UC San Diego
JACOBS SCHOOL OF ENGINEERING

Pulse

WINTER 2016/2017

SHAKE BURN AND LEARN

QUAKE TESTS, DRONES AS SENSORS, POST-QUAKE FIRES, AND BIG-DATA VIRTUAL REALITY FOR SAFER BUILDINGS.

Building the Digital Future

I am laying the groundwork, literally and figuratively, for a new building where we will invent a digital future powered by real-time data analytics. In the new facility, we will develop and deploy algorithms, devices and systems that empower humans and intelligent systems to make decisions and take actions with unprecedented speed and accuracy. This is the real-time data revolution, and it will lead to a wide range of useful advances for society—things like wearable medical diagnostics and treatments powered by 5G connections; superb robotics for aging in place; cybersecure digital and physical infrastructure; personally optimized microbiomes; zero-carbon transportation systems; and global real-time climate monitoring.

Our engineers and computer scientists will collaborate with campus and industry partners in a series of shared laboratories or "collaboratories" in the new building. In these labs, we will obliterate traditional research silos and get the right multidisciplinary teams of Jacobs School researchers working with the right industry and campus partners, always with an eye on technology transfer and commercialization.

We are constantly strengthening our faculty in ways that align with the School's strategic priorities. In Fall 2016, we hired 13 stellar professors into the Jacobs School, including six robotics faculty. This comes on the heels of the 17 professors we hired in 2015, and 19 in 2014. In addition to robotics, we have been hiring faculty in clinical medicine, wireless technologies, genomics, data sciences, cybersecurity, clean energy and advanced manufacturing. The thread that weaves these wide-ranging research areas together is real-time data analytics. We aim to grow the faculty to 280 by 2020.

We are growing the faculty to meet the great educational, research and technical workforce needs of our community. The Jacobs School is the largest engineering school in California. We train a culturally and economically diverse student body and prepare our students—including mid-career engineers—to become the technology leaders that companies and government institutions in San Diego, California and the nation need. The new building will include executive education facilities where we will expand our efforts to advance the technical and leadership skills of professional engineers.

I am convening industry partners, technology visionaries, and friends and alumni of the Jacobs School to work with us to realize the real-time data revolution and to build the collaborative facility that will help us make this happen. If you'd like to get involved, please contact me directly at:

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Albert P. Pisano, Dean

Jacobs School of Engineering

LEADERSHIP

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Researchers are combining the Jacobs School's shake table with cutting-edge virtual reality technologies to accelerate research aimed at improving building safety.

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LAST PRINT ISSUE

This is our last print issue of Pulse. Going forward, we will focus on digital communications and print features in UC San Diego's Triton magazine. Sign up for newsletters from the Jacobs School: bit.ly/JacobsSchoolNews

UC SAN DIEGO LAUNCHES NEW MAKER STUDIO

VISUAL ARTS AND ENGINEERING CONVERGE TO TRANSFORM EDUCATION

"I am learning an absurd amount of engineering theory, and that's in addition to the whole 3D printing shebang," said structural engineering undergraduate Nicolette Nguyen. She was part of the first group of students to take a hands-on class in the EnVision Arts and Engineering Maker Studio at UC San Diego. Nguyen was on a team of engineers and visual artists that created the black and white 3D-printed sculpture pictured above. It represents the ones and zeros of our digital world. The students created the sculpture as a joint final project for a pair of collaborating engineering and visual arts courses held in the new maker studio during its very first quarter of operation.

In January 2016, the Jacobs School of Engineering and the Division of Arts and Humanities partnered to launch the 3,000 square foot facility in the Structural and Materials Engineering building. The maker studio provides a wide range of design, fabrication and prototyping tools from 3D printers and a sophisticated laser cutter to soldering stations; power drills and other hand tools; and craft tools like sewing needles. The space is designed for hands-on, project-based classes that help engineering and visual arts students connect theory with practice as they think, design, make, tinker, break and rebuild. Nearly 2,500 students have worked in the maker studio since January 2016. The maker studio is a key component of the Jacobs School's Experience Engineering Initiative, a school-wide effort which aims to give every engineering and computer science undergraduate student a hands-on or experiential engineering course or lab each and every year—starting freshman year.

"We are giving students new opportunities to gain the confidence and motivation they will need to succeed in classes, internships, faculty research projects and ultimately their careers," said Albert P. Pisano, dean of the Jacobs School of Engineering. "We need to make sure that our incoming students experience firsthand how the math and the engineering theory connects to the real world. Giving students these 'ah-hah' moments is crucial for our retention efforts."

After struggling on the midterm, structural engineering freshman William Jablonski—who was on Nguyen's team—found himself deeply engaged in their final project. "We had lectures, homework and labs, but this project was the slam dunk that I needed," Jablonski said. "Going into the final, I had an understanding of what the theory actually means."

The EnVision Maker Studio is also a space where engineering teams and artists create outside of class; where student entrepreneurs build, prototype and innovate. The maker studio has already hosted many hands-on workshops. Interested in leading a workshop? Contact envision@ucsd.edu.

Learn more: EnVision.ucsd.edu

HANDS ON

PINBALL MACHINES AND MORE
ELECTRICAL ENGINEERING'S NEW HANDS-ON CLASSES

Andrew Saad and Leandro Lubrico, both electrical engineering juniors, teamed up to create a working pinball machine they called Pinball of the Caribbean. They designed, iterated and built it from scratch without blueprints, as part of a new electrical engineering class at the Jacobs School taught by professor Michael Yip. ECE 115 was the first time Saad and Lubrico had used laser cutters or tackled computer-assisted design. "Everything we learned about in classes without labs started to make sense," Saad said.

Yip designed the class so that students get to build a robotic system in a short amount of time. "The faster you can get things done, the faster you can fix your mistakes," said Yip, who taught students how to use motors, touch sensors and computer assisted software. Students modeled their parts and created working computer-assisted designs made from laser-cut and 3D-printed parts. They created circuits to connect sensors and actuators, which they then integrated into a microcontroller. They programmed the device to run the whole system, leading to a practical hardware system that combined mechanics with electronics. The design and rapid prototyping class is part of the Jacobs School's Experience Engineering Initiative (pg. 4).

"By the time they reach their senior year, their capstone project will be much more meaningful because they've had so much hands-on experience," said Truong Nguyen, a faculty leader for Experience Engineering and chair of the electrical and computer engineering department, which has already implemented experiential learning courses in each of the undergraduate years. Classes take place in the EnVision Arts and Engineering Maker Studio and other making and inventing spaces on campus, including the new ECE Maker Space.

Freshmen take ECE 5: Making, Breaking and Hacking Stuff, in which they get an introduction to sensors, signal processing, programming and circuit building. At the end of the course, they use their knowledge of each of these components to build a line-following robot. Sophomores have the option to take ECE 16: Rapid Hardware and Software Design, which applies C programming skills learned in previous classes to program microcontrollers. They also analyze data using Python.

Juniors can take Yip's pinball class, and by the time students get to their capstone course senior year, they are prepared to propose their own projects and then complete them. To make things more exciting, students have the option to enter their senior design projects into the annual ECE Design Competition. The competition is open to any student team with at least one member from electrical engineering and, as of 2016, also a student from social sciences. One of last year's design competition winners began work on a protective, wearable device designed for senior citizens that will inflate if a person starts to fall.

To give undergraduate engineers as many meaningful hands-on learning experiences as possible, Nguyen and his electrical engineering department have also launched the Project in a Box initiative—a four-credit course series in which students select, design and build a project of their choice. The projects of varing difficulty come in boxes that contain all the materials necessary. Students have access to the ECE Maker Space staffed with experienced TAs.

Download ECE 5 course materials:
ece5.ucsd.edu

INSTITUTE FOR THE GLOBAL ENTREPRENEUR

EMPOWERING ENGINEERS TO DRIVE INNOVATION

ige.ucsd.edu

Nick Forsch relies heavily on clinician feedback for his research. As a bioengineering Ph.D. student at UC San Diego, he is developing computational tools to enable doctors to better understand their patients' diseases. The challenges of translating his research to real-world doctors and patients led Forsch to join a new UC San Diego program that places Jacobs School of Engineering graduate students and Rady School of Management MBA students in the same classes, including Rady's signature Lab to Market program.

This collaboration is part of the new UC San Diego Institute for the Global Entrepreneur, which the Jacobs School of Engineering and Rady School of Management launched in June 2016. Through the Institute, UC San Diego's world class engineering and management schools are working together to ensure the talent and research innovations coming out of UC San Diego have the maximum positive impact in San Diego, in California and around the world.

"We have partnered with the Rady School to empower our faculty, students and industry partners to commercialize their research advances and bring them out of their labs and into society," said Albert P. Pisano, dean of the Jacobs School of Engineering.

Electrical engineering Ph.D. student Somayeh Imani is part of the first group of engineering graduate students going through the Institute's educational program that mixes engineering and MBA students. She designs circuits for biomedical applications that could help improve human health and quality of life.

"There is so much opportunity in the field of wearables to commercialize technology. I realized I needed this specific skillset to help our research group bring some of their wearable sensors to market," said Imani.

The Institute includes the Jacobs School's existing von Liebig Technology Accelerator and Gordon Engineering Leadership Center. The Hacking for Defense and NSF Innovation Corps (I-Corps) programs run by the Institute use lean startup and customer discovery methodologies to help student innovators turn their ideas and advances into real-world solutions.

The Institute offers a suite of programs for faculty and industry partners interested in commercializing innovations and focusing research on relevant challenges. In addition, the Institute provides entrepreneurism advisory services and gets students and faculty innovators exposure to venture capital and broader innovation networks; as well as strategic investment partners including the Triton Technology Fund (pg. 7) and the Rady Venture Fund.

"With the Institute for the Global Entrepreneur, we are creating an ecosystem of innovation where the participants are empowered to do extraordinary things and create products and companies like we have never seen before," said Robert S. Sullivan, dean of the Rady School of Management.

ige.ucsd.edu

LEADERSHIP

Sujit Dey
Director, IGE
Jacobs School Professor of Electrical and Computer Engineering

Vish Krishnan
Associate Director, IGE
Rady School Professor of Innovation, Technology and Operations

BRINGING UC SAN DIEGO INNOVATION TO LIFE

Vertical Venture Partners, the venture capital fund created and managed by David C. Schwab (B.A. '79, Applied Sciences), closed its first fund on June 30, 2016 with $51.3M in committed capital. A quarter of this fund is tagged for companies with ties to UC San Diego via the Triton Technology Fund, which is embedded within Vertical Ventures. The Triton Technology Fund invests in UC San Diego startups, companies with IP licensed from UC San Diego, and companies with alumni in leadership positions.

"It's gratifying to be making investments in great UC San Diego companies in order to help them grow and create jobs and solve problems," said Schwab.

The investment bar is high, Schwab noted, but he is confident there are many more UC San Diego companies out there that could be a good, mutual match.

"I think we are missing opportunities," said Schwab. He invites UC San Diego alumni, students, faculty and staff who are involved in promising startups to send business plans and inquiries to: info@tritontechnologyfund.com

A selection of the UC San Diego companies the Triton Technology Fund has invested in are listed below.

Portfolium

Product: Sharable online portfolio platform for higher education.

Details: Students and recent graduates use Portfolium to share projects and presentations with top employers, giving companies a preview of what they can do on the job.

UC San Diego connection: Adam Markowitz (B.S. '08, mechanical engineering) is CEO and founder of Portfolium.

MANTA Instruments

Product: Scientific instruments for the measurement of nanoparticles.

Details: MANTA's scientific instruments characterize nanoparticles more effectively than existing products. Capabilities include: measuring concentration of nanoparticles; accurately visualizing and measuring samples with mixed nanoparticle sizes; and reliably measuring particle kinetic processes.

UC San Diego connection: The technology was developed at the UC San Diego Scripps Institution of Oceanography, and former SIO scientist Dr. Kuba Tatarkiewicz is now MANTA's full time VP of Engineering.

GrollTex

Product: An early stage company with breakthrough technology for the mass production of graphene.

Details: Low-cost graphene is crucial for mass production of a wide variety of products including nanometers-thick solar cells, multimodal sensors, water desalination membranes, CO_2 scrubbing membranes, invisibility cloaks and rollable tablets.

UC San Diego connection: Co-founder Alex Zaretski (Ph.D. '16, nanoengineering) spun this project out of nanoengineering professor Darren Lipomi's lab.

General Automation Lab Technologies (GALT)

Product: GALT brings to market next generation tools for the study, isolation, cultivation and screening of microorganisms.

Details: GALT addresses unmet needs for companies and academics studying microbiomes, which are the communities of microorganisms that live on and in people, plants, soil, oceans and the atmosphere.

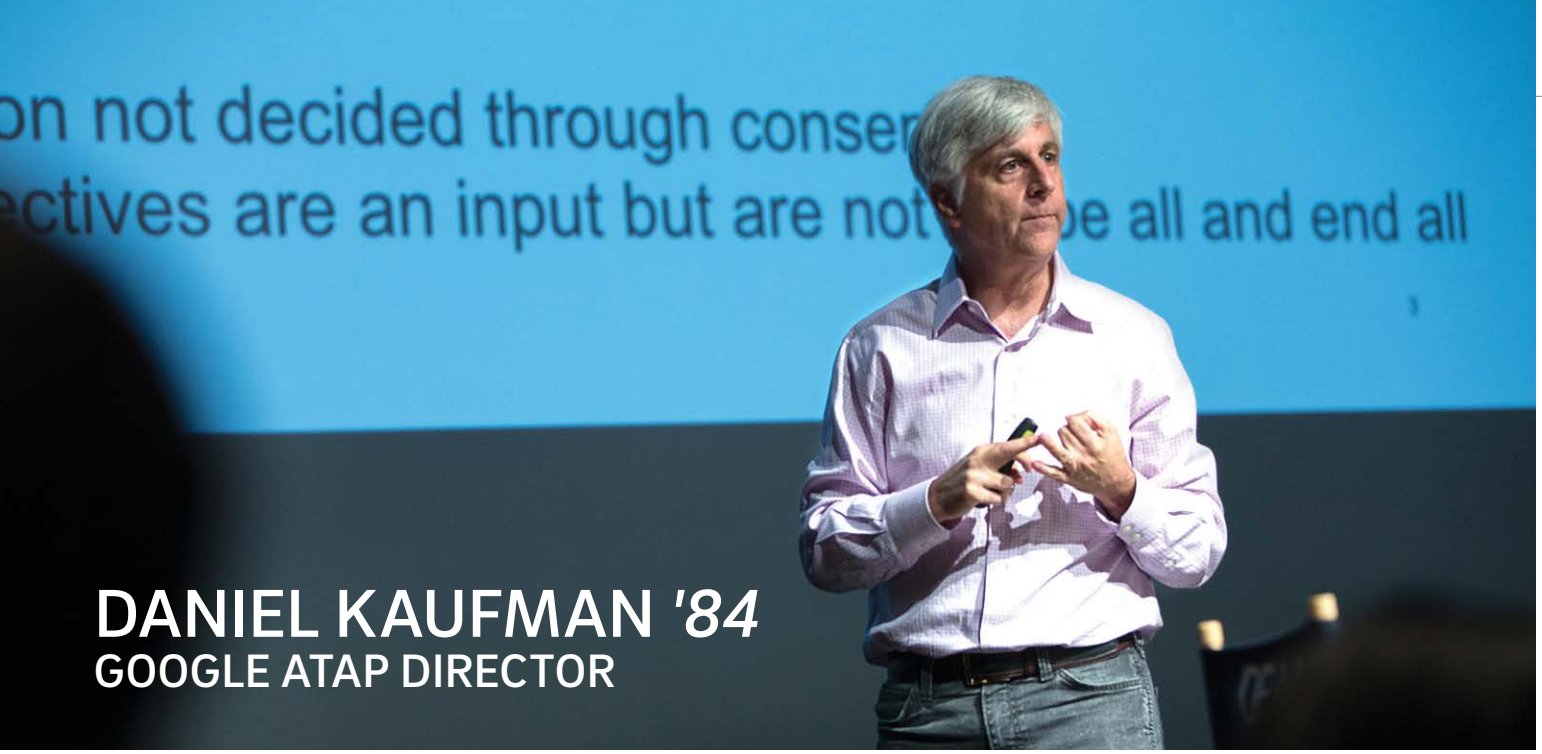
UC San Diego connection: UC San Diego Health Sciences professor Karsten Zengler is a co-founder.

Abreos Biosciences

Product: Point-of-care tests for personalized dosing and counterfeit detection of "biologic drugs" which are a class of therapeutic products derived from biological (rather than synthetic) sources.

Details: Platform to rapidly measure the levels of biologics in fluids such as serum or blood. This is useful for improving clinical trials and for optimizing the regulatory process for new biologics.

UC San Diego connection: Founder and CEO Bradley Messmer is on the faculty of the UC San Diego Moores Cancer Center.



DANIEL KAUFMAN *'84*
GOOGLE ATAP DIRECTOR

"There is this cry for consensus, and I don't like consensus. Most likely, if everyone agrees on it, that it's a really good idea, then it's probably not far thinking enough for us," said Daniel Kaufman (B.A. UC San Diego, '84), Director of Google's Advanced Technology and Projects group (ATAP).

As he explains it, ATAP pairs the speed, efficiency and execution of a startup with the scale and distribution of Google.

On June 2, Kaufman spoke about Google ATAP and innovation at the launch event for the UC San Diego Institute for the Global Entrepreneur.

"I like finding people that are brilliant and passionate about what they do. I want that one person who thinks they can make the impossible, possible," said Kaufman. "You have to fundamentally move the needle." That's how Kaufman described the ATAP projects pursued by "a small band of makers and believers that is mobile first, lean, agile and optimized for speed."

Kaufman hears a lot of pitches for new ATAP projects, and sometimes they sound like bad Seinfeld routines that start with "Don't you hate it when...".

But when you step back and look at why things are the way they are, you often find fundamental scientific and technological problems that are in the way.

"Clearing these roadblocks sometimes requires developing new materials, or creating new processes, under tight time constraints. We conduct fundamental scientific research, but we do it in a way that furthers a particular problem that we care about," said Kaufman.

Teams get just two years to turn a specific idea into a compelling demonstration at a convincing scale that can be built into a commercial product. Kaufman pointed to a conductive fibers project that one of his teams is integrating into Levi's jackets using their actual production lines.

HUMAN-COMPUTER PARTNERSHIP

"I don't believe in predicting the future," quipped Kaufman during his Q&A. He doesn't think anyone knows what the world will look like in ten years, but he did highlight a trend. "I'm really interested in human-computer partnerships. Today, we make people act like computers...and we try to make computers do human things, which they are abysmally bad at. When you do a search, we make you type because that's how engineers think about things. But it's a completely non-natural way to do anything," said Kaufman.

The sweet spot is when we think about machines as partners. "Time will tell, but I believe that people are going to start focusing much more on 'Explainable AI.'"

If you've worked with AI, you've run into a situation where an AI system gives you a stupid answer to a question.

"And you think, 'that's a stupid answer, so I'm not going to trust any of your answers.' So you throw away the whole system, and you build another one. But think about it for a moment: you have friends that say stupid things all the time, but you don't throw them away. I mean if they say A LOT of stupid things you do, but mostly you don't. So what's the difference? The difference is this: when your friend says something stupid, you can ask them why they said the stupid thing, and it often turns out not to be stupid: they misunderstood or they didn't quite hear what you said. You get calibrated back to 'OK, they're not stupid, we just had a miscommunication.' You can't do that with a computer. But imagine that you could. I think that's a really interesting area of research. If your AI systems gives you a dummy answer, imagine that you don't just throw it away, imagine that you ask, 'But why?'

"A computer will just go through the stack and report on how things are weighted: I was told this, and I was told this, and I was told this, so I concluded THAT.

"And the human can identify what idea was wrong, and rebalance the weighted items the system is relying on.

"If I had to think of one trend in the future, I would think of human-computer partnerships."

Full story: bit.ly/DanKaufman

NEW ROBOTICS HIRES

Laurel Riek works on algorithms that allow robots to solve problems in real-world environments, such as hospitals, homes and factories. Nick Gravish combines robotics, biology and physics to discover how organisms and robots move and interact. They are among a group of eight new UC San Diego professors whose research is crucial for developing safe, useful, and human-friendly robotics systems that are deeply integrated with how people live.

UC San Diego is building a world-class robotics cluster in the region through the Contextual Robotics Institute, which launched in October 2015 as a partnership between the Jacobs School of Engineering and the Division of Social Sciences. The 2016-17 hires include computer science professor Henrik Christensen, a world-renowned roboticist who serves as the Contextual Robotics Institute's first director. He is working to boost robotics research efforts; expand partnerships with industry; build educational programs at the undergraduate and graduate level; and create new robotics outreach programs for kids. "We are going to do all this better than anyone else in the world," he said.

Christensen is a leader in setting national policy for robotics and is the head of a nationwide effort to draft a robotics roadmap and explore the field's potential to transform U.S. society. At the Contextual Robotics Institute's third annual forum on October 28, 2016, Christensen presented the latest version of the robotics roadmap. Download the roadmap at: bit.ly/RobotRoadmap

The robotics institute's new executive director, Todd Hylton, is an electrical engineering professor of practice at the Jacobs School. He comes to UC San Diego from San Diego-based Brain Corporation, a robotics start up where he served as executive vice president of strategy and research. Hylton, also a former DARPA program manager, is looking forward to helping the institute spin out startups, license breakthroughs and feed the robotics talent pipeline in the region, state and nation. He will teach courses focused on enabling technology for robotics and pursue research. Both Hylton and Christensen are currently housed in UC San Diego's Qualcomm Institute.

RUBI the robot at the Contextual Robotics Forum

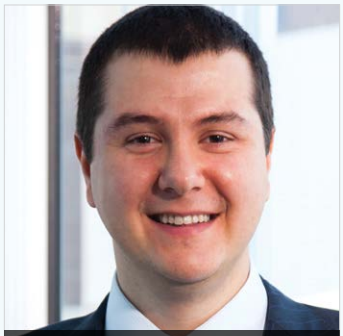

LAUREL RIEK


NICK GRAVISH


HENRIK CHRISTENSEN


TODD HYLTON


NDAPA NAKASHOLE

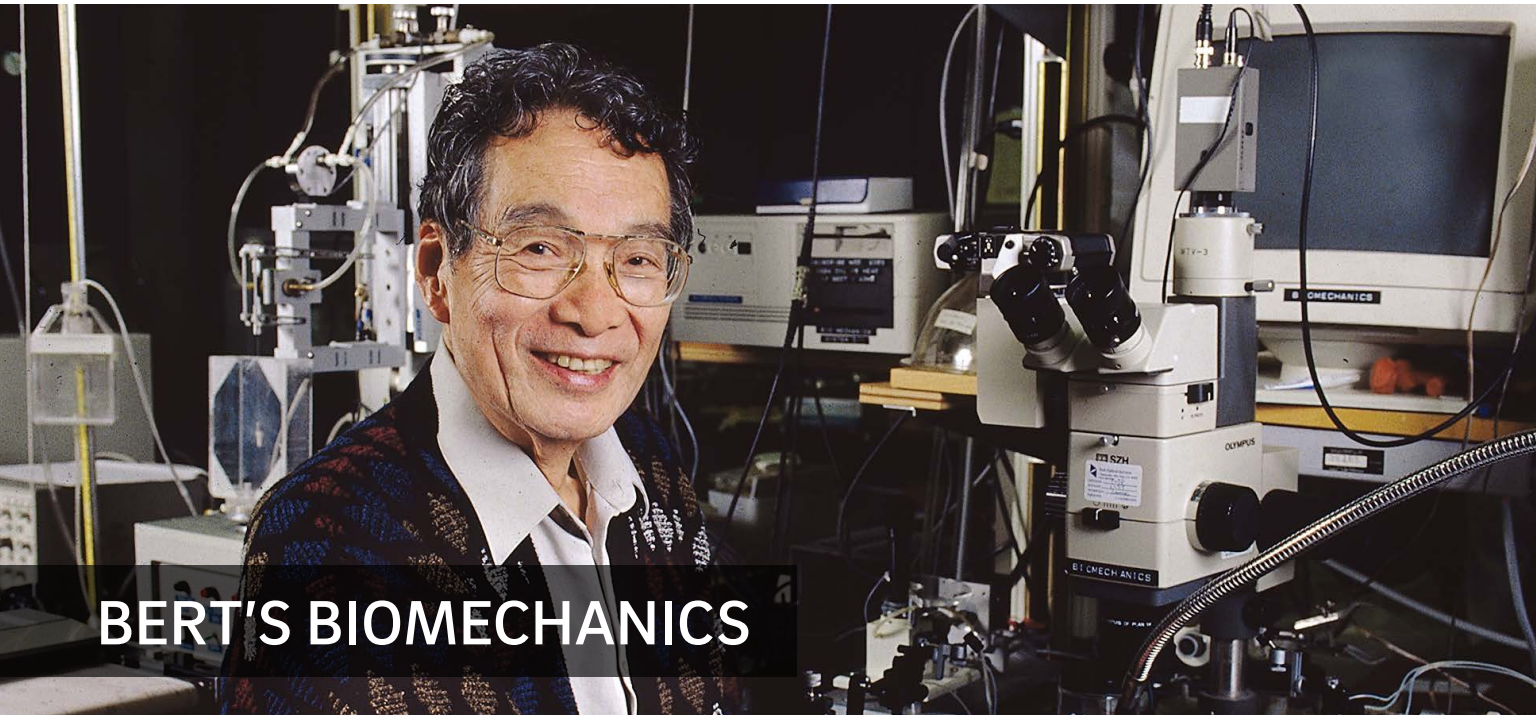

NIKOLAY ATANASOV

This year's robotics hires also include computer scientist Ndapa Nakashole, who works at the interface of human language and computers, and electrical engineer Nikolay Atanasov, who aims to increase the autonomy and reliability of robotic sensing systems.

UC San Diego hires with robotics-related expertise this year also include cognitive scientists Steven Dow and Philip Guo. Dow researches human-computer interaction, social computing and creativity. Guo studies online learning, human-computer interaction and computing education.

These eight new professors join several others with expertise related to robotics and artificial intelligence hired at UC San Diego in 2014 and 2015. These hires include computer vision experts Ravi Ramamoorthi and Manmohan Chandraker, biomedical roboticists James Friend and Michael Yip, and soft robotics experts Michael Tolley and Sheng Xu.

Learn more: contextualrobotics.ucsd.edu



BERT'S BIOMECHANICS

Bioengineering professor emeritus Dr. Yuan-Cheng (Y.C.) "Bert" Fung, now age 97, was a successful aeronautical engineering professor at Caltech when his mother developed acute glaucoma in 1958. He was on sabbatical in Germany that year and immersed himself in the glaucoma literature in a library near the aerodynamics research institute. He sent summaries of what he learned to his mother's physician back in China.

"Gradually one thing became quite clear to me: the biologists do not think about what we engineers always think about — namely, the force, motion and transport phenomena. Furthermore, biology is full of interesting nonlinear problems ... I found the field very attractive," Fung said in 2000 in a wide-ranging IEEE History Center interview conducted by Frederik Nebeker.

Fung went on to found the discipline of biomechanics, which uses physics to understand the mechanical properties, structure and function of biological systems. He helped uncover fundamental biomechanics principles that affect every organ and tissue in the body, including the heart and lungs. Fung discovered, for example, that blood cells flow through capillary beds in the lung similarly to how cars meander in an underground parking garage, leading to a better understanding of microcirculation, which is the circulation of blood in the smallest blood vessels. This "sheet-flow" theory provided a quantitative description of pulmonary circulation, hypertension, edema, and respiratory distress syndrome.

Fung's research is also central to automotive safety design — all crash tests today rely on his fundamental studies of tissue response. His Exponential Law explains how tissue deforms under stress, and problems related to severe thorax impact injuries have been solved by his "stress wave propagation" theory.

Fung grew up in mainland China, where he completed his undergraduate and master's degrees in aeronautical engineering. He earned his doctorate at Caltech in 1948 and joined the Caltech faculty that same year. In 1966, he and Caltech colleagues Dr. Benjamin Zweifach and Dr. Marcos Intaglietta moved to UC San Diego to start the school's bioengineering program.

From the beginning they recognized the importance of microcirculation. Zweifach worked on measuring physiological parameters in different animal models and Intaglietta invented sophisticated instrumentation, while Fung provided the mathematical theory and models that could explain the mechanics of circulation. In the process, he came up with a universal pseudoelastic law that describes the behavior of biological tissues.

Fung coined the term "tissue engineering." He also took the first steps in developing theories that provide a mathematical framework for identifying gene expression during tissue growth in three dimensions.

"This is one of the most innovative ideas that he developed," said Geert Schmid-Schönbein, professor and chair of the Department of Bioengineering at UC San Diego, who was Fung's Ph.D. student.

Fung's research provided a foundation for industrial applications in many fields, including tissue engineering of cardiovascular, musculoskeletal, gastrointestinal and cutaneous systems, and advancing products to treat burns and severe tissue injuries such as diabetic foot ulcers.

Fung has the rare distinction of being elected a member of all three National Academies: the National Academy of Engineering (NAE), Institute of Medicine, and National Academy of Sciences. He also received the President's National Medal of Science in 2000, the NAE's Fritz J. and Dolores H. Russ Prize, and the NAE's Founder's Award. He received a 2016 UC San Diego Revelle Medal and even has an asteroid named in his honor. Learn more about Y.C. Fung via the IEEE oral history at: bit.ly/BertFung

COMBATING ANTIBIOTIC RESISTANCE

Bioengineers and physicians at UC San Diego received a five-year, $9.5 million award from the National Institutes of Health (NIH) to study antibiotic resistance from the perspective of systems biology.

Bacteria that are immune to antibiotic therapy, so-called "superbugs"—such as MRSA (methicillin-resistant *Staphylococcus aureus*)—pose great threats to humans and modern medicine. The U.S. Centers for Disease Control and Prevention estimate that at least two million Americans become infected with antibiotic-resistant bacteria and at least 23,000 people die each year from these infections.

This new antibiotic resistance project builds on systems biology, which explores the complexity of living systems—from the genome to the entire organism—using experimental and computational methods. The initiative from the National Institute of Allergy and Infectious Diseases at the NIH is led by Bernhard Palsson, Distinguished Professor of bioengineering, and Dr. Victor Nizet, a professor of pediatrics and pharmacy at UC San Diego.

Concerned by the exploding problem of drug-resistant bacterial pathogens, Palsson, a pioneer in systems biology, reached out to Nizet, a world leader in bacterial pathogenesis, to explore whether systems-level approaches could be coupled with experimental models of antibiotic drugs, living bacterial pathogens, human immune cells and animal models of infection to combat antibiotic-resistant infections.

A problem with current approaches to evaluate antibiotic activity, Nizet said, is that they address the drug's action only on lab-grown bacteria without considering the human immune system.

"Improving treatment outcomes in serious or antibiotic-resistant bacterial infections will require systems-level analyses at the molecular level," Palsson said.

HEALING HEART TISSUE AFTER A HEART ATTACK

Bioengineers led by professor Karen Christman are developing injectable biomaterials for treating cardiovascular diseases. Her lab has a strong translational focus with the main goal of developing minimally invasive therapies for cardiovascular diseases. Projects are highly interdisciplinary and involve collaborations with basic scientists, engineers and physicians.

An injectable hydrogel technology developed by her team, which is designed to repair damaged cardiac tissue after a heart attack, has been licensed by San Diego-based startup Ventrix, which Christman co-founded along with CEO Adam Kinsey. Ventrix is currently conducting a clinical trial of VentriGel in patients who previously experienced a heart attack.

This year, Christman and her team also developed a potential new therapy for critical limb ischemia, a condition that causes extremely poor circulation in the limbs and leads to an estimated 230,000 amputations every year in North America and Europe alone.

Learn more: bit.ly/healingtissue

STEM CELLS MAKE NEW BONE

Researchers have cooked up a simple recipe for growing bones from human pluripotent stem cells—a discovery that could lead to new treatments for people with critical bone defects or those who have suffered traumatic bone injuries.

Pluripotent stem cells can become any type of cell (muscle, heart, skin or bone), making them promising sources to repair or regenerate various tissues and organs. But existing methods to direct stem cell transformation into specific—and functioning—cell types are complicated, costly and inefficient. There's also the risk of tissue made from pluripotent stem cells developing tumors called teratomas when transplanted.

A team of researchers led by bioengineering professor Shyni Varghese discovered that they could coax stem cells to become functional osteoblasts—bone-building cells—simply by adding a molecule that occurs naturally in the body, called adenosine, to their growth medium. When transplanted into mice with bone defects, the osteoblasts formed new bone tissues *in vivo* without any signs of teratoma formation.

"It's amazing that a single molecule can direct stem cell fate," Varghese said.

Learn more: bit.ly/newbones

FROM SHAKE TABLE TO VIRTUAL WAVE AND BACK

On a recent afternoon, two Jacobs School engineers equipped with 3D glasses stood in front of a towering 12' digital reproduction of a six-story building, projected onto a curved wall of screens. They had tested the building a few weeks before, putting its light-weight steel frame through a series of increasingly powerful earthquake and fire tests on the world's largest outdoor shake table at UC San Diego. Now researchers were zooming in and out of the building's digital twin to assess damage.

This virtual inspection was made possible by data gathered by small drones, which flew around the building, first before the tests to help create a digital, 3D map of the structure, and then during the tests to capture the impact of the earthquake. Finally, after the tests, they took to the sky to look for damage. Researchers used powerful visualization algorithms to turn the data the drones collected into an immersive 3D environment. The combination of these unique technologies—a one-of-a-kind shake table and powerful data visualization methods—allows structural engineers at the Jacobs School to get an incredibly detailed digital model of the structures they test. This in turn allows them to make recommendations to improve design methods and building codes around the nation and the world.

"This series of tests is particularly important because, for the first time, we simulated on a shake table an aftershock and main shock occurring after a live fire," said principal investigator and UC San Diego structural engineering professor Tara Hutchinson.

In the past 12 years, many projects have been put to the test on the shake table at the NSF-funded Englekirk Structural Engineering Center—everything from wind turbines, to parking garages, to one-story masonry structures and six-story concrete buildings.

Back in 2011, Hutchinson assembled a team of engineers to test the safety of a five-story building's nonstructural components—elevators, stairs and facades. Those tests resulted in new building design requirements and new construction methods—and will likely yield more insights in coming years.

More recently, researchers tested different ways to retrofit wood-frame soft-story structures, which feature large open spaces on the first floor. The series of tests was critical to an initiative to seismically retrofit about 6,000 of these buildings in California alone.

"Earthquake engineering is very important for society because engineers help lessen the number of deaths in earthquakes and decrease disruptions on society," said Joel Conte, a professor of structural engineering and the principal investigator on the Jacobs School's shake table. The facility has made a significant impact on building design and codes, he said.

Hutchinson's latest $1.5 million project is a good example of the facility's mission. It is supported by a coalition of government agencies, foundations and industry partners including the U.S. Department of Housing and Urban Development, the California Seismic Safety Commission and partners from the steel industry and insurance companies. The researchers received approximately $1 million in in-kind donations from industry partners to build and outfit the structure.

The building's architectural layout was designed to replicate a multi-family residential condominium or apartment building at full scale. But in this case, engineers were pushing the limit of structural height, erecting the building 64 feet above the shake table. The largest building of this construction type tested before was a two-story residential structure. Testing a building at full scale is important because certain failure mechanisms can't be reproduced when structures are scaled down, said Conte. In this recent experiment, engineers were trying to find out

Left to right: Tara Hutchinson, Joel Conte, Falko Kuester

how a mid-rise building made of cold-formed steel framing would perform during an earthquake and a post-earthquake fire. The answer is that it did well after going through the seismic tests. "The building could have been easily repaired," Hutchinson said. "The occupants would have gotten out safely."

Hutchinson believes that it's likely because the structure is lighter than a concrete building of the same height and as a result has less mass to generate damaging forces.

The fire tests however were less kind to the structure, which was equipped with few fireproof materials and fire-stop systems. Researchers led by Brian Meacham, a professor at the Worcester Polytechnic Institute, ignited pans of heptane, a liquid fuel, in eight rooms on the building's second and sixth floors to achieve temperatures as high as 1000 degrees Celsius (almost 1800 degrees Fahrenheit) within the seismically damaged rooms. Doors fell off their plastic hinges, which melted. Several of the researchers' video cameras, installed to record the fire's progression, suffered a similar fate. Finishing materials detached from ceilings and walls. The simulated earthquakes occurring after the fire tests further weakened some of the structure's floors, bringing them close to collapse.

The building's performance was captured by an extensive array of more than 250 analog sensors, as well as digital cameras — and of course, by drones. The drones, operated by the research group of professor Falko Kuester, took 4K video footage of the building during each of the tests as well as hundreds of high-resolution images, before and after.

"We used the drones to get the right sensor to the right location at the right time," Kuester said. He and his team then compiled the data into high-resolution 3D models consisting of billions of data points, called point clouds.

Hutchinson, Conte and colleagues navigated through the point clouds together using the tall, curved display environment called the WAVE (for Wide-Angle Virtual Environment). The WAVE is a Holodeck-like environment that allows the viewer to step into a virtual recreation of the research. An array of 35 monitors that ends in a crest above viewers' heads and a trough at their feet, the WAVE fills a person's field of view for 180 degrees at the vertical and 160 degrees at the horizontal. If you are wearing special 3D glasses, the display can also tell where you are looking and adjust the images it shows accordingly. Users can step back to study the entire structure and then zoom in to see the tiniest details, such as cracks and changes in shape and color. "This is big VR for big data and big science," Kuester said.

The WAVE and its software allow researchers to travel through space and time to explore how structures have changed and how they have been damaged by natural disasters such as earthquakes.

At the same time, the shake table allows researchers to gather baseline data before and right after an extreme event, an opportunity that they wouldn't have in real life.

"We'll then have high definition data from before, during and after the test, which was never available before," Kuester said.

The next step for engineers is to look closely at this data and produce a series of technical reports and scientific papers — a process that could take a year or so.

UC San Diego's shake table is funded by a $5.2 million grant from the National Science Foundation. The facility is part of the NSF's Natural Hazards Engineering Research Infrastructure — a network of state-of-the-art research facilities and tools designed to better understand and prevent earthquakes as well as wind and water hazards.

nheri.ucsd.edu

BHAVIN SHAH

Bhavin Shah (B.S. '99, Computer Science) is a serial entrepreneur. "My first entrepreneurial bet was in educational gameplay," said Shah. "We pivoted several times and ended up developing traditional games."

In 2011 he launched Refresh.io, a platform that helps sales professionals learn about the people they are selling to. LinkedIn acquired the company in April 2015, and Shah is currently building an enterprise software company.

Now that Shah has launched several successful companies and started a family, he is looking to give back. "I've hit a number of milestones in my career, and I want to have an enduring impact," he said. For Shah, giving to the Jacobs School is a way to reconnect with his passion — giving students access. Shah's professors at UC San Diego were dialed into the startup scene, and growing up in a technology family gave him access to mentors and industry leaders who provided him with great advice each time he needed it.

Shah is supporting the Student Success Initiative, which is a school-wide master plan created by the Jacobs School's IDEA Engineering Student Center. It aims to increase retention and diversity through academic support, community building and leadership opportunities. "A program like Student Success is critical, in my opinion, because it helps to bridge the gap for those that don't have a network of support they can leverage," Shah said. "Student Success gives students the type of tutoring that everyone ought to have."

Shah's gift supported Diego Miranda, a freshman mechanical and aerospace engineering student, for seven weeks during the summer of 2016 as he worked on a research project connected to microrobotics in professor Olivia Graeve's lab.

"Without Mr. Shah's generous support, I never would've discovered that I have a great love for research," said Miranda. "I plan to do more of it."

When asked "why now" as it relates to his decision to give to the Student Success Initiative, Shah said he wished he had done this sooner. "The idea of giving back in your early years doesn't feel like a priority, however giving back at an early stage in life allows you to have a more enjoyable and potentially enduring impact in a variety of ways."

Why the Jacobs School? "There's a better signal to noise ratio here," said Shah. "Every gift, no matter how small, makes an impact."

Read more: bit.ly/BhavinShah

BEN POULADIAN

Ben Pouladian (B.S. '04, Electrical Engineering) was always a tinkerer. With small business owners for parents, he also learned to work hard. He wanted to challenge himself in college, so he set his sights on engineering.

"You learn how to approach life logically — how to break down a problem and arrive at a solution," said Pouladian. "Also, I was applying for colleges during the dot-com boom and saw that technology could create value and make an impact on the world — and not just one person at a time."

While at the Jacobs School, and driven by the desire to change the world through technology, Pouladian enrolled in an entrepreneurism class taught by the von Liebig Entrepreneurism Center. After graduating, he went to work for a company in Silicon Valley.

"Everyone has an idea in Silicon Valley," said Pouladian. "I wanted to be on that side of the table. At the time, we were working with a lighting company. I realized that lighting wasn't going to go away — I also knew from my time in a materials science class at UC San Diego that LED technology was a potential replacement light source. It was just a matter of when that would happen."

Together with his cousin, a businessman, Pouladian co-founded DECO Lighting in 2005. After pivoting the direction of the company multiple times, DECO Lighting saw exponential growth as LED lights became the new norm. The company now specializes in the manufacturing of innovative, next-generation LED lighting solutions that improve lighting quality and efficiency, and enhance the environment through reduced energy consumption. DECO Lighting was a finalist for the E&Y Entrepreneur of the Year 2016 Award in Greater Los Angeles.

Read more: bit.ly/Pouladian

REMEMBERING SOL PENNER

SOL PENNER SERVED AS FIRST CHAIR OF AMES, THE FIRST ENGINEERING DEPARTMENT ON CAMPUS

Stanford S. "Sol" Penner, one of the founders and creators of the engineering program at UC San Diego and a professor emeritus, passed away on July 15, 2016 at his home in La Jolla. He was 95. Penner's research program was broad and included work that profoundly influenced the design of liquid propellant rocket engines used for space exploration. Penner joined the UC San Diego faculty in 1964 and became the first chair of the campus' first department of engineering. The department was named AMES—the Aeronautical and Mechanical Engineering Sciences Department (aeronautical later became aerospace).

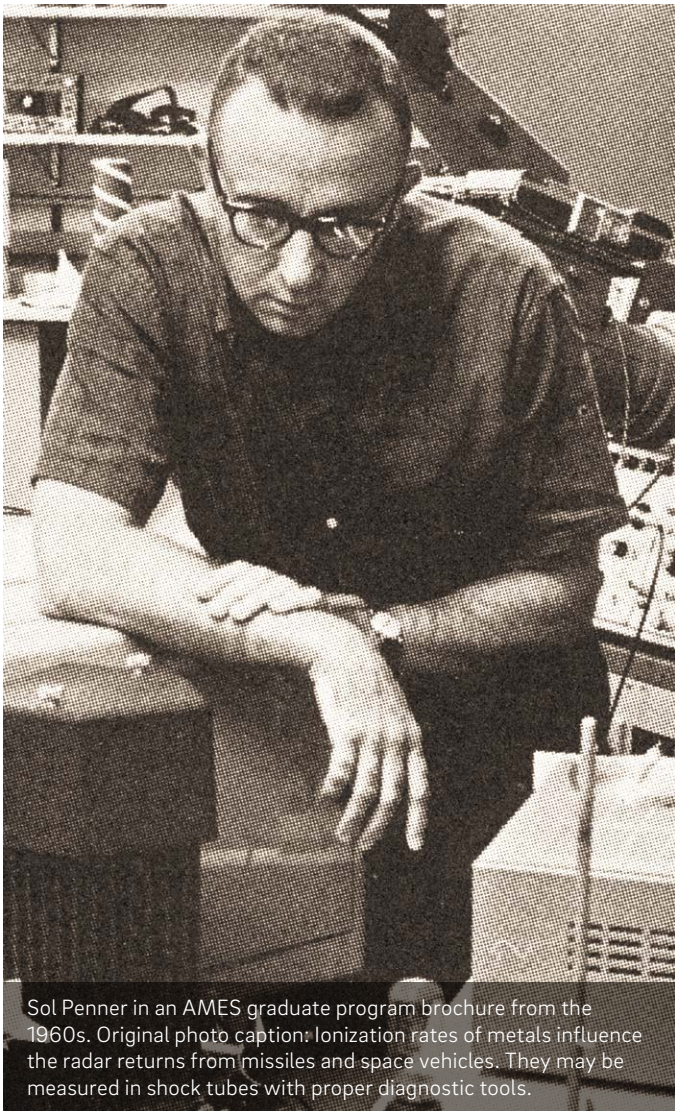
"We have lost one of the most brilliant minds and one of the pillars on which UCSD is standing. We have had many illustrious colleagues during these 50 years since the formation of UCSD, but one can say with total honesty that very few have been as loved and admired as Sol Penner, especially among all of us in engineering. Sol Penner was not only our founder and leader, but he was a generous colleague and a dear friend to many of us," said UC San Diego distinguished mechanical and aerospace engineering professor Juan C. Lasheras.

As AMES department chair, Penner hired or helped hire many of the profoundly influential professors who worked together to build what grew into four of the Jacobs School of Engineering's six academic departments: Bioengineering, Mechanical and Aerospace Engineering, NanoEngineering (which includes Chemical Engineering), and Structural Engineering. In 1973, he created the Center for Energy Research at UC San Diego as a place for researchers from across campus and around the world to come together to pursue critical, interdisciplinary energy research.

In 2004, in a Jacobs School of Engineering publication, Penner described some of what drew him to UC San Diego in the early 1960s. "After that first visit and meeting with the principal designers of the new campus in the beguiling environment provided by the La Jolla location, I was totally convinced that a great university would be the result. Also, I was enthusiastic about the exciting opportunity of founding a single department where engineers and applied scientists from many disciplines could interact with colleagues while working on common long-term goals. The innovative programs were especially appropriate at the height of the Cold War when there was a strong demand for Ph.Ds. in advanced engineering and applied science R&D," he said.

Penner is recognized worldwide for his research contributions and expertise in a wide range of areas including thermophysics, applied spectroscopy, propulsion, combustion, and a variety of topics in energy. His theoretical and experimental work on relaxation processes in nozzle flows, propellant burning, laminar flames, droplet burning and ablation profoundly influenced the design of liquid propellant rocket engines used for space exploration.

Learn more: bit.ly/SolPenner



Sol Penner in an AMES graduate program brochure from the 1960s. Original photo caption: Ionization rates of metals influence the radar returns from missiles and space vehicles. They may be measured in shock tubes with proper diagnostic tools.

PENNER'S UC SAN DIEGO LEGACY

In 2000, Penner established the endowed Stanford S. and Beverly P. Penner Lecture Series in the Department of Mechanical and Aerospace Engineering (MAE). He conceived the lecture series as a continuation of the early days of UC San Diego, when every new faculty member was invited to give a lecture to the entire faculty and student body—from all departments. In 2008, Penner created the Stanford S. & Beverly P. Penner Endowed Chair in Engineering or Applied Science in MAE. Juan C. Lasheras is the first recipient.

At the direction of the Penner family, a memorial fund in Dr. Penner's honor has been created to support post-doctoral researchers in the Mechanical and Aerospace Engineering Department. For more information on how you can contribute to the legacy of Sol Penner, please contact Kristi Ingles: +1 (858) 246-1179 or kingles@eng.ucsd.edu.

You can give directly at: bit.ly/PennerFund

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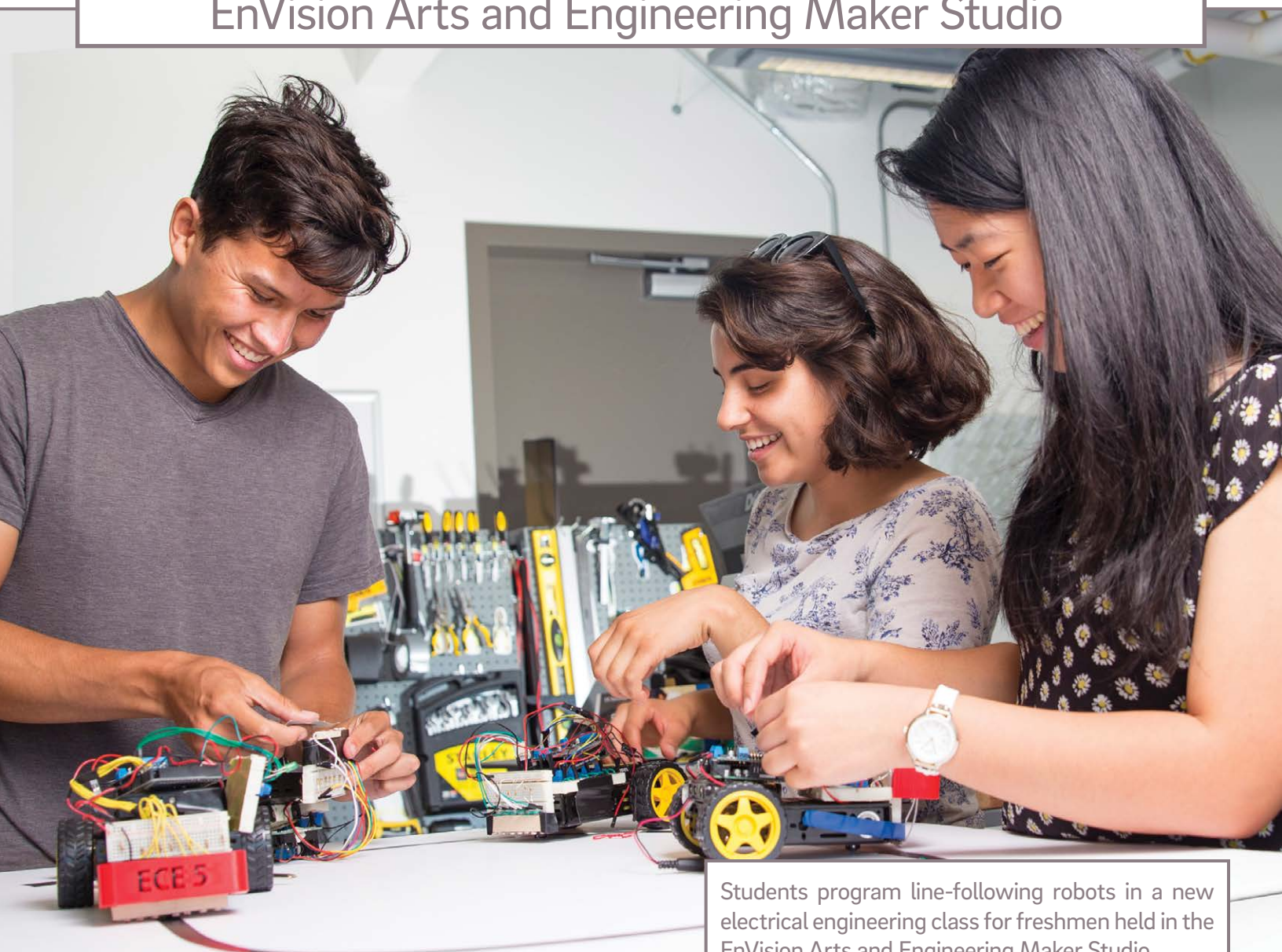

Students program line-following robots in a new electrical engineering class for freshmen held in the EnVision Arts and Engineering Maker Studio.

Learn more on pg. 4-5 and at EnVision.ucsd.edu