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California Institute
for Telecommunications
and Information Technology
CALIT2

Volume 15 | Issue 1 | Fall 2019
University of California, Irvine

Changing Coastline

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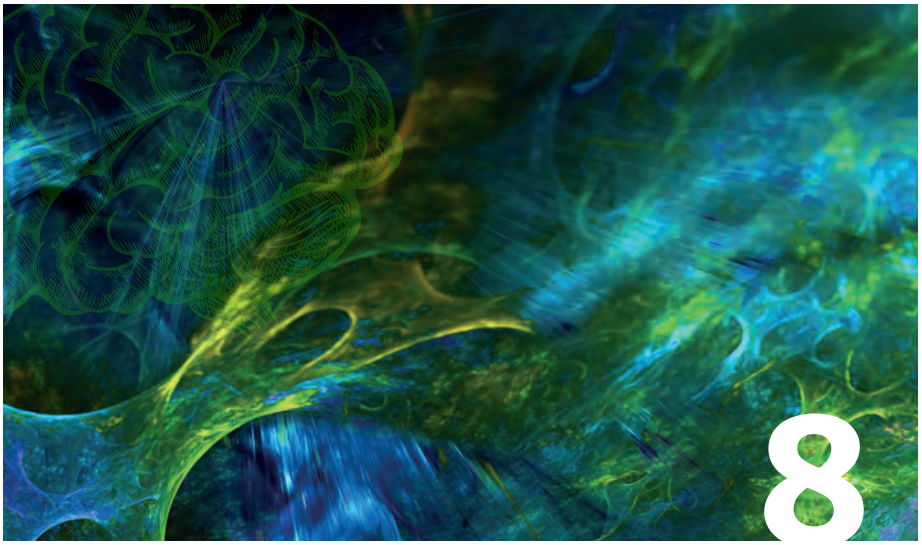


interface

Fall 2019
Volume 15 | Issue 1

The award-winning *Interface* is published semiannually by UC Irvine's CALIT2 Communications Department.

Editor: Shelly Nazarenus
Contributors: Lori Brandt, Sharon Henry, Anna Lynn Spitzer, Heather Ashbach
Art Director: Michael Marcheschi, m2design group
Photographers: Debbie Morales, Steve Zylius, Francisco Chanes
Publisher: Mike Delaney, Yebo Group

On the Cover: Southern California's Crystal Cove shoreline captured by Professor Brett Sanders research group's drone outfitted with high-resolution onboard digital cameras to monitor coastal erosion.

UCI CALIT2
4100 CALIT2 Building
Irvine, CA 92697-2800
(949) 824-6900
www.calit2.uci.edu
info@calit2.uci.edu

> “Computer visualizations are an extremely powerful way for anyone to immediately appreciate complexity in beach dynamics and to engage more deeply and thoughtfully in discussions about the risks and how to manage them.”

NEW COURSE HELPS ENGINEERS UNDERSTAND

BEACH

3

THE EFFECTS OF HUMAN ACTIVITY ON A CHANGING COASTLINE

DYNAMICS

Sharon Henry Debbie Morales


UCI
SAMUELI SCHOOL OF ENGINEERING

Professor Brett Sanders and graduate student Shu Li use Emery boards to measure the shape of the beach. The simple, yet accurate, survey tool was devised by renowned coastal-scientist and geologist Kenneth O. Emery (1914-1998), who found that by using two boards, he could take a series of beach elevation measurements at intervals parallel to the shoreline. Plotting the data points produces an accurate mapping of the slope.

Last December, visitors at Dana Point's Capistrano Beach watched in disbelief as the iconic 250-foot boardwalk collapsed into the ocean – a victim of severe erosion.

A month later at nearby Doheny Beach, high waves battered parking lots and infrastructure until concrete and pavement crumbled. As beach after beach is besieged, Southern Californians are facing the dismal reality of a coastline ravaged by human activity, and according to a report released by the state, it's going to get worse.

"California's Fourth Climate Change Assessment" concludes that without large-scale interventions, an expected sea level rise of one to two meters will wipe out up to 67 percent of Southern California beaches. By the end of this century, California's once sandy coastline will have disappeared, leaving behind little more than bedrock and bare sea cliffs. Not only are beach access and a billion-dollar tourism economy at risk, but so, too, is the first line of defense against the impact of coastal storms.

Brett Sanders is a UC Irvine civil and environmental engineer who leads the Flood Hazards and Poverty division of the UCI Blum Center, headquartered in CALIT2. Sanders has spent the last decade studying coastal flood risks and developing information systems with stakeholders to support flood-risk adaptation measures. This year, he introduced a new beach dynamics course for graduate students. "Engineers need to understand how beaches are changing and find ways to manage the impacts," Sanders says. The class, a partnership with California State Parks and the Crystal Cove Conservancy, provides a mix of field-based and classroom-based instruction. Students visit Southern California beaches, see erosion firsthand and develop beach monitoring expertise.

"Coastal communities are increasingly confronting erosion issues," Sanders says. "The follow-up questions are, 'Why is this happening?' and 'How can we address it?'"

Answers require understanding multiple issues: rivers and cliff erosion, which supply sand to the coastal zone; barriers to supplies, such as dams and coastal structures; and the wave climate. "You start looking at the factors that supply sediment. Then you look at how the waves and tides shape sand movement, and how this will change in a warming climate with higher sea levels. This is the perspective we want engineering students to bring to future challenges," Sanders explains.

Sanders' research emphasizes the role of human activity. Across Southern California, storm water infrastructure has been designed to capture sediment in the foothills so flood control channels don't get choked with debris and trigger inland flooding. The unfortunate consequence is a deficit of sand at the coast, increased erosion and coastal flooding. This can lead coastal property owners to

construct riprap (rock piles) and other forms of armoring to limit damage to their properties. "Unfortunately, this only accelerates beach erosion," Sanders says.

Preserving beaches as sea levels rise will be costly and tricky. One strategy used in Southern California for decades is known as beach nourishment. It involves importing sand to the site, an often-expensive proposition.

"The most cost-effective projects rely on local sources of sediment, sometimes available just offshore of the impacted beach," says Sanders. But sometimes even costly projects fail – the sand may quickly disappear or have negative impacts.

Retreat – moving roads and infrastructure to higher ground, is another option, one that Sanders believes engineers must consider. However, there is growing interest in hybrid systems or "living shorelines," which combine elements of green and gray (concrete) infrastructure.

Sanders is inspired by Katwijk Beach in the Netherlands, where a reinforced underground concrete parking structure, which doubles as an emergency flood wall, is covered with sand and vegetation to create a beach dune habitat. "Businesses get parking spots for customers, residents get beach access, the environment gets critical habitat, the owner gets parking revenue, and everybody is protected from floods – it's a brilliant project."

Developing a systems viewpoint of sediment dynamics is critical. Sanders' group uses unmanned aerial vehicles outfitted with high-resolution onboard digital cameras, and with support of the California State Parks, they've begun monthly monitoring of south coast beaches. In as few as 10 minutes, at an altitude of about 80 meters, hundreds of images are captured and combined with computer vision algorithms to construct a detailed 3D image of the coastline with unprecedented spatial resolution.

"Computer visualizations are an extremely powerful way for anyone to immediately appreciate complexity in beach dynamics and to engage more deeply and thoughtfully in discussions about the risks and how to manage them," Sanders says.

He believes engineers must do a better job of engaging the community when designing civil infrastructure projects, a conviction he emphasizes in his graduate courses. "I'd like students to be aware that visualization tools, models and simulations can not only be useful for helping stakeholders understand a proposed project, but also for the engineer to learn from stakeholders about what they care about and how these concerns can be addressed," he says. "Engineers can't just read a technical spec, design a project and share it with the public. The project design has to reflect what the community cares most about."

Crystal Cove State Park serves as a microcosm of the beach management challenges facing California. For several years, Sanders has served as an adviser to the Crystal Cove Conservancy, helping develop a new high school-level coastal dynamics course funded by the California Coastal Commission. "We bring students from inland communities to the beach and for many, it's their very first time," he says. "It's critically important that all Californians have access to the beach and value it, not just those in coastal communities."

Regular shoreline monitoring and mapping by high school students is now providing valuable data for research about climate change and coastal management. Sara Ludovise, director of education for the Crystal Cove Conservancy, expects to expand the program. "Next year we'd like hundreds of high school students to be involved," she says.

The alarm has sounded about the threat to Southern California's picturesque beaches. Thanks to Sanders, the next generation is learning the processes by which beaches are changing and helping develop solutions that reflect the values and resources of the community. Says Sanders: "There is going to be a lot of work for them."

"We bring students from inland communities to the beach and for many, it's their very first time. It's critically important that all Californians have access to the beach and value it, not just the coastal communities."

Top left: Research specialist Jochen Schubert demonstrates drone-based technology for building a 3D digital model of the coastline.

Top right: Image of a 3D model of Crystal Cove generated by data captured from drone flights.

Bottom: Sanders and students review their current findings at the Marine Research Facility at Crystal Cove State Beach.

Transformational TO

A UNIQUE MICROSCOPE CHAMBER AND A HOST OF IMAGING SERVICES ADVANCE THE SCIENCE OF MOLECULAR HISTOLOGY

QLS 9

Anna Lynn Spitzer

When an ambitious UC Irvine graduate student decided on a doctoral research project, he and his adviser realized the necessary instrumentation wasn't available on campus. So they built it themselves – or at least part of it. Their efforts resulted in Translucence Biosystems, one of the newest tenants in CALIT2's TechPortal incubator.

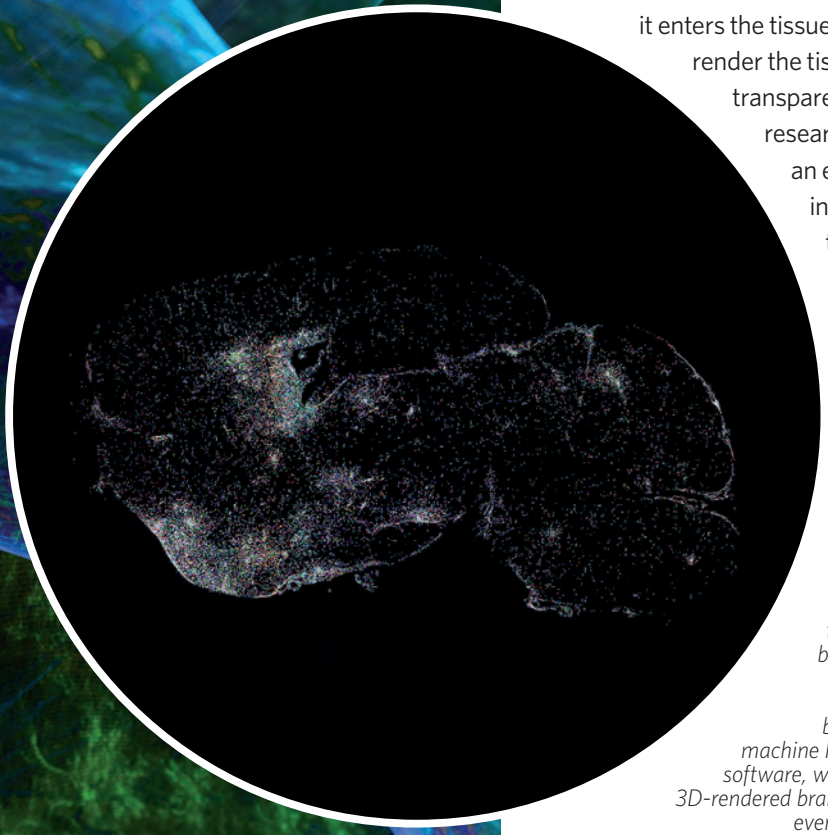
Translucence seeks to transform the study of cellular structures in animal tissue – a field known as molecular histology – by offering tools, software, assays and data processing services that open the door a little wider to a cutting-edge methodology.

> “Because whether it’s five or 10 or 20 years from now, someday there will be only 3D histology. No one will be slicing things to image them. We’re right at the forefront of that.”

The company’s premier product is a novel chamber that attaches to a Zeiss lightsheet microscope. The chamber allows researchers to view intact, large tissue samples at the cellular level at high resolution, something they could not do before. Manufacturing and selling the chambers is just one aspect of the new company’s business, however. Translucence offers its clients a complete package of specimen analysis, including tissue clearing, 3D imaging and data processing.

To understand the company, one has to understand its origins. In 2016, Ricardo Azevedo entered UCI’s M.D./Ph.D. program. He and his adviser, neurology and behavior Associate Professor Sunil Gandhi, were discussing research projects involving tissue-clearing, a chemical technique that allows biological tissue to be examined at the cellular level using a light microscope.

Fat in tissue does not allow light to pass through, so samples must be treated first. The tissue-clearing process chemically removes fat while leaving the proteins intact in order to homogenize the refractive index – how light bends as it enters the tissue. These steps render the tissue optically transparent, allowing researchers to view an entire sample in a specialized tool called a lightsheet microscope.



A 2D ‘slice’ through a mouse brain. The colored specks represent cells identified by Translucence’s machine learning-enabled software, which scans entire 3D-rendered brains and identifies every cell of interest.

The process is groundbreaking. For centuries, scientists who wanted to examine tissue at the cellular level had to shave it into thin slices, affix those slices to slides, stain or otherwise treat each sample, then reconstruct the images into a three-dimensional model for analysis. The method is laborious and expensive, and severely limits the amount of information available. Until several years ago, it was the only way to examine tissue at the cellular level.

Azevedo had experience with tissue clearing, having helped to develop the technology as a research assistant at Rockefeller University in New York City. But UCI didn’t have the right microscope, so Azevedo and Gandhi traveled to Caltech in Pasadena to use its Zeiss lightsheet microscope. When they returned, Gandhi proposed that UCI purchase a lightsheet microscope of its own.

That led to a dilemma. There were two competing brands available, each with distinct advantages and disadvantages. The Zeiss brand, which could easily image very small organisms like fruit fly embryos and tiny fish, had higher resolution and better optics than its competitor, which could accommodate larger tissue samples but at lower resolution.

“In theory, the Zeiss microscope is a better microscope,” says Translucence CEO Damian Wheeler. “But it doesn’t work very well as it comes out of the box for large tissue samples.”

So Azevedo and Gandhi decided to design an adjustable chamber, which attaches to Zeiss’ Lightsheet Z.1 microscope and can hold larger tissue samples, like biopsies or mouse brains. They succeeded, and along with CEO Wheeler, incorporated Translucence in August 2018.

Says Azevedo: “That back and forth between size and resolution kept coming up. And the best solution was the Zeiss microscope and creating the attachment.”

The company moved into TechPortal last January. “TechPortal has been

invaluable for us," says Wheeler. "We're largely self-funded, so this opportunity to have a space that helps us and is affordable has been amazing. It's much better than my kitchen nook," he adds, laughing.

In addition to its self-funding, the company has earned two SBIR grants totaling nearly $675,000 from the National Institute of Health's Brain Initiative. Those funds enable continued research into cellular-level brain activity.

The company's founders are all neuroscientists. So current research focuses on analyzing brain tissue, including neuroinflammation and neuronal activity. But brains are just the beginning for Translucence, which has four employees and is hiring more. Potential applications for its technologies include biopsies for cancer, kidney disease and other conditions, or for improving assays used to gauge clinical trials or aid in drug development. "We often talk about brains simply because we are neuroscientists but these techniques can be used on any tissue in the body," Wheeler says.

With large pieces of tissue, the tissue-clearing approach to histology is orders-of-magnitude faster than slicing. "We can take a mouse brain that, using state-of-the-art technology from a couple of years ago, would take about a week to image, and we can image it now in as quickly as 20 minutes," says Gandhi.

The real advantage, though, lies in the technology's ability to image a tissue sample in its entirety, as opposed to one slice at a time. "It opens the ability to ask different questions," Wheeler explains. "Because with the same effort you would have spent looking at two different areas, you can now look at 1,200 different regions of the brain in parallel and find things you would never have seen before."

The technique also allows for easy comparisons with living tissue. "This technology lets us link between the three-dimensional view we can get through live imaging of animals and humans to the underlying cellular view," Gandhi says.

The test tube on the left holds a mouse brain before tissue clearing. On the right, after the process is complete, the tissue is nearly invisible.

Zeiss, an optical and optoelectronics company, initially balked at the idea of partnering with the startup. Before long though, the multinational conglomerate became an ardent supporter, helping Translucence promote its chamber to their lightsheet microscope customers.

"A growing group of researchers all over the world have chosen the Zeiss Lightsheet Z.1 system for its sensitivity, speed, ease of use and flexibility. We are happy that group will be able to further expand the flexibility of sample handling toward even larger and/or organic solvent-based cleared samples," says Sven Terclavers, European head of regional product and application sales for Zeiss Research Microscopy Solutions. "The company always aims for scientists to be able to advance their research, and as this chamber extends the Lightsheet Z.1 system's flexibility even more, I'm sure it will positively influence their research."

That is proving true in UCI's Optical Biology Core facility, which is using the new instrumentation. "Translucence's technology adds a valuable component to the higher resolution and faster imaging of the Zeiss lightsheet," says Adeela Syed, developmental and cell biology associate project scientist and director of the facility. "The community within and out of UCI are very excited about the new chamber. We have more and more researchers wanting to try clearing and imaging because of images seen from Dr. Gandhi's lab."

More importantly, perhaps, the company is developing software, computational models and statistical methods that can extract important information from the reams of data – gigabytes to terabytes – that result from tissue analysis. "Our clients are thrilled about the data: it's beautiful and very exciting," Gandhi says of the 3D images their techniques capture. "But the big question is, how do we analyze it and make it into something that's useful?"

Wheeler, Gandhi and Azevedo see Translucence leading a histology revolution. "Because whether it's five or 10 or 20 years from now, someday there will be only 3D histology. No one will be slicing things to image them. We're right at the forefront of that," summarizes Wheeler.

Shelly Nazarenus
Debbie Morales

UNDERGRADUATES SHARE THEIR CALIT2 SUMMER RESEARCH EXPERIENCES

Spread the WORD

Shweta Karkee

Business Administration

"We're working to collect qualitative data in order to see the most common gaps and pain points caregivers face in outpatient care, and we're creating an app around that. After graduating, I'd like to go into health care consulting, and then eventually work for, or start a mobile health company. I love seeing how technology is bridging deficits and gaps in health care – the app that we're working on is one great example. I hope that mobile health care will make care much more accessible and affordable than it is today; health care should be a right, not a privilege."

Steven Hu

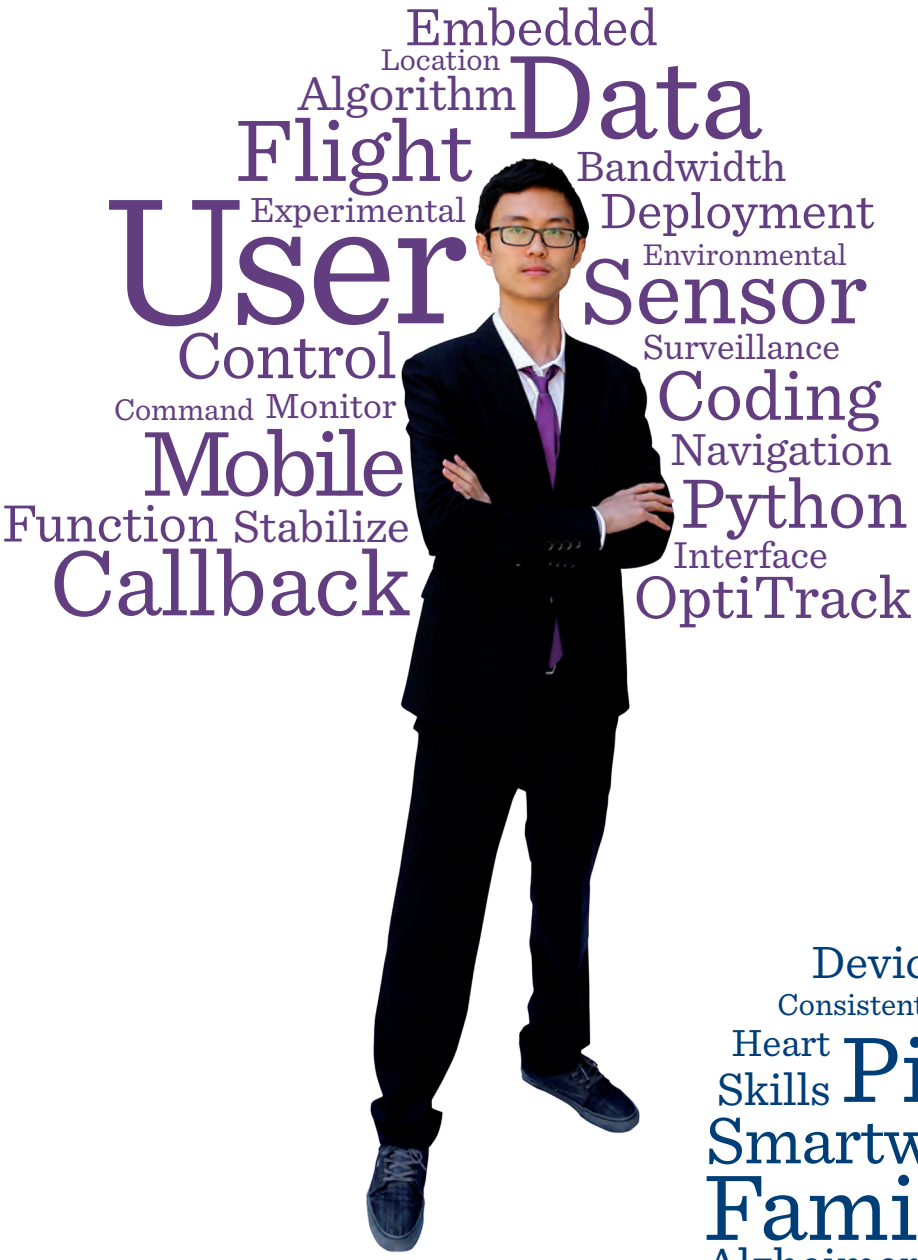
Computer Science and Engineering

"My summer research is building a web-based control station for drones that can allow anybody to control them in any place where there is an internet connection. It is a very fun project and I learned a lot about web development and software to control drones. I have always wanted to pursue graduate school and a career in software engineering, and this project gave me more insights into what it means to be an engineer."

Tingjue Yin

Data Science

"Pain scales and questionnaires are commonly used to assess pain, but they are not precise because pain is subjective and multidimensional, so the goal of the study is to measure pain objectively and accurately. Using biophysical data as parameters in machine learning generates a learned algorithm that can clearly distinguish pain from no pain. We discovered that among the biophysical signals from people's muscles, heart rate and skin, the muscle signals have the highest accuracy score of measuring pain."



Wenzhuo Wang

Computer Science and Engineering

"The SURF-IoT program gave me an opportunity to learn more about embedded software. It was challenging because understanding the quadcopter's coding was difficult since the copter model I was using had limited documentation. I had to do a lot of research on the internet of similar quadcopters to solve problems I encountered. Through the process I learned to be patient, especially when working with hardware. I will take this experience into my graduate school training."

Anthony Park

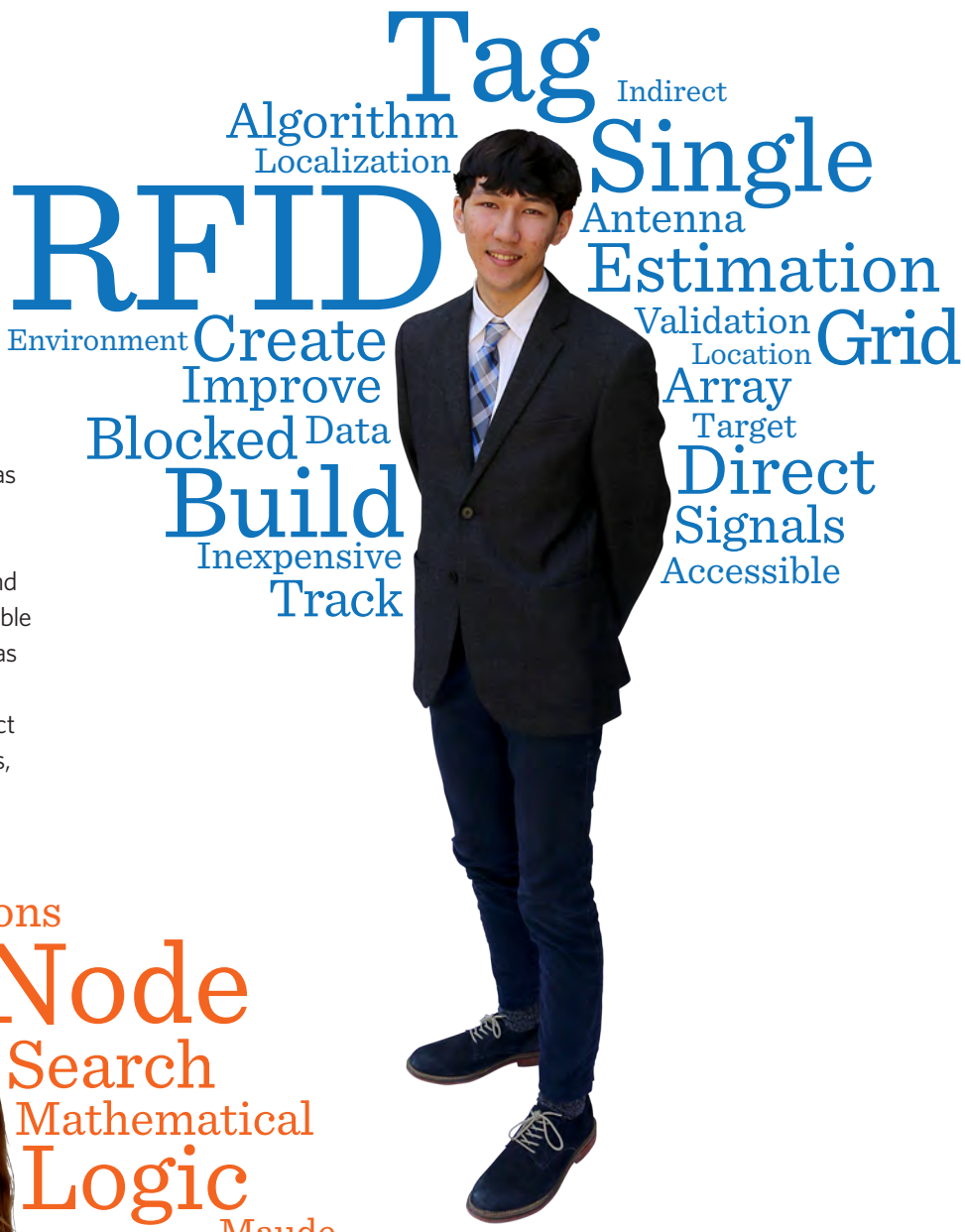
Computer Science

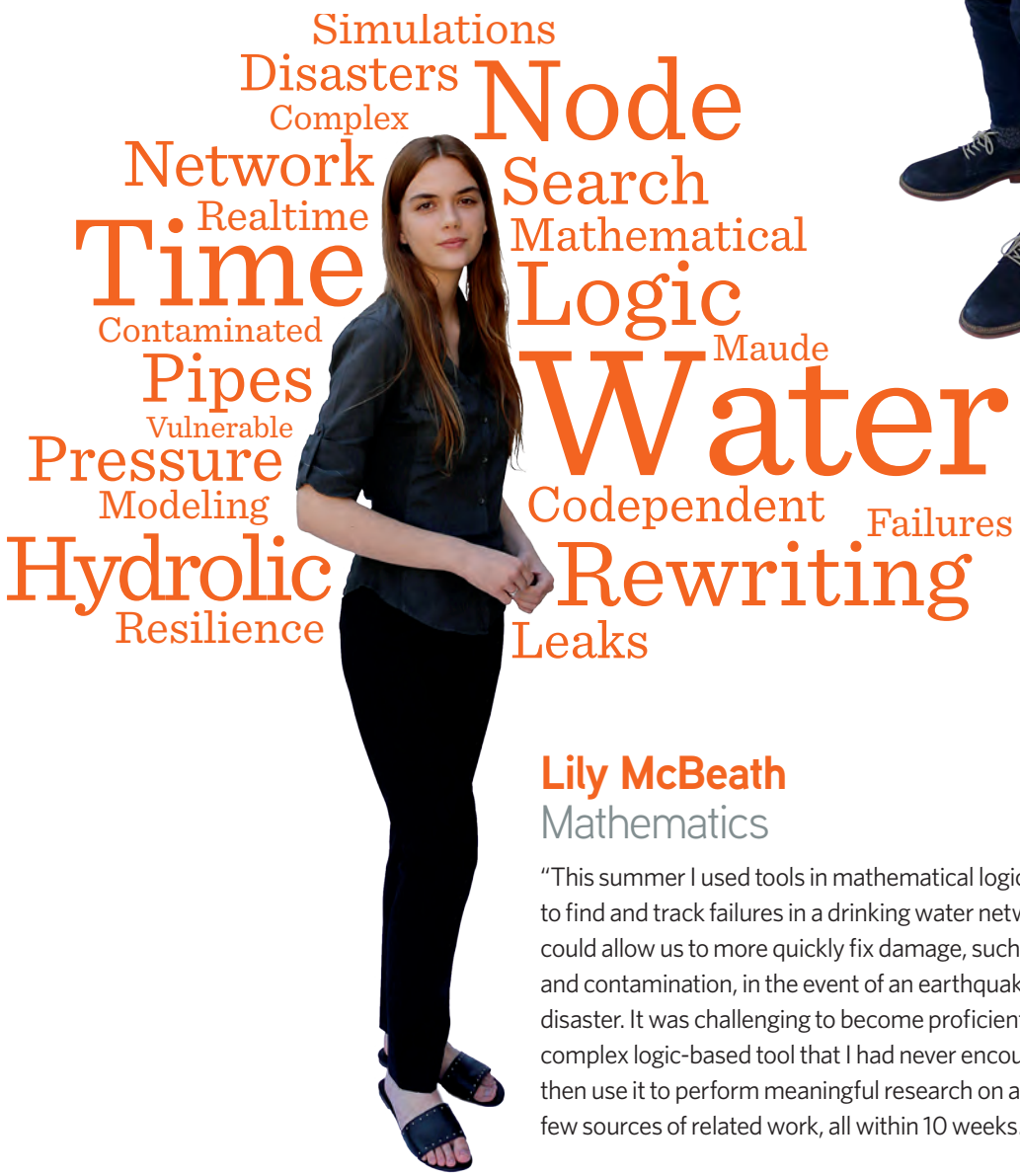
"My research project is conducted in collaboration with computer science and nursing science, and I worked on handling and analyzing health-related data. Naturally, I was introduced to the field of big data and was fascinated by the potential of integrating the various health-related data, ranging from electronic body signals to medical imaging and public health records. I wasn't sure what I wanted to specialize in my computer science studies, but after this summer, I genuinely became interested in the field of data science, especially in health care."

Kenzo Spaulding

Mechanical Engineering

"The goal of the project was to implement a localization algorithm on a real system (which I had to build). My research is about finding a target within a known region regardless of disturbances within the space. The most challenging aspect was managing the numerous systems that are interconnected. I had to handle the interfaces between each subsystem and facilitate communication in a manageable fashion. The most rewarding aspect was when I managed to get something to work as I intended it to. Since the project was the sum of many smaller problems, solving each in order kept me going."





Lily McBeath

Mathematics

"This summer I used tools in mathematical logic and programming to find and track failures in a drinking water network. This research could allow us to more quickly fix damage, such as pipe breaks and contamination, in the event of an earthquake or other natural disaster. It was challenging to become proficient in Maude, a complex logic-based tool that I had never encountered before, and then use it to perform meaningful research on a topic with relatively few sources of related work, all within 10 weeks."

Yilei Wu

Computer Science

"It is a worthwhile fellowship if you would like to have an immersive research experience; you will be given the opportunity to learn and explore. I got a lot of opportunities to interact with faculty and students from other departments and that was an amazing experience for me. Most of my work is concentrated on the deep learning application, which is a very new and interesting topic for me. I plan to continue working on this project during the academic year."

Loan Lee

Pharmaceutical Sciences

"The most challenging aspect of the SURF-IoT program for me was to learn new technologies and take a rational approach to problems. The work itself was hard because I had to learn the basic concepts of computer programming and metagenomic analysis, and familiarize myself with bioinformatic tools. However, the more I interacted with the commands, the easier it became, and I was finally able to utilize different platforms to approach the project. My research experience has significantly enriched my knowledge of working in the scientific and technological world and left me with skills that will be useful throughout my career."

Yinan Zhou

Computer Science

"Texera is a web-based big data analytics system with an interactive user interface. The goal of my project is to improve Texera by allowing the users to see more information about the back-end engine on the front-end interface. For my undergrad major, I have taken a variety of courses, such as machine learning, computer vision and internet security. However, I did not find much interest in these fields. After joining Texera, I realized I am most passionate about software development both at the front end and back end."

Leo Peng

Computer Science

"The main purpose of my project was to provide a tool for application developers to easily develop smart space applications to be integrated into an IoT network. Part of that task requires providing clear documentation on how to use our tool. What I found out was that there is a package I could add to my code that automatically generates clear, human-readable documentation. So instead of having to spend hours writing documentation by hand, just a few extra lines of code in my project did all the work for me."

Sharon Henry

PODCAST BASICS

An abundance of inexpensive production tools, internet access and MP3 players led to the boom in audio file sharing, known as podcasting. Here's a look at the basics of how podcasting works and the technology that makes it possible:

SENDING SOUNDS

1 Audio is recorded and converted from analog to digital data, then stored in sequence in an audio file. The most common audio file format used in podcasting is MP3.

2 MP3 file is uploaded to an online podcast host.

MP3 file

Podcast host

PODCASTING TOOLS

Recording and editing software

Microphone and headphones

MP3 player or phone

3 Listeners download the podcast on demand or subscribe via an RSS (Really Simple Syndication) feed.

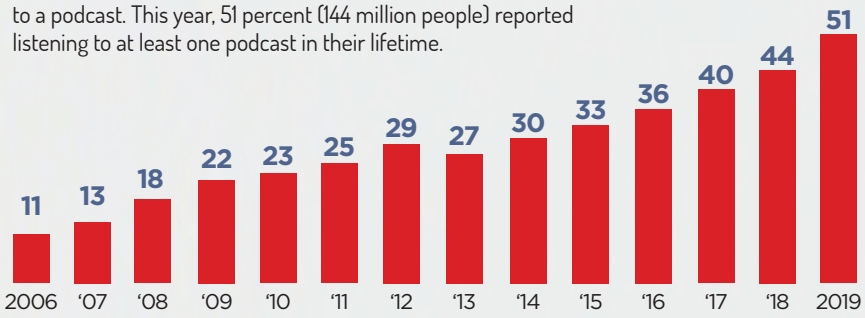
THE FIRST PODCAST

In 2004, former MTV video jockey Adam Curry wrote a program called iPodder to automatically send MP3 files to a digital music-playing device. Since then, podcasting has grown worldwide. As of June 2019, more than 30 million podcast episodes have been released.

Sources: Edison Research; Triton Digital; Infinite Dial; internethistorypodcast.com; Library of Congress; epmagazine.org; mpeg.chiariglione.org; Silicon Labs

PODCAST LISTENERS

Percent of total U.S. population over age 12 who have listened to a podcast. This year, 51 percent (144 million people) reported listening to at least one podcast in their lifetime.



WHAT IS AN MP3?

MP3 stands for MPEG Audio Layer III – a standard for audio compression that makes a sound file smaller with little or no loss of sound quality.

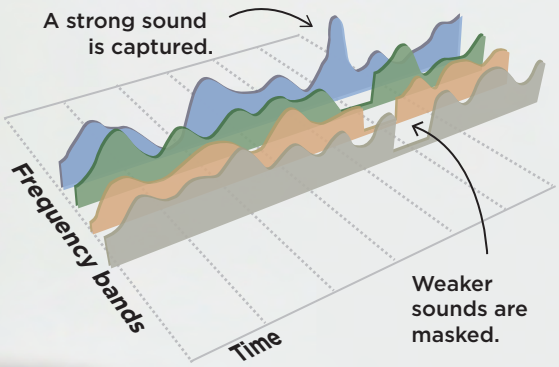
COMPRESSING

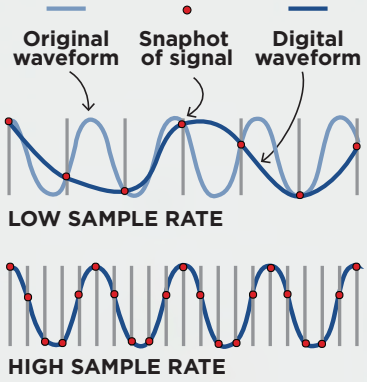
The MP3 compression algorithm uses **psychoacoustics** – a technique that adapts characteristics of the human ear.

Sounds with volumes too low or frequencies too high for humans to hear are removed.

When a strong and weak sound plays at the same time, the weaker sound is masked and ignored.

This process can reduce file size by a factor of 10.





SAMPLING

Sample rate indicates the number of snapshots taken per second of an audio signal. The higher the sample rate, the more closely the digital representation shape matches that of the original analog waveform.

Bit depth is the number of bits of information in each sample. The **bit rate** is the sample rate multiplied by the bit depth.

WHO INVENTED THE MP3?

Karlheinz Brandenburg has been called the father of the MP3.

In 1987, as a Ph.D. student at the German University of Erlangen-Nuremberg, Brandenburg was asked by his professor, Dieter Seitzer, to work on a project they hoped would enable music to be transferred over digital ISDN phone lines. The project was called the EUREKA project EU147.

Brandenburg used one song, "Tom's Diner" by Suzanne Vega, to test and develop the compression technology that would come to be known as MP3.

In 1989, the new format was approved in Germany.

In 1992, MP3 was accepted as a standard for compressing and transferring audio data by the Moving Picture Experts Group (MPEG), an international collaboration of engineers formed to set standards for coding audio and visual information in a digital compressed format.

The first MP3 player was released in 1998 by a South Korean company, SaeHan Information Systems, followed by the Apple iPod in 2001 and Microsoft Zune in 2004.

By the late 1990s, "MP3" had replaced "sex" as the most often searched term on the internet.

Anna Lynn Spitzer
Steve Zylius

ALWAYS PROBING

NO PROBLEM IS TOO HARD FOR AN INTREPID ENGINEER IN PURSUIT OF ANSWERS

Peter Burke is insatiably inquisitive.

That relentless curiosity has propelled the UC Irvine electrical engineering and computer science professor from one complex research endeavor to a host of others. From cosmic ray detection and quantum mechanics to semiconductors, carbon nanotubes and the electric properties of mitochondria, Burke's research, he laughs, "has been all over the map." He turns serious, though, when asked to describe his methodology. "I look for hard problems that have no known answer."

The son of a career Air Force officer, Burke and his family moved every few years as the senior Burke's assignments changed: from Massachusetts to Virginia, from Greece to Germany, from Oklahoma to Colorado. Young Peter learned to speak Greek in preschool and German a few years later, skills he says serve him well to this day. "It tuned my mind to new languages and I think that goes to why I can move easily to other fields," he says. "In a new field, specific words have specific meanings. And no matter how smart you are, if you don't know what that particular lingual is, you'll never understand what's being said."

He laughs again as he recounts another advantage. During his preschool years in

Greece, he did something some young friends disapproved of, and they proceeded to tattle on him to his mother, in Greek. "She couldn't understand them, and I kept saying, in English, 'I didn't do it! I didn't do it!' So I got away with whatever it was."

The family moved back to the U.S. when Burke was in 4th grade, settling in Oklahoma. Aside from not knowing what a McDonald's was, Burke considers his nomadic childhood normal. "For military brats, when you move around, it's not hard. You just don't know anything different."

He attended junior high and high school in Colorado, while his dad was stationed at the Air Force Academy. "We lived there about eight years. We got lucky," Burke says about his final pre-collegiate home.

A top-notch student and an Eagle Scout, Burke originally aspired to be a fighter pilot. "But my vision was bad and I was too tall," he states matter-of-factly. Instead, he studied physics at the University of Chicago. "It was the most intellectually rigorous university, period," he explains, when asked why he chose Chicago. He completed his senior thesis under the tutelage of Nobel Laureate James Cronin.

Burke still marvels, not only at his former professor's considerable accomplishments – Cronin discovered why the universe contains more matter than antimatter – but also at his hands-on style. Burke's senior project involved working with Cronin on a cosmic ray detection program that analyzed data from more than 1,000 detectors, built in Cronin's lab and placed throughout Utah. Burke remembers Cronin painstakingly gluing each detector to glass himself. "Here's a guy who already has the Nobel Prize and he's in the lab gluing these things himself."

The experience taught Burke a life lesson. "People who are interested in what they do, do it until they die. And I think that's important: do something you love."

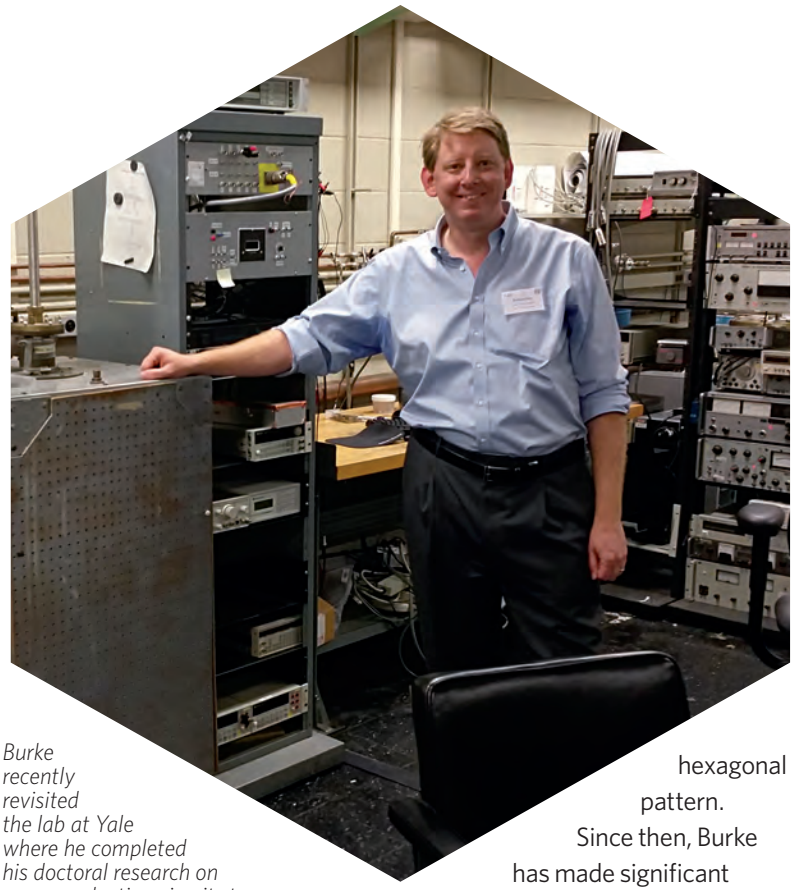
An interesting tangent: Cronin's thesis adviser, also at University of Chicago, was another Nobel Laureate, Enrico Fermi, who created the first self-sustaining controlled nuclear reaction. Burke pulls out a textbook that he uses to teach an undergraduate electrical engineering class on semiconductors. On the cover, he points out a graph that depicts the energy known as Fermi energy. "The work that Fermi did, he passed on to Cronin, who passed it on to me, and I'm passing it onto my students," he says with understandable pride.

After graduate school at Yale, where he studied the wave properties of electrons and circuits, Burke did postdoctoral research at Caltech, investigating two-dimensional electronic systems and semiconducting devices. It was during his postdoc that Burke met his wife, Emily, at a swing dance in Pasadena. The couple now have three children: Scott, 16; Christopher, 13; and Grayce, 11.

He joined the UCI faculty in 2001, settling into research on carbon nanotubes, one-dimensional cylindrical molecules of carbon atoms that can be used in electronic circuits and other devices. He transitioned a few years later to graphene, a single layer of carbon atoms, tightly bound together in a

Below: 10-year-old Burke, far left, poses with his younger brother, Scott, and a U.S. Air Force Thunderbirds pilot after an air show in 1980. Always infatuated with aircraft, Burke originally wanted to become a fighter pilot.

Bottom: Burke with his mother, circa 1974.



Burke recently revisited the lab at Yale where he completed his doctoral research on superconducting circuits to detect microwaves. He is pictured with a cryostat, a device that maintains very low temperatures for samples and devices.

hexagonal pattern.

Since then, Burke has made significant contributions to quantum electronics and quantum information science, as well as high-speed semiconductor devices.

His current research focuses on designing and using nanoelectronic-based instrumentation to probe, measure and analyze electrical activity in mitochondria, which are known as the cell's power source.

Because the organelles are so tiny – one cell can contain 1,000 mitochondria – the human eye cannot see their structure, even with high-resolution light microscopes. Electron microscopes can detect the miniscule mitochondria, but, Burke explains, that requires the organelles to be frozen. So he and his team are investigating ways to probe live mitochondria using nanoelectronics.

His goal is to build a tiny radio that can fit inside a single cell to learn more about the electrical behavior of mitochondria, and to better understand the basic biology of the cell and the pathways used by disease. "It goes back to my original theme of finding hard problems that are important and unknown," Burke says.

Cancer, in particular, has a very direct link to mitochondria's electrical behavior. "So understanding that is very important for understanding cancer ... and could allow us to develop a whole new class of chemotherapies. And that's just cancer," he says, adding that the research could also benefit diabetes, aging, Parkinson's and heart disease, to name a few.

"Peter is at the frontier of mitochondria research," says G.P. Li, CALIT2 Irvine division director, who has worked with Burke for many years. "He has that drive to develop the next generation of instrumentation that will allow us to probe the nanodomain in biological systems. This is what the world needs: someone who is not afraid of a very challenging task. Peter has that sort of drive and energy. Once he's into it, there's no return; he's fully committed."

Burke became involved with CALIT2 in the institute's earliest days, attending design meetings for the new building, in which he hoped to have a quantum computing and low-temperature physics lab. Priorities for the new institute shifted, and the lab was never built. "This was not CALIT2's fault," he emphasizes. "It's typical of new buildings."

But in 2015, Li tapped Burke to run the institute's new BioNano lab. Equipped with wet benches, fume hoods, compressed air, nitrogen and more, the lab enabled research at the intersection of biology, nanotechnology, information technology and medicine. It was a perfect fit for Burke's research, and he jumped at the opportunity.

"At the time, I was looking for more space for my mitochondrial work," he says. The lab also provided a research venue for two life science-oriented startup companies, which used it to test their prototypes. In 2017, the space was reappropriated, and Burke moved his research headquarters elsewhere. He has remained an important fixture at CALIT2 though, continuing to use BiON and the institute's materials characterization capabilities, winning a successful Army Multidisciplinary University Research Initiative (MURI) grant through INRF and holding meetings in the building.

He also founded a startup of his own, RF Nano, based on his research. Founded in 2005, the company built carbon nanotube antennas and integrated radio frequency systems enabled by nanotechnology. RF Nano raised over $15 million in venture capital but like many startups, ended up closing its doors after nine years. "As with many new and risky technologies, the return-on-investment timeline turned out to be longer than the market's patience," Burke says.

DARPA and the DOD have continued to fund research built on Burke's pioneering work, however, including several startups involving Burke's former students, who continue to move the field forward. "I'm proud of them," Burke says. "That is what we train students to do… not to be robots, but to be pioneers."

Burke calls the entrepreneurial experience positive, and he credits Li and CALIT2 for encouraging and supporting him. "Somebody at the university has to be willing to sit down [with potential entrepreneurs] and say, 'Yes, we're going to try to make this work for you.' GP has always been willing to do that, and it is just amazing."

Burke, who was elected an IEEE senior member in 2017, has been the recipient of numerous awards, including the Office of Naval Research's Young Investigator award and the Young Investigator Program award from the Army Research Office. In 2017, the Boy Scouts of America recognized the former Eagle Scout with its outstanding lifetime achievement award.

He is still involved with scouting, serving as his middle son's assistant scoutmaster. He enjoys hiking, camping and biking expeditions alongside the troop.

Burke has raised more than $16 million in research funding since joining UCI. His curiosity – and his efforts to educate – extend well beyond his research lab, however. He recently demonstrated (and published in IEEE) the world's lightest internet-connected drone, built in his garage and weighing in at under two-thirds of a pound. He's working with his brother, a former air force officer, to remotely pilot the drone over the internet, a feat that could lay the groundwork for remote identification, an important national security topic.

He also developed an independent iOS and Android app called iNanotube, which teaches the properties of nanomaterials to a lay audience. With a 5-star rating, it has been downloaded thousands of times in more than 35 countries.

Jinfeng Li, who earned his doctorate this year under Burke's advisement and founded a startup company based on work he did in Burke's lab, mentions his mentor's constant search for answers. "Despite his great pool of knowledge, Peter has a mindset of learning together with his students," Li says. "He likes research across different fields and explores freely, the same thing he tells his students, [which is]: 'Do not limit your imagination.' Peter is an explorer who gains a lot of joy through research."

Burke comes from a family of educators. Both parents earned doctorates; his mother was a high school principal and college professor, and his father was a college president after retiring from the Air Force. His grandfather, however, never graduated from high school. "It's the story of the American Dream," says the grandson.

For Burke, though, academic success goes far beyond the accomplishment of earning an advanced degree. "A lot of people think that a Ph.D. is useful because you're an expert on some topic and your expertise is what's important. In my opinion, nothing could be further from the truth," he states.

"The most important thing is that you move the ball forward in advancing knowledge in a topic. It's painstaking and it involves many dead ends [as well as] dedication, long hours, creativity, patience and problem-solving skills."

That forward momentum is his goal for the next several years as he continues to develop new tools to understand mitochondria. "I've always looked at what's not known and what's hard and what's important," he summarizes. "If it was easy, somebody would have done it. But the things that are hard to find out, those are the things that are important."

Top: Burke who received a 2017 Boy Scouts of America lifetime achievement award, serves as an assistant scoutmaster for his son Christopher's troop.

Bottom: Burke and his wife, Emily, and their kids visited Alaska's Mendenhall Glacier in 2015.

DOCTORING WITH

Lori Brandt Francisco Chanes

NEW CENTER TRANSLATES AI-BASED CONCEPTS INTO CLINICAL TOOLS THAT IMPROVE HEALTH

DATA

Doctors Daniel Chow and Peter Chang have landed in the right place at the right time.

About a year ago, the two neuroradiologists at UC Irvine Medical Center launched the UCI Center for Artificial Intelligence for Diagnostic Medicine (CAIDM) on the fourth floor of CALIT2. It's an ideal location for a center that needs to rapidly and securely access huge amounts of scientific data from multiple institutions.

The center focuses on developing and applying AI tools that can detect, characterize and provide prognosis for a variety of conditions in an effort to advance patient care, improve health outcomes and lower costs in all areas of health care. The burgeoning center integrates the expertise of health care professionals, scientists, software engineers and data scientists to provide a central research core for all UCI faculty, physicians and researchers.

The CALIT2 Building is equipped with leading-edge technologies to support data sciences, including access to the Pacific Research Platform (PRP), a high-capacity fiber optic network connecting data servers at all the UCs and their six medical centers, plus several large research institutions throughout the country.

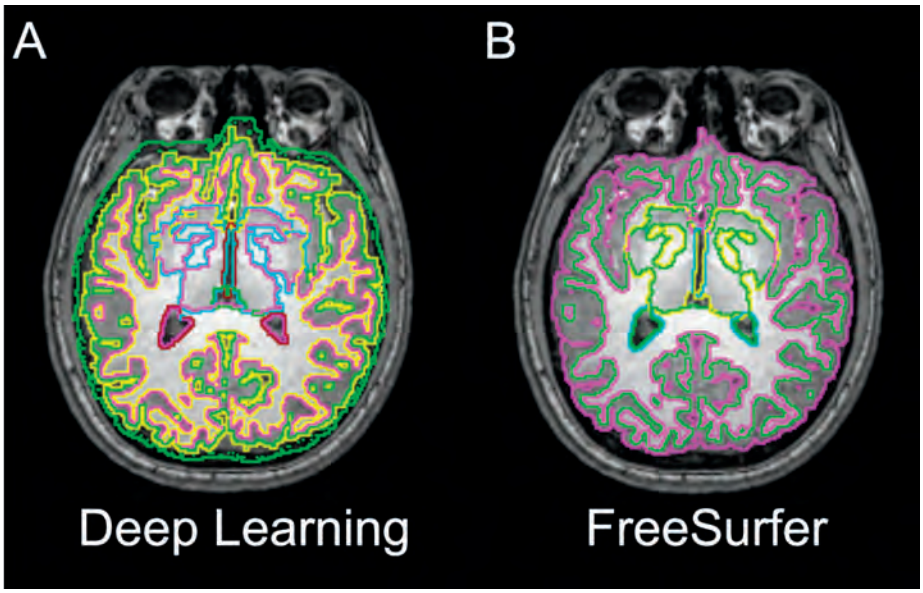
This access, combined with today's advancements in deep learning technology, holds great promise for using artificial intelligence to improve medical care, especially in radiology. Chow *(pictured far left)* and Chang are capitalizing on this opportunity.

In fact, it was while working a shift in the medical center's imaging services department that Chow thought there had to be a more efficient way to help patients who are waiting in the emergency room for results of their imaging tests (X-rays, CT scans, MRI scans). He had an idea for applying AI technology to the multiple brain scans that are taken for each patient who comes to the ER with a headache, and whose images must be methodically reviewed by a radiologist. Chow says the clinicians have to rule out brain leed, hemorrhage or any sign of stroke, because if a hemorrhage is identified, a neurologist or neurosurgeon must be called in right away to assess the course of treatment.

"Ninety percent of the scans obtained in the ER are going to be normal, but we have a ton of images to go through and we go in order. It would be nice if something told us, 'Look at me right

away,'" says Chow, assistant professor in residence with an appointment in radiology and neurology.

That was the first AI tool Chow and Chang developed and it's currently in clinical trials at the medical center. They designed a custom algorithm that identifies and assesses a hemorrhage at the point the scan is captured, then immediately sends an alert to a specially set up inbox. This tells the doctor to review those flagged scans right away. "We're not replacing the radiologist, just helping speed up the process for results of concern," explains Chow.



CAIDM researchers have developed an automated deep-learning method capable of fast and highly accurate brain extraction – removing brain from non-brain tissue – on images, above, and segmentation of tissue types for neuroimaging analysis.

Chow and Chang completed their fellowship training together at UC San Francisco. Chang is both a radiologist and self-taught software engineer, so he brings insights in both domains. He had been consulting with AI startups in health care institutions while finishing his medical degree when Chow called him to join the effort at UCI. He saw CAIDM as the perfect chance to start a center from the ground up.

A year later, the center has nine permanent staff, half a dozen visiting researchers, and multiple residents, fellows and medical students. And there are more than a dozen projects in the works. In addition to the brain hemorrhage triage tool, they are developing several AI algorithms capable of identifying normal vs. abnormal anatomy of the head and neck. They have AI methods in the works for automated detection of prostate lesions and kidney cancer as a clinically efficient diagnostic tool. And there are a couple projects involving breast imaging: one that enhances detection of breast lesions on MRIs and one that automatically segments fibro-glandular from surrounding breast tissue, which will help clinicians better evaluate a patient's risk of possible breast cancer. In collaboration with other physicians interested in applying AI to their practices, the center is working on tools that can detect lung nodules on chest CTs, assess the risk of prostate cancers and do a virtual brain biopsy.

Although artificial intelligence in medicine is growing, it's still an emerging area, with uncharted territory. Chang explains the advantage offered by the UCI center. Both he and Chow are practicing clinicians. "Most of the innovation in machine learning in medicine has been driven by Ph.D.s, not M.D.s," says Chang, "where the computer scientists look to take the techniques that they've learned in self-driving cars and facial recognition and apply them to medicine."

Instead, Chang and Chow are bringing clinicians to the table and letting them determine what they want to study and what problems they need to solve, and then the two work together to design an AI application and determine how best to incorporate it into the clinical setting. The algorithm has to match the application, whether it is to make a diagnosis, a detection, a quantification or a comparison. And an algorithm is only as smart as the data it's trained on.

This brings us back to the right place at the right time. "With all these research institutions connected through the PRP,

it's an amazing resource, like a distributed supercomputer," says Chang. And with sensitive patient data, without the PRP, it would be almost impossible to share outside of the hospital firewalls. "In the world of medical AI, there is a real bottleneck when it comes to data."

"I am excited about Peter and Daniel's idea of using the PRP to couple the training of machine learning on radiological images at two different sites (UCI and UCSD), without having to move the data out of its protected environment," says Professor Larry Smarr, CALIT2 founding director and principal investigator of the PRP. "This is a novel use of the PRP that we had not imagined when we wrote the proposal to NSF five years ago."

Chang explains, "An algorithm that is trained at one hospital would not be able to generalize and work in another hospital with the same degree of accuracy. Every hospital is different – the imaging technology, the patient population, the configuration of patient care, etc. But by training an algorithm on multiple hospitals, we end up with a more powerful and general tool."

CAIDM has built a full enterprise-level infrastructure to provide de-identification imaging services to all UCI researchers in a secure process to help streamline the current workflow. They are able to query, download, anonymize, store and transmit data for optimal efficiency across high-bandwidth data center networks.

As a result, CAIDM's algorithms are extra smart because they have seen data from so many institutions. "It's a diverse representative sample because we've found a way to share without compromising privacy rules," says Chang.

Both Chang and Chow are excited about the potential collaborations available by being on the campus as opposed to the medical center. Chang, assistant professor in residence in radiology and computer science, leads the new health care AI curriculum, which trains the next generation of physician-scientists in understanding and developing cutting-edge AI tools. His students are able to propose and design projects, and this contributes to a community of ideas, in which the center is educating and executing.

Chow says the idea of personalized or precision medicine is not far from reality. "I think we are on the cusp. With this AI technology, we can take on questions we never thought of tackling before; we can really push the boundaries."

PRP: THE BIG DATA SUPER HIGHWAY

The Pacific Research Platform (PRP) is a high-performance end-to-end network architecture funded by a grant from the National Science Foundation in 2015. Led by researchers at UC San Diego and UC Berkeley, the seamless research platform allows scientists to securely share large amounts of scientific data among labs and their collaborators through integrated high-capacity, high-speed networks that extend the campuses' reach to regional, national and even global scales.

The platform is built on top of CENIC's California Research and Education Network enabling researchers across the partnership to transfer data over dedicated optical light paths at speeds from 10Gb/s to 100Gb/s.

A partnership of more than 50 institutions, including all UC campuses, the National Science Foundation, Department of Energy and multiple research universities in the U.S. and around the world, the PRP encourages collaboration on a broad range of data-intensive fields and projects, with wide-reaching impacts on science and technology. Cancer genomics, galaxy evolution research, climate modeling, and the creation of virtual reality gaming systems are just a few of the projects that are benefiting from the use of the PRP.

> "With all these research institutions connected through the PRP, it's an amazing resource, like a distributed supercomputer."

READY, SET, SLEEP

Sharon Henry

STUDY REVEALS WAYS TO IMPROVE COMPUTER USERS' ENERGY-SAVING BEHAVIOR

There are more than 2 billion personal computers in the world today, according to data from Forrester Research, each plugged in and ever ready to process and perform.

Although laptops are growing in market share, in many homes they are supplementing rather than replacing desktop computers. "This is important because desktop computers use – and waste – more energy than any other consumer electronics device," says Joy Pixley, research director of the California Plug Load Research Center (CalPlug) at CALIT2 UC Irvine.

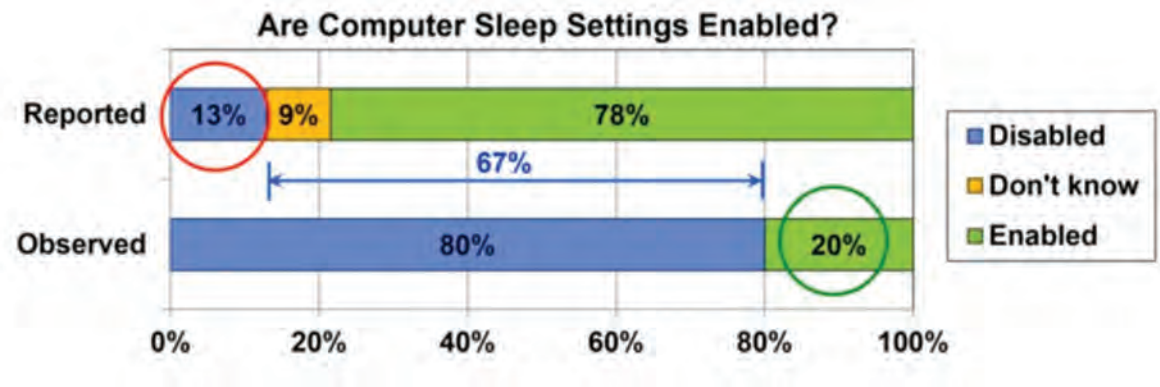
Desktop computers come with built-in settings that put the computer or the monitor into sleep mode after a certain amount of idle time – that is, when the user hasn't touched the mouse or keyboard for a while. In sleep mode, the average desktop computer uses about 2 watts of electricity, compared to about 48 watts in active mode. The trouble is that too many computers have their sleep settings disabled, so they stay on all the time, using almost as much energy while idle as when they're being actively used.

"Computers have perfectly good sleep settings if they are enabled, yet we have increasing evidence that they are not enabled. Something is going wrong," says Pixley, a behavioral researcher.

She has been lead or co-lead on several large-scale studies of computer users' behaviors sponsored by agencies including the California Energy Commission's (CEC) Research and Development Program and the Electric Program Investment Charge (EPIC). Her past work was instrumental in informing the CEC's appliance standards that took effect on Jan. 1, 2019. These standards apply to desktop computers, laptops, small-scale servers, workstations and monitors, and could potentially save more than $370 million annually – enough to power about 350,000 average California homes for one year.

In an initial survey, completed in 2014, Pixley asked more than 2,000 people about their home and work desktop and laptop computers. Later,

In front of graphical presentations of data collected from their PMUI app, researchers, from left, Joy Pixley and Sergio Gago Masague, and field-testing coordinator Sabine Kunrath show off the energy monitoring hardware used in their survey.



her team conducted a second study that monitored more than 100 of the subjects' office desktops. Comparing the results of the two studies held a surprise: in the first study, 78 percent said the sleep settings were enabled. "However, when we went and observed those same desktop computers, only 20 percent actually had sleep settings enabled," she says.

For the third and most recent study, Pixley focused her attention on the two-thirds of users whose sleep settings were disabled but who thought the settings were enabled or didn't know. "How could this group be encouraged to voluntarily enable sleep settings?" she asks.

Two common techniques are used to promote energy efficiency with computer settings. Computers can be shipped to consumers with the sleep settings already enabled. "This works great," Pixley says, "up until the moment somebody disables them." Another option used by businesses with centralized IT departments is to control the workers' computer settings. But IT departments don't always welcome the possible hassle and pushback from employees, and it doesn't work for smaller companies that don't have a centralized IT unit, or whose employees have home desktops, she adds.

Previous interventions have tried giving people feedback on the energy consumption of their computers (or more often, their whole office), which does seem to reduce energy consumption. However, this requires special metering, and prior studies haven't established whether users are enabling sleep settings (an effect that lasts), or simply turning their computers off more often during the study.

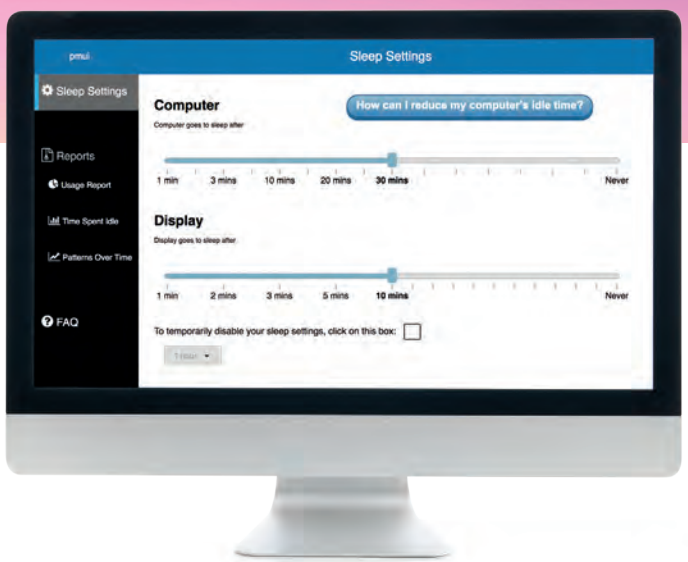
The goal for Pixley's research group was to create a no-cost software application that provides users with feedback on how much time their computers were idle, in the hope it would encourage them to enable their sleep settings.

CALIT2 researchers Sergio Gago Masague and Raquel Fallman helped Pixley design and program the application, PMUI (Power Management User Interface), based on behavioral theory and intervention research.

A field test of more than 400 desktop computers was conducted in UCI's campus offices to test the effectiveness of PMUI and to collect data on users' behaviors toward power management.

The intervention included three visits from the researchers. On the first visit, PMUI was installed in observation mode only to collect baseline data. Only 14 percent of the computers had their sleep settings enabled at the beginning of the study.

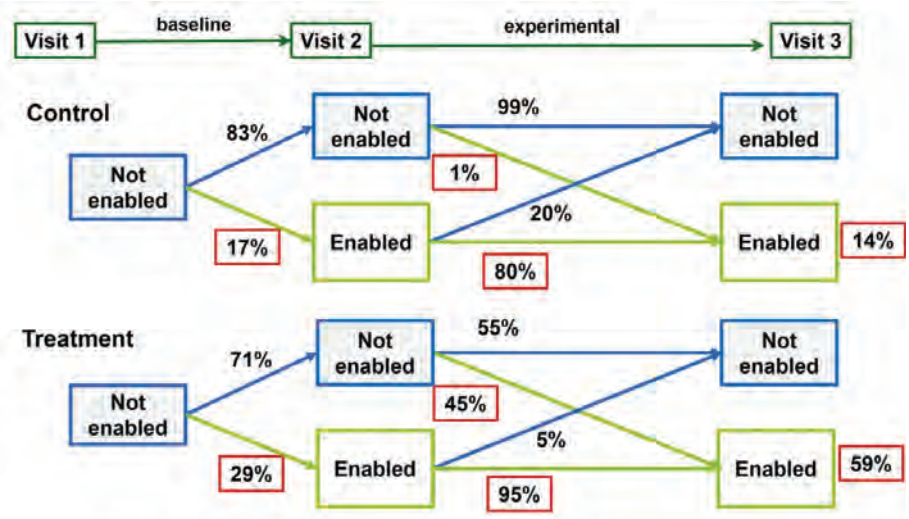
> "Computers have perfectly good sleep settings if they are enabled, yet we have increasing evidence that they are not enabled. Something is going wrong."



After one month, the control group subjects were shown how to locate their computers' regular sleep settings, while the PMUI interface was activated on the computers of the treatment subjects, and they were shown how to open it. No one in either group was urged to change their settings. Two months later, the researchers returned for a final visit to remove PMUI and the plug meters.

The results showed that PMUI changed users' behaviors for the better. After being shown the PMUI app at the second research visit, the treatment group was much more likely to enable sleep settings than the control group, who were only shown regular sleep settings. The difference was even greater two months later. Those who had the PMUI app were significantly more likely to keep their sleep settings enabled, or to enable them by the end of the study.

Over the course of the experiment, 14 percent of the control group had enabled their sleep settings, compared to 59 percent of the treatment group.



> The exciting thing is proving that a free software app can change behaviors and save so much energy, without needing to install extra equipment. Giving people feedback, encouragement and engagement works.

Charts provide app users with feedback on how much time their computers spend idle, encouraging them to enable their computer's sleep settings.

The effects of enabled sleep settings were found to deliver an energy savings of 34.9%. "If you have a large office building, that's going to add up pretty quickly," says Pixley.

"Many people don't know how their computers are set; providing users with feedback on how computer settings impact energy use is valuable and can result in reducing cost to California consumers," says Bradley Meister, CEC project manager. "As California pursues a carbon-free future, it is important to ensure that we maximize energy efficiency, and this software program provides consumers with the tool to do so and produce savings beyond the current state standard."

One unexpected finding revealed that two-thirds of computers with sleep settings enabled experienced problems with transitioning into sleep mode, including 42% that spend at least 25% of the day idle when they should be sleeping. Something is blocking the settings and keeping the computer in idle mode. Pixley considers that peripherals and perhaps other applications are overriding the sleep-setting commands and preventing the computer from shifting into a more energy-efficient state. Many programs interrupt sleep settings, such as virus checks, backups or system updates, she says, "but your computer is supposed to go back to sleep" in order to conserve energy. Computer experts know sleep block is a problem, but the complaints are anecdotal so it's difficult to say how large the problem is. Pixley has been unable to find data on this subject. "I'm always hesitant to say this, but as far as I can tell, this is the first data set to quantify the extent of the problem of sleep block."

Results from the study provide strong evidence that feedback on computer idle time can convince users to change their sleep settings, saving a substantial amount of energy – something no prior study had addressed. "The exciting thing is proving that a free software app can change behaviors and save so much energy, without needing to install extra equipment," Pixley says. "Giving people feedback, encouragement and engagement works."

Building a Better

AN INTERDISCIPLINARY UCI TEAM IS IMPROVING ASSISTIVE ROBOTIC TECHNOLOGY FOR HOMEBOUND CHILDREN, LIMITED-MOBILITY ADULTS

BOT

Heather Ashbach Steve Zylius

If you were in UC Irvine's Social & Behavioral Sciences Gateway this summer, you may (or may not) have been surprised to find a robot riding the elevator solo, delivering documents to the fifth floor and winding its way through one of many hallways.

The intriguing automaton is CARL SR – short for Cognitive Anteater Robotics Laboratory Support Robot – a state-of-the-art robot on lease to UCI from Toyota Motor Corp. to be optimized for a specific task: helping homebound children and adults with limited mobility navigate everyday experiences, such as attending school and doing household chores.

"Children who can't go to school due to either long-term illness or limited mobility have begun to rely on telepresence robots that livestream video of the remote student and the classroom, giving the student the social interaction that they miss when they must do their work from home," says Jeffrey Krichmar, UCI cognitive scientist and CALIT2-affiliated faculty *(pictured previous page)*. "But current assistive robotic technology has its limits. It can't move on its own or reach out and touch objects, and it requires constant Wi-Fi connectivity. All this reduces a child's ability to naturally engage with a teacher and fellow classmates."

Assistive technology for adults similarly leaves a lot of room for improvement, he notes, and applications developed through work with homebound children can extend to limited-mobility adults and elders.

CARL SR may very well be the solution. The project began in 2017 with a chance meeting between Krichmar, director of the campus's Cognitive Anteater Robotics Laboratory and Veronica Newhart, a postdoctoral fellow in UCI's National Institutes of Health-funded Institute for Clinical and Translational Science. She studies the impact of telepresence robots on home- and hospital-bound children but wasn't satisfied with the existing technology.

"After working on this research for four years, I realized that it wasn't enough to explore robot-mediated experiences for homebound children. We also needed to contribute to the design and production of improved technologies," says Newhart, who earned a Ph.D. in education at UCI in 2018. "Currently available off-the-shelf robots were designed for adults in medical or corporate settings. We needed robots designed for children to engage in their real-world settings – school, community, extracurricular – on a daily basis."

She approached Krichmar – who, with his lab, was already developing autonomous robots to meet this demand – about utilizing data collected from her user-centered studies to improve robot design, and an all-star research team was born.

Over the past year, Krichmar and his lab members have been adapting a robot designed by Toyota for household use to operate in a classroom setting. It has four onboard cameras, including one with high enough resolution to livestream a teacher's whiteboard notes to a student thousands of miles away. The robot also has a movable arm with a grasping "hand" that can be raised when a homebound child has a question or wishes to contribute to a class discussion, reducing the need for verbal or other interruptions that may be necessary with current telepresence models. The same technology could help limited-mobility adults and elders perform common household tasks.

But what really makes CARL SR stand out from the crowd of assistive robotic devices is the very thing for which the UCI CARL team is internationally renowned: artificial intelligence modeled on the mammalian brain. Since joining the UCI faculty in 2008, Krichmar has received more than $4 million in public and private funding for his work in neurorobotics, which involves programming robots

Opposite page: Veronica Newhart is working with Krichmar and his team to improve robot design technology for classroom settings.

with real-life neural data to approximate thinking, moving beings.

"We design robots whose behaviors are guided by large-scale simulations of the brain," he says. "And because these simulated nervous systems are embodied in a robot, they provide a powerful tool for studying brain function and developing smarter robots."

Supported by over $300,000 from Toyota Motor North America, Krichmar tapped into the expertise of Tiffany Hwu, a UCI graduate student in cognitive sciences who received her Ph.D. this month. She enhanced CARL SR's operating system with software

> **"This is an ambitious project that addresses an important need, and none of it would be possible without a strong interdisciplinary effort to accomplish our goals."**

that mimics the human brain's neural networks – particularly those pertaining to contextual memory. The robot is now able to "remember" how to behave differently in a classroom versus a cafeteria or break room and which items are commonly found in each setting.

"The software is based on the idea that context is important," Hwu says. To help, the team transformed the lab into a break room and a classroom. CARL SR, through trial and error, began to "learn" where it should go, if asked, to locate things that belong in a classroom – such as books and backpacks – or a break room – such as food and cups – and retrieve them.

Another lab researcher, Hirak Kashyap, a UCI graduate student in computer science, developed a software model based on the human visual system that allows the robot to predict where an object in motion will go.

"It's similar to when a car goes behind a tree," he explains. "We know it'll come out on the other side, so we look there." His model imbues CARL SR with the same predictive behavior. When applied, this will enable a telepresence robot to turn its head to follow a teacher or friend who may be moving, letting the remote operator spend more time engaging with peers than running the robot.

And thanks to undergraduate researchers Lara Mirzakhanian, who's majoring in cognitive sciences, and Giselle Tian, a psychology major, CARL SR can be moved from point A to point B at the click of a mouse. This ease of navigation – coupled with the robot's movable arm, grasping hand, and obstacle avoidance and contextual recognition features – means that homebound students can participate in the classroom in a more active and seamless way than permitted by other assistive devices on the market.

Recently, the team demonstrated that CARL SR could travel from Krichmar's robotics lab on the second floor of Social & Behavioral Sciences Gateway to the elevator, ride up to the fifth floor and navigate to the social sciences dean's suite – all with only a few clicks from the remote user.

Mirzakhanian and Tian were also part of an undergrad group that, based on their work with CARL SR, fabricated an inexpensive robot alternative from basic parts, kits and 3D-printed components – suggesting that more inclusive, affordable access to telepresence robots may be well within reach. They, along with group members Mikayla Minton, a mechanical engineering major, and Steven Seader, a computer science major, presented the prototype in May at UCI's annual Undergraduate Research Opportunity Program symposium.

"This is an ambitious project that addresses an important need," Krichmar says of CARL SR. "And none of it would be possible without a strong interdisciplinary effort to accomplish our goals."

A Parting Shot

With the start of a new academic year, the CALIT2 director's office moved forward with its plan to get the building's occupants better connected. In October, the institute hosted a town hall meeting for faculty and graduate students to learn more about the benefits and obligations of working in the building. In rapid-fire succession, 20-plus faculty occupants presented their research group, projects and collaborative opportunities – each in a mere three minutes. "The meeting proved to be a great way for the CALIT2 Building residents to get to know their neighbors and what they are working on," said G.P. Li, the institute's director.

Participants also received a pair of custom-made CALIT2 socks – encouraging them to take the next steps together toward future multidisciplinary collaborations.

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 health care, energy, the environment and culture.

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