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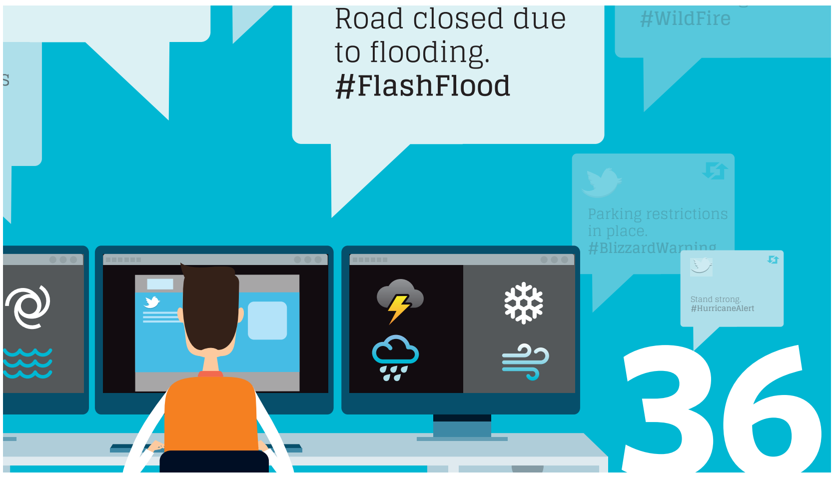

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On the cover: *A form of machine learning, deep learning increasingly is used by researchers in their quest to produce artificial intelligence. Three experts weigh in on AI's progress.*

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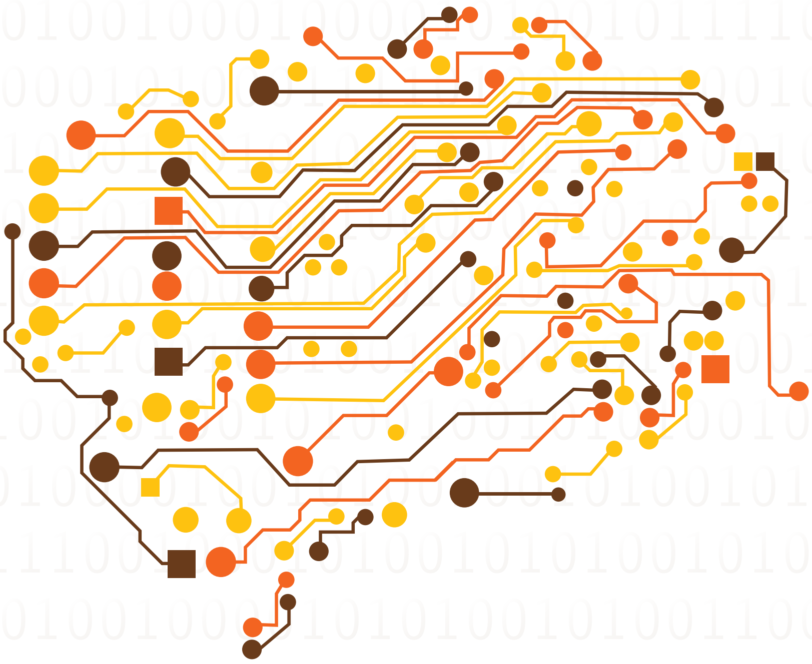
Is AI technology getting smarter and scarier?

Sharon Henry



Artificial intelligence (AI) is commonly defined as the science of making computers do things that would require intelligence when done by humans.

Five years ago, IBM's computer system Watson defeated "Jeopardy" champions Ken Jennings and Brad Rutter by using algorithms and relevant search terms to explore more than 200 million pages of archived material and promptly produce a correct answer – time after time. The man-against-machine tournament illustrated how AI promises a future that is both awe-inspiring and eerie.

Two years later, IBM announced the same AI software system employed by Watson would be used by Memorial Sloan Kettering Cancer Center to help make management decisions in lung cancer treatment.

In March, Google's artificially intelligent computer system "Alpha Go" claimed victory over grandmasters of Go, a game developed in Asia more than 2,500 years ago and considered more complex and intuitive than chess. This AI milestone happened years sooner than experts had predicted. And as early as this summer, Google plans to introduce prototypes of its self-driving cars on the roads in California. The AI pioneer expects that autonomous vehicles soon will enable drivers to safely send texts and sip coffee during their daily commute.

At the same time, warnings of AI-created doomsday scenarios flourish. Some scientists predict super-intelligent machines will eliminate millions of jobs, while others fear smart robots one day could develop beyond their original mission and decide to wipe out mankind.

We reached out to three UC Irvine professors deeply involved in AI research to get their insight into this technology.

Prior to joining UCI as a professor in the Department of Cognitive Sciences and the Department of Computer Science, **Jeff Krichmar** worked with Nobel Laureate Gerald Edelman for nearly 10 years on the Darwin robot series of brain-based devices (BBDs). A BBD is a realistic brain model that controls a robot performing a behavioral task. That led to Krichmar's interest in using robots to understand the brain and intelligence. His current lab, the Cognitive Anteater Robotics Laboratory, or CARL, continues this tradition of understanding through building.

Pierre Baldi is a UCI Chancellor's Professor of computer science and the director of the university's Institute for Genomics and Bioinformatics. His research includes artificial intelligence, statistical machine learning, data mining and their applications to problems in the natural sciences. His main interest is understanding intelligence in both brains and machines.

In January, **Kai Zheng** joined the faculty of the Donald Bren School of Information and Computer Sciences, Department of Informatics. He is responsible for advancing biomedical informatics – also known as health informatics – research at UCI. Zheng has used AI primarily to process large volumes of patient care data in an effort to identify patterns that could allude to important underlying and overlooked mechanisms, such as associations among seemingly unrelated diseases.

Q: How does machine intelligence differ from human intelligence?

KZ Generally speaking, machine intelligence is based on mathematical reasoning, whereas human intelligence is largely driven by heuristics (estimates and past experience). For example, when determining if it is safe to cross through an intersection when the traffic light turns yellow, human drivers largely rely on heuristic judgment, while AI would base the prediction on a precise calculation with a range of factors, such as travel speed, distance from the crossing and weight of the vehicle. Another key distinction is human intelligence is much more adaptive, while machine intelligence often has difficulties handling unfamiliar situations.

JK I believe our bodies, the materials they're made of, our goals, internal drives and needs critically shape our intelligence. I think we will be able to create machines that mimic many aspects of human intelligence, but they will never be the same.

PB In computers, processing and storage are separate. In brains, processing and storage are intimately intertwined. In part for this reason, brains are roughly four orders of magnitude more efficient than computers from an energy standpoint. The IBM Watson supercomputer that surpassed human performance in the game of Jeopardy consumes 80,000 watts. A human brain consumes 20-40 watts. Today, machine intelligence is still fairly limited to well-defined, specialized domains and tasks. It is far from having the universal quality of human intelligence. However, the gap is rapidly shrinking.

Q: Is the goal of AI to simulate human intelligence?

PB No. The main goal of AI is to build intelligent machines that can emulate and sometimes surpass human intelligence. The goal of AI is also to understand intelligence at a deeper, more unified level, beyond issues of hardware implementations.

JK That is the goal of many in the field of AI. My primary goal is to understand the brain, and that may ultimately lead to understanding human intelligence. A secondary goal is to make smarter robots, based on principles of the mammalian nervous system.

KZ To a degree, yes. There are two distinctive efforts: strong AI versus weak AI. The former intends to simulate human intelligence – to create machines that can think and function the same as human beings. Weak AI, on the other hand, develops AI systems that imitate specific human behaviors, such as voice recognition and natural language processing. It should be noted that we are currently unable to build machines that truly replicate human intelligence because we don't yet fully understand how human intelligence works.

Q: What is the origin of AI?

JK Many attribute the beginning of AI research to a meeting at Dartmouth College in 1956 that included John McCarthy, Marvin Minsky, Allen Newell and Herbert Simon. They originally thought that human problem-solving capabilities could be achieved within a summer by a select group of researchers.

PB The source of AI is the human desire to understand, emulate and surpass human intelligence. It is the human quest to "forge the gods" and build machines that behave intelligently, like humans and beyond.

KZ AI reflects mankind's aspiration to build mechanical or computing devices that can function like the human brain. It can be traced back to classical philosophers' attempts to describe human thinking as a symbolic system. In his 1950 paper Computing Machinery and Intelligence, British mathematician Alan Turing for the first time posed the question: "Can machines think?"

Q: What types of tasks is AI ultimately not capable of achieving?

KZ None. I think ultimately AI is capable of achieving everything that human intelligence has to offer. Again, machines may not truly replicate nervous systems and human brains (nor do they need to), but they can arrive at the same or similar outcomes using different mechanisms, such as fast processing of large volumes of data.

JK I think most tasks are achievable if you think of AI in the broad sense. That is, any algorithm, method or machine can be used to create an intelligent system. Some tasks will be achieved in the near term, while others may take decades.

PB From our current understanding, there are many tasks that cannot be solved by current computers, or Turing machines. Besides the issue of capability, there is also the issue of efficiency. The classic example here is the traveling salesman problem, or finding the shortest tour among a set of 'n' cities. A program exists to find the shortest tour; in fact it does not require any intelligence — you just have to list all possible tours, measure their lengths and pick the shortest one. This procedure, however, takes exponential time to complete as a function of the number of cities and cannot be carried for say 100 cities. So the question is whether there exists a clever AI program that finds the shortest tour efficiently, in time that is polynomial in the number of cities. Most computer scientists believe that such a computer program does not exist, although proving that it does not exist remains one of the main open challenges in computer science and mathematics.

Q: What are some examples of how machine learning is used today?

PB Today machine learning is already everywhere. You use it constantly without even being aware of it. It is hidden in the search engines that you use to search the Internet. It is hidden in your cell phone, your car, your appliances, your house and so forth. It is used in all the computer-vision systems, speech-recognition systems, natural language understanding and translation systems, etc. that are being deployed everywhere. It is used in robots, drones, self-driving cars and many other control systems. The list goes on. As scientists, we use it every day to analyze complex data to make new discoveries in physics, chemistry and biology. We use machine learning to analyze data from complex instruments ranging from particle colliders to telescopes to genome sequencers, and to predict the properties of molecules and materials, or the outcome of chemical reactions.

KZ IBM Deep Blue, IBM Watson and Google AlphaGo are probably the most prominent examples of AI-based technologies; all three made their fame by outperforming human contenders in competitions. However, AI-based applications can be much more commonly found in our everyday lives. For example, speech-recognition software such as Siri and Cortana, and voice commands widely used in modern vehicles, are all applications of AI.

Q: What are the remaining big challenges for AI?

PB While there has been a lot of progress, our theoretical understanding of AI and machine learning is still very incomplete. For those of us interested in understanding natural intelligence, the ways in which intelligence is implemented in the wetware of the human brain remains a major challenge that will take a long time. To understand intelligence in the brain, you must first understand how the brain stores information, and this is still a very messy story, in spite of all the progress being made.

KZ Poor adaptability will continue to be a key challenge to AI. While machines can learn from training data and their past performance, this process is often cumbersome, and they are not yet versatile enough to transform knowledge acquired in a given setting to solve new problems in unknown territories.

JK AI systems are very good at doing one thing, but are not flexible enough to adapt to change and context. As an example, take a look at the movie "Ex Machina." We are nowhere near the point shown in the movie where artificial systems are self-sufficient, have real understanding of what they are sensing and doing, and can interact with humans in a natural way. But what really struck me as the biggest challenge was making an AI that moved and manipulated objects as fluidly as Ava did in that movie. We are not close to seeing that level of sophistication in our robots and AI systems. And I think this is crucial for an AI that mimics nature. This again brings up the importance of coupling brain, body and behavior with the environment.

Q: Physicist Stephen Hawking, Microsoft founder Bill Gates and SpaceX founder Elon Musk have all expressed concerns about the possibility that AI could evolve to the point that humans could not control it, with Hawking cautioning that AI could "spell the end of the human race." What do you think about dystopian warnings like these?

JK Like any new technology, we need to be careful how it is applied. But I think the benefits outweigh the risks. AI has great potential for benefiting society in healthcare, elderly care, disaster relief and high-risk or mundane tasks, just to name a few. We are a long way from the point where these systems are truly intelligent, but I think it is important to have discussions now about how AI technology should be applied.

PB I think they are healthy and justified. AI is an extremely powerful technology, far more powerful than anything we have seen before, and the human race should be careful about its use and deployment. There is no immediate danger and no reason to panic in the short term. But it is wise for us to monitor the situation and carefully think through possible future scenarios.

KZ It will not happen in the foreseeable future, obviously, but I believe that it will ultimately become a reality that future generations will confront. What concerns me more is the degrading of human intelligence due to the increased popularity of AI. For example, more and more we rely on GPS for navigation, and consequently, many of us are no longer able to read and process maps. This generational degradation of intelligence, in contrast to rising machine intelligence, may one day create a severe problem threatening the existence of mankind. We may eventually destroy ourselves due to our over-reliance on machines.

Q: Are you eager to own a self-driving car?

JK Absolutely! I think the roadways will be safer and more efficient once self-driving cars become prevalent. And I think this will be a great game-changer. Most of us want to multitask. I'd love to be reading or corresponding while in the car. Also, self-driving cars could be a great societal benefit for the elderly and handicapped.

KZ Yes. While it requires a lot of engineering to achieve perfection, the AI techniques utilized in a self-driving car are actually relatively simple (compared to the ambiguous task that the field of AI sets out to do: creating machines that can function like the human brain). With more advanced sensors and optics, increased computing power and more accurate object-recognition algorithms, I think self-driving cars can be highly reliable and can easily surpass the performance of average human drivers. I look forward to owning one.

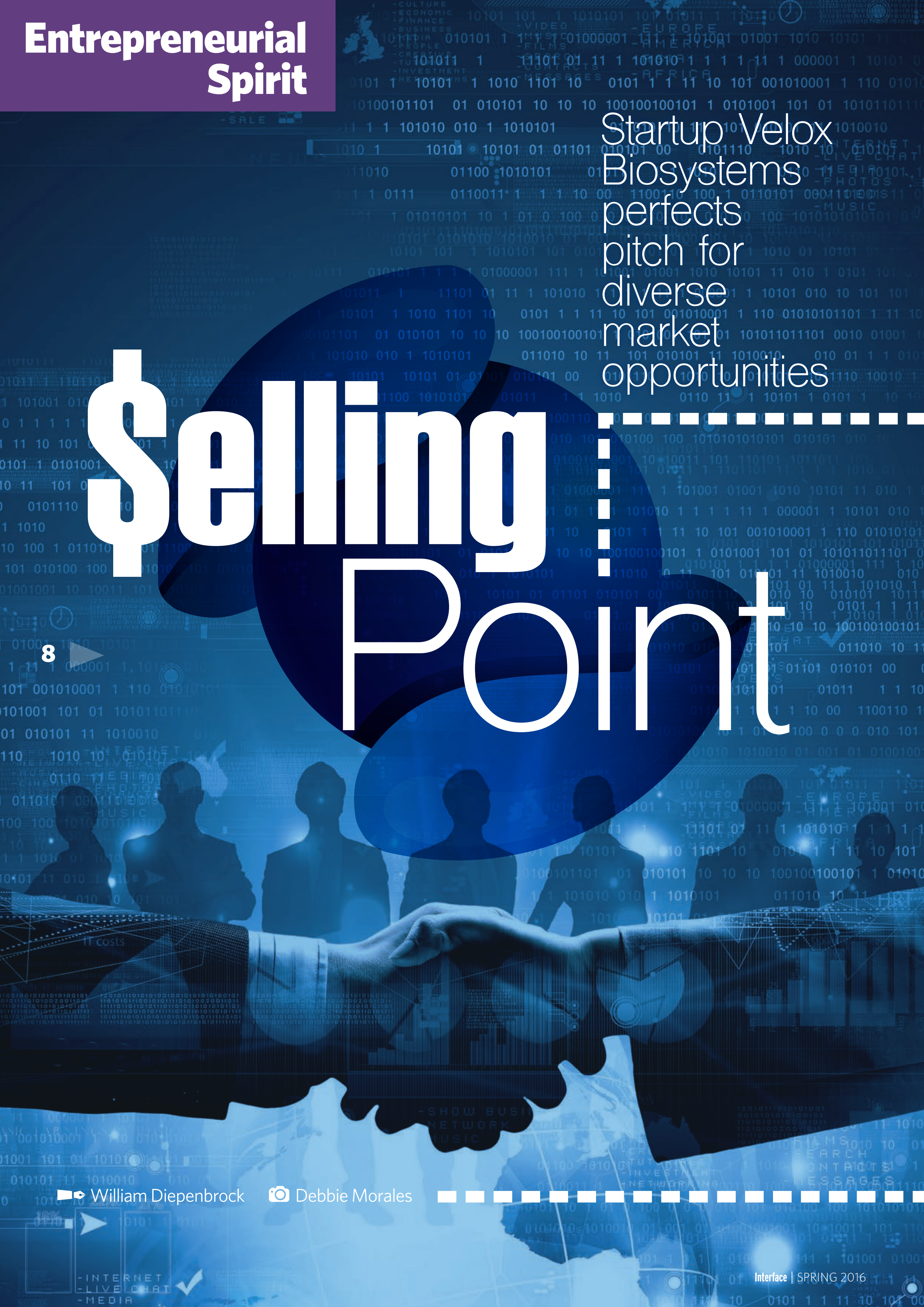
PB Not particularly. I actually like driving cars with manual transmissions.

Q: What does the future hold for AI?

JK I think the next big breakthroughs will be seen in the neurosciences. One specific area I am excited about is neuromorphic engineering, where the goal is to design computers based on the brain's architecture. Using this approach, we are constructing machines that use very little energy, but have more computing power than conventional computers. These cutting-edge computers have the potential to create AI that thinks more like humans and are efficient enough to be self-sufficient.

KZ I am very optimistic about the future of AI. Thanks to advancement in computing technologies, we now have unprecedented computing power that can be delivered via high-speed networks to very small devices such as cell phones, watches and pacemakers. Many AI techniques that were only theoretically possible in the past are now commonly used in practice and will soon make their way to consumer electronics.

PB You are going to see more and more of it, everywhere, from smart houses to smart grids, from self-driving cars to smart drones, from advanced speech recognition to personal assistants, and so forth. In addition, there is going to be a trend toward increasingly more general forms of intelligence – intelligent systems that can integrate information from, and perform in, multiple domains. There also is going to be progress toward "universal intelligence," using techniques where agents can interact with any environment and progressively learn how to behave intelligently. What is much more opaque is the more distant future of AI, and while I think about it, I would rather not make any predictions.



$elling Point

Startup Velox Biosystems perfects pitch for diverse market opportunities

William Diepenbrock
Debbie Morales

Velox Biosystems

defining the future of rapid and sensitive tests

They didn't teach this in grad school.

UC Irvine biomedical engineering alumnus Christopher Heylman is standing in a room with 30 potential investors who are grilling him about his vision for a novel device that can return biological testing results faster and more accurately than anything on the market.

"It's a pressure cooker, even with all the practice you get in academia defending your research, all those times when the smartest people in your field pick your science apart," Heylman says.

"This is a whole different ballgame. They don't want to know about the science or the data; they want to know about you and your team. In a pitch for funding, you have to say, 'We're going to change the world and here's how we're going to do it. Here's our device, here's our team, here's our vision. We need your money to make this happen.'"

A year ago, Heylman was an expert in fluorescent microscopy and tissue engineering, a self-described academic introvert more at home in front of lab equipment than human beings.

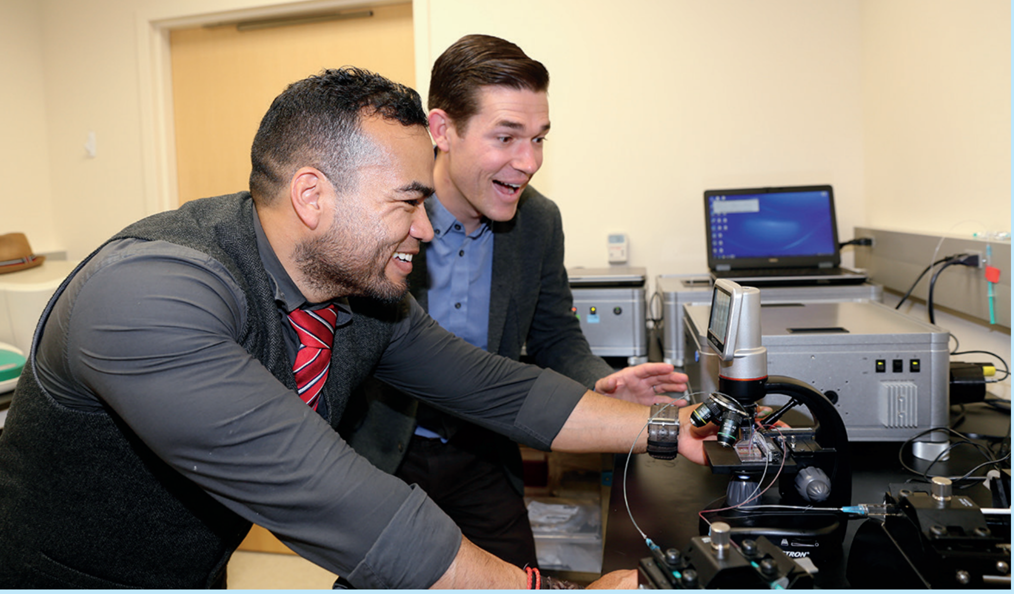
Then UCI pharmaceutical sciences professor Weian Zhao, whose lab developed the microfluidic device, tapped Heylman to run Velox Biosystems, a startup company housed in the TechPortal incubator at Calit2.

TechPortal helps UC scientists launch businesses based on ideas they cook up in their labs, and has assembled a host of resources that provide help with business plan creation, market research and lab services.

Heylman, who had worked on the technology behind the tool, became CEO of Velox; a colleague, UCI graduate student Neto Sosa, became the company's chief technology officer. Company founder Zhao works closely with the duo, but plans to reduce his involvement as the business takes off.

Heylman and Sosa work out of Velox's lab facilities in TechPortal and enjoy access to UCI resources that include fabrication and prototyping facilities, and even attorneys who can help them navigate patent filings en route to marketing their device. In exchange, the university benefits from royalties on sales and creates a speedier pathway to market for ideas developed in its labs.

"At the traditional storybook startup, you're on your own; you're going on a hope and a prayer," Heylman says. "This is a bit gentler."



Above: Velox Biosystems execs Neto Sosa (left) and Chris Heylman are experts in biomedical engineering, but asking investors for money to fund their company is a skill they are still perfecting.

"We recognized the potential of the technology right away, and it made sense to go ahead and start a company," Zhao says. "It is a very fast, very simple solution to a medical challenge."

Storytellers

Velox's initial tasks include deciding which market to enter first. The decision calls on the firm's scientific prowess and its growing business acumen. Top contenders include testing for Lyme disease, detecting cancer and identifying E. coli in water.

"You have to know who your customers are, what the market looks like, whether they will adopt what we're selling – all before you can go and ask investors for money," Heylman says.

So he and Sosa hit the phones and the streets.

"We've talked to emergency room doctors in the Northeast about Lyme disease, we've talked with oncologists and pathologists all over the world to understand how they would use our technology for cancer detection, and we've talked to every water district we could get our hands on," Heylman says.

The research helped the duo create a narrative about IC3D, translating technical information into a vision they now share with investors.

"I've had to learn storytelling – a totally foreign skill set for me," Heylman says. "We tell the story of a patient. You walk into your doctor's office, show him your symptoms. They draw your blood, drop the sample into our machine, push go and, in an hour, we'll know if you have the disease, and if so, you can begin the proper treatment immediately."

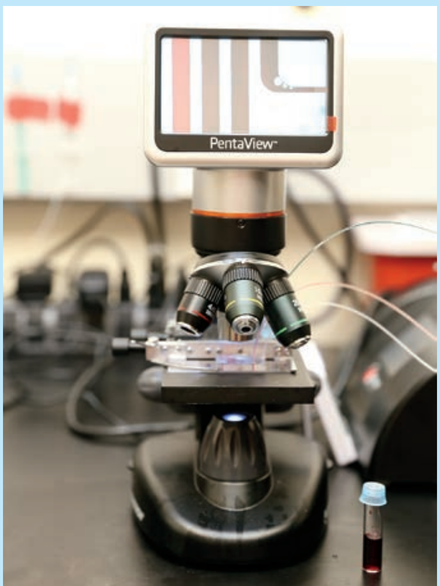
Still, while standing in front of investors, Heylman is often acutely aware of the limits of his fledgling business knowledge.

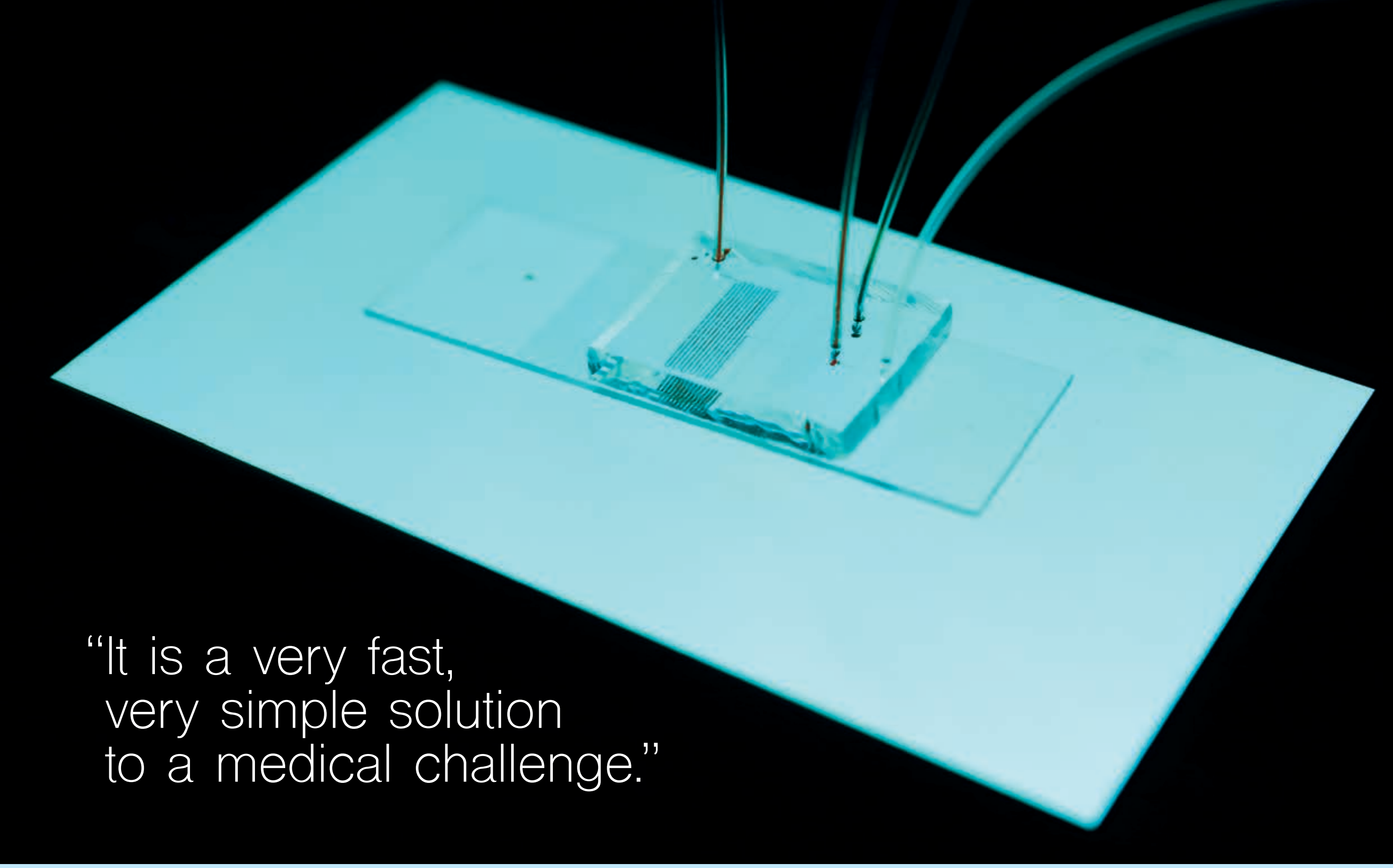
How it Works

Velox's product takes a biological sample – for example, blood or water – mixes it with chemical reagents and then channels it through a stream of oil. This creates hundreds of millions of tiny droplets. The droplets are loaded into a cuvette, a beaker about 2 inches tall by one-half inch wide. The cuvette is agitated, spinning the droplets into a mini-tornado. A laser illuminates the now 3-D sample, causing droplets carrying specific markers – such as contaminants or diseases – to glow.

The entire process takes about an hour.

Each of the techniques previously had existed, but no one had combined them to create such a novel process, dubbed Integrated Comprehensive Droplet Digital Detection, or IC3D (pictured below). By comparison, typical biological sampling takes several days to two weeks, requires additional steps such as growing cultures, samples far less material and is limited to one or two dimensions.





> “It is a very fast, very simple solution to a medical challenge.”

“It’s a ‘Shark Tank’ scenario, absolutely,” he says. “There have been investors who say, ‘nope, not interested,’ even before you get the words out of your mouth.”

At one stage, Heylman was making three pitches a week to raise funds – efforts that secured Velox about $100,000 in investments in its first year. It was enough to begin product development and market research.

Turning the laboratory version of IC3D into a functional physician’s tool will take a lot more money.

Readying for Market

Velox will need to raise substantial funds to finance federal product reviews and to hire a specialty firm to design the tool. Reviews – needed if Velox enters a medical field – can take up to two years. Design efforts can take a year.

The firm also is exploring licensing the tool to medical firms that would develop their own applications, another possible revenue stream.

All those efforts will put Heylman back into pitch rooms, in front of potential investors and partners.

“It’s been very exciting,” he says. “I’ve had to come out of my shell a little bit. I’ve learned to talk to people and listen to them, to understand their needs. Then, you fit your solution to their needs.”

After 10 years in university research, Heylman says his life has taken a surprising and exciting turn.

“I was on the path to be an academic professor, to run a lab. That’s essentially why you do a postdoctoral fellowship – to get further training, learn how to write grants, how to manage a lab.

“Now, even in just the short time I’ve been working with this, I think I’m an entrepreneur for life. I really like this startup environment. The idea of taking exciting technology and translating it into real-world applications is right where I want to be.”

The company is developing a system that creates 3-D blood or tissue samples, reducing the time needed for biological testing from days or weeks to an hour.

THE COLOR sche

Lori Brandt

me

Researchers cross disciplines to plot more efficient and accurate methods for transcribing color language surveys, unlocking novel crowdsourcing applications white

black

The dozen or so boxes sat unopened in a garage for nearly 10 years. The archive of late cognitive anthropologist Robert E. MacLaury, they contained thousands of pages of handwritten survey results collected more than 35 years ago.

UC Irvine cognitive scientist Kimberly A. Jameson strongly believed their contents held key insights for researchers interested in learning how people form concepts to name and categorize color. She won a small grant from the UC Pacific Rim Research Program that allowed her to obtain the archive in 2011 and move it to UCI's Institute of Mathematical Behavioral Sciences, where she is an associate project scientist.

For Jameson, it is a treasure. "This is 30 years of raw data collected by Dr. MacLaury – what a shame for it not to be available to the public."

To understand why she felt this way, one has to look back to 1969 when seminal research on the theory of cross-cultural color categorization was published by anthropologist Brent Berlin and linguist Paul Kay, both of UC Berkeley. Their field study, which used missionaries to run color tests on indigenous societies they encountered in remote areas around the globe, collected color-naming data from speakers of 110 unwritten languages. Berlin and Kay believed that the order and way people identified color was universal, limited in part by human biology. Today the World Color Survey (WCS) is one of the most widely cited datasets in psychology.

MacLaury was a student and colleague of Berlin and Kay, and he went on to conduct his own color surveys. His archive includes the Mesoamerican Color Survey (MCS), a collection of irreplaceable observations of color-categorization behaviors gathered in 1978-81 from 900 monolingual speakers in over 116 indigenous languages.

MacLaury's survey is seen as a valuable extension of the WCS. "Rob's data was carefully collected since he either directed its collection, or personally collected it himself," says Jameson. "There is detailed documentation and all the techniques and instructions are standardized, which means there is a lot of regularity, and we can appreciate what's really going on comparatively."

Psychologists, linguists, anthropologists and cognitive scientists like Jameson study the evolution of color terms and how their meaning is understood and shared by societies over time. Researchers strive to capture how people think about and identify colors, aiming to precisely measure the behaviors and model them mathematically. The study of these data can thus potentially lend insight to a diverse range of human activities: organization and design of transportation systems, quality and risk in medical diagnoses, and physical and virtual design of retail markets and consumer goods, to name a few.

Jameson knew the MacLaury archive was valuable, and she felt a responsibility to share it.

It took three years to scan the archive's 23,000 pages. There were 142 different handwriting styles, and many surveys contained random notes and ethnographic reports. But just preserving each page as a digital PDF was not enough. The next step is to make the surveys accessible online in an interactive format. Jameson envisions a resource in which researchers could easily query and manipulate the data to find linkages that could inspire original research and tools that would allow users to run their own simulation studies.

With nearly $1 million in support from the National Science Foundation, she assembled a team that included colleagues in cognitive sciences, mathematics, and ecology and evolutionary biology. She turned to Calit2 and its director, G.P. Li, to expand the team's technological expertise and for its experience in supporting multidisciplinary work.

"This project intrigued me. They wanted to apply Internet-based research methods to transform a paper archive," says Li, who wrote a letter of support in Jameson's NSF grant proposal. "It involves humanities, anthropology, information theory and computer sciences, a truly multidisciplinary project. It's perfect for Calit2, whose mission is to promote cross-disciplinary interaction with our own skill set in communications and information technology."

With the institute on board, the project gained Calit2 senior technology specialist Sergio Gago, as well as two undergraduate student research teams. Gago is working on a cloud-based collaborative framework, which runs a wiki engine *(Colcat.calit2.uci.edu)*, to house the digital archive. By modifying and enhancing the wiki framework, he is establishing the foundation on which to create a unique resource for users: a one-stop fully integrated platform that incorporates a host of tools, including maps, and search and simulation capabilities.

blue

green

> "It involves humanities, anthropology, information theory and computer sciences, a truly multidisciplinary project. It's perfect for Calit2, whose mission is to promote cross-disciplinary interaction with our own skill set in communications and information technology."

Meanwhile, student teams are tackling ways to efficiently transcribe the data. "This is our main challenge," says Gago.

They are writing optical character-recognition software to automatically convert handwriting into computer-addressable files. And they are designing the wiki to allow experts who are researching languages that have not yet been transcribed to download the files, and perform and enter the transcriptions themselves. In fact, each team member has transcribed one of the languages. However, the most promising approach to transcription has been crowdsourcing through Amazon's Mechanical Turk, an online job forum where people across the United States are able to log on and complete a human intelligence task, like transcribing a handwritten document.

Each document must be transcribed by several people to validate results. Prutha Deshpande, a cognitive science researcher working with Jameson on the project, explains that the team adapted a consensus-modeling approach to the Turkers' data.

Originally developed by UCI social scientists, the Cultural Consensus Theory is used by anthropologists to aggregate information and determine an agreed-upon truth. "We are expanding this model and applying it to perceptual tasks," says Deshpande.

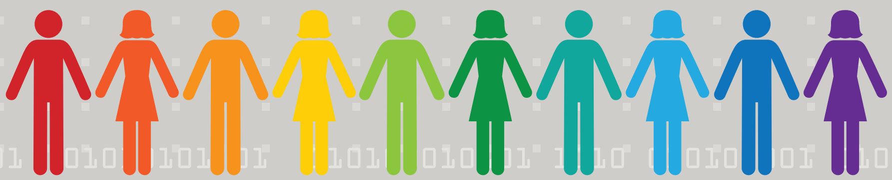
Turns out, it's a really smart approach. "This model means we can reliably aggregate and get correct answers using crowdsourced data from small numbers of respondents," says Jameson. "Typically, one might need hundreds of inputs to obtain accurate 'majority-rule' answers. With this approach, we need fewer subjects' input to get the right answer with a high probability of certainty."

Jameson is happy with the progress. "We work well as a team, and some amazing things have happened."

It took the WCS about 23 years to convert and prepare for public distribution what had been recorded by the missionaries. The MacLaury archive contains many more languages, but is expected to be largely finished in three years.

"More importantly, we have developed a very robust and accurate modeling method by which to automate it and complete it quickly," says Jameson.

It is a technique that can be applied to other areas. She believes it's generalizable to any perceptually based crowdsource task that requires human participation, especially when machine learning is not adequate to provide reliable results. It may help with not



only other transcription projects, like deciphering soldiers' Civil War diaries, but also such tasks as looking at satellite images of the ocean in a search for downed or missing aircraft.

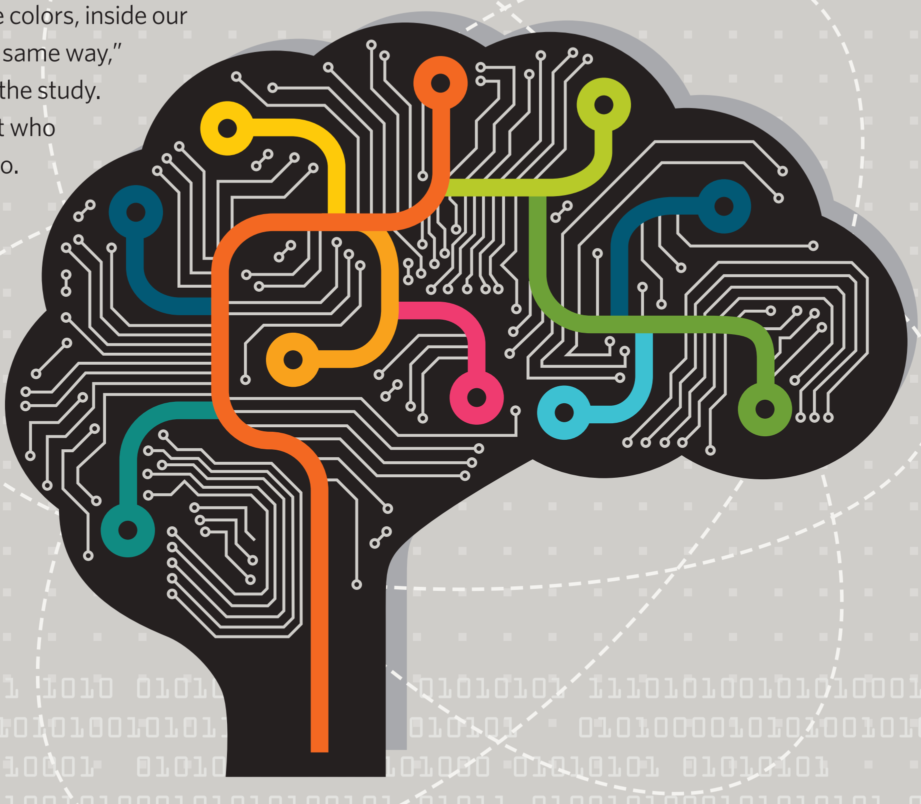
Jameson is also excited about her team's effort to develop simulated models of artificial populations and then study how they categorize color. She feeds her virtual societies information about what their environmental colors are, then speeds up time and sees through communication interactions how they would develop a categorization system.

"We want to understand how human concepts are formed and how they evolve, but science on this is constrained since researchers can't go back in time and observe what initially prompted the formation and sharing of a particular concept. Exploring concept evolution in artificial learners permits the testing and evaluation of factors that may have contributed to the shaping of our present human color concepts," she explains.

Two color researchers, Ohio State professors Delwin Lindsey (psychology) and Angela Brown (optometry), are looking forward to the database's public release. They have been studying individual differences in color naming within the same languages, using the WCS data, and they've found that color naming is not a matter of nature versus nurture, but a combination. Their results suggest that cultures create color names, but individuals from vastly different societies share the same understanding of colors in their mind.

"Though culture can influence how people name colors, inside our brains we're pretty much seeing the world in the same way," Lindsey said in an Ohio State news article about the study. "It doesn't matter if you're a native of Ivory Coast who speaks Abidji or a Mexican who speaks Zapoteco.

"We would like to test the conclusions of our analysis against another large dataset such as the MCS," said Lindsey. "This is a great service to the community of scientists who study the relationship between color and language. It will be an indispensable tool for those of us who investigate about how color-naming systems come into existence and how they change over time."



brown

Face of Calit2

18

View Master

Dedicated computer scientist seamlessly blends her perspective on research, teaching and family life

Anna Lynn Spitzer
Steve Zylius

Aditi Majumder is demure, professorial and friendly as she welcomes a visitor to her spotless office in Donald Bren Hall.

The computer scientist's scholarly demeanor and easy smile, however, belie a steely determination and a fierce tenacity. And as the soft-spoken, bespectacled researcher has demonstrated on occasion, she is not averse to nudging aside a societal convention or two if they block her way.

Born to middle-class parents in Calcutta, India, in an era when most young career-minded women were expected to marry before pursuing professions, Majumder had other plans. After graduating from Jadavpur University – a five-minute walk from her childhood home – with honors and a degree in computer science and engineering, she enrolled in graduate school on the other side of the world, at the University of North Carolina at Chapel Hill.

Majumder prioritizes family time – here, with her parents, husband and their daughters.

"It was not very common to send an unmarried daughter halfway across the world, all alone, to get her Ph.D.," Majumder says. "Even very supportive people would say, 'Oh, get a husband, and then go and continue your career with him.'"

Long accustomed to their daughter's doggedness, her civil engineer father and her mother, a former high school English teacher, successfully concealed any misgivings and cheered her on. "They were very encouraging," she recalls. "Later on, I realized how much trauma I caused them."

Computer science had long mesmerized her. A cousin on the computer science faculty at the Indian Institute of Technology had regaled his much-younger relative throughout her childhood with inspirational stories. He spoke to Majumder of Charles Babbage, who spent his life trying to build the first digital computer, and Alan Turing, the British mathematician whose computer program helped the Allies defeat Nazi Germany in World War II. "I always wanted to study computers, even though computers were not as popular at that time as they are now," she says. "And fortunately, once I started studying it, I stayed in love with it. So I was lucky."

Lucky, yes, but also smart. And hard-working. As a first-year undergraduate, Majumder was awarded a prestigious Jagadish Bose National Science Talent Search scholarship – the only woman in the group of finalists that year. The award included the opportunity to attend lectures delivered by worldrenowned computer scientists, an experience that sealed the deal for the ambitious student. "I got a lot of exposure to people who were really studying these things," she says. "It was very inspirational and really opened my horizons in terms of research."

Ultimately Majumder would focus on computer graphics and data visualization, a field in which she has since distinguished herself, but one that was unfamiliar to her when she arrived in Chapel Hill. She was surprised to learn that UNC had the highest-ranked computer graphics graduate program in the U.S., and it was there that she realized she wasn't as enthralled with her own area of concentration, distributed systems. "All my friends were in graphics, and they were showing me all these really cool things," she remembers. "And here were my little packets, going at such-and-such a speed. I just couldn't connect to them. I didn't feel the passion."

A couple of years into her program, she knew what she had to do.

Majumder walked into the office of prominent researcher Henry Fuchs, a UNC faculty member widely known as the father of virtual reality, and applied for a research position. She told Fuchs she really wanted to change her focus, and she was taking graphics classes to prepare herself. "Welcome aboard," Fuchs said.

"I'd forgotten that Aditi had no experience in graphics when she joined our group!" says Fuchs, the university's Federico Gil Distinguished Professor of Computer Science and a National Academy of Engineering member. "What I remember is that she always worked hard, and that she was determined to get results, that she had a positive attitude, and she was always friendly. We're so proud of all that she's accomplished."

Majumder, who serves as the Calit2 Visualization Lab manager, today focuses on spatially augmented reality. She still creates multiprojector displays – software-driven, high-resolution, scalable plug-and-play systems – which automatically align images, eliminate color variation and can be projected onto almost any surface. "Professor Majumder's work shows how to use low-cost equipment to produce high-quality displays. It has the potential to have a large impact for data visualization, and training and simulation applications," says Hal Stern, dean of the Bren School of Information and Computer Sciences.

She's also delving into augmented and virtual reality (AR/VR), a specialty she views as a springboard for further exploration.

"I think we are in a great age, where AR/VR is starting to get more accessible to people. So all the research we have done over the last several years now can be applied to different domains," she says. "I see it as an opportunity to take my work to the next level."

"Professor Majumder's work shows how to use low-cost equipment to produce high-quality displays. It has the potential to have a large impact for data visualization, and training and simulation applications."


photo: Paul R. Kennedy

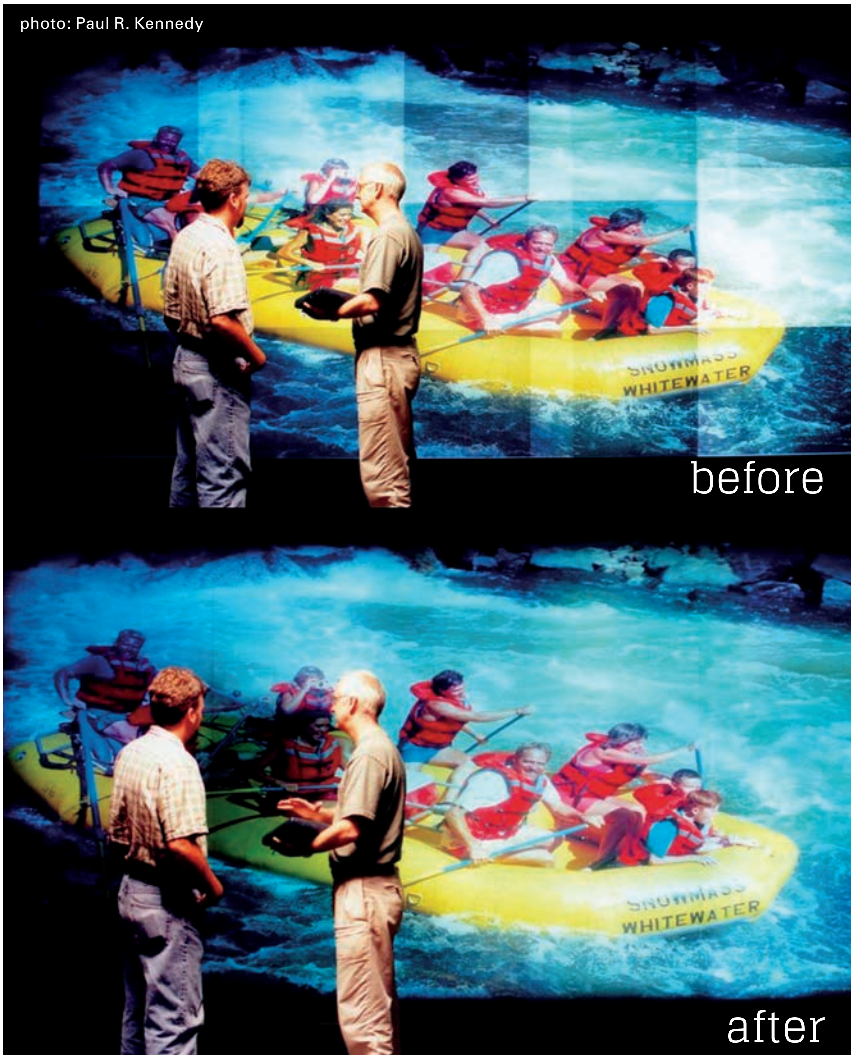


photo: Paul R. Kennedy

Calit2 Irvine Director G.P. Li says Majumder's research provides a much-needed conduit between content developers and domain experts in the rapidly emerging field. "This technology is going to provide a truly immersive, interactive learning experience. It's important to understand how to really roll it out in an affordable, accessible, portable way," Li says. "Aditi has done this with projectors; she is clearly a leader in our efforts to ramp up our know-how and bring these same benefits to AR/VR."

Majumder cherishes her relationship with Calit2, praising the institute's collaborative approach and the many opportunities it provides to showcase her research. "I love Calit2. It gives me exposure, from the campus level to local industry, that is very valuable. The contacts you build are a path you can take to make sure your research goes out into the world."

She has a long history of shepherding her work to those outside the walls of academia. Majumder has consulted with a variety of companies, including Ostendo Technologies, Disney Imagineering, Cubic Corp. and Vortex Immersion. She and her husband, ICS professor M. Gopi, currently are working to launch a spinoff company that will bring plug-and-play projectors to the consumer marketplace.

She met her husband, whose formal last name is Meenakshisundaram but who uses Gopi (it's a long story, one involving Indian tradition and U.S. passport requirements), on her first day in Chapel Hill, in 1996. He was a year ahead of her in a doctoral program, and as a member of the Indian Students Association, he was assigned to pick her up at the airport and help her acclimate to campus.

Was it love at first sight? Majumder is emphatic. "NO! I didn't believe in that. I had too much computer science to believe in love at first sight." She smiles coyly. "Over time … we did start to like each other."

They married in 1998, and Majumder decided to keep her own last name, a practice that was not exactly widespread. "By that time, I had started publishing, my passport was done and I thought, 'I'm not moving into a 17-letter name,'" she says with just the tiniest hint of defiance. Their two daughters, Sucheta, age 11, and 2-year-old Sumedha, use the last part of their father's formal name as their surname. "We are one hell of a confused family," Majumder laughs. "All of us have different last names."

When Gopi finished his thesis in 2001 and was offered a job at UCI, Majumder, who still had a couple of years of graduate work left, offered to follow him to Southern California. "Are you crazy?" she says Gopi asked her. "You are in the number one graphics program in the country. You just stay here; we will work this out." Two years, one doctorate and thousands of airline miles later, she joined him on the UCI faculty.

Like many women, Majumder successfully integrates career and family, but says she couldn't do it alone. "My husband is such a dear person. He has always been so supportive, whether it's decision-making, career or helping out with the kids."

The door to Majumder's office opens, and as if on cue, Sucheta walks in, carrying a backpack and violin case. Majumder explains that after-school homework in her office is a daily ritual for her eldest.

The petite, dark-haired girl declines a snack offered by her mother and begins her homework. She is seemingly oblivious to the conversation around her until Majumder describes herself as very organized, and adds: "Actually I feel like I'm going mad if I'm not organized," which causes Sucheta to giggle. Adds Majumder, deadpan: "My kids know that too."

Asked to describe herself further, Majumder calls herself happy, ambitious, caring, loving and responsible. "I'm so responsible, that I can sometimes be a pain." Sucheta looks up again. "You forgot hardworking," she tells her mother, and Majumder, who is loath to appear boastful, reluctantly concedes: "She is probably right."

That sentiment rings particularly true for Behzad Sajadi, Majumder's former graduate student, who is now a vice president at D.E. Shaw group, a global investment firm. He remembers that when Majumder's university tenure was approved, he thought about taking a few days off from his graduate research. "It's common for professors to give themselves a long and well-deserved break after getting tenure," he says. It didn't quite turn out that way. "Let's just say that my vacation turned out to be barely a two-day break."

Opposite page: Majumder's software-driven, high-resolution, scalable, plug-and-play projection systems automatically align images, eliminate color variation and can be projected onto almost any surface. Above: Relaxing at home. Daughters Sucheta (Sue-chay-ta) and Sumedha (Sue-may-da) disguise themselves; Majumder and Gopi, who met as graduate students at the University of North Carolina, Chapel Hill.

Above: Majumder seeks to create a new generation of researchers by encouraging her students to explore and develop their own research ideas. Below: Former doctoral student Duy-Quoc Lai, who cut his teeth in the Visualization Lab, is now Hiperwall, Inc.'s lead developer.

The diligent teacher also is intent on creating a new generation of researchers. "Aditi is very passionate about her work, and she cares a great deal about guiding her students to become independent researchers, who come up with their own ideas or even new areas of research," says Sajadi, who adds that her passion was contagious. "Working with Aditi made me think that maybe I can feel the same way about my work," he says. "Even more than three years after my graduation, that lesson is with me; I work hard because I enjoy new challenges and I feel good about reaching my full potential."

Another of Majumder's recent graduate students, Duy-Quoc Lai, uses the identical words – passionate and caring – to describe his former professor. "She motivates her students to excel beyond their own expectations," says Lai, who earned his doctorate last year and is now lead developer at Hiperwall, Inc.

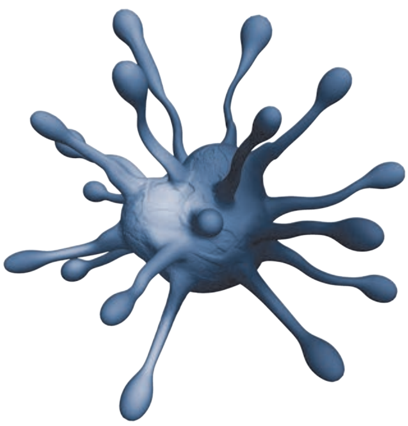
For Majumder, her career is the culmination of a lifelong dream that combines two of her passions – education and computer science. "I love teaching," she says. "The small ways we touch students mean a lot to me. It's very personal."

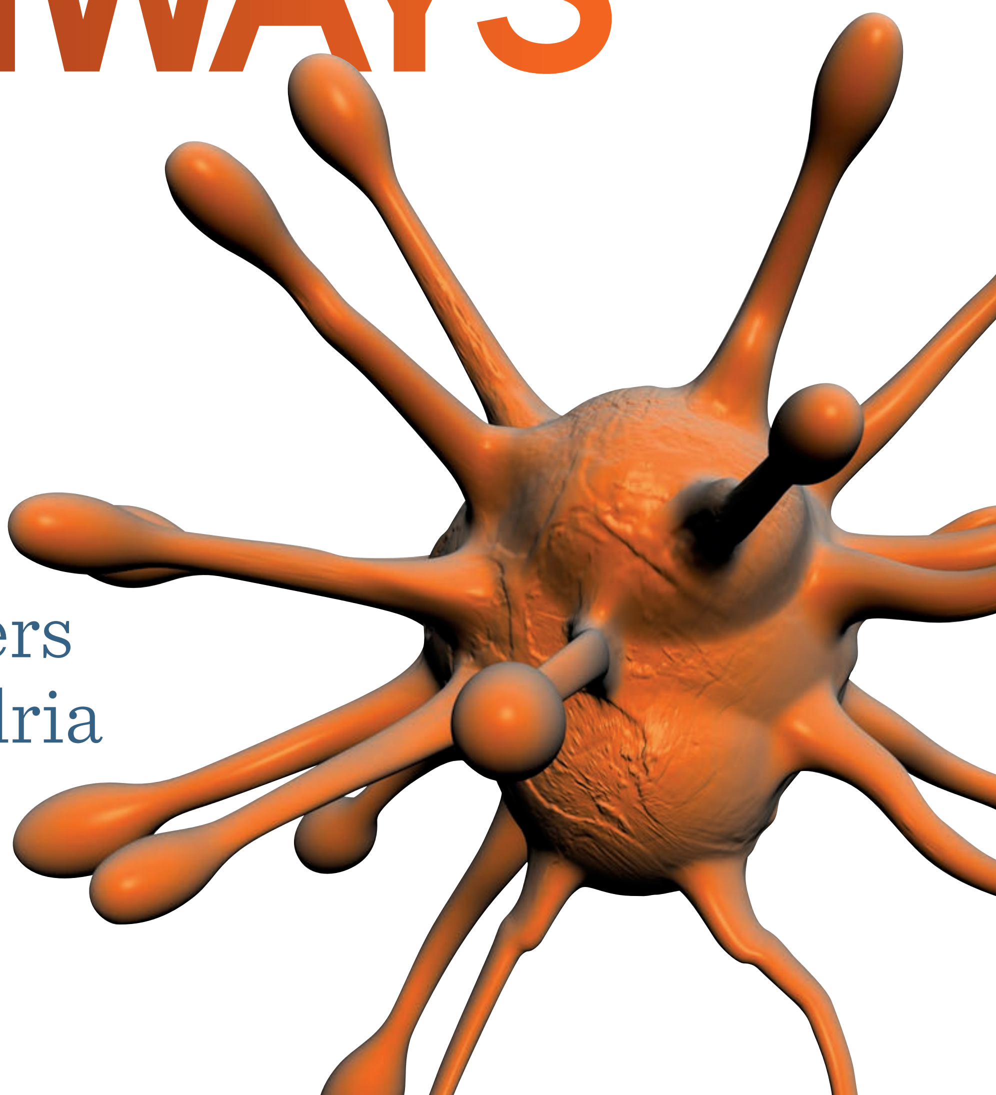
She adds: "My work is very gratifying, very rewarding. I don't know how many people could say that about their job."

Ultimately though, for Majumder, her biggest accomplishment is maintaining that often precarious equilibrium among home, family and career. On top of managing a thriving research career and a busy household with two active kids, she helps her aging parents, who live with her for several months each year. "I always try to make sure that everybody is happy and gets a good amount of my time, as they all deserve. I'm fortunate that they all help me and think that I'm a very important part of their lives," she says. "Maintaining that balance has been the hardest thing to do, and some days are easier than others. But I really pride myself on that."

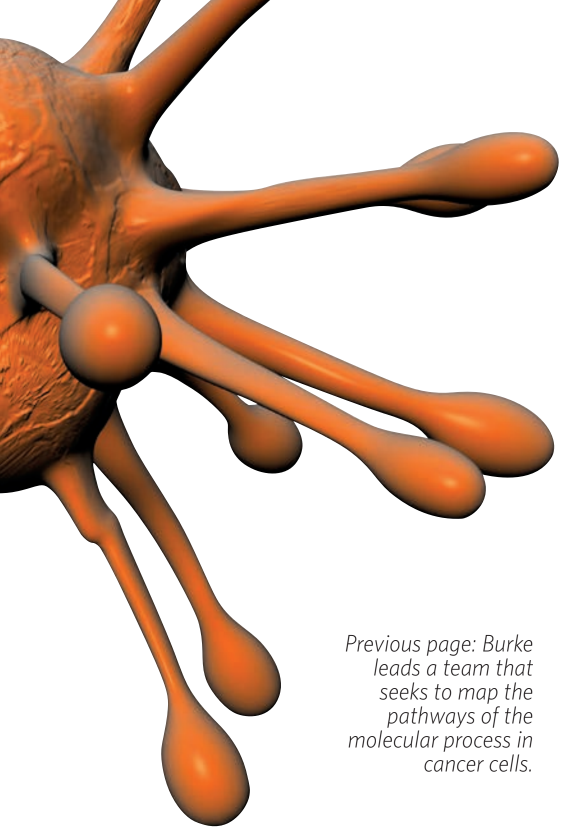
PROMISING PATHWAYS

Anna Lynn Spitzer
Steve Zylius





Researcher peers into mitochondria to understand cancer cell behavior



How do cancer cells survive – and even thrive – despite bombardment by drugs alarmingly lethal to the body's other cells and systems? A national team of scientists, led by Calit2 affiliate Peter Burke, believes the answers may lie deep inside cellular mitochondria.

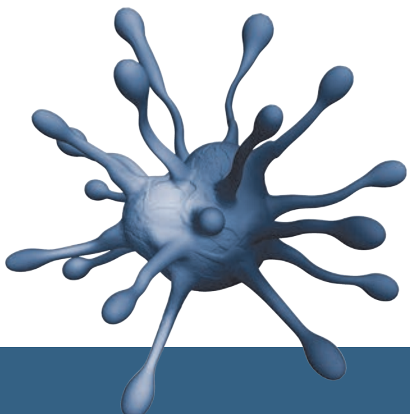
Previous page: Burke leads a team that seeks to map the pathways of the molecular process in cancer cells.

Burke, professor of electrical engineering and computer science, along with collaborators from Harvard and the University of Pennsylvania, are using nanofluidics to peer into the cells' life-and-death cycle, hoping the information will one day lead to personalized treatment protocols and targeted pharmaceuticals.

Using nearly $1.2 million from the National Cancer Institute's Innovative Molecular Analysis Technologies program, they seek to map out pathways of the molecular process in cancer cells – pathways that allow the cells to avoid natural cell death and continue proliferating.

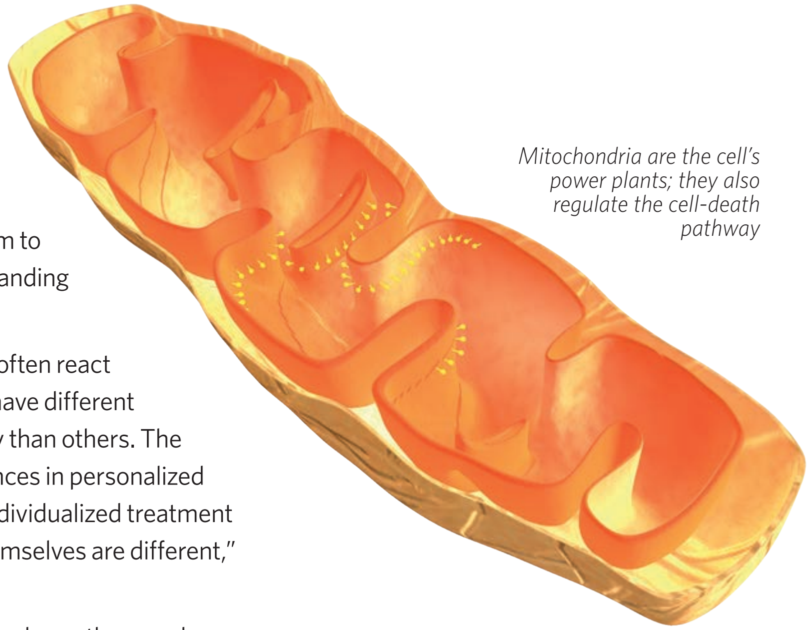
At the heart of the research is a nanofluidic chip, which can manipulate and probe single mitochondria from healthy and cancerous cells, allowing them to be tested with libraries of proteins and chemicals – both natural and manufactured – to learn more about why cancer cells respond to signals differently than non-cancerous cells. Researchers are measuring the cell life-death decision-making process, using a variety of methods including nanosensors capable of measuring mitochondrial electrical energy.

The mitochondria, often known as the cell's power plants, metabolize sugar to create energy; this energy is stored as a voltage across their surface. But mitochondria have a secondary role: they regulate the cell-death pathway. Normal cells react to stress by undergoing a process called apoptosis – programmed cell death. In response to certain triggers, the mitochondria form a pore or pores on their surface, spilling out a signaling protein that prompts the cell to self-destruct. When a cell dies, the voltage from the mitochondria shuts down as well. But cancer cells express an abundance of BCL2, a protein that keeps these apoptotic functions suppressed.



By subjecting mitochondria from cancerous tissue to different combinations and concentrations of chemotherapy drugs, and manufactured and natural proteins, researchers hope to learn which unique combinations can overpower the effect of BCL2 cell proteins on apoptosis and force mitochondria to form the pores that lead to cell death.

> "Here is the question we're trying to answer: Why don't cancer cells die and how does chemotherapy work? Cancer cells are resistant to the signals that cause them to die. Understanding that process is very important in understanding cancer."



Mitochondria are the cell's power plants; they also regulate the cell-death pathway

"Here is the question we're trying to answer: Why don't cancer cells die and how does chemotherapy work?" Burke says. "Cancer cells are resistant to the signals that cause them to die. Understanding that process is very important in understanding cancer."

Researchers do know that two people with the same cancer often react differently to the exact same treatment. Similar tumors can have different properties, causing some cells to depolarize (die) more easily than others. The team's lab-on-a-chip technology could one day lead to advances in personalized medicine, using test results from specific tumors to create individualized treatment plans, "because not only are people different, but tumors themselves are different," Burke says.

Current cancer treatment has another well-known drawback; chemotherapy drugs routinely kill healthy cells along with tumors. "This [technology] could help us figure out a way to cause the cancer cells to commit suicide without causing the same reaction in other cells," according to Burke.

The tiny chip, currently in development, ultimately will contain thousands of ½-micron-wide channels, allowing high-throughput testing. (One-half a micron is 500 nanometers, less than 1/100 the width of a human hair.) Current tumor profiling is still rudimentary; it requires tens of thousands of cells to obtain a small amount of information.

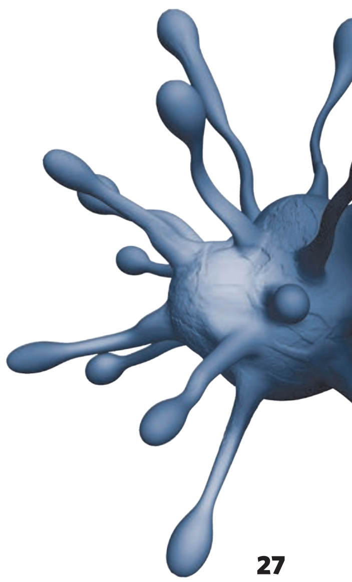
The chip being developed in Burke's lab will have the capability to test single cells or mitochondrion, allowing researchers to get a lot more information from tissue samples much more quickly. According to Burke, a 10,000-cell assay on the chip could yield up to 1 million times more information than current techniques. "We're going to make that assay thousands of times more powerful by testing not just one or two drugs at a time but thousands of different combinations of drugs or different concentrations."

Project collaborator Dr. Anthony Letai, a Harvard physician and researcher whose lab studies mitochondria, says that understanding how the organelle works can eventually allow doctors to better pinpoint drugs for individual patients. Faster, cheaper assays that require fewer cells for testing are essential.

"This makes it more of an engineering problem than a basic science problem," he says. "We are very happy to be able to work with Peter on this, to be able to take advantage of his novel readouts of mitochondrial dysfunction to hopefully make a better assay to direct therapeutic decision-making in cancer patients."

Researchers also hope to develop on-chip technology that will allow them to understand the biophysical mechanisms that create the formation of the mitochondrial pores. They aren't sure exactly how the pores form, what their electrical properties are and whether mitochondria produce one pore or multiple pores during apoptosis.

"If we can figure out what is causing the mitochondria to depolarize, we will have a better understanding of why the cancer cell lives or dies," Burke says.



To IoT and

Smart-technology maker space

Anna Lynn Spitzer Debbie Morales

BEYOND

opens its doors to innovation and market opportunity

A new maker lab, one with a high-tech twist, opened on the UC Irvine campus last fall. Combining the latest in integrated circuit technology, a panoply of cutting-edge fabrication and analysis equipment, and a come-one, come-all approach to users, the Microsemi Innovation Lab quickly is becoming known as the smart-technology maker space.

Backed by leading Orange County semiconductor manufacturer Microsemi Corp., the 1,090-square-foot space on the second floor of the Calit2 Building is an electronics aficionado's wonderland. Adorned with brightly painted murals and top-notch electronic prototyping equipment, the main attraction is the Microsemi SmartFusion2 chip, a Field Programmable Gate Array (FPGA) integrated circuit that functions like an erector set for electronics designers.

A generous donation from Microsemi launched the lab, which opened to great fanfare last November. It is the latest addition to Calit2's innovation pipeline, offering a unique, on-campus, one-stop shop for the design, prototyping, testing, characterization and analysis of electronics and Internet of Things (IoT) applications.

"UCI has the ideas to solve problems, and our technology will help you turn your IoT ideas into high-performance products," Microsemi Chief Technology Officer Jim Aralis said at the grand opening ceremony.

Michael Klopfer, CalPlug technical director, serves as acting lab manager. He says a wide variety of users – from undergrads working on senior design projects to graduate students conducting research, to faculty to corporate customers – can utilize the high-speed, high-bandwidth logic analyzers, function generators, oscilloscopes, soldering tools and other printed circuit board fabrication equipment.

"Circuit board prototypes, robotics, control systems, instrumentation and all things IoT – all of these can be produced in the Microsemi Lab," Klopfer says. "Users are able to prototype, fabricate and test."

Calit2 Irvine Division Director G.P. Li, who was instrumental in the lab's creation, compares IoT's potential to that of the iPhone as an application platform. "IoT is anything you can think about; there are unlimited ways to use it. The Microsemi Lab will provide a place where students, faculty and the community can come in and develop apps," Li says. "We're making this infrastructure available for anyone to come and innovate."

Microsemi is supplying the lab with strategic guidance and products, including the SmartFusion2 – a self-contained system-on-a chip that offers a wide variety of applications. User-constructible on-chip fuzzy logic, digital signal processing and cognitive computing capability allow point-of-deployment intelligence that one day soon may permit advanced user behavior-based control in IoT devices.

The SmartFusion2 also offers advanced security and cryptography features. The chip automatically self-destructs if somebody tries to reverse engineer a design programmed on it, and every enabled chip has a unique system that employs manufacturing variances in the chip's construction to generate a unique seed value, which can be used for advanced cryptography.

Other Microsemi products, including advanced digital signal processing and signal analysis tools, integrated circuits, audio processors, tiny full atomic clocks and power electronic components also are expected to be available in the near future.

In the lab are four types of user-friendly demo boards outfitted with the smart chips, including one made with the same footprint as an Arduino (a common prototyping board). This facilitates fabrication of proof-of-concept devices using Arduino-compatible accessories, only with the added power of the SmartFusion

Below, left: Microsemi CEO Jim Peterson (center) addresses the crowd at the Microsemi Innovation Lab's grand opening, as UCI Executive Vice Chancellor Enrique Lavernia (left) and Calit2 Irvine Division Director G.P. Li look on. Right: Microsemi executives celebrate the new collaboration with UCI. From left, CTO Jim Aralis, Peterson, President and COO Paul Pickle, and Farhad Mafie. Opposite page: Everardo Camacho demonstrates his smart-climate system during the grand opening celebration.

chip. "It's a launching pad that makes it easy for people to make electronics, by using prototyping systems they are familiar with as a stepping stone," Klopfer explains.

He collaborated with Microsemi Training Director Tim McCarthy to create a multi-part video series that helps new users get started. "We went through a bunch of lab examples and recorded the whole thing – the set-up, device capabilities, hints and tips, how to avoid potential pitfalls … everything for users to get started with the SmartFusion2 product." *(https://www.youtube.com/user/mklopfer)*

Even for projects that don't utilize Microsemi products, the lab is open and well-equipped for the fabrication, analysis and characterization of many types of electrical circuits and equipment.

Everardo Camacho created a smart-climate demonstration system using the Microsemi SmartFusion2 FPGA for the lab's grand opening last November. The UCI Integrated Nanosystems Research Facility (INRF) employee, who graduated from the university in 2014, created an IoT-themed system, which senses and logs room temperature, then sends the data to a server via wired and wireless network communication.

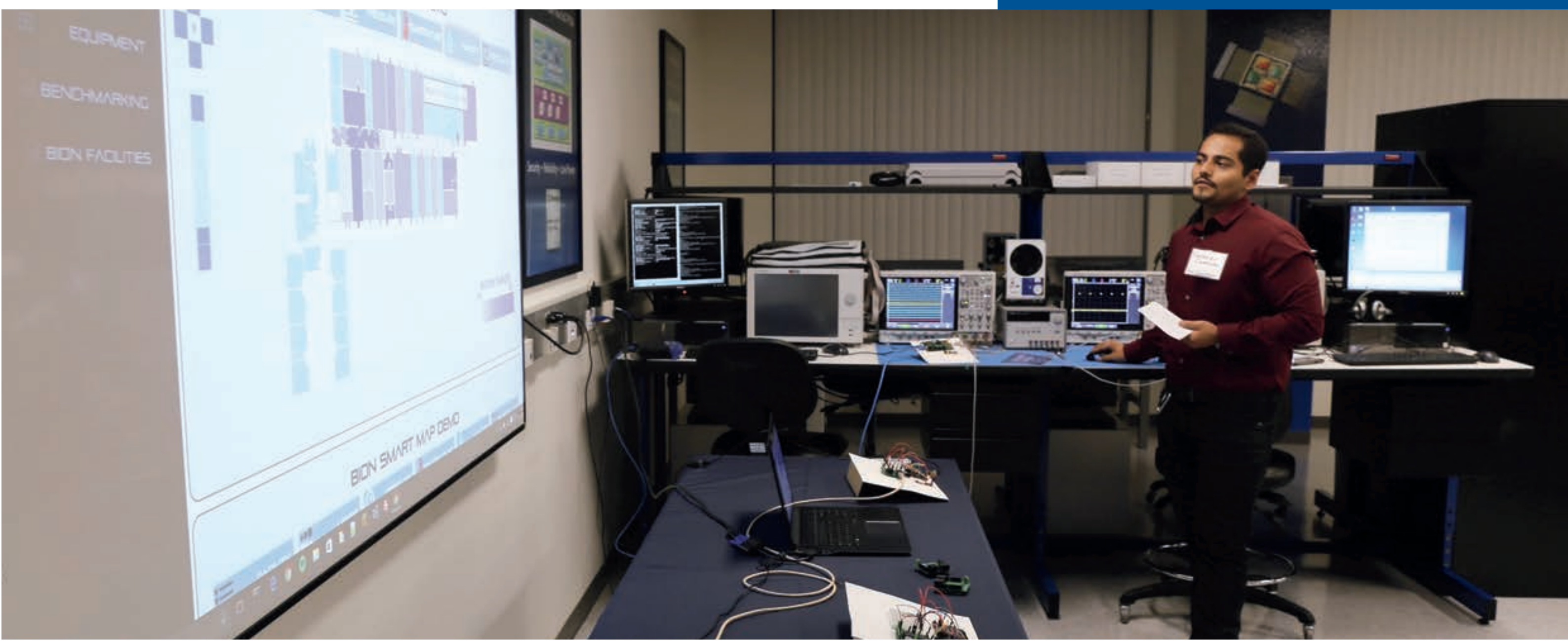
"The system showcased the functionality of the SmartFusion2," says Camacho, whose eventual goal is to build a cleanroom monitoring system with programmable logic controllers that will interface with all tools in the INRF. It will have the capability to shut down equipment that doesn't meet operational specifications, ultimately saving time and money in both processing and repairs.

"Think of this SmartFusion chip as an erector set," says Klopfer. "It can be used for different things … to build out new solutions. This chip can do all these different things, depending on how it's programmed and what kind of board it's put onto. It permits one to build a virtually limitless number of circuits inside the chip itself, simplifying many final designs."

Features of the Microsemi Innovation Lab include:

- Soldering and assembly work stations, including microscopes that allow users to place parts on boards, tweezers, board vices, anti-static equipment, a probe station and a professional, programmable oven for baking on the soldering;
- A pick-and-place system that helps users pick up a part, align it perfectly and put it down on the circuit board, while viewing their work in a microscope;
- Extra maker supplies – blank boards and an assortment of parts to populate the boards;
- A board mill – a rapid-prototyping unit used for quickly cutting circuit boards and interface boards;
- Four computers running the Microsemi tool chain software used for programming the boards;
- Board analysis and characterization equipment – high-speed, high-bandwidth logic analyzers, oscilloscopes, multimeters and programmable power supplies; and
- Project guidance and parts provided by Microsemi.

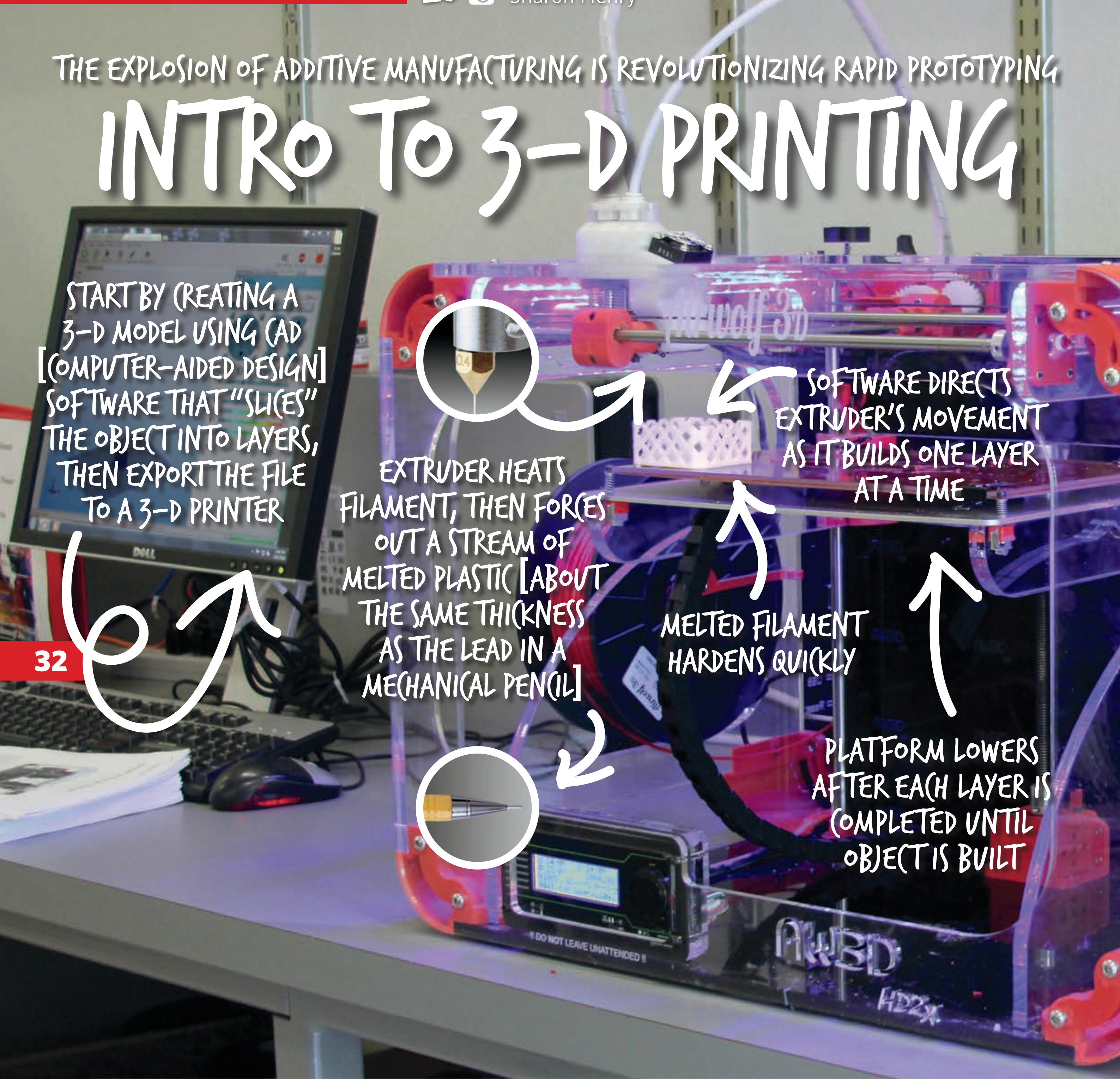
Interested users should contact the Calit2 information desk at (949) 824-6900 to schedule lab access.



Sharon Henry

THE EXPLOSION OF ADDITIVE MANUFACTURING IS REVOLUTIONIZING RAPID PROTOTYPING

INTRO TO 3-D PRINTING



WHO INVENTED 3-D PRINTING?

CHUCK'S BIG IDEA

In 1983, Charles (Chuck) Hull invented the process known as stereolithography (3-D printing). He'd been working for a company that used ultraviolet lamps to harden the coating on tabletops, and was exploring ways to prototype more rapidly.

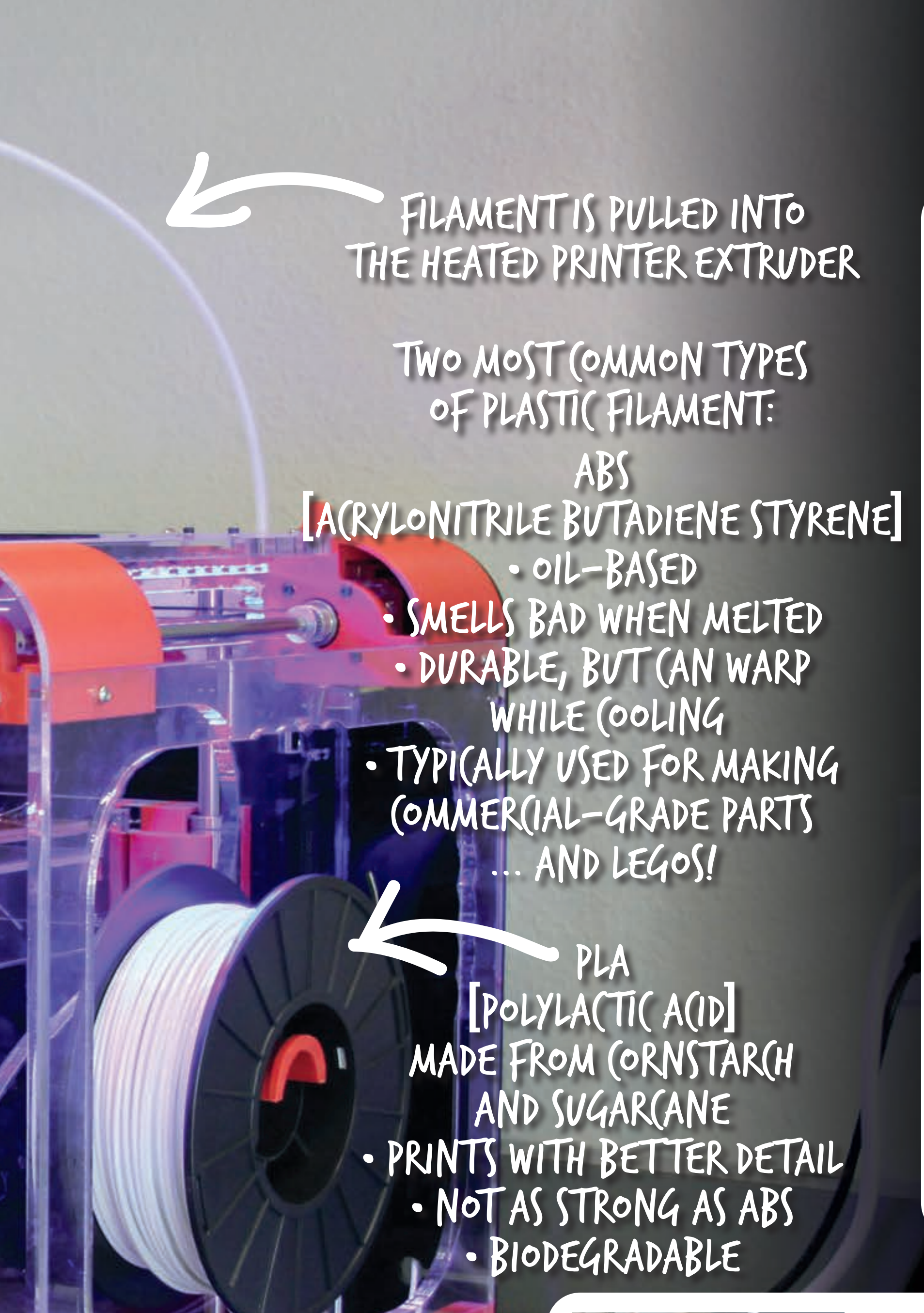
"Prototyping plastics was a really big issue at the time," Hull said.

It took weeks to months for engineers to create a first prototype from their design. This new process of building a 3-D object by applying multiple layers of a medium hardened by ultraviolet light meant a prototype could be created in hours.

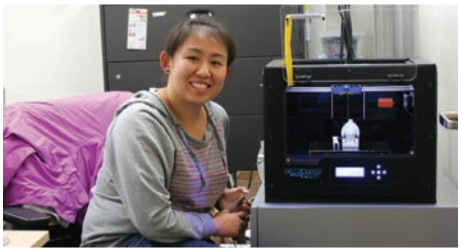
BIG NIGHT

On March 9, 1983, at 8:39 p.m., Hull produced the first-ever 3-D printed object – a small eye-wash cup.

He immediately phoned his wife and asked her to come to his lab.



3-D PRINTING IN CALIT2

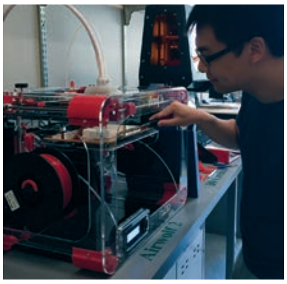


Linyi Xia, a project manager at Calit2, has a 3-D printer in her office

Xia got her printer in early 2015. Since then, she's made dozens of unique objects, from custom circuit-board enclosures to prototypes for medication dispensers.

One of Xia's latest 3-D printed projects, an electric violin

It took about 28 hours to print the six pieces needed to construct the instrument. Xia plays the violin, but created this to test the amount of energy used in long-duration printing, as well as the object's durability under stress, strain and humidity over time.



LEARN 3-D PRINTING

Make your own 3-D objects. FABWorks, located in the Calit2 Building, offers classes and access to a host of equipment, including 3-D printers. For more info, visit *Fabworks.eng.uci.edu.*

She responded, "This had better be good."

Hull's wife plans eventually to donate the 3-D printed cup to the Smithsonian Institution, but for now she keeps it in her purse.

BIG NIGHT

3D Systems Inc. Chief Creative Officer will.i.am

In 1986, Hull co-founded 3D Systems Inc. to manufacture and sell 3-D printers.

Thirty years later the company has 2,100 employees. Hull is CTO, and the current CCO is William Adams, better known as will.i.am, seven-time Grammy winner and founding member of The Black Eyed Peas.

On May 21, 2014, Hull was inducted Into the National Inventors Hall of Fame in Alexandria, Virginia, alongside Henry Ford, Steve Jobs and Thomas Edison.

BAD VIBRATIONS

Brian Bell   Debbie Morales

With findings that could have been taken from the pages of a spy novel, researchers at UC Irvine have demonstrated that they can purloin intellectual property by recording and processing sounds emitted by a 3-D printer.

The team, led by Mohammad Al Faruque, Calit2-affiliated computer science engineer and director of UCI's Advanced Integrated Cyber-Physical Systems Lab, showed that a device as ordinary and ubiquitous as a smartphone can be placed next to a machine and capture acoustic signals that carry information about the precise movements of the printer's nozzle. The recording can then be used to reverse engineer the object being printed and re-create it elsewhere. Detailed processes may be deciphered through this new kind of cyberattack, presenting significant security risks.

"In many manufacturing plants, people who work on a shift basis don't get monitored for their smartphones, for example," Al Faruque said. "If process and product information is stolen during the prototyping phases, companies stand to incur large financial losses. There's no way to protect these systems from such an attack today, but possibly there will be in the future."

Al Faruque's team achieved nearly 90 percent accuracy using the sound copying process to duplicate a key-shaped object in the lab. They presented their results at April's International Conference on Cyber-Physical Systems in Vienna.

State-of-the-art 3-D printing systems convert digital information embedded in source code to build layer upon layer of material until a solid object takes shape. That source file, referred to as G-code, can be protected from cyberthievery with strong encryption, but once the creation process has begun, the printer emits sounds that can give up the secrets buried in the software.

Opposite page: "Initially, we weren't interested in the security angle, but we realized we were onto something," explains Al Faruque, who leads an NSF-funded cyber-physical systems research grant.

UCI Researchers Find Security Breach in 3-D Printing Process

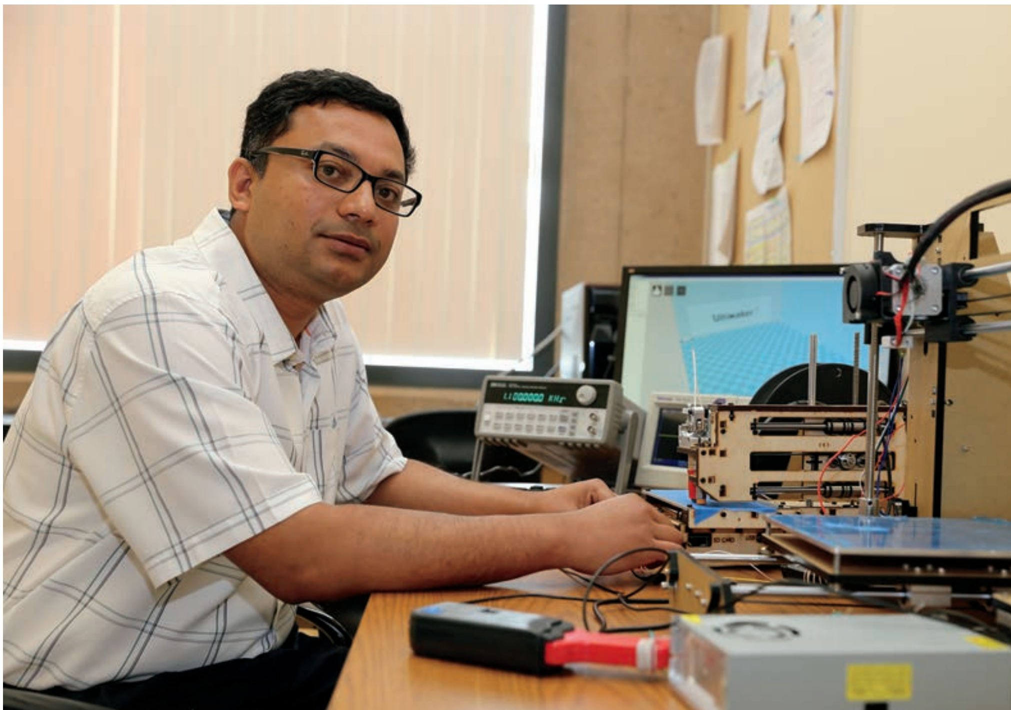
"My group basically stumbled upon this finding last summer as we were doing work to try to understand the relationship between information and energy flows," said Al Faruque. "According to the fundamental laws of physics, energy is not consumed; it's converted from one form to another – electromagnetic to kinetic, for example. Some forms of energy are translated in meaningful and useful ways; others become emissions, which may unintentionally disclose secret information."

The emissions produced by 3-D printers are acoustic signals that contain a lot of information, he said, adding: "Initially, we weren't interested in the security angle, but we realized we were onto something, and we're seeing interest from other departments at UCI and from various U.S. government agencies."

"President Obama has spoken about returning manufacturing to the United States, and I think 3-D printing will play a major role because of the creation of highly intellectual objects, in many cases in our homes," Al Faruque said. But he cautioned that with the convenience of these new technologies come opportunities for industrial espionage.

He suggested that engineers begin to think about ways to jam the acoustic signals emanating from 3-D printers, possibly via a white-noise device to introduce intentional acoustic randomness or by deploying algorithmic solutions. At a minimum, Al Faruque said, a fundamental precaution would be to prevent people from carrying smartphones near the rapid prototyping areas when sensitive objects are being printed. Today's smartphones, he noted, have sensors that can capture a range of analog emissions.

The study was funded by a cyber-physical systems research grant from the National Science Foundation.



A Parting Shot

Almost anyone who is anyone has a Twitter handle these days. But the popular microblogging platform is about more than celebrity sightings and status updates. Public agencies have adopted social media to impart vital information during emergency situations. And when those important missives go "viral," it can be an effective outreach tool.

UC Irvine sociologist and Calit2 affiliate Carter Butts and colleagues at the University of Kentucky reviewed tweets sent by emergency officials during a terrorist attack, a wildfire, a blizzard, a hurricane and a flash flood. The team recorded the number of times each message was retweeted and then analyzed factors related to the probability the tweets would be retransmitted by recipients.

Messages describing hazard impacts and emphasizing cohesion among users generated the most retweets, according to their NSF-funded study, published in Proceedings of the National Academy of Sciences. They also found that strong emotional appeals can sometimes enhance the retransmission rate.

"Our work is helping to reveal the differences between messages that people pass on and those that they don't," said Butts.


Fires still threatening homes. #WildFire
Stand strong. #HurricaneAlert
Road closed due to flooding. #FlashFlood
Fires still threatening homes. #WildFire
Parking restrictions in place. #BlizzardWarning
Road closed due to flooding. #FlashFlood
Fires still threatening homes. #WildFire
Stand strong. #HurricaneAlert

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.

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