:30 pm Networking Buffet Dinner

CALIT2 Building, UCI

Register at www.calit2.uci.edu

While 5G isn't expected to debut until 2020, an increasing number of companies are investing now to prepare for the new mobile wireless standard. 5G, which stands for fifth generation, will be significantly faster with lower latency, and will integrate networking, computing and storage resources into one programmable and unified infrastructure. This 5G innovation platform will enable emergent technologies, such as the Internet of Things, to become integral parts of our economy and lifestyle. With 5G, factories of the future will have more agile mobile-communication support, enabling greater efficiency and better energy productivity. The next-generation network will give advanced manufacturers the agility to move quickly to meet customer needs and stay ahead of the competition.

Join us June 7 to:

- Learn why 5G is considered a game changer
- Envision new capabilities that will help industries create innovative products and services to grow their markets
- Discover how next-generation mobile networks will increase manufacturers' productivity and efficiency to reduce costs
- Understand the challenges of cybersecurity in this new paradigm
- See new revenue streams and business models unfold

Igniting Technology is a semiannual program sponsored by Knobbe Martens Olson & Bear LLP.

DEEP DOWN

Anna Lynn Spitzer

After a couple of detours, an informatics professor dives into his true passion

Above: In Dunedin, New Zealand, Tomlinson records video of kelp drifting with the waves. (Photo: Sam Mann)

Below: Tomlinson's 2010 book investigates how IT can help humans tackle the large-scale problems associated with environmental sustainability.
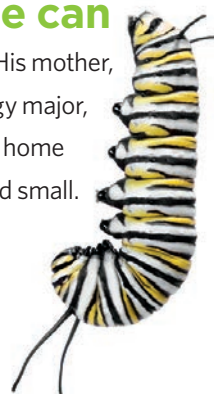

A self-described "nerdy" kid, Bill Tomlinson has been a nature enthusiast as long as he can remember.

His mother, a former college zoology major, filled their Philadelphia home with creatures large and small. "There'd be monarch caterpillars hanging from the chandeliers," Tomlinson says, "and lots of pets."

It's no surprise then, that the UC Irvine informatics professor has placed the environment at the heart of his career, seeking ways to use information technology to improve sustainability. He has written extensively on the subject, including a 2010 book, "Greening Through IT." He's developed apps for children, created a series of research projects aimed at improving the environment and is an active participant in sustainability organizations.

What's a little unexpected, however, is the circuitous route he's traveled. There was a little wandering and a setback or two, but now, Tomlinson says, he is exactly where he belongs.

After studying animal behavior at Harvard College, it was time for the soon-to-be-graduate to plot his next move. Tomlinson had taken several media arts classes at Harvard, and now, he found himself wavering between a career in biology and one in the arts.

In a creative twist, he tossed a virtual coin, applying both to art schools and biology Ph.D. programs. His strategy – to attend the best school that would accept him, regardless of discipline – led his Harvard career counselor to opine: "That's a lousy way to plan your life."

"I did it anyway," Tomlinson says, laughing.

UC San Diego's marine biology department invited him for an interview. He arrived in Southern California on a beautiful February day, "and I was coming from Boston, which was miserable and wretched," he says.

This could be it, he thought. That is, until one interviewer asked Tomlinson to explain his mediocre grades. His reply: "I've been putting on plays and stuff." In perfect hindsight he quips, "That ultimately isn't the right answer for a tuna fish biology Ph.D. program."

Another asked him to explain why he also had applied to four art schools. That one stumped him. "I didn't think they'd have that information," he says

sheepishly. "I was outed. They didn't admit me."

But the California Institute of the Arts, known as CalArts, did, and thus began a foray into animation. Tomlinson planned to get a master's degree in computer animation, but the 1994 Northridge earthquake damaged the school's computer labs. So he opted for experimental animation instead, or as he calls it: "making puppet films."

Serendipitously, this decision, coupled with many hundred hours of tedious work, resulted in an award-winning film called "Shaft of Light," which he wrote, animated and produced. The nine-minute take on worker oppression in post-industrial society starred robots made from metal tubes. It earned international acclaim, screening on several cable channels, at Sundance and the Director's Guild of America, and at more than 20 other film festivals worldwide.

Tomlinson earned a master's degree in 1996 from CalArts, finishing the three-year program in two years. But an unsuccessful attempt to find work made him realize, "I really wasn't employable. There aren't very many stop-motion animation jobs in the world." He moved back to Philadelphia and worked for a temp agency. "I was floating in the wind," he says.

Then a friend told him about the Media Lab at MIT. A quick internet search convinced him to delve deeper. He bought a train ticket from Philadelphia to Boston, excitedly appearing at the Media Lab's front desk, where he was summarily dismissed and told to come back when he had an appointment.

Three weeks later, requisite appointment in hand, he returned and was introduced to Bruce Blumberg, a recent MIT doctoral graduate who was forming a research group focused on artificial life and computer graphics. Blumberg was seeking animators, biologists and computer scientists, and Tomlinson fit neatly into two of those three categories. He snagged a spot in the program.

Five years later, he graduated with a doctorate in media arts and sciences. In 2003, he was hired by UCI to plan and implement a now defunct master's program called ACE: Arts, Computation and Engineering.

Debra Richardson, UCI informatics professor, founding dean of the computer science school and fellow sustainability researcher, hired Tomlinson into the ACE program and worked closely with him afterward. "Bill is an eminently collaborative scholar who does high-quality research and imparts his expertise to students through excellent teaching

and mentoring," she says. "He works on extremely important topics – such as sustainability – and shifts direction if he doesn't view his work as having significant impact. It is this forward thinking that has made it so much fun to work with him."

ACE's cross-disciplinary focus ultimately introduced him to CALIT2, where he says he found an intellectual home, "similar in many ways to the Media Lab." He also found financial support that allowed him to dive back into his passion.

"I had started thinking more about environmental topics and sustainability," he says, and in 2005, a CALIT2-administered $80,000 Nicholas Foundation Prize for Cross-Disciplinary Research gave him the opportunity. He partnered with Lynn Carpenter (pictured above), a UCI professor of ecology and evolutionary biology, on an interactive exhibit called EcoRaft, which used computer tablets and animation to teach environmental concepts to children.

Tomlinson had found his calling. "Ultimately, the thing I care deeply about is the living world and the ecosystems we live in," he says. "Given my experiences, my intellectual background and the contexts in which I had embedded myself over the previous decade, I wondered how I could bring those to bear on what

I cared deeply about. The CALIT2 grant gave me a chance to do that."

The institute nurtured his career in other ways, too, he says gratefully, specifically "hugely instrumental" multidisciplinary collaborations and the opportunity to demonstrate his work to a steady stream of visitors. "That is a really important part of the educational experience at all levels in research … having to think about how your work relates to lots of different people."

He adds: "You know how there are situations in your life where something happens and then you have undying loyalty to that institution or person? That's how I feel toward CALIT2."

Over the past decade, his Green IT Lab in the CALIT2 Building has spawned a host of environmentally focused, human-computer interactive projects. In addition to EcoRaft, the restoration ecology project, the list includes (but is far from limited to): GreenScanner, a database for helping shoppers understand the environmental credentials of consumer products; WebBEST (web browser environmental sustainability toolkit), which highlighted the impact of everyday choices on the environment; E-waste tracking, which traced the movement of discarded computer components; Plant Guild Composers, an effort to create a functional ecosystem by integrating IT with agroecology; and Better Carbon, a web-based carbon footprint calculator.

Even on vacation with his family, Tomlinson is a constant ambassador for CALIT2.

"I feel like I'm on the right track, and I continue to be excited about it. I have an opportunity to do something every day that is well-aligned with how I would like the world to be for my kids."

With his wife, Rebecca Black, an informatics associate professor, Tomlinson also developed Seed Cycle, an engaging iPad app that teaches kids about plant growth and pollination. It has sold more than 11,000 copies since its 2011 release.

Tomlinson and Black met at UCI in 2007, and CALIT2 played a supporting role in their courtship. "Immediately upon meeting her, I asked her if she wanted to come back to my lab in CALIT2 and see one of my demos," he laughs. "It's the academic version of 'Do you want to see my etchings?'"

The couple married in 2008, and are parents to 7-year-old Miles and 2-year-old Addie.

Tomlinson exudes passion about his work. "If we are going to cause civilizations to become sustainable, we are going to need to do things differently," he says. "Even in the presence of the will to live sustainably, without appropriate information resources and tools, we would still not be able to [succeed] because there are too many of us for the resources that we are attempting to share."

"Bill has been a champion of sustainability research at UCI, on the national level and even internationally," says Don Patterson, computer science associate professor at Westmont College in Santa Barbara, Calif., and a visiting UCI informatics professor. "His book 'Greening through IT' planted a flag in the space. He has repeatedly convinced me of the value of working on this problem because the implications of ignoring it are scary to consider."

Tomlinson's research, though, has imparted some unsettling lessons about the limited abilities of humans. "Sustainability deals with problems that are outside the ranges that humans can cope with. People largely make decisions based on narrow concerns, like, is this delicious? Or can I park there? They don't think about habitats they may never visit, where the effect won't be felt for 50 or 100 years."
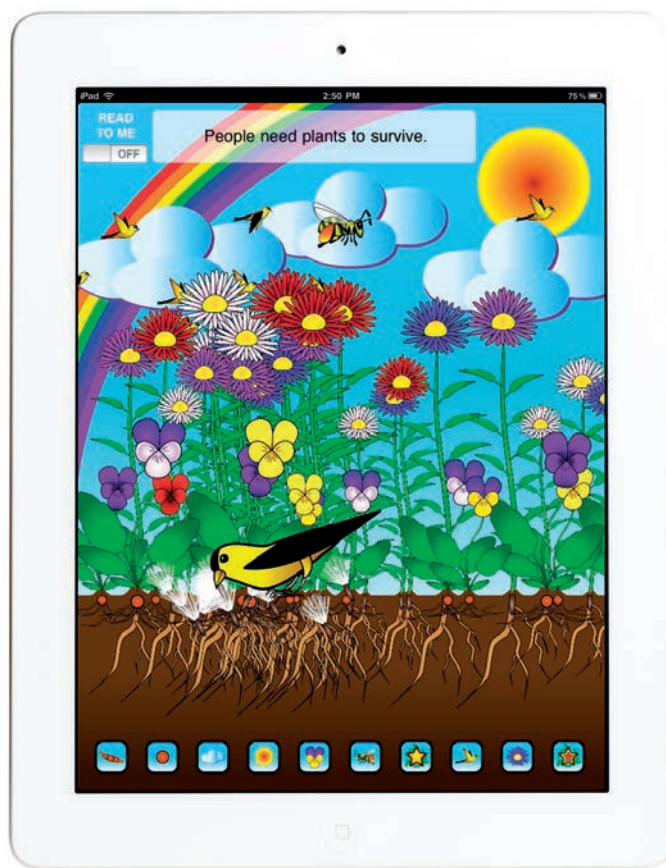
Seed Cycle lets children experience plant growth and pollination in a colorful, easy-to-understand format.

Information technology is the link that could make sense of these complex causal relationships, he hopes, ultimately leading to "better decision-making and more sensible action from a global perspective."

This, above all else, is the lesson he strives to pass on to his students. "Whether they know it or not, they are all embedded in complex causal chains with the rest of the world. Becoming more aware of these chains can help them live lives that are more in line with how they would like the world to be."

One former student says Tomlinson was instrumental in shaping his awareness. Jack Pan, who graduated in 2013 with a degree in Earth systems science, worked with Tomlinson in the Green IT Lab. He is now in a doctoral program at UCSD's Scripps Institution of Oceanography. (Tomlinson, who wrote a letter of recommendation for his student, says when Pan got accepted, he himself felt that he had come full circle. "I didn't get to go, but one of my people went.")

"Bill fostered a welcoming and productive environment," Pan says. "I learned to embrace ideas from other academic disciplines while critically thinking about ideas from my own.

"More importantly," he concludes, "Bill's pioneering work ... has profoundly transformed my view on sustainability and climate change."

Does Tomlinson see ultimate success in humankind's pursuit of sustainability? He admits to having good days and bad days. "We're getting bigger and faster in a malignant kind of way, and we need instead to arrive at sustainable ways of supporting quality of life for humans and other species on this planet," he says.

So he perseveres. "I feel like I'm on the right track, and I continue to be excited about it. I have an opportunity to do something every day that is well-aligned with how I would like the world to be for my kids." *it*

INTRO TO VR HEADSETS

→ **How virtual reality (VR) headsets immerse the user in an alternate world**

DISPLAY

A high-resolution screen (such as a smartphone) is positioned inches away from a user's eyes. **Two video feeds** are displayed side by side.

The slightly different images mimic how each eye naturally sees a different perspective.

The **brain combines both views** to create one image that appears to have depth and distance. This technique is known as stereoscopy.

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LENSES

Two biconvex lenses embedded in the headset warp the pictures to fill the user's field of vision (FOV).

FOV is the total area seen without moving the eyeballs.

Vertical: 135°

Horizontal: About 180°

AUDIO

Sensory stimulation provides an added sense of immersion.

HEADSET HEADSTARTS

THE ARTIST

Morton Heilig is generally recognized as the father of virtual reality. As a documentary filmmaker, Heilig was seeking to enhance the movie-viewing experience. In 1960, he patented the first VR head-mounted display called the "Telesphere Mask" and described it as a "stereoscopic-television apparatus for individual use."
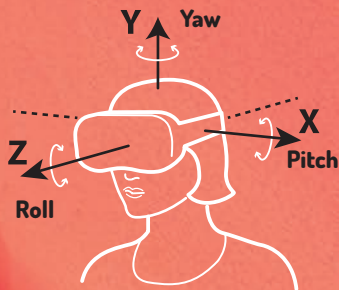
Heilig's headset included stereoscopic 3-D displays, wide-angle vision and stereo, but lacked motion tracking.

Sharon Henry

HEAD TRACKING

Sensors (gyroscope, accelerometer and compass) in the smartphone track the user's head position. Those data tell the VR computer what view to render that will follow the user's movements.

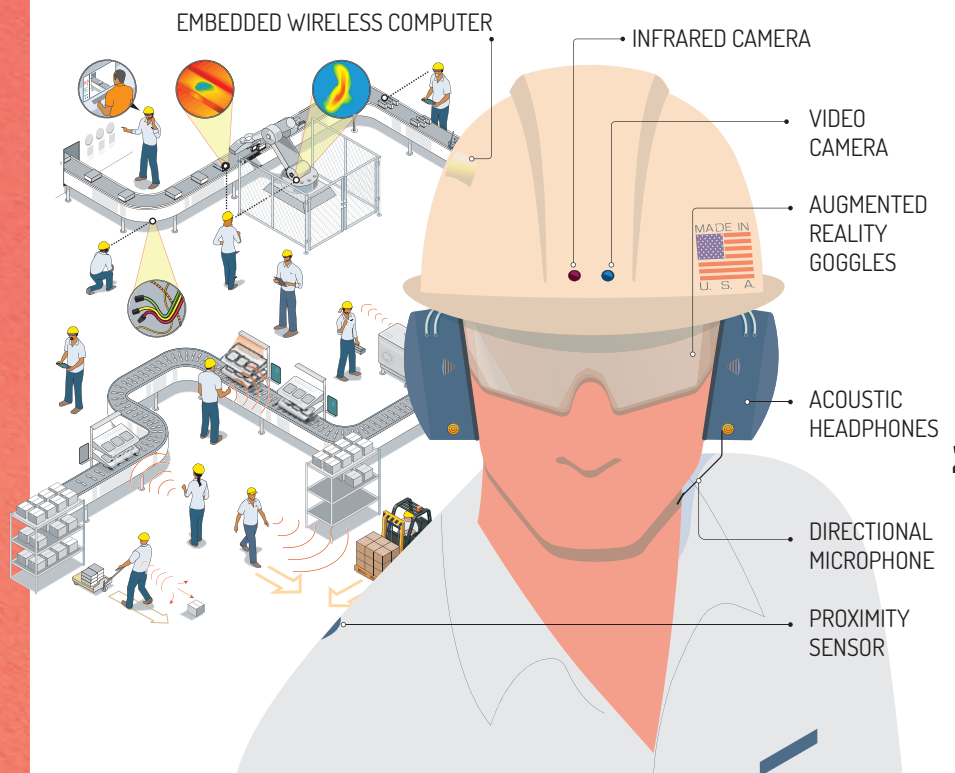Tracked movements are known as the six degrees of freedom:
• Surge (forward/back)
• Heave (up/down)
• Sway (left/right)
• Pitch
• Yaw
• Roll

MAKING A SMARTER HEADSET

Researchers from CALIT2, in collaboration with the Institute for Virtual Environments and Computer Games (IVECG) and Institute for Software Research (ISR) are developing a headset of the future. The Smart Worker headset combines game-based learning experiences and interfaces. Individual features include embedded video and infrared cameras, augmented reality goggles, ultra-sensitive microphones and headphones, and an array of sensors designed to enable a rich, multimedia awareness of workplace conditions and events.

"The plan is to rapidly design, develop, deploy and continuously improve the Smart Worker technology," said Walt Scacchi, research director, IVECG, Bren School of Information and Computer Sciences at UC Irvine.

UCI CALIT2 Smart Worker Concept

EMBEDDED WIRELESS COMPUTER

INFRARED CAMERA

VIDEO CAMERA

AUGMENTED REALITY GOGGLES

MADE IN U. S. A

ACOUSTIC HEADPHONES

DIRECTIONAL MICROPHONE

PROXIMITY SENSOR

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VR SICKNESS (SIMULATION SICKNESS)

VR sickness is common. It was first noticed in the 1980s when the U.S. military reported their pilots often became nauseated when training in flight simulators. A theory is that VR sickness is a reaction to the brain receiving extremely contradictory information. The eyes tell the brain the body is moving, while all other senses tell the brain the body is stationary.

THE ENGINEER

In 1968, **Ivan Sutherland**, with the help of his student Bob Sproull at the University of Utah, created a head-mounted display that tracked head movements and superimposed a geometric grid over the user's view of a room. It was the first VR headset to replace a camera with a computer.
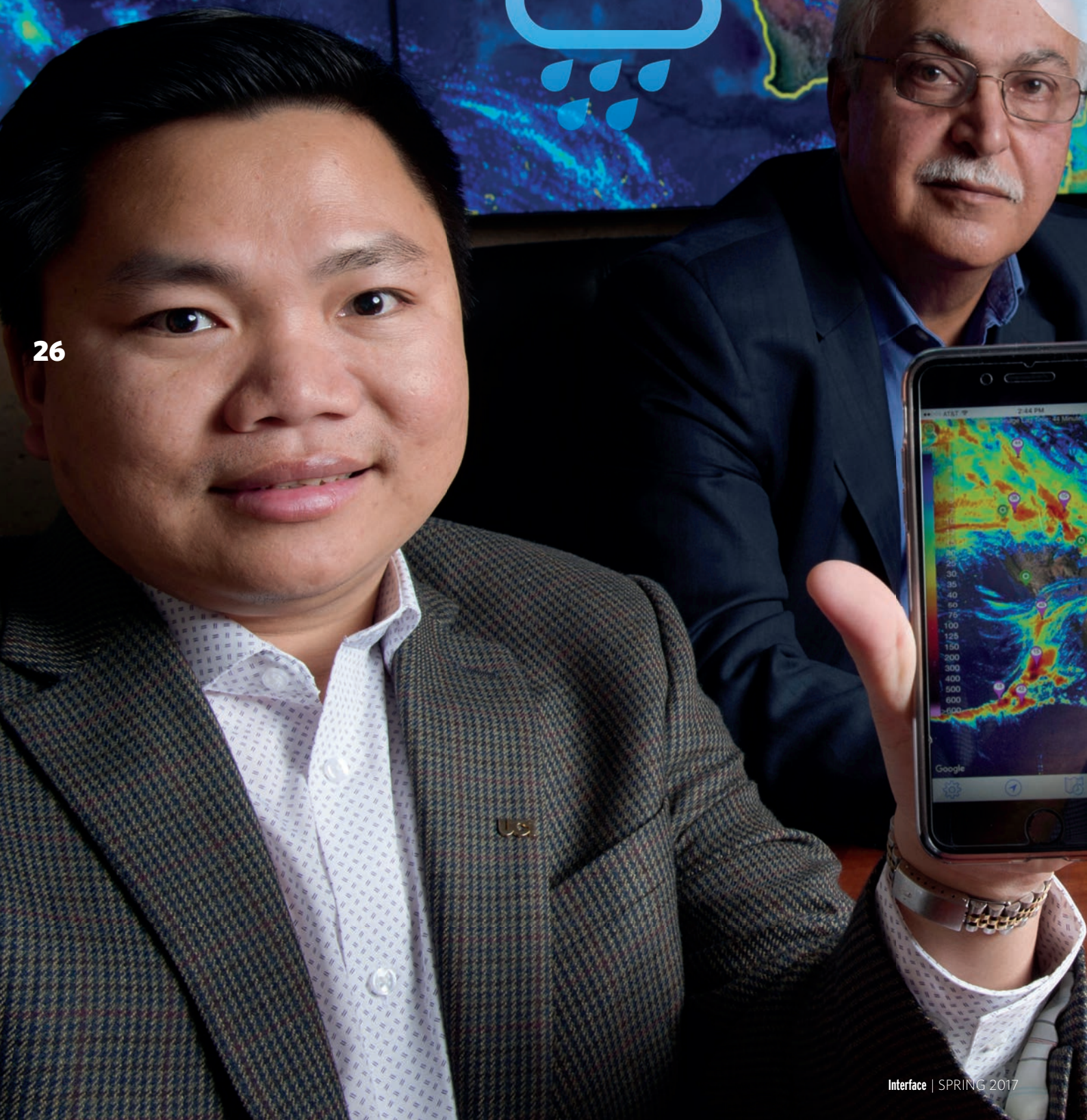
The sheer weight of Sutherland's invention required it to be suspended from the ceiling while the user's head was securely fastened into the device. Its imposing appearance earned the device the nickname "the Sword of Damocles."
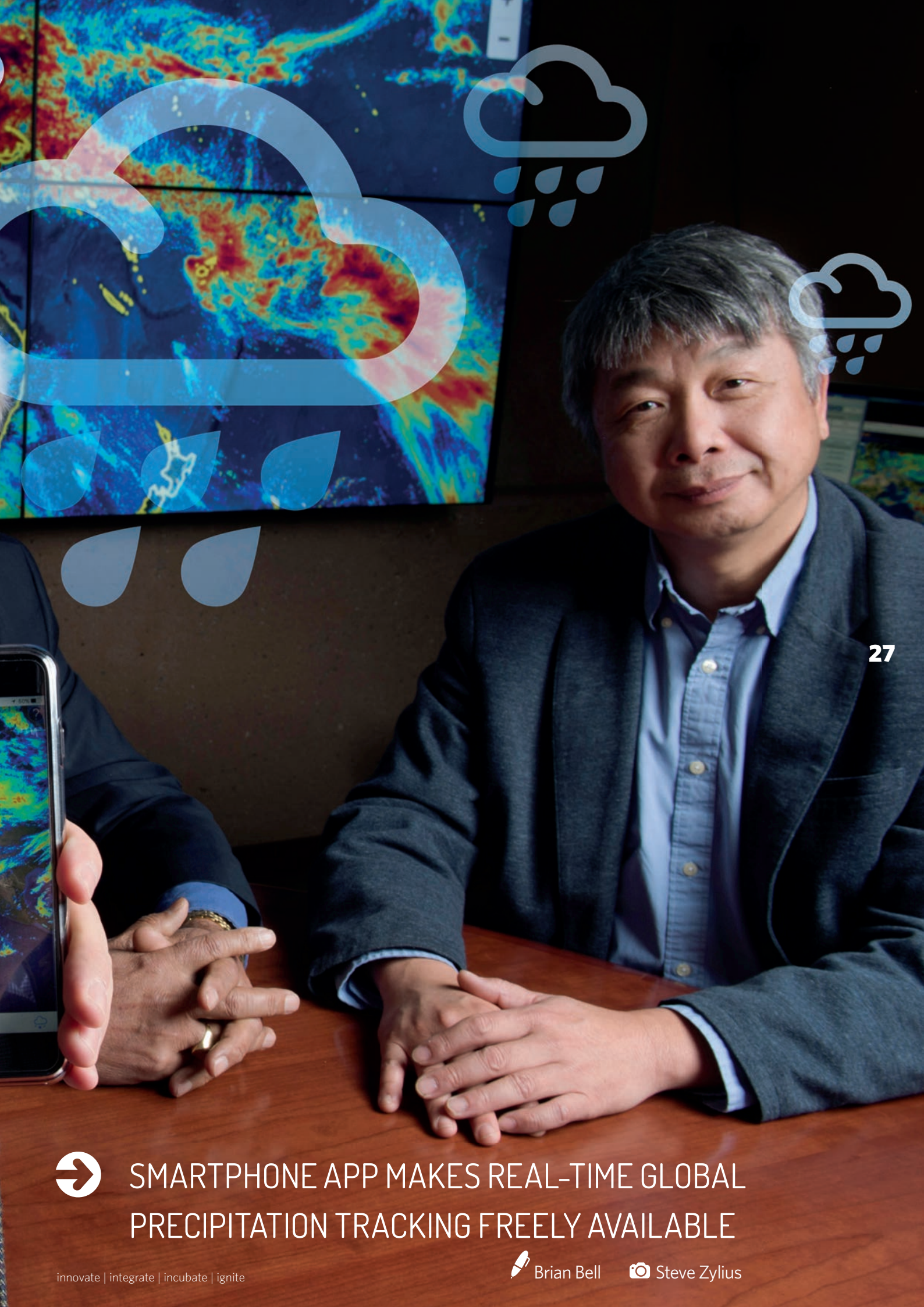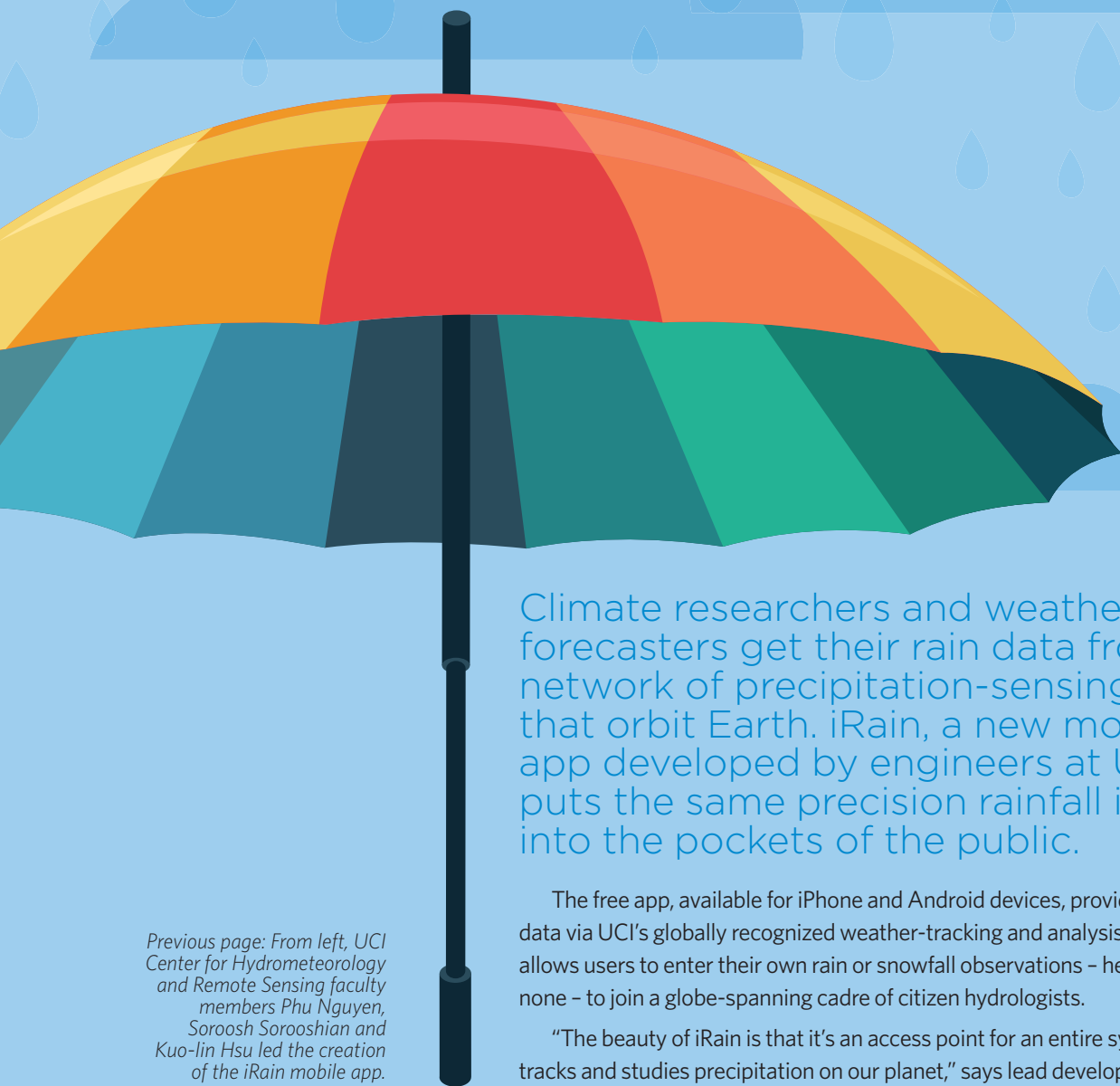
RAINING DATA

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SMARTPHONE APP MAKES REAL-TIME GLOBAL
PRECIPITATION TRACKING FREELY AVAILABLE

Brian Bell   Steve Zylius

Climate researchers and weather forecasters get their rain data from a network of precipitation-sensing satellites that orbit Earth. iRain, a new mobile phone app developed by engineers at UC Irvine puts the same precision rainfall information into the pockets of the public.

The free app, available for iPhone and Android devices, provides timely satellite rain data via UCI's globally recognized weather-tracking and analysis system. iRain also allows users to enter their own rain or snowfall observations – heavy, moderate, light, none – to join a globe-spanning cadre of citizen hydrologists.

"The beauty of iRain is that it's an access point for an entire system that detects, tracks and studies precipitation on our planet," says lead developer Phu Nguyen, assistant adjunct professor of civil & environmental engineering. "We process the data from satellites and offer it to the end user, free of charge. As far as I know, we're the only institution offering such a system."

Features of the mobile app include a tool that displays the top 50 current extreme weather events around the world, animations that show varying levels of rainfall intensity and movement, a function to choose different time spans and a tool to zoom in to a local area.

Many of the functions of the app are also available through a website, which is useful for researchers who often need to generate and download reports.

UCI uses data from U.S., European and Japanese satellites in collaboration with agencies such as NASA and NOAA to produce rainfall information now being accessed by people in more than 180 countries.

"The power of iRain is that it brings state-of-the-art rainfall estimation based on actual observations to anyone, anyplace in the world at any time," says Robert Pietrowsky, director of the U.S. Army Corps of Engineers Institute for Water Resources, who helped launch the app at the United Nations Climate Change Conference in Marrakesh, Morocco, in November.

iRain is part of UCI's PERSIANN project, the culmination of decades of research and development by scientists and engineers in the Center for Hydrometeorology and Remote Sensing (CHRS).

Nearly 20 years ago, Kuo-lin Hsu, professor of civil & environmental engineering, created an algorithm for the retrieval of rainfall data from satellite images. His algorithm is based on technologies that enable rainfall estimations to grow in precision and reliability over time based on the accumulation of data.

Hsu says one of the key challenges for his developers over the years has been to reduce the wait time between retrieval of data, processing and distribution through government servers. With the launch of iRain, UCI demonstrates that it's possible to compress that down to about an hour.

"The meteorological agency in the African nation of Namibia is using our data, and we're seeing it used in China, Thailand and other Southeast Asian nations that have a serious stake in flood monitoring," says Hsu. "Support from UNESCO has enabled us to dramatically expand the number of users for the data around the world. With internet connection to their computers and smartphone devices, people all over the world can view and receive the data in nearly real time."

"We had a vision on how we could use satellites to come up with estimates of rainfall that would have applications for flood forecasting and other purposes," says CHRS director Soroosh Sorooshian, Distinguished Professor of civil & environmental engineering. "At a meeting in Italy years ago, I presented the concept of introducing machine learning tools such as artificial neural networks to address the problem. There were many skeptics in that audience, but here we are today; people around the world are benefiting from our efforts."
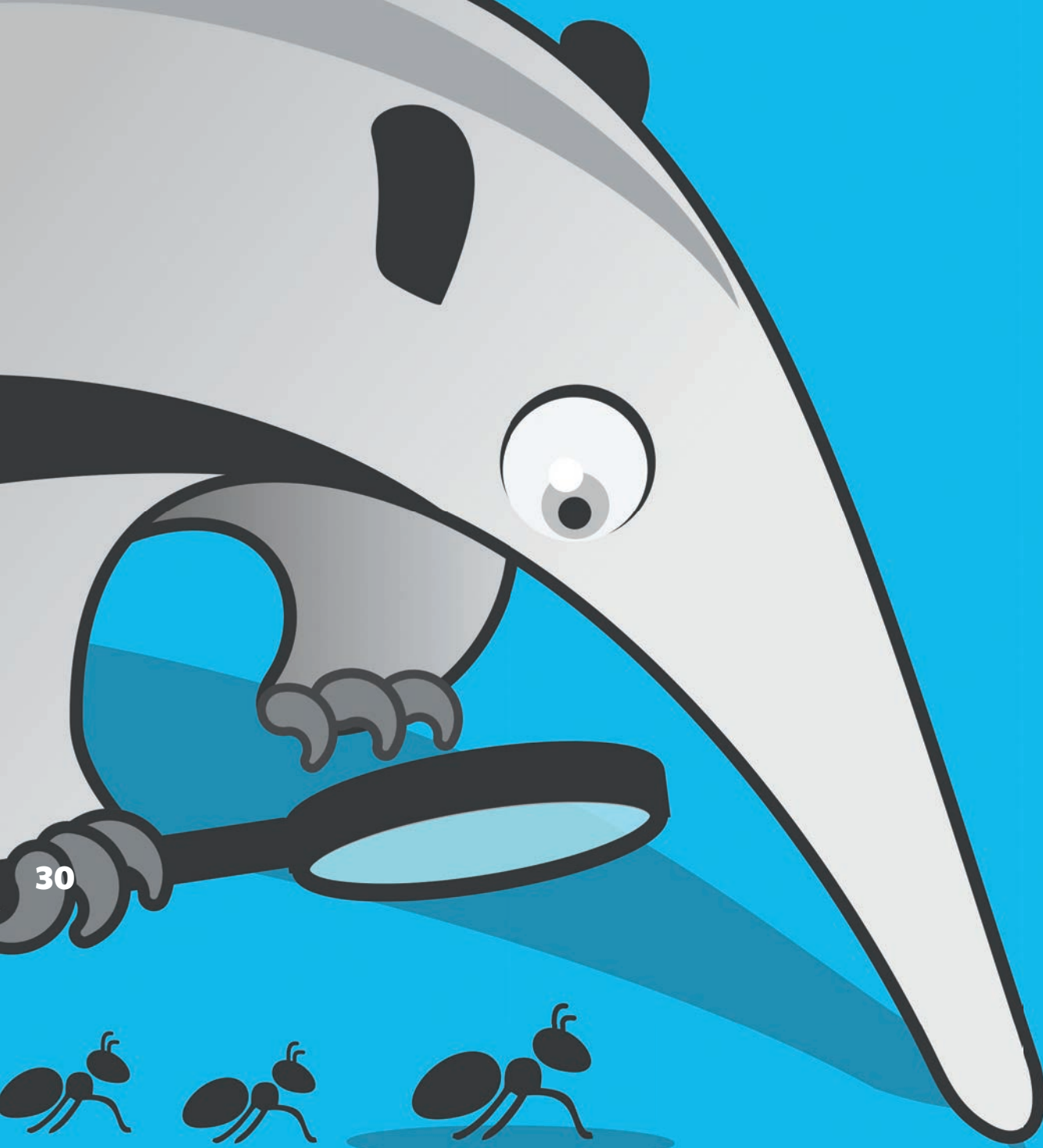
The free app, available for iPhone and Android devices, provides timely satellite rain data via UCI's globally recognized weather-tracking and analysis system.

iPhone app https://itunes.apple.com/us/app/irain-uci/id982858283?mt=8

Android app https://play.google.com/store/apps/details?id=irain.app&hl=en

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ANTMONITOR ADVANCES MOBILE DATA TRANSPARENCY

private

Anna Lynn Spitzer

Mobile devices are today's technology of choice, generating the majority of internet traffic.

They're ubiquitous tools for working, socializing, communicating, shopping and more. But they also harbor a treasure trove of personal data, which, unbeknownst to users, can leak information to a host of unauthorized recipients.

A research group led by Athina Markopoulou, CALIT2-affiliated researcher and associate professor of electrical engineering and computer science, is working to plug those leaks by letting users know when they happen and where the information is bound. The team is developing AntMonitor, a mobile app that can perform real-time detection and prevention of private information leaked from devices to the network.

"It's useful to understand where your data are going," Markopoulou says. "If half of my data plan is going to ad servers … that's something I would like to know. If information like my location, my email address, my phone number or device ID are going to trackers, that's important to know, too."

She uses a chilling example: "If your phone is sending your credit card number to an unknown server in another country every day from midnight- 2 a.m., you'd be able to stop it."

AntMonitor analyzes the packets going into and out of mobile devices, discerning where they're coming from and where they're heading. But, Markopoulou emphasizes, this powerful tool does not need to read or collect the content of the packets; packet headers (such as origins and destinations) convey useful information as well. When it senses something unusual, AntMonitor can alert the user to take action. Users can personalize the app to define privacy criteria using filters. If preselected data begin leaking from the phone, AntMonitor will notify the user.

It also can learn routines. "If the app notifies me that my phone is contacting a new server, I can tell it to block those packets. Or, if it's something I've authorized, the app will remember and won't ask me again. Over time, it learns what's normal and what's not," says Markopoulou.

Users also could gain control of the economics associated with personal data. Companies that make money from users browsing the internet could be held accountable and perhaps even forced to share profit. "If it becomes explicit to us that a company makes a certain amount of money each month from us [browsing the internet] maybe we can get some of that back," Markopoulou says. "It's good to put users in control of where their data are going and how they are monetized."

In addition to being available as a downloadable app, AntMonitor is offered as a software development kit (SDK) that third-party app developers can integrate into their products. Telecommunications companies, mobile software and analytics companies, as well as universities have expressed interest in the technology. Their goals can be a bit different, though – and could involve market research, user behavior statistics and other data collection that can seem at odds with privacy goals.

"I'm trying to navigate that challenge now," Markopoulou admits. "If a developer or a marketing company uses our software, it should be their responsibility to disclose to their customers what they will collect."

The app uses a VPN (virtual private network) to intercept incoming and outgoing packets. This means traffic is not being redirected to a middle server, just observed and analyzed on the device.

While other groups are engaged in related research, Markopoulou says AntMonitor's preliminary testing reveals several advantages. "It significantly outperforms comparable approaches with regard to throughput and energy," she says, adding that it uses up to 12 times less energy, doesn't drain the device's battery and achieves speeds up to eight times those of existing mobile approaches.

Currently in beta testing, AntMonitor is funded by a two-year $300,000 National Science Foundation EAGER grant and a $50,000 prize from the Data Transparency Lab. DTL, a nonprofit consortium that seeks to advance online data privacy and transparency, received 54 submissions in a recent funding competition and selected AntMonitor as one of six winners this year.

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detective

Ask Iris

→ NEW ORANGE COUNTY DIGITAL COMMUNITY ENCOURAGES HEALTHY LIVING ✎ Lori Brandt

Folks at Irvine Health Foundation (IHF) are hoping that Orange County residents will become as comfortable turning to Iris-OC for guidance on healthy living as iPhone users are with asking Siri for information.

That's the idea behind a new CALIT2 project in development, a digital community for adults interested in leading healthier, more vibrant lives. A collaborative effort of IHF and CALIT2, Iris-OC will provide Orange County residents with information, local resources, social networking and support, shared data, group connections and more in an effort to help adults navigate do-it-yourself aging.

The number of older adults living in Orange County is expected to nearly double by the year 2040, when almost one in four residents will be 65 and older. The fastest growing segment of the region's population is adults over 85.

"Studies have shown that our health is influenced by our local community," says Mark Bachman, the project's technical director. "There's a lot of information on the internet, but it could be junk and it's not specific to Orange County. With this social platform, we are aggregating and vetting specifically for our local population."
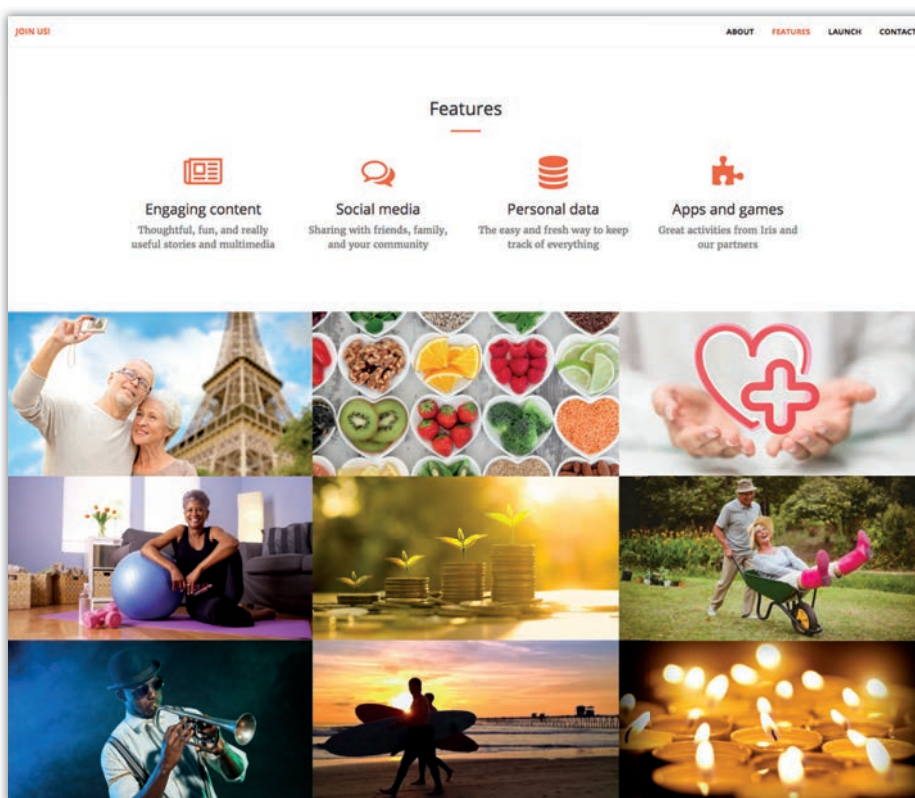
A test version of Iris-OC will debut this summer at www.iris-oc.com.

For example, patients coming home from a hospital after surgery may need to find home health care assistance or a meal delivery service. Maybe they would like to look for physical therapy, yoga classes or a local walking group. They might seek healthy recipes, nutrition advice or medication interaction information. These are just a few of the ways Iris-OC will be able to help.

IHF has made a substantial financial commitment toward the project. "After 30 years of working to help people access health care, IHF re-evaluated its direction. "We changed our strategy to be less around health care and more around keeping people healthy," says Edward Kacic, IHF president. "Our new focus is technology-enabled healthy living, specifically for seniors and military veterans in Orange County. Right away, we thought of CALIT2 as a partner because of its interest in health and strong technological capabilities."

Bachman and Kacic envision not just a content portal, but also a social network. Multifaceted, Iris-OC is a bit like Facebook, Pinterest, Google, Meetup, YouTube and more all rolled into one, with all content curated for local residents. Users will be able to build their own community of support centered on healthy aging.

Iris-OC project director Linda Zimmer, a digital communication strategist, works closely with the Orange County Strategic Plan for Aging group and with the local community to ensure local organizations – nonprofits, business and tech sectors,

government and public health agencies – are invited into this collaborative effort. The digital platform also will be a place for Orange County experts to communicate and share content with the community.

One such expert is Jung-Ah Lee, an associate professor at UC Irvine's Sue and Bill Gross School of Nursing. In partnership with CALIT2's technical experts and students in nursing, computer science and art, Lee developed a health app to help those using blood thinners safely track and monitor their therapy. She says anticoagulation medicines can be tricky.

"If you skip a dose, you could end up with a stroke or heart problems. If you double up on your dose, you create a risk of bleeding," she says. Additionally, some blood thinners interact with other medications and certain foods. Lee's app, called My Happy Blood, features a medication reminder, a diary, progress charts and a database of common foods containing Vitamin K, a culprit of adverse reactions. It's an app users will find available on Iris-OC.

"Most social networks are designed with millennials in mind," says Bachman, but more and more older adults are embracing today's online communication channels. While young adults (age 18-34) are the heaviest social media users (90 percent), usage by adults 65 and older has more than tripled since 2010, according to the Pew Research Center.

Iris-OC focuses on being simple to use at any age. The event function in particular will be easier to navigate than what is currently available, allowing users to organize events with small or large groups. The social networking feature will let users share pictures, videos and chats, but also "things you don't normally think about sharing," says Bachman. "People can create collections and share them, like recipes and playlists, or restaurant and movie lists."

The platform will serve as a one-stop source for personal data, too. "We have lots of data in our lives today and it's hard to manage," explains Bachman. "As we get older, we have a hard time remembering. Iris-OC can help people keep track of their contacts, doctor visits and medications."

Bachman also plans to develop apps that can connect to third-party devices, like treadmills, scales, fitness devices and the like. A test version of Iris-OC will debut this summer. Watch for it at *www.iris-oc.com*.

"Older adults, in particular, don't often have a place online to find information specific to their issues as they age," says Zimmer. "Our ultimate goal is to build an online space that connects people to each other and to the resources within their own community for healthy living. It will be a social platform and a tool. Really, there's nothing out there quite like it." *it*

Iris-OC Features

INFORMATION
A healthy-living multimedia online magazine and library for adults and seniors, with content from reliable sources and contributors with domain expertise.

RESOURCES
Directory of approved, credible Orange County organizations and businesses integrating member rankings, comments, maps and third-party reviews.

SOCIAL CONNECTIONS AND NETWORKING
Interacting through messaging, photo-sharing, chats, support, check-ins, private data sharing and integration with third-party sites such as Facebook.

EVENTS
Public or private community event pages. Event invitations, promotion, updates, emails, RSVPs and reminders. Events are moderated and controlled by event leader.

SPECIAL INTEREST GROUPS
Shared common-interest groups and group-hosted learning topics. Public for all site members or limited by group manager/moderator, allowing private group communication.

PERSONAL AND SHARED DATA
Member-controlled private contacts, personal lists, calendar, medication notes, reminders and more. Personal data may be shared with family members, caregivers or third parties. Can create groups.

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One man's trash may be another's treasure, but some trash is just garbage. Now there's a robot for that: meet the Garbage Processing Unit. A Dean's Choice award-winner at this year's UCI Samueli School of Engineering Winter Design Review, the fully automated trash-collecting robot was designed and built by students under the supervision of CALIT2's project specialist Linyi Xia.

Custom circuit boards, 3/16-inch laser-cut acrylic sheets and 3-D printed parts, as well as off-the-shelf components comprise the robot, which can navigate rooms and hallways locating, recognizing and picking up trash. Powered by two batteries, the

autonomous robot has an Arduino-controlled arm, in which imbedded cameras help it navigate and detect detritus. Raspberry Pi and algorithms from the Open CV software library process images, allowing the robot to recognize rubbish. The prototype currently identifies soft drink cans, but the software's machine-learning algorithms can train it to recognize other types of refuse, too. "We want to help clean up our environment one can at a time," said team member Michael Wegener (right), an electrical engineering student who will graduate this year. Wegener, along with teammates Takahiro Ishikawa (left) and Steve Cho, plan to explore commercialization, potentially deploying the robot as a remedy for Southern California beach litter.

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