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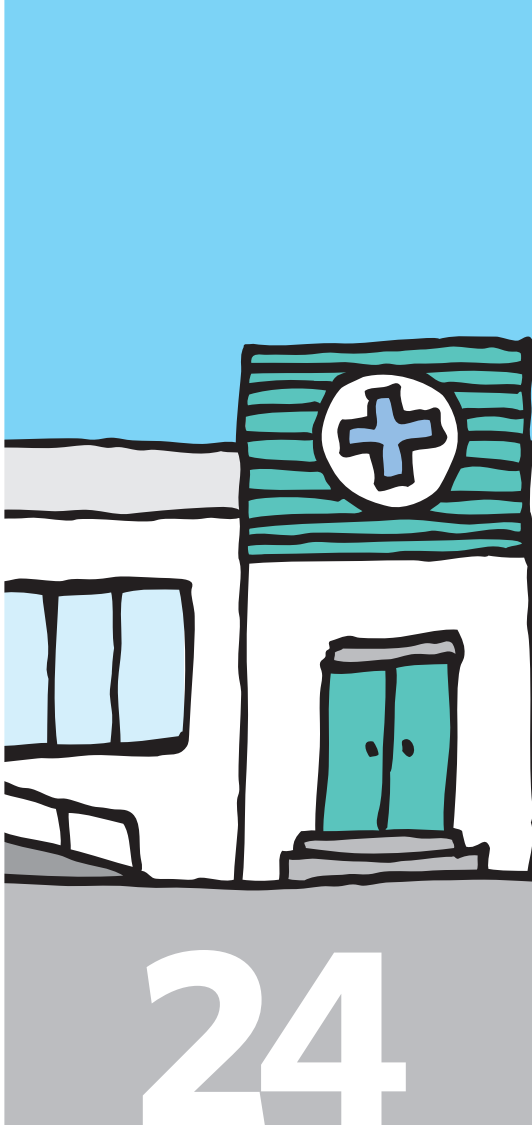
California Institute for Telecommunications and Information Technology

Calit2

Volume 11 | Issue 1 | Fall 2015

University of California, Irvine

It's About Time



features:

departments:

On the cover: *A physicist and his engineering-student son use modern technology to build a delicate timing tool, proving (and updating) an 18th-century genius's theories*

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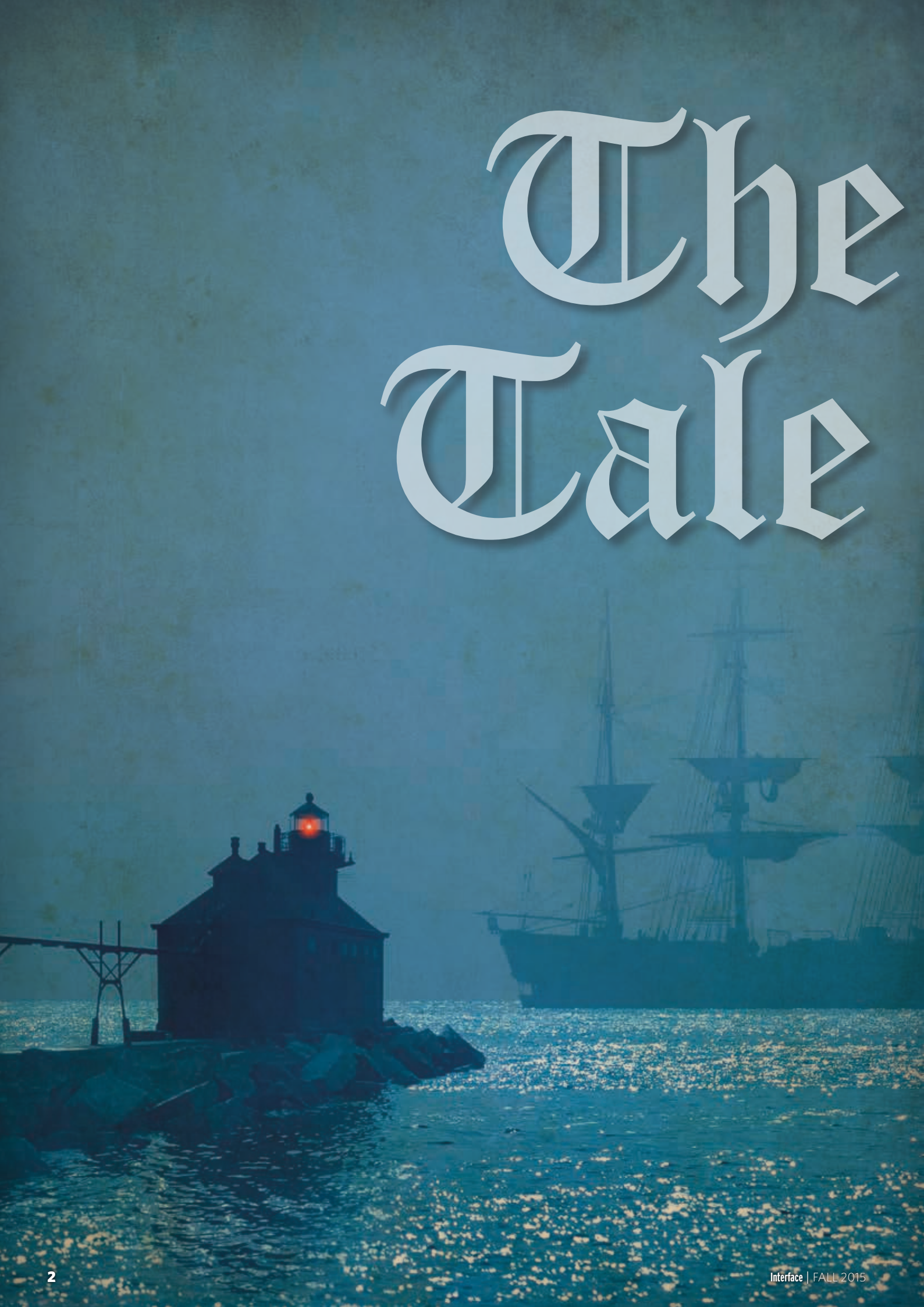
Executive Editor: Shelly Nazarenus
Managing Editor: Sharon Henry
Contributing Writers: Lori Brandt, Anna Lynn Spitzer, William Diepenbrock
Art Director: Michael Marcheschi, m2design group
Photography: Michael Kitada
Publisher: Mike Delaney, Meridian Graphics

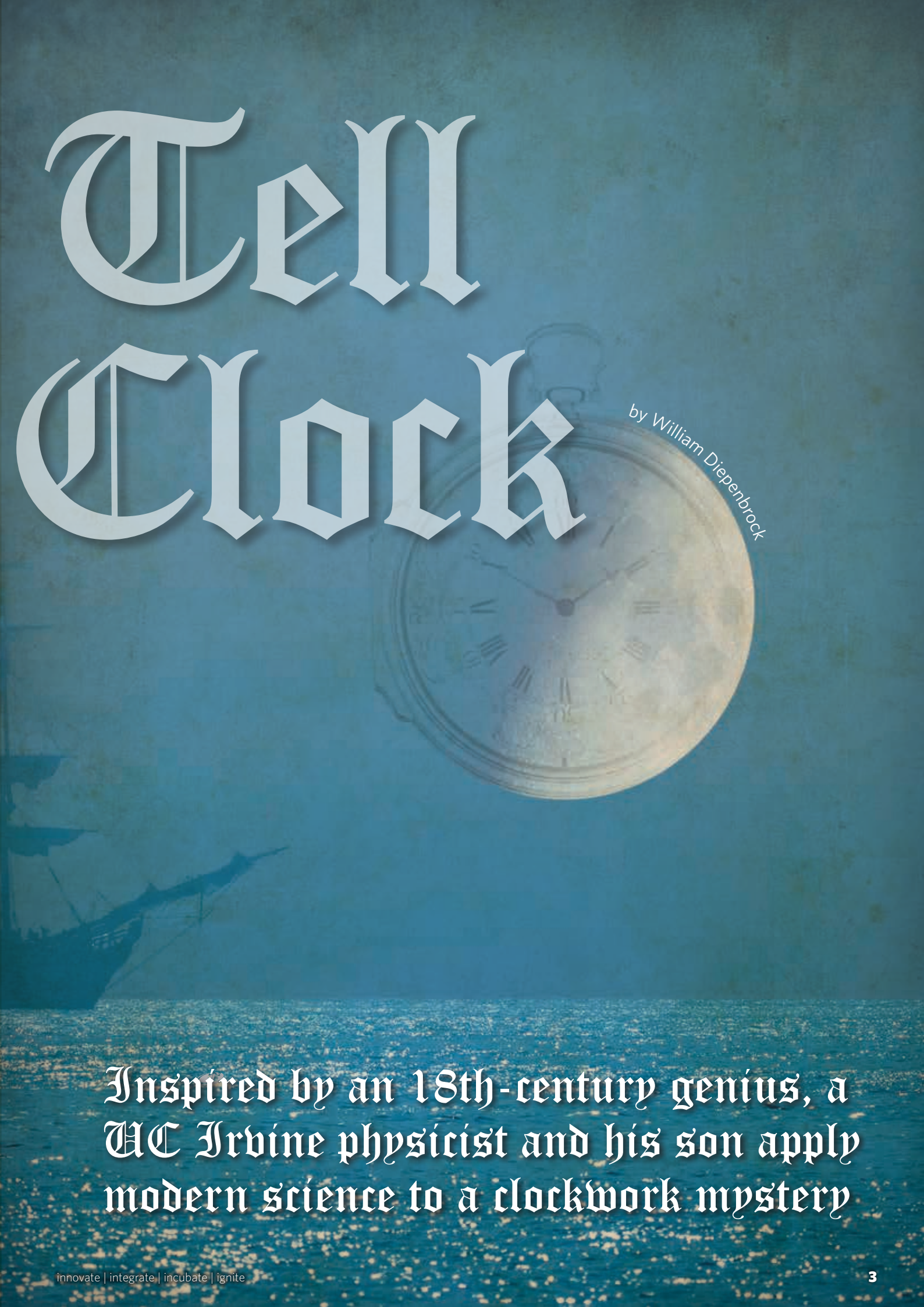
Calit2

University of California, Irvine
4100 Calit2 Building
Irvine, CA 92697-2800
(949) 824-6900
www.calit2.uci.edu
info@calit2.uci.edu


The
Tale

Tell Clock

by William Diepenbrock



Inspired by an 18th-century genius, a UC Irvine physicist and his son apply modern science to a clockwork mystery

This is the tale of how the centuries-old ravings of a mad genius inspired a UC Irvine physicist and his son to craft a novel device so sensitive it can potentially measure the impact of the moon's orbit or the Earth's revolution on the intricate mechanisms of a mechanical clock.

Like the creators of many such breakthroughs, they made it in their garage.

"It's really a unique project because we are using modern technology to try to unravel the secrets of cutting-edge, 18th-century technology – technology that we still don't fully understand," says UCI experimental physicist and Calit2 affiliate David Kirkby. "It's a fascinating intellectual challenge."

"We've both pushed the limits of what we've done before," adds Dylan Kirkby, an electrical engineering student at Cal Poly San Luis Obispo. "I think we've both learned a lot."

The Kirkbys launched their effort in 2013 after David's uncle, a British clockmaker, complained about the lack of tools precise enough to continuously monitor the accuracy of pendulum clocks – the standard for clockmaking from the late 1600s until the early 1900s.

They knew it would be a challenge, but they never guessed the hidden rewards tackling the clockwork mystery would bring.

RAVINGS OF A MAD GENIUS

Among the greatest of the early clockmakers was John Harrison, a cabinet maker by trade, who helped Britain solve the problem of measuring longitude – at that time, a life-and-death issue for the British Navy – by inventing a hyperaccurate sea watch in the mid-1700s.

Near the end of Harrison's life, after a series of frustrating battles with authorities who often discounted his theories, the genius made the fantastic claim that he could create a pendulum clock that would be accurate to a second over 100 days using a design discounted by all common practice.

Where other clockmakers created designs to limit the impact of humidity, barometric pressure and temperature, Harrison's design embraced them. Where conventional practice favored small pendulum arcs, Harrison advocated larger arcs.

His designs were dismissed, even derided, as the ravings of a madman.

More than200 years ticked by before the clockmaker's vision would be given shape.

In 1975, amateur clockmaker and Harrison enthusiast Martin Burgess began building a clock with modern materials based on Harrison's designs as a way of proving his claim. In 2009, the clock was completed and, earlier this year, it was tracked for 100 days at the Royal Observatory at Greenwich.

The stunning result: accurate to within five-eighths of a second.

THE STAGE IS SET

The experiment appeared to vindicate Harrison's theories, but it also posed new conundrums for England's leading makers of mechanical clocks: Why was the Burgess clock so accurate? Could the results be replicated on a broader scale?

To find out, the clockmakers want to build a covey of clocks based on Harrison's designs beefed up with improvements made possible by today's more accurate manufacturing standards and materials. But first, they need a delicate timing tool that can show how and why they work.

"They can build these fantastically small gears using fantastically large machines but really don't have the expertise in modern electronics or software to measure their accuracy," David said.

In the Burgess experiment, horologists checked the clock's accuracy once a day by calling Britain's national speaking clock. A commercial electronic measuring system provided added information, but neither system could show tiny fluctuations in clock performance.

Enter the Kirkbys.

ACCURATE TO MICROSECONDS

Their timing tool constantly tracks a clock's accuracy in millionths of seconds and the arc of the pendulum in hundredths of a degree while simultaneously tracking air temperature, humidity, barometric pressure – even the subtle pull of the moon's 27-day trip around the Earth and the Earth's 365-day voyage around the sun.

So, how did they do it?

First, they mounted a simple pendulum clock to the wall of their Irvine garage. The clock's metal mechanism – exposed directly to the environment – includes four gear wheels, the pendulum and a 13-pound lead weight.

Next, they designed a circuit board to route clock and environmental measurements to a custom-crafted software program that presents and analyzes the data. It's a tried-and-true technique for the senior Kirkby.

In their garage, David Kirkby and his son Dylan designed and built a system to measure tiny fluctuations in a clock's performance.

"I have experience with these kinds of designs from my background in particle physics," he says. "It's a branch of physics where we can't buy our equipment off the shelf; we have to make it. So we design a lot of electronics and software. Only now, instead of tracking galaxies, I'm measuring the movement of a clock."

Dylan assembled the circuit board – an effort that involved more than 100 parts and about three days to complete. One microchip is so tiny, the Kirkbys had to warm its pins in a pancake pan so they could attach it to the board.

The board is fed by meteorological sensors, a GPS antenna mounted on the roof of the family home to ensure a constant stream of accurate time measurements, and an infrared beam that targets a thin titanium comb attached to the bottom of the pendulum.

“They can build these fantastically small gears using fantastically large machines but really don’t have the expertise in modern electronics or software to measure their accuracy.”

NOVEL APPROACH

The heart of the tool is the infrared beam, which rests in a small aluminum block on its own shelf below the clock.

"What's really novel about this is that the infrared beam is very deep in there and shoots through a very narrow hole, so it's very tightly focused, and therefore not affected by changes in ambient lighting. If you could see it, it would look like a light saber," David says.

As the pendulum swings, six teeth on a comb break the light.

"The design of the comb is such that the beam gets broken and unbroken many times on each swing," says David. "That generates a lot of information. From one end to the other, that's not only telling us when it passes, but how fast it passes and, indirectly, how far it swings."

A shorter, seventh tooth designed by Dylan tracks changes in pendulum length as small as one ten-thousandth of an inch in response to changing temperatures.

"That's something nobody's done before," Dylan says.

After gathering data on and off for more than a year, the Kirkbys learned some basic truths.

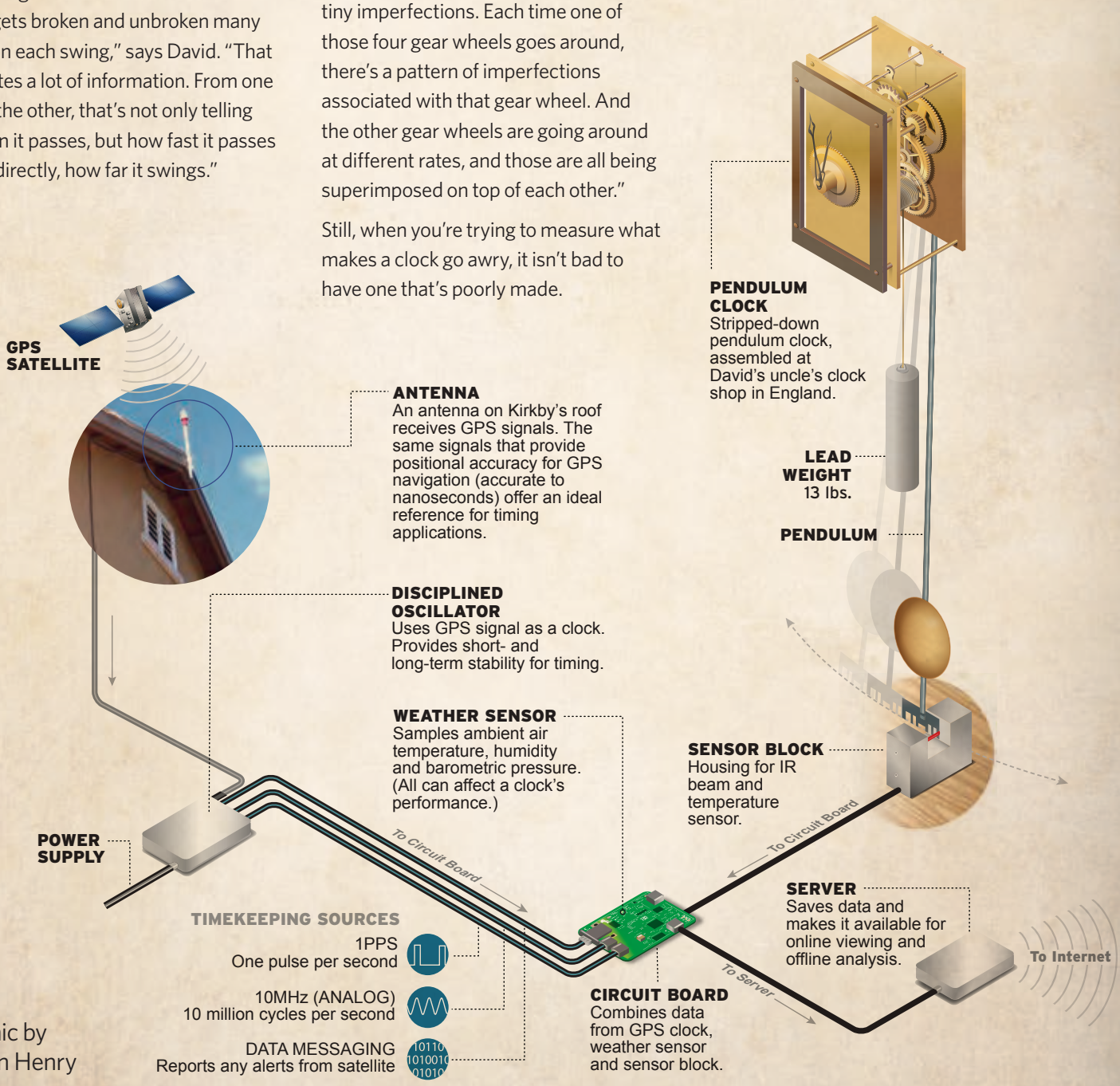
"One of the first things we learned is this clock isn't very well made," David says. "Every tick is different because the gears are hand-cut. Each tooth has tiny imperfections. Each time one of those four gear wheels goes around, there's a pattern of imperfections associated with that gear wheel. And the other gear wheels are going around at different rates, and those are all being superimposed on top of each other."

Still, when you're trying to measure what makes a clock go awry, it isn't bad to have one that's poorly made.

BIG DATA

On that front, the Kirkbys' two-bit timepiece has been a data bonanza, generating so much information that some subtler influences – such as changes in gravity – are harder to see.

That's why they've launched a second stage to the experiment. This month, they will send their sensor array, circuit board and software suite to David's uncle in England. The tool will be attached to a far more accurate clock to begin a more sensitive round of studies, with the expectation that its sensitivity



Graphic by Sharon Henry

and analysis of subtle environmental impacts will clarify why Harrison's design works so well.

If the tool proves itself, it will become part of the next stage of the Harrison saga.

"The clockmakers have a design for a super-Burgess clock," David says. "Ideally, they would like to build several of these to prove to the world that the textbooks are all wrong on how to build an accurate pendulum clock."

"That way, they can let the data do the talking," adds Dylan.

RICH REWARD

The triumph of the British clockmakers, however, will remain secondary to the Kirkbys' reward for their sleuthing. That's because, for them, the project hasn't been about starting a business, selling timing tools to clockmakers or proving Harrison right. They showed that when they posted their ideas to the web.

"Our system's hardware and software are open source, so anyone can study how this new generation of clock designs responds to its environment and achieves its accuracy," David says.

No, for the Kirkbys, the reward lies in a two-year journey taken side by side in a sweltering garage, soldering circuit boards, checking lines of code and persistently winding a cranky clock.

"It's been fun to work together," says Dylan. "It's been a great learning experience for me. I'm pretty gung-ho – let's get in there, just slap it all down – and Dad is more 'no, you've got to build a test program.' He's definitely more methodical, and I picked that up a little bit, which is probably a good thing."

For David, the experience has added a new dimension to his relationship with Dylan.

"This has been a unique experience for me, working with my son as a colleague and learning from each other," he says.

UNLOCKING VISUAL DATA

Kirkby's timing tool is precise enough to record subtle effects of gravity, weather and mechanical imperfections on a clock's performance.

Data is delivered in a visual format and can be viewed in real time or as historical graphs.

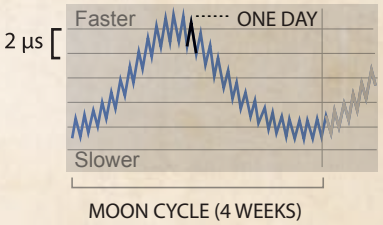
GRAVITATIONAL INFLUENCE

Clock runs faster and slower on one-day and four-week cycles. Because faster times are balanced by equal slower times, there is no change at the end of a cycle.

Moon orbits the Earth: about every 27 days

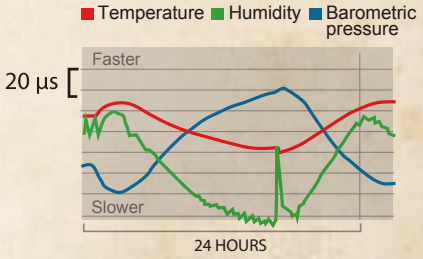
Earth completes rotation: about once a day.

(1 µs = 1/millionth of a second)



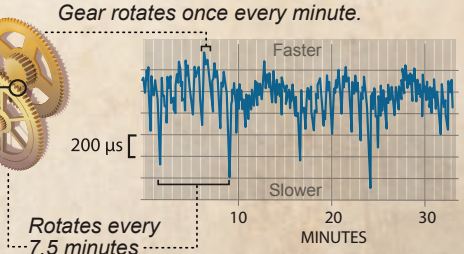
ENVIRONMENTAL INFLUENCE

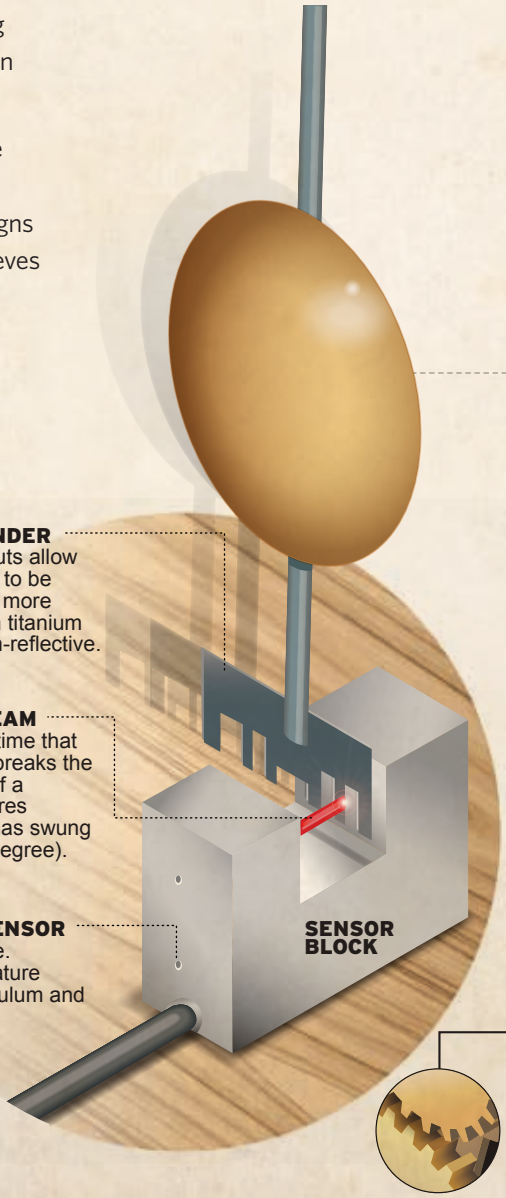
Effects of weather on clock performance



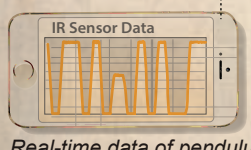
MECHANICAL INFLUENCE

Each gear has its own fingerprint. Data for two gears (gear train) show time variations for each tooth in the gears.





CLIENT
Any web browser can be used to view data.

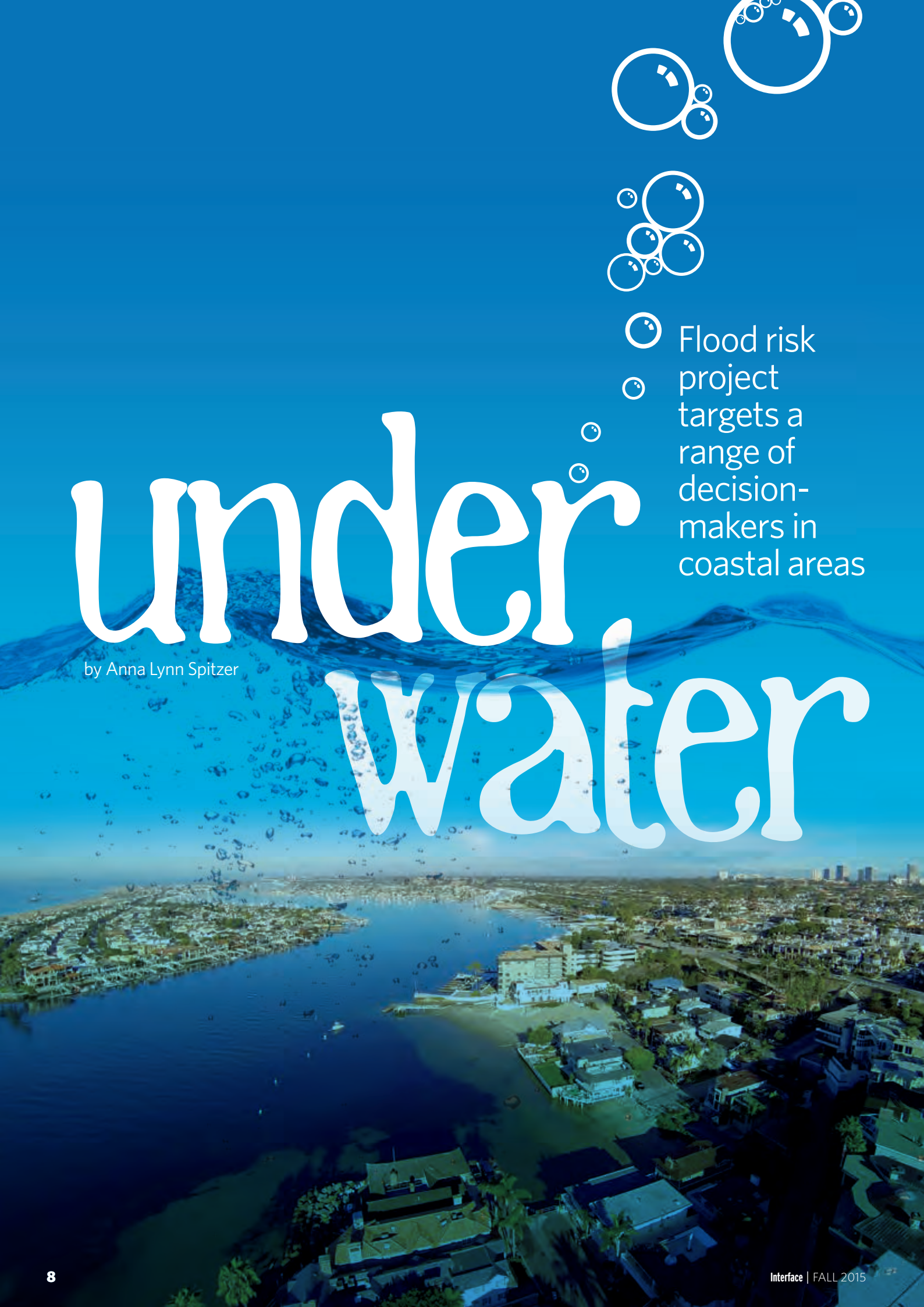


Real-time data of pendulum breaking IR beam.

under water

Flood risk project targets a range of decision-makers in coastal areas

by Anna Lynn Spitzer



Californians struggling through the fourth year of a withering drought might not see good reason to prepare for flooding.

They need look only as far as Texas, though, where last May, a similarly severe five-year drought ended violently when a deadly deluge dropped 37.3 trillion gallons of water over a few days – enough to cover the entire state nearly eight inches deep.

Such is the capricious nature of weather on a planet beset by warmer temperatures and varying climate patterns. These planetary fluctuations can increase the risk of flood, and for residents of coastal areas, destructive flooding can occur even during severe drought.

That's the message a group of researchers is determined to convey. In a lab at UC Irvine's Samueli School of Engineering, civil and environmental engineers are fine-tuning the science of flood risk probability and, in collaboration with UCI's social scientists, seeking ways to communicate this omnipresent threat to a wide range of constituents.

Led by department chair Brett Sanders, researchers on the FloodRISE (Flood-Resilient Infrastructure & Sustainable Environments) project are knee-deep in advanced, fine-resolution computer models that can simulate flooding with more accuracy than ever before.

The four-year, $2.8 million interdisciplinary project, funded by the National Science Foundation, is creating technology that can map street level flood risk to illuminate the unique threats facing individual properties.

Researchers parameterize the flood model by using topographic and infastructure data, "meshing" the site to compute flow across triangle cells.

"Flooding happens with a certain probability, but that probability is not easy to communicate," Sanders says. "We're trying to understand how to take this digital technology – simulating flooding, mapping it, visualizing it – and tailor that to make the information useful to different types of people with different needs."

Flood probability is a complex science that involves lots of intertwined, yet distinct, moving parts: sea level analyses, wave height calculations, tidal data, and rates of river flow, runoff and rainfall, as well as predictions about the way each will behave in the future.

The past several decades have seen a tenfold increase in the rate of sea-level rise, and scientists expect global mean sea level to continue to rise. More carbon dioxide in the atmosphere has led to melting ice caps, expanding the volume of water in oceans. Warmer temperatures also have spawned more intense rainfall, and with the continued expansion of cities around the world, runoff into floodplains is rapidly increasing.

"Historically, we have analyzed the risk of flooding based on river flow, but now we realize that sea level rise is becoming more and more of a concern," says Amir AghaKouchak, a Samueli School assistant professor. "The higher the sea level, the less water rivers can discharge into the oceans during floods."

Explains graduate student Adam Luke, who does much of the project's modeling work: "It's a little warmer so the water in the oceans is less dense, there's more energy for storms, there's more evaporation, and in turn, more precipitation ... the entire hydrologic cycle is intensifying."

Those data tell only part of the flood-risk story, however. Equally important to determining more precise flood probabilities are a specific location's topography and existing infrastructures.

> **We need forward-looking maps of flood risk that reflect the variability we expect to see in the coming decades, and not backward-looking maps based on what we've seen in the past.**

The FloodRISE team measures sea walls with high-precision, real-time kinematic GPS receivers. They integrate high-resolution topographic datasets from airborne Light Detection and Ranging (LIDAR) that samples the terrain at one-meter intervals. They survey sand berms with laser scanners boasting 360-degree viewing angles and one-centimeter resolution. They compile all these bits of information into dynamic, fine-resolution computer models capable of identifying risk probability down to the level of an individual homeowner's lot or an exact spot on the Balboa Peninsula boardwalk. This is known as "street level" flood mapping.

It's a giant leap forward from standard-issue FEMA flood maps that designate whole areas as flood zones without detailing probability rates or honing in on site specifics. FloodRISE's modeling technology solves a system of equations that predicts the flow of water – how fast floodwater might move, how deep it will be, in what direction it will flow and how those parameters will change over time – all across cells as small as 10 feet.

Each triangle in the digital three-dimensional rendering, known as a mesh, represents the water flow inside a small parcel of land or sea, and researchers can zoom in when they want a closer look. "Every time the triangle gets smaller, we get a more accurate reading because we get a more accurate representation of the topography," says Jochen Schubert, a Samueli School research specialist who helped develop the hydraulic model.

With the computer model built, the team's challenge now is to "force" it. That means incorporating input to the model that accounts for causes of flooding: the rise and fall of the tide; the passing of a storm system that causes rainfall, runoff and storm surge; and the height, direction and duration of ocean waves that will break on the beach, possibly causing overtopping.

> **Historically, we have analyzed the risk of flooding based on river flow, but now we realize that sea level rise is becoming more and more of a concern.**

"The question is: what mix of tides, waves, runoff and rainfall do we use? You can't just layer one extreme scenario, say extreme rainfall, on top of another because that assumes they're independent of each other," Sanders explains. "Our team is working on ways of blending these factors that are scientifically credible yet can be easily explained to decision-makers."

"In such a complicated system, where flooding is caused by different drivers, we have to find a way to address these combinations in an appropriate way, where we're not overestimating or underestimating flood risk," says AghaKouchak.

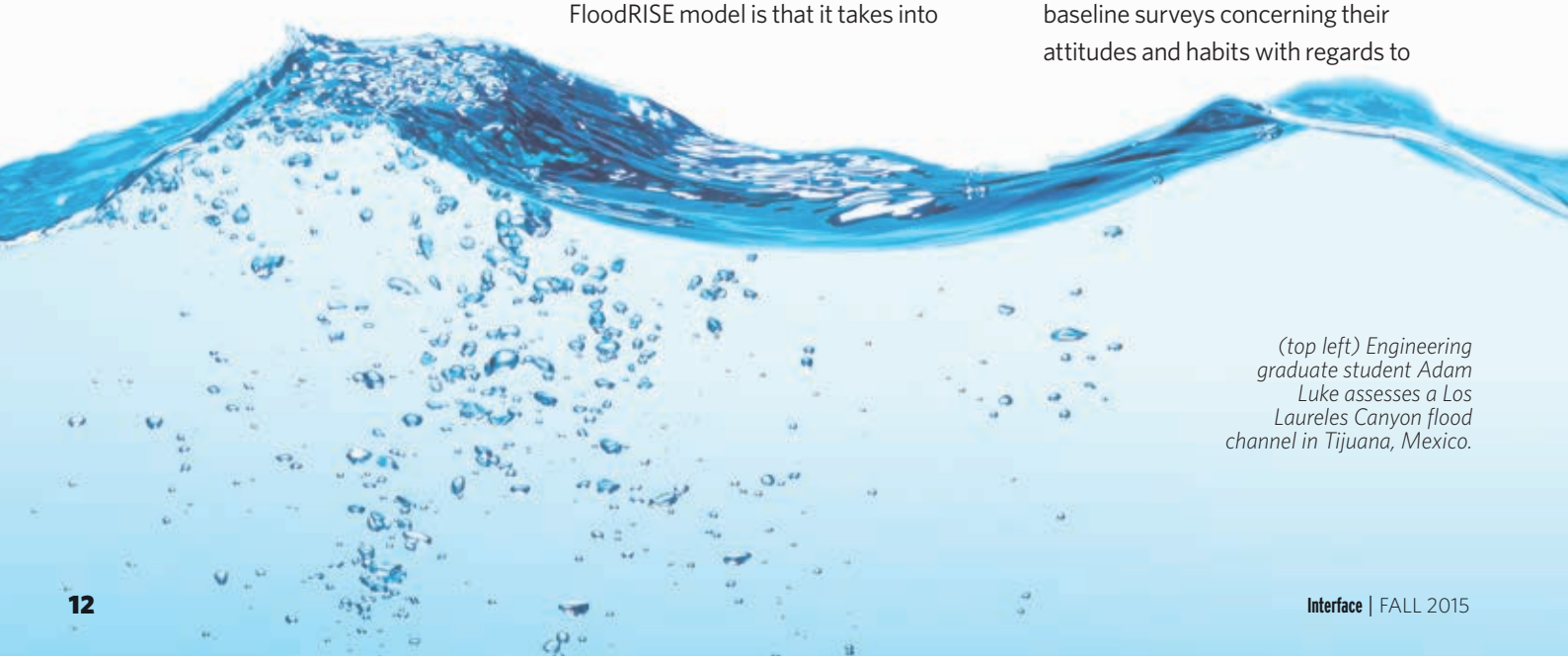
Another distinguishing feature of the FloodRISE model is that it takes into account trends in the factors that pose a risk to flooding. Most models assume that flooding probability doesn't change from year to year, but global warming and urbanization actually are causing the probability of flooding to increase over time. The researchers are developing nonstationary models that account for these changes, allowing risks to be measured over time scales ranging from years to decades.

"We need forward-looking maps of flood risk that reflect the variability we expect to see in the coming decades, and not backward-looking maps based on what we've seen in the past," Sanders says.

FloodRISE's ultimate goal is to create an effective communication medium that delivers essential information to a variety of stakeholders. Experts predict that flooding risk will increase, bringing with it destruction and economic damage that, according to the U.S. Geological Survey, could exceed that of a large earthquake.

"There's a huge gap between what scientists know is happening and what people are willing to do," FloodRISE co-director Richard Matthew, professor of planning, policy and design, told UCI Magazine earlier this year. "Our project is unique because we're learning from the communities what they value, where they see problems and how they respond to scientific evidence."

Residents in Tijuana, Mexico and Newport Beach, Calif. have completed baseline surveys concerning their attitudes and habits with regards to



(top left) Engineering graduate student Adam Luke assesses a Los Laureles Canyon flood channel in Tijuana, Mexico.

heavy rain and flood. They have seen detailed probability maps pertinent to their neighborhoods, where water depth is measured in a rather unorthodox way. Instead of inches or centimeters, potential flood depths are calculated as ankle-high, knee-high and chest-high.

"If we tell them one foot or two feet, they may not relate; this makes it more intuitive," Sanders says. "It's an example of what happens when social scientists interact with engineers."

Later this year, a set of five maps will be presented to focus groups, such as city planners, homeowners, emergency responders, business owners and environmental groups, for example. Participants will be queried on the maps' effectiveness and will be asked what is missing. Researchers plan to take that information back to the lab and produce updated versions. "The hypothesis is that depending on what kind of decision you need to make, you'll need different types of maps," Sanders says.

"Social scientists have known for a long time that communication is most effective when information is personalized, and with street-level flood models we can portray flood risk at the same scale that people process most information. The bigger issue we're trying to figure out is: can personalized flood-risk information, combined with community engagement, trigger more cost-effective responses to the alarming worldwide growth in coastal flood risk?"

(top right) A boat crew from the U.S. Geological Survey measures the effects of levee detonations, meant to ease flood risk along the Mississippi River in 2011. Photo Courtesy USGS

BEFORE THE PEAK by Pat Brennan

FloodRISE Modeling Team Offers Valuable Insights on Levee Detonations

A controversial decision in 2011 to blow up Mississippi River levees reduced the risk of flooding in a city upstream, lowering the height of the rain-swollen river just before it reached its peak, according to a newly published computer modeling analysis led by UC Irvine scientists.

The work focused on a Missouri agricultural area called the New Madrid Floodway that was inundated when the levees were detonated. The researchers found that the region would have flooded anyway if the river had been allowed to overtop the levee banks. And separate modeling showed that the resulting damage to crops and buildings would have been similar either way, though the detonations did shift the damage zone toward Missouri and away from Illinois and Kentucky.

Previous studies had reported more than $50 million in levee repair costs as well as damage solely from the rapid flow of water across the floodway after the detonations, which scoured farmland and left behind thick deposits of unwanted sand. The new research found that allowing those levees to overtop naturally would have resulted in less erosion.

Still, the flood risk was reduced for the upstream city – Cairo, Ill. – just as intended.

"Our model's not saying the water would have definitely overtopped the levees at Cairo," said UCI professor and chair of civil & environmental engineering Brett Sanders, an author of the study led by UCI graduate student Adam Luke. "It doesn't say it wouldn't have happened. What we're saying is that detonation reduced the risk of flooding."

Luke built a computer model of the devastating 2011 floods along the Mississippi and Ohio rivers. Then he compared modeling runs conducted both with and without the levee detonations. He discovered that they resulted in a lowering of Mississippi River levels near Cairo by 2.6 feet.

The team also used a separate computer model developed by the Federal Emergency Management Agency to estimate the costs: more than $250 million in building and crop damage in the flooded area. That's about $11 million less than it would have been had the levees not been detonated but allowed to overtop without intervention.

The study's findings support earlier work showing the erosion of flood plains caused by levee bursts, leaving scour holes and sand deposits. With that being a potentially major drawback to flood control by detonation, the authors recommend that engineers place greater emphasis on minimizing erosion when creating such a flood control system.

SURF-IoT

by Shelly Nazarenus

Calit2's decade-long summer undergraduate research fellowship program embraces the Internet of Things movement

This summer we wanted to finish a beta version of the application, and it's wonderful to finally see it in the hands of patients and (hopefully!) contributing to the quality of their care.

Project: Pain Buddy

Fellow: Tyler Stevens

Mentors: Michelle Fortier and Sergio Gago

Abstract: An Android application that addresses the challenges of at-home healthcare for children with cancer and other long-term diseases. Patients take a survey twice a day and are then guided through in-application relaxation and pain-management exercises to ease their symptoms. Healthcare providers are able to track patients' progress over time, enabling them to monitor their patients' needs from afar and provide better care. *(See article, page 24.)*

Some of the data I collected from the participants were unexpected, and it made me realize the challenge of making false assumptions and the impact it can have on design.

Project: Mobile App for Latina Breast Cancer Survivors

Fellow: Nicole Ulgado

Mentors: Dara Sorkin, Yunan Chen and Alfred Kobsa

Abstract: Breast cancer is the most common cancer diagnosed in Latinas in the U.S., and only 32 percent of survivors engage in the recommended level of physical activity. This project aims to generate a technological solution for improving lifestyle behaviors. Data were collected from 48 Latina breast cancer survivors through surveys and focus groups, and analyzed to determine behavioral patterns and technology usage. The findings were integrated into a motivational mobile application.

I discovered that maybe hardware is not my thing.

Project: M2M Tracking

Fellow: Albert Lau

Mentors: Mohammad Al Faruque and Andrew Chen

Abstract: The global positioning system has been a useful tool to accurately map location. The problem with GPS is that it consumes a lot of energy and cannot be used indoors. This project uses Bluetooth, which is known to last for months on a single coin battery, to predict a person's indoor location. Conditional random field or particle filters were used to help pinpoint the object location. If this project determines low-energy Bluetooth is feasible for indoor localization, it can be used in multiple applications, from something as small as finding a lost item to something as big as building smart homes.

It has been amazing seeing my computer screen go from nothing to a fully functioning website.

Project: Health360

Fellow: Thomas Wurzer

Mentors: John Billimek and Anmol Rajpurohit

Abstract: People often do not take their medication as prescribed. Health360 is a web application that encourages patients to take charge of their health by providing an easy-to-use interface that helps monitor their well-being while taking their medication. The application collects and shares the patient's data with his/her doctor so together, they can view the progress and more easily determine the most effective medication considering the patient's specific circumstances.

Working across disciplines made me stretch because I had to learn other fields' jargon.

Project: Cloud-based Tools to Empower Interdisciplinary Research

Fellows: Nathanial Benjamin, Stephanie Chang, Yang Jiao and Jungkyu Park

Mentors: Kimberly Jameson and Sergio Gago

Abstract: This project is focused on creating a resource for researchers and students to access the data of the Mesoamerican Color Survey Archive – a large anthropology survey of color categorization from monolingual respondents in 116 indigenous languages. The team created and developed various applications and methods for organizing and digitizing this data, which is currently only available as scanned handwritten notes. Some of these methods are utilizing optical character recognition and crowdsourcing, while others are focused on analyzing and finding patterns in the data. The goal is to make the data accessible online via a Wiki website.

There has been nothing but endless support from the mentors, allowing me to shape the experience to what I wanted it to be.

Applying the stuff I learned in machine learning class and seeing how it works amazingly well to solve our problem is very exciting.

Not all my ideas provided results the way I imagined.

The most rewarding part is helping a real-world product get built from the ground up in such a short amount of time.

Project: Qualoscopy

Fellow: Luke Raus

Mentors: Dr. William Karnes and Don Patterson

Abstract: Colorectal cancer is the leading cause of cancer death among nonsmoking Americans. The majority of colorectal cancers can be prevented by finding and removing colorectal polyps. Quality colonoscopy has become a major emphasis of Medicare's new quality measures program. Doctors are now required to report several quality indicators with associated benchmarks that will determine their level of reimbursement. Qualoscopy is a web-based application that allows nurses and doctors to document important information and quality measures during a colonoscopy examination.

The most difficult aspect was pinning down the requirements, or seeing the impact of the project from the user's eyes.

Project: BrainTrack

Fellow: Wilmer Domingo

Mentor: Gillian Hayes

Abstract: The BrainTrack platform tracks and assists in the treatment of children who have recently sustained concussions and are suffering from cognitive and physical impairment. The platform includes a mobile application with a clear and simple design, providing recovery guidelines for patients and a channel through which they may express concerns or feedback on their progress. Within this framework, we use the Microsoft Band to directly message patients and record health data to be sent to physicians, which will improve administration of the concussion-recovery protocol.

In 10 weeks time, I ended up learning a lot about coding tools and mathematics.

Project: VR Goggles for Vestibular Rehabilitation

Fellow: Thomas Lee

Mentors: Dr. Hamid Djalilian, Crista Lopes and Marlon Maducdoc

Abstract: The vestibular system of the inner ear is responsible for sensing orientation and rotation of the head. Patients with vestibular dysfunction may experience dizziness and vertigo. Studies show that patients with chronic vertigo improve after repeated exposure to optokinetic stimuli, but this therapy requires massively sized, expensive equipment to obtain the desired outcome. This project is designing and developing a realistic, immersive virtual environment using virtual-reality goggles that can make vestibular rehabilitation far more affordable and accessible.

IoT Calit2

Face of Calit2

NOT JUST Toolin' Around

by Anna Lynn Spitzer

Calit2's cleanroom manager is serious about his responsibilities as well as his leisure pursuits

(above) Don't be fooled by the smile; Hes is all business when it comes to his cleanrooms. "When I see any risk," he says, "I get pretty uptight about making sure things are the way they're supposed to be."

It all began with a Heathkit. The do-it-yourself electronics kits, popular in the 1960s and '70s, were a go-to playtime choice for a young Jake Hes. "I was always kind of handy with TVs, radios, mechanical things," Hes recalls. "I just started tinkering around and before I knew it, I had short-wave radios, various types of altimeters, scopes, power supplies ...."

It seems altogether fitting then, that today, Hes oversees Calit2's two equipment-laden cleanrooms: the Integrated Nanosystems Research Facility (INRF) and the Bio-Organic Nanofabrication (BiON) facility. Fabrication and testing sites for devices like accelerometers, microswitches, microfluidic devices and gyroscopes, and new materials like nanotubes and graphene, both facilities contain Class 100-1000 cleanroom areas. Between them there is a plethora of sophisticated micromachining, photolithography, laser ablation, glass etching and nanoimprinting tools – a veritable playground for a grown-up Hes.

Hes was also instrumental in designing, assembling and opening both cleanrooms, alongside Calit2 Irvine Director G.P. Li, whom he met in the late 1990s.

At the time, Hes had worked nearly 30 years for Northrop Grumman's research and development team, first in the space travel program and later, in defense. Li was collaborating on a project with Northrop, and was looking for someone who knew cleanrooms to help him train students to use the INRF equipment.

"My bosses said G.P. had some old equipment that was pretty similar to what we had and asked if I'd go over and take a look," Hes recalls. "So I went over and met G.P. … and I'm thinking, 'Wow, you guys have some pretty old stuff here.'" Nevertheless, he signed on as a consultant and agreed to help out in the evenings and on weekends.

"I've been married to the same woman for 43 years and I don't know how she lasted that long because I wasn't home that much," he says, shaking his head. "I'd be dragging my rear end in at about 9 o'clock at night and leaving at 6 o'clock in the morning. I'm kind of an adrenaline junkie and I enjoy a good challenge."

In a fortuitous chain of events, Northrop, which was in the process of selling off some of its properties and relocating research programs, decided to donate lab equipment to INRF in lieu of moving it out of state. The company figured it would have access to the equipment for ongoing projects should the need arise. "G.P. was all enthused about doing that," Hes says, "because it would bring new life into the facility."

But now, Li needed someone to manage the cleanroom. Again, he turned to Hes, and as fate would have it, the timing was perfect. Northrop was planning to reassign him; he'd end up in Baltimore, Philadelphia or New Town, N.D., or he could stay in California in a role he knew wouldn't challenge him. After talking it over with wife Martha, Hes made a decision: he took an early retirement from Northrop, and began his second career – one with indisputable differences from the first.

"After I decided to come here, I asked G.P. how much money we had to work with," Hes recalls. Li's response – "We don't have any money" – provided him with a rude awakening to the realities of university funding challenges.

"I said, 'WHAT? What do you mean we don't have any money?'" says Hes, laughing at the memory.

"The cleanroom has one of the most successful health and safety records on campus because Jake requires involvement from all the professors and students. He constantly reminds students and faculty that safety is everyone's responsibility."

Li eventually obtained some funding from then-engineering school Dean Nicolaos Alexopoulos and also contributed some of his own research funds; together he and Hes rebuilt and re-instrumented the INRF and opened it to academic and corporate users. In 2005, as a way to avoid cross-contamination of materials, the two repeated the exercise, outfitting and opening BiON for biomedical device fabrication and testing. From then on, INRF was reserved for semiconductor, micromachining and MEMS fabrication.

Hes (back row, second from right) and G.P. Li (far right) lead industry visitors from Japan on a tour of the cleanroom.

Hes, who is genial and self-effacing, becomes brisk and businesslike when he steps into a cleanroom. "He's a completely different person," Li says.

"I wouldn't say I'm paranoid, but I have seen incidents and accidents, and even some fatalities when I was at Northrop," says Hes. "So when I see any risk, I get pretty uptight about making sure things are the way they're supposed to be. Sometimes people don't take this kind of environment seriously. But this is just like a chemistry lab; there are a lot of things that could go wrong."

Before retiring last year, Rebecca Lally supported cleanroom operations for 15 years as a specialist in the UCI Department of Environmental Health and Safety. She says safety has always been priority number one for Hes, who holds weekly safety meetings with research groups and helps them design safer experiments.

(below) Hes checks the settings on the Mark 50 E-beam evaporator.

(Opposite page, top, middle, bottom) Hes scaling Mt. Whitney, the highest summit in the contiguous U.S.; rock climbing with former student Harrison Chang; and rafting the Kern River with a group of students. "What's really neat is when they get the same kind of enjoyment from it that I get," he says.

"It's not unusual to see Jake working late nights and weekends to make sure all students are working safely," she says. "The cleanroom has one of the most successful health and safety records on campus because Jake requires involvement from all the professors and students. He constantly reminds students and faculty that safety is everyone's responsibility."

Regardless, accidents can happen, as Harrison Chang knows all too well. A graduate student at the time, he was working late to complete an experiment and somehow allowed the vacuum chamber on the E-beam evaporator to fill with water. "I was worried that G.P. was going to kick me out of the program, but I was more worried that Jake was going to kill me," he remembers. "I was pretty sorry for letting G.P. and Jake down, but especially Jake because I was one of the few students he granted tool access to during off hours."

Chang, who says that Hes was a "great mentor," was given a second chance. "He told me I should learn from my mistake because people make mistakes all the time. I was really grateful since it helped me learn how to give people a second chance as well." Chang received his doctorate in 2004, and is now a manager at the Taiwan Semiconductor Manufacturing Company.

Peter Burke, UCI electrical engineering professor, has collaborated with Hes for years in the INRF, and attests to his bond with the students. "They come in young and eager, but also make mistakes that he has never seemed upset about," Burke says. "He just tries to help them understand the correct way forward."

"They come in young and eager, but also make mistakes that he has never seemed upset about. He just tries to help them understand the correct way forward."

Burke also lauds Hes' dedication, recounting an incident when he and a student were working late and heard a hissing noise from one of the machines. "I called Jake and woke him up, but he seemed cheery and was happy to troubleshoot over the phone, even though it was the middle of the night."

Former graduate student Yu-Hsiang (Shawn) Hsu, an assistant professor at National Taiwan University, also remembers Hes' knack for fixing errant equipment. "If we had trouble on the machines, we would just get Jake. He would come and give the machine some tweaks and it would work just fine," Hsu says. "I believe INRF and BiON would not be this productive if we didn't have Jake."

It would be difficult to dispute Hes' commitment to the job – he once spent the night in the lab "babysitting" a reactive bottle so no one would unwittingly open it and be exposed to fumes – but the man also knows how to relax.

An avid hiker, kayaker, rock climber, river rafter and mountain biker, he owns a quarter of an acre in Kernville, in the southern Sierra Nevada Mountains, and takes abundant delight in introducing his students to the great outdoors.

They raft or rock climb during the day, then set up tents, build campfires and eat s'mores at night. "Some of the foreign students didn't even know what this type of activity was," he says. "What's really kind of neat is when they get the same kind of enjoyment from it that I get."

One of six siblings, Hes says that he's the only one who participates in thrill-seeking pastimes; the family joke is that someone must have dropped him on his head. "But it comes down to this adrenaline rush," he says.

His two daughters and a couple of his three grandchildren share his love of the outdoors, albeit to a less hair-raising degree. His 20-year-old grandson often rock climbs alongside him.

He explains the thrill he gets from his physical exploits: "It really makes me feel like I'm alive," he says. "And I pass that along when I'm working with the students. You can't just sit there and look at a tool all the time."

Once back in the lab, though, Hes relishes his interactions with students. "I feel that I'm giving back to the industry that has given me everything I've got," he says. "If I can just make a change in one individual and spark that passion that someone sparked in me ... Some of them dread having to get gowned up and work in the lab, but when you explain to them the rewards and what is possible, they have a different outlook. And when they credit me in their papers," he says proudly, "I feel like, hey, I made a difference. It's really gratifying."

Ganesh Varadarajalu, a recent recipient of a doctorate in electrical engineering, praises Hes for helping him attain his degree. "He worked several late nights and weekends to enable me to complete my fabrication process during my Ph.D.," Varadarajalu says. "Jake has a unique ability to connect with the students and is a pleasure to work with."

Despite the long days and frequent seven-day workweeks, Hess gets constant satisfaction from his job. "Some people's lives drag on so slowly because they have nothing to look forward to. I can't think of a day that's gone by that I haven't had something to look forward to."

And future goals? His are pretty simple. "I always kid around with the students. They'll say, 'Hey Jake, how you doing today?'" Hes recounts. "I'll say, 'I'm above ground, so I'm doing great.'" And that, he adds, "is my goal for the next several years."

Welcome To PAIN BUDDY

by Anna Lynn Spitzer

New app helps young cancer patients communicate and manage pain during treatment

Eighteen-year-old Gregory Cholula was just months from high school graduation last year when his plans for the future changed abruptly.

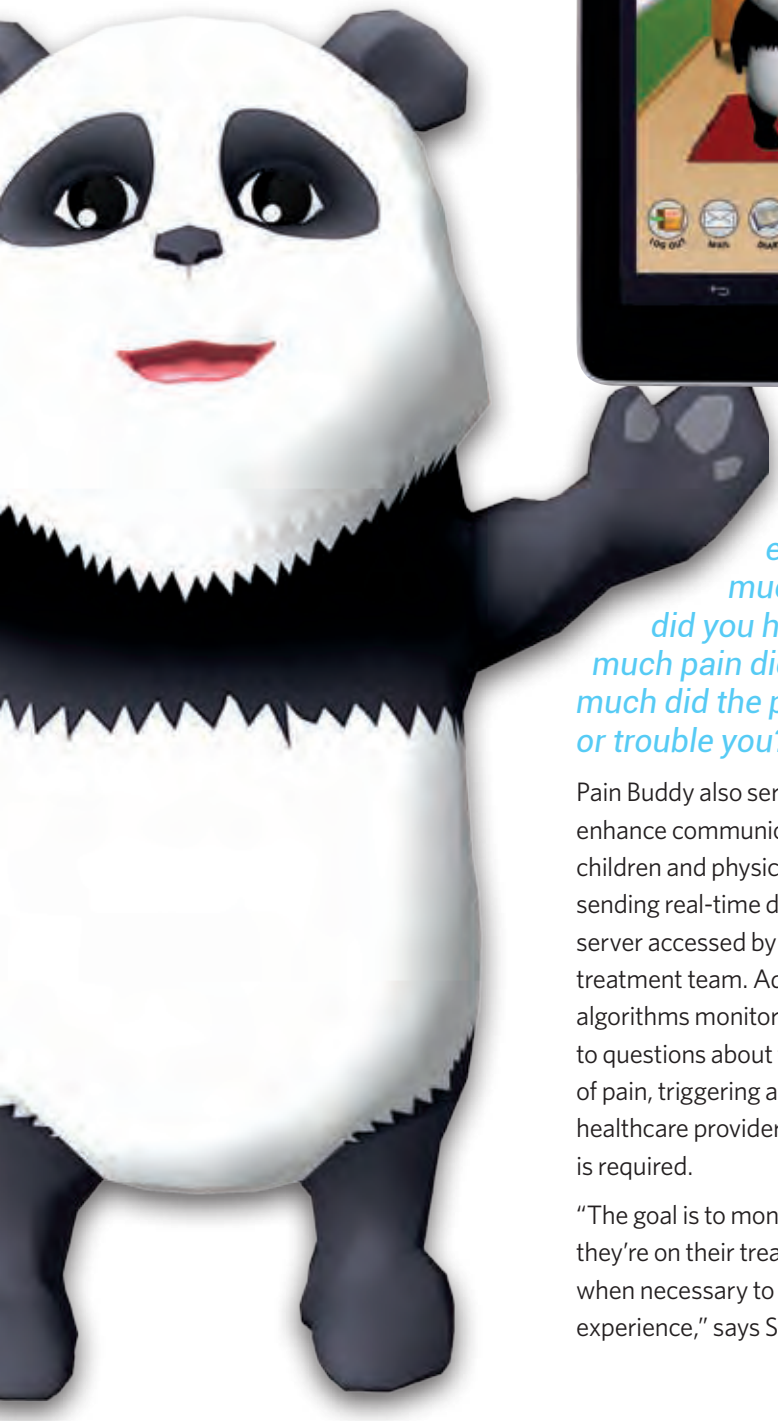
He had been feeling some weakness in his limbs but brushed it off, attributing it to a reduced workout schedule. That is, until a terrifying seizure sent him to the emergency room at CHOC Children's Hospital, and a battery of tests indicated acute lymphoblastic leukemia. Instead of departing for college in Colorado as planned, he found himself traveling to the CHOC clinic to undergo chemotherapy.

Unfortunately, Cholula is not alone. Childhood cancer diagnoses have increased steadily over the last few decades. Every day in the U.S., 43 children are diagnosed, and the average age of diagnosis is 6 years old. Each year, more than 40,000 children undergo cancer treatment.

In general, Cholula says, he handles the chemo pretty well but does contend with intermittent bouts of nausea and pain.

He, and other young cancer patients like him, spent two weeks last summer beta-testing a Calit2 mobile app designed to help them more effectively manage their symptoms during treatment.

Called Pain Buddy, the app's engaging, animated avatars provide support and encouragement, help kids gauge their pain level, and teach them coping skills and other pain-management strategies.



"Did you have any pain since your last diary entry? How much of the time did you have pain? How much pain did you feel? How much did the pain bother you or trouble you?"

Pain Buddy also serves as a tool to enhance communication between children and physicians, automatically sending real-time data to a dedicated server accessed by the oncology treatment team. Additionally, its algorithms monitor children's responses to questions about frequency and level of pain, triggering alerts to parents and healthcare providers when intervention is required.

"The goal is to monitor the kids while they're on their treatments and intervene when necessary to improve their experience," says Sergio Gago, Pain Buddy's lead designer. He collaborates on the project with Michelle Fortier, a psychologist at UCI's Center for Stress and Health, which focuses on family-centered care and alternative approaches to reducing pain and anxiety in children and families.

"Did you have anything else that made you feel bad or sick since your last diary entry? Please type in your symptoms."

Funded by the American Cancer Society (and a local foundation that requests anonymity), the app, built for now into a Nexus 7 tablet, is designed for 8- to 18-year-olds. Animated avatars verbally encourage the patients to use the touchscreen interface to answer a series of questions twice daily in a Pain and Symptom Diary. Participation earns them virtual coins, which they can use to buy accessories for their avatars, or unlock and personalize new background scenes, some of which were drawn by children who are themselves cancer patients.

"Tap on the areas on the body where you have pain."

Gago, Calit2's information technology specialist, set out to make an app that is engaging, interactive, rewarding and fun – a crucial mix, he says, for enticing kids to actually use it. "Most digital health information systems are boring, overly complex and have minimal involvement. Our goal is a program that communicates meaningful information and builds influential health-promoting relationships."

"Select as many of these words that describe your pain."

The multidisciplinary design team, which includes graduate and undergrad student researchers, spent several challenging months designing and animating the initial avatar, a panda bear, as well as a brown bear that teaches behavioral training. Two more avatars – an elephant and a penguin – are in the works. Using motion capture software, the team developed nearly 200 animations, synched the avatars' speech to their facial expressions and tediously, frame by frame, perfected facial expressions and body movements.

"Sometimes communicating with others can be challenging for kids. But if they communicate with a friendly virtual character, they may feel more comfortable," Gago says.

Fortier, the project's principal investigator, says Pain Buddy is filling an important niche as more children receive outpatient treatment. "Kids undergoing treatment are spending more time at home, which is fantastic for quality of life, but parents are not always well-equipped to manage pain and symptoms."

A firm believer that medication is just one instrument in the pain-management toolkit, she is especially pleased with the app's "Skills Discovery" section, which provides cognitive behavioral training. "Overall relaxation skills are important, and a child normally would work with a psychologist to learn these," Fortier says.

"Which skill would you like to discover? Belly Breathing? Body Relaxation? Guided Imagery? Distraction? Mindfulness?"

> "It's more about quality of life during treatment: helping children cope better, minimize their pain, eat better and sleep better."

> The literature shows us that children age 8 and up can really use these electronic devices to monitor their health information. It's a great way to provide them with improved pain management but also is a tool that can be their buddy during cancer treatment.

The Skills Discovery site can be accessed in two ways: children can opt to participate, or, based on their answers in the Pain and Symptom Diary, the app automatically takes them to the training section, where they're given easy-to-follow tutorials.

Cure rates for childhood cancer continue to improve; survival rates are now over 80 percent. But Pain Buddy is not intended to influence treatment outcomes. "It's more about quality of life during treatment: helping children cope better, minimize their pain, eat better and sleep better," Fortier says.

This, and projects like it, are integral to Calit2's mission to develop digital information and communication technologies that impact society. "One of our key goals is to explore the digital transformation of healthcare," says Calit2 Irvine Director G.P. Li. "This app can help physicians and healthcare providers tailor treatments in a more effective way to better meet the needs of the patients."

Joseph Solis, a 14-year-old who was diagnosed with optic nerve glioma, receives weekly chemotherapy, which he says "makes him feel sick sometimes," with fever, nausea, and pain in his stomach and feet. Pain Buddy, especially the relaxation techniques, helped him feel "a little better," and he continues to practice the behavioral skills, especially the breathing. His advice to other kids undergoing treatment: "You should try it because it will help a little. The breathing exercises helped me the most."

Pain Buddy also could have an impact on long-term chronic pain, which often results from poorly managed acute pain, like that which occurs during cancer treatment. Datasets from the National Childhood Cancer Survivor Study indicate that childhood cancer survivors have a higher likelihood of experiencing chronic pain as adults, and Fortier hopes Pain Buddy can impact this long-term trajectory. "We think if we can manage pain during cancer treatment, we're also changing longer-term outcomes, and maybe these kids won't be at higher risk for chronic pain."

"Since your last diary entry, did you feel more tired than you usually do?"

In the meantime, Pain Buddy continues to evolve with help from its target audience. "Everything we design is vetted by kids in informal focus-group settings," Gago says. Feedback gleaned from the recent pilot testing will result in additional changes to the prototype, ahead of a randomized-control clinical trial involving 100 patients, scheduled for later this year.

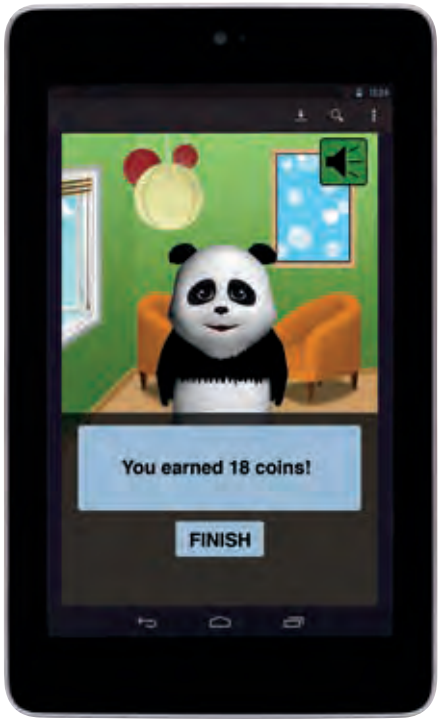
"We want to eliminate bugs and fix major issues and things that are distracting the children," he adds. "Anything to make sure we won't have technical issues during the clinical trial."

So far, the app appears to be a hit with the beta-testers. "The response has been pretty good so far," says project coordinator Ariana Martinez, who

oversaw the trial and cataloged the feedback. "The kids like the app; a few of them like some questions more than others, and some had suggestions about modifying the avatars. About half especially liked the relaxation training."

Eight-year-old Veronica Fernandez is undergoing treatment for optic nerve glioma. Chemotherapy leaves her weak and makes eating difficult. She said she liked Pain Buddy's talking interface, and "answering the questions was fun." The best part about the app? "It teaches me to think about how I feel," and even, she concedes, helped her to feel a little better.

"You have finished the diary! You earned 18 coins!"



Dr. Leonard Sender, medical director of the oncology services team at UCI Medical Center's Chao Family Comprehensive Cancer Center and an expert in children and adolescents with cancer, has not seen the app yet. But he gives two thumbs up to the concept. "A way to connect a patient to their care provider [in order] to provide real-time data analysis and feedback to interventions, I think is extremely helpful," he says.

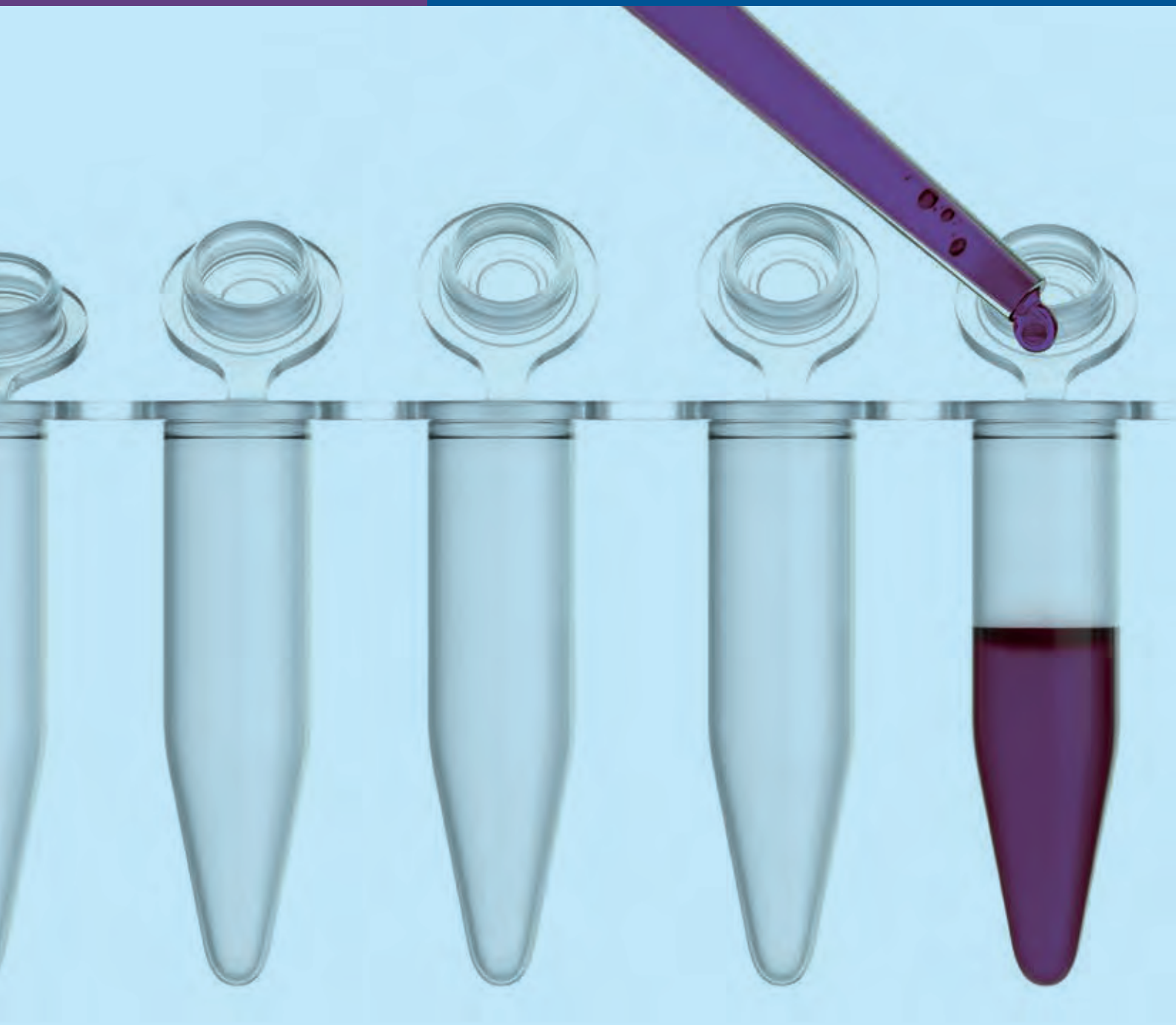
Fortier has high hopes for the project and its eventual impact on children undergoing cancer treatment. Future versions may include a social-networking component so kids can communicate with fellow patients. Other possible iterations include voice-recognition technology and a Spanish-language version.

"The literature shows us that children age 8 and up can really use these electronic devices to monitor their health information," she says. "It's a great way to provide them with improved pain management but also is a tool that can be their buddy during cancer treatment."

One day, she hopes, Pain Buddy will be the standard of care for children diagnosed with cancer. Up-to-date data about pain and symptoms are essential to designing effective, proactive approaches but it's nearly impossible to report retroactively about pain.

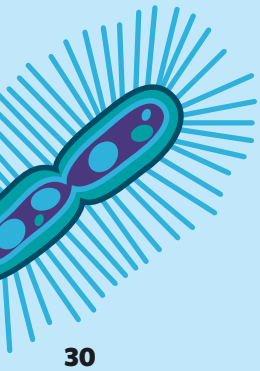
"Pain Buddy will give us real-time, accurate data that we can use to prevent and decrease pain and symptoms," Fortier says.

Perhaps more importantly, she adds, the app can empower kids to help themselves. "They can see that when they use this, they feel better … they can have an impact on how they feel. And that is vital to helping kids gain a sense of control over what's going on when they're faced with a pretty devastating illness."



BUSTING BACTERIA IN WAST

by Lori Brandt



NEPTUNE DIAGNOSTICS USES DNA-IDENTIFICATION TECHNIQUES TO ALERT

It helps diagnose genetic disorders, identify viruses and even match criminals to crime scenes. Medical and forensic scientists routinely rely on polymerase chain reaction (PCR), a fast and inexpensive technique that amplifies, or copies, small segments of DNA to gather information on a molecular and genetic level.

A new startup company in Calit2's business incubator TechPortal is taking this DNA-identification technique to the wastewater industry. Called Neptune Diagnostics, the small company is developing a PCR-based product that rapidly detects and quantifies troublesome bacteria lurking in wastewater. It received a $5,000 seed grant from the National Collegiate Inventors and Innovators Alliance, followed by a $150,000 Small Business Innovation Research grant from the National Science Foundation to test and commercialize its product, B&F Alert.

As California enters the fourth year of an unprecedented drought, water officials are looking for alternative sources and new technologies to mitigate shortages.

EWATER

WASTEWATER TREATMENT PLANTS OF DISRUPTIVE ORGANISMS

Recycled wastewater is an integral part of the state's water supply. Indeed, Orange County's pioneering Groundwater Replenishment System (GWRS) produces up to 70 million gallons of drinkable water every day. Turning sewage into potable water, however, is rigorous and requires a multistep process involving solids separation, aeration and disinfection.

Neptune Diagnostics' B&F Alert is a diagnostic test that identifies bulking and foaming organisms early in the treatment process, before they can cause disruptions in the system. (Bulking and foaming refer to what happens to the solids, or sludge, when filamentous bacteria prevail, stopping or slowing down the solid/liquid separation process.)

When bulking and foaming occur, it's costly for wastewater treatment plants. They may incur regulatory violations and fines, or they could experience increased operating costs from the purchase of additional chemicals and higher labor. Perhaps the largest impact, though, is on energy production; most plants recover methane, a sustainable fuel, using it to generate electricity or to power motor vehicles. Foaming lowers methane production, requiring plants to draw electricity from the carbon-emitting grid. Other potential impacts include public health and economic losses that occur when beaches or recreational waters must be closed due to bacteria being discharged from wastewater plants.

photo: Paul R. Kennedy

Professor Betty Olson conducts research on how microorganisms influence water quality and how to use molecular biological techniques to optimize wastewater treatment. Olson is the associate director of UCI's Water-Energy Nexus Center.

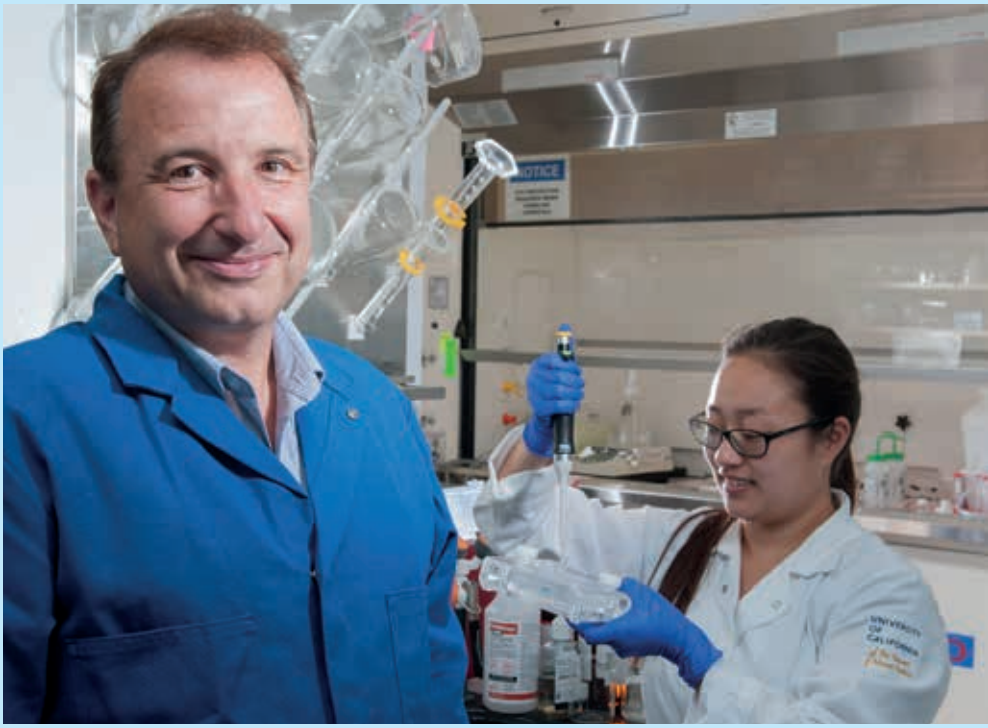
The idea of using PCR with wasterwater was born in the lab of civil and environmental engineering professor Betty Olson, whose research expertise is in molecular techniques as well as the microbiology of drinking and wastewaters. "Right now, the way the industry diagnoses these organisms is with a microscope, and they can only be identified after they've become a problem," Olson explains. "So treatment plant operators use harsh chemicals like chlorine, which kills everything — the good and bad bacteria," she says.

When she was a doctoral student in Olson's lab, Pitiporn Asvapathanagul completed a proof-of-concept study and wrote her dissertation on the idea. Today, she is an assistant professor of civil engineering and construction engineering management at California State University, Long Beach. Her research came to the attention of Paul Merage Business School student Joseph Nadolski in 2013 during the Merage Business Plan Competition.

The B&F Alert didn't win any major prizes, but it intrigued Nadolski, a retired U.S. Army lieutenant colonel and a civil engineer who is interested in clean technology and in commercializing innovations to improve the environment. After earning an executive MBA, he figured he'd find the project's students and see if he could help. UCI's Office

of Technology Alliances told him they all had graduated. The technology was available for development, so Nadolski nabbed it and has applied for a license.

Nadolski started Neptune Diagnostics, with Olson as an adviser. He hired Xuan He, an environmental engineer, and Trisha Westerhof, a doctoral candidate in molecular biology and biochemistry. They've recruited three demonstration customers: Victor Valley Water Reclamation Authority, Santa Margarita Water District and the city of Simi Valley.



Neptune Diagnostics CEO Joe Nadolski and graduate student researcher Trisha Westerhof are working to launch a product that would help wastewater plant operators use DNA instead of a microscope to identify problem levels of bacteria.

Nick Steffen, an operations supervisor at Simi Valley's wastewater treatment plant, will begin collecting samples to send weekly to Neptune Diagnostics for analysis. "Over the course of a year, we will have a good baseline of data. What we are hoping to do with Joe is to quantify specific bacteria, and when we see a certain threshold reached, we'll be able to make process control changes. We need to establish what the normal amount is, then if we see that number increase, we'll know to intervene. "

B&F Alert is the company's launch product, but the platform could be used for multiple examinations. He says that they could potentially test for 96 organisms at once, and water is just the first sector. In time, they could move into agriculture and food manufacturing.

"There are a lot of choices for us. We want to see what wastewater needs first, right now," says He, who earned her master's degree in environmental engineering at UCI in 2014.

"Ours is more of a business model innovation," Nadolski explains. "This is old technology in the medical field, where they will spend a lot of money for a diagnostic test. Our goal is to get the cost point to where it could be attractive to public utilities and other industries."

"One great challenge will be to convince current wastewater operators, engineers and lab personnel of the benefits associated with the use of metagenomics (applying molecular diagnostic techniques to study DNA extracted directly from environmental samples)," says Victor Santa Cruz, a biologist with Inland Empire Utilities Agency and an informal adviser to Neptune. "In many ways, overcoming entrenched operational-engineering philosophies will be like teaching an old dog new tricks."

Nadolski agrees that the company has to consider the mindset of the wastewater operators. "They're conservative. They've been doing this for years by gut, and right now, they react. This will give them new tools allowing them to anticipate and be preventative."

"This is an early diagnostic test," reiterates Olson. "You can see the advantage of being able to diagnose something like cancer when you have just a few cells versus when you have a tumor already formed. That's what this is, an early warning signal."

"Right now, the way the industry diagnoses these organisms is with a microscope, and they can only be identified after they've become a problem."

BITS AND BYTES

A timeline of select Calit2 activities

APRIL

15 A panel of women entrepreneurs discusses the challenges and successes in starting companies as part of the "This is What a Scientist Looks Like" STEM series program.

17 Ralph Brockhaus, CEO of SmileFish, delivers a presentation on mobile application development and cloud solutions for the Internet of Things.

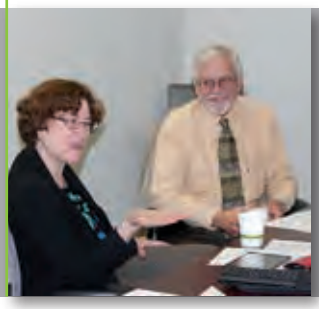
20 A group of deans and administrators from University of Science and Technology of China tour Calit2 as part of a UCI Marketing and Innovation program.

MAY

5 Public health and policy expert Terry Schmidt shares his perspectives on global health initiatives with participants in the Multidisciplinary Design Program (MDP).

7 Calit2 affiliate Athina Markopoulou presents her research on measurement and analysis of mobile and social networks as part of the engineering school's Distinguished Lecture series.

11 Members of the CalPlug Advisory Board discuss the plug load research center's progress at their annual meeting.



JUNE

3 The director of the National Weather Service, Louis W. Uccellini, offers insights on climate change and the challenges of building a weather-ready nation.

4 Finalists in Broadcom Foundation's University Research Competition tour FABWorks, where they see some of the items produced in the maker space.

8 After a decade of servicing Calit2 labs' nitrogen needs, the old Praxair tank is removed from the loading dock for a smaller, more efficient model.

27 A Singapore delegation from Nanyang Technological University asks questions about the Wall of Power demonstration in the CalPlug Center.

23 Calit2 Director G.P. Li (right) and IoT Evangelist Mark Bachman (left) invite Shaun Kirby from Cisco to give a talk on the future of the Internet of Everything.

28 Arquimedes Canedo, a Siemens principal scientist, offers IoT insights in advanced manufacturing as part of the Smart Worker Igniting Technology program.

12 The semiannual CalPlug workshop covers research advancement of energy-efficiency studies for network equipment and small data centers.

30 The undergraduate team working on the HippoTime project demonstrates its app for children with autism at the MDP closing symposium.

22 Middle schoolers attending FABcamp try a round of air pong to understand how many kilowatt hours a hairdryer consumes in the course of a game.

24 A new group of summer undergraduate research fellows participates in orientation led by UROP Director Said Shokair.

23 High school students participating in UCI's Gifted Student Academy listen to researcher Sergio Gago explain how much energy plug load devices consume.

26 Calit2 Advisory Board members get situated for their annual meeting, this year hosted by the Irvine division.

BITS AND BYTES

A timeline of select Calit2 activities

JULY

7 SURF-IoT weekly seminar series kicks off with the research group working on the Pain Buddy app for children coping with cancer.

15 UCI engineering alumnus Michael Klopfer joins CalPlug as the center's new technical manager.

21 AssociateProfessor of Medicine Dara Sorkin explains the project she and her SURF-IoT student are developing to address obesity among Latina breast cancer survivors.

AUGUST

7 Engineering professor Mohammad Al Faruque presents the future of computing and cyber-physical systems during the weekly SURF-IoT seminar series.

10 Representatives from Hanyang University, ranked among the top 10 universities in South Korea, visit Calit2, posing for a picture in the CalPlug Center.

11 UCI Health Policy Research Institute researcher John Billimek explains his team's SURF-IoT project, which tackles medication underuse to reduce disparities in chronic disease management.

SEPTEMBER

1 Calit2 Director G.P. Li, a champion of the IoT revolution, gives a passionate keynote presentation at the ANSYS virtual prototyping conference in the Calit2 auditorium.

2 An undergraduate intern in FABWorks shows one of the projects created in the make lab to UCI's new Provost and Executive Vice Chancellor Enrique Lavernia.

15 Director G.P. Li represents Calit2 at the 2015 American Energy & Manufacturing Competitiveness Summit in Washington, D.C.

29 Christofer Hierold, professor of micro- and nanosystems at ETH Zurich, updates researchers about the latest work his Swiss lab is conducting on carbon nanotube sensors.

22 A delegation from Seoul National University Bundang Hospital poses for a group picture before touring Calit2's eHealth Collaboratory.

30 Co-founder and CEO of Integra Devices James Spoto shares his perspectives on the Internet of Things revolution and the new generation of enabling technologies.

25 After his presentation on the role of IoT in the automotive industry, KIA representative Henry Bzeih fields questions from attendees during the networking session.

27 The class of 2015 summer undergraduate research fellows completes another successful 10-week program.

18 Dr. William Karnes, a co-mentor for the SURF-IoT Qualoscopy project, demonstrates how a web-based application will improve new reporting guidelines for colonoscopies.

26 During a tour of FABWorks, a member from the Orange County STEM executive committee takes a closer look at a piece of equipment in the maker space.

25 The third annual Microbiome Symposium, co-hosted by UCI's Institute for Genomics and Bioinformatics, Calit2 and UCI Data Science Initiative, is well attended.

24 Computer expert Walter O'Brien, a.k.a. Scorpion, shares his insights on intelligence on demand in a highly connected world.

28 Twenty MBA students from the University of Science and Technology of China tour several labs as part of a leadership exchange program through UCI's Merage School of Business.

Under the direction of Professor G.P. Li, Calit2@UCI develops IoT technology-based innovations in a multidisciplinary research environment. By integrating academic research with industry experience, the institute seeks to benefit society, incubate new technology companies and ignite economic development. Calit2 focuses on the digital transformation of healthcare, energy, the environment and culture.

University of California, Irvine
California Institute for
Telecommunications and
Information Technology
4100 Calit2 Building
Irvine, CA 92697-2800

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