

UC San Diego
Jacobs School of Engineering

Pulse

Winter 2015

UC San Diego Center for
Extreme Events Research
experimental + computational expertise

19 New Jacobs School Professors

I am pleased to report that we hired 19 new professors to the Jacobs School of Engineering during the last recruitment cycle. That's one for the record books. I hope you take a moment to look through the talented group of faculty we are so pleased to welcome to the Jacobs School (p. 8–11). Depending on the final values of a few variables, we may be on our way to another record breaking faculty recruitment cycle. Stay tuned for an update this coming fall.

One of our new faculty members is J.S. Chen, Director of our Center for Extreme Events Research (p. 6), which we launched in Fall 2014. This research center connects our world-renowned expertise in experimental and computational methods for extreme events research. By strengthening interdisciplinary collaborations, these engineers work with research and industry partners to make our built infrastructure safer—before, during and after extreme events like earthquakes, blasts and landslides.

This past fall, I also formalized three lines of code that capture the values that we live by here at the Jacobs School.

- Engineering for the global good
- Exponential impact through entrepreneurship
- Collaboration to enrich relevance

My leadership teams and I return to these values again and again when we make decisions and plan for the future. As you read through this issue of Pulse, peruse our websites or interact with Jacobs School faculty, students and staff—you'll encounter many of the ways in which we live by these values.

An interdisciplinary group here at the Jacobs School, for example, is introducing middle-school girls to engineering through hands-on projects (p. 4). In addition to the direct benefits to all involved, this program is part of a larger move at the Jacobs School and beyond to inspire diverse pools of students to study engineering. An engineering workforce that reflects

society is critical for solving so many of the challenges we face in California, the nation and the world.

One such challenge is security. A group of computer scientists recently uncovered security vulnerabilities in backscatter X-ray machines previously used in airports (p. 12). This is important work in its own right. It also serves to advance discussions regarding transparency and rigor in the testing and assessment of increasingly connected public safety systems and consumer products.

Speaking of high-tech consumer products, a team of undergraduates (p. 5) has created "the world's first smart earplugs." The idea had its beginnings in a product design class at the Jacobs School and came to life thanks to our entrepreneurship programs for students. I look forward to seeing these students, and our many other student entrepreneurs, thrive while they are here at the Jacobs School and long after.

I value your feedback on our values and any other topics that matter to you—the alumni, friends and champions of the Jacobs School of Engineering. As always, I can be reached at DeanPisano@eng.ucsd.edu.

Sincerely yours,



Albert P. Pisano, Dean



Jacobs School of Engineering

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aboard Orion

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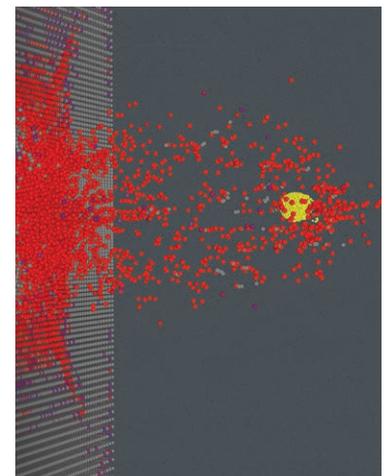
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Back Cover: Orion at Launchpad
Photo credit: NASA/Radislav Sinyak

Pulse

Center for Extreme Events Research

On the cover: a computer simulation of perforation of a concrete panel with a high speed projectile. J.S. Chen's research group has developed a meshfree method with unique contact algorithms and multiscale damage models capable of predicting the complex material behavior during fragment-impact processes for general application to damage assessment of structures subjected to extreme loads (pg. 6).



Engineering SISTERS



How do you build the perfect water filter? With cotton balls or coffee filters? How about sand? And how about decorations: feathers or duct tape? These were the questions groups of girls energetically debated on a warm Thursday afternoon in December at Paul Ecke Central Elementary School in Encinitas.

It was all part of a girls-only after school program led by undergraduate students at UC San Diego, and funded by a three-year \$800,000 grant from the National Science Foundation. The project is called SISTERS, short for Sustaining Interest in Science, Technology, Engineering, and Research in Society. It reaches more than 130 girls in 5th- and 6th grade at four Encinitas elementary schools, where anywhere from 20 to 40 percent of the students live below the poverty line.

"We want this program to make a profound and lasting difference in these girls' lives," said Mandy Bratton, SISTERS' principal investigator. "We hope the engaging curriculum and the interaction with female scientists, engineers and undergraduates will ignite their interest in careers in science and engineering in which women continue to be underrepresented."

On this particular Thursday afternoon, girls were building water filters to purify a concoction of tea, cornstarch and oil. Their devices were made from empty soda bottles filled with a wide range of materials, including felt, coffee filters, wire and colorful pebbles. The girls were getting help from Encinitas sixth-grade teacher Ilse Escobedo and UC San Diego students Andia Pibdani, a senior and environmental systems major, and Katie Huang, a third-year computer science major.

"Hopefully, we'll be bringing more girls to STEM," Huang said. A woman in computer science, she works in a heavily

male-dominated field—a fact that she's hoping to change.

SISTERS emerged from a close collaboration between the Jacobs School's Global TIES (Teams in Engineering Service) program, which Bratton directs, and the Encinitas Union School District. Global TIES students led by Jan Kleissl, an environmental engineering professor, taught science and engineering lessons in the school district from 2009 to 2014. Kleissl is the co-principal investigator of SISTERS and oversees the program's curriculum.

Encinitas Union expects the program to be transformational for students, said Nancy Dianna Jones, the district's administrator of support services. "We want them to be confident problem solvers who know how to work with others. We want them to love science," she added. "We want them to have a desire to make a difference in their community and in the world."

Girls in the program are getting the message. "Before I did the program, I didn't like science so much," said Megan Pusch, 10. "Now I like it a lot. It's made science fun." She wants to become a coder, after one of the program's sessions focused on programming.

Global TIES Fiji Project

A Global TIES team wants to build kindergarten classrooms in Fiji and needs your help. The team, which needs funds for travel and materials, is one of the first to be highlighted on Crowdsurf, UC San Diego's new crowdfunding platform for student and campus projects.

The project will soon be posted on crowdsurf.ucsd.edu



Hush Technology raised close to \$600,000 to develop their wireless smart earplugs.

Hush

A Startup Promises Quiet

When Daniel Lee enrolled in Nate Delson's Product Design and Entrepreneurship class, becoming an entrepreneur wasn't on his radar. But a little more than a year later, Lee has co-founded a startup, developed first at the Moxie Center for Student Entrepreneurship here at the Jacobs School and then at San Diego's EvoNexus incubator. The class gave him the tools to take his professional destiny into his own hands and the courage to start his own company, he said.

Lee and two other students at the Jacobs School have already raised more than \$593,000 through crowdfunding for their company, Hush Technology. Their product? Smart wireless earplugs that block out external sounds, but still allow users to hear their alarm clock and important messages via a smartphone app. The earplugs also double as a sound machine that plays white noise and ocean wave sounds, among others. The devices will be manufactured here in San Diego.

Lee, a mechanical engineering major, dreamed up the product during Delson's class. It was inspired by his years of living in loud campus dorms and apartments shared with roommates. He and three other students built a prototype. When the class ended, the other students dropped out of the project, so Lee drafted his roommate, Daniel Synn, a structural engineering major, to help. A computer

engineering student, also named Daniel Lee, but distinguished by his Korean first name, Chesong, joined the pair a few weeks later.

The three engineering students divided up roles fairly quickly. Lee took charge of hardware and product development. He graduated in June 2014 to focus on Hush Technology full time. Chesong Lee focused on developing the app. Synn became the lead designer and chose to take a year off school to focus on the startup. Classes and training through the von Liebig Center's NSF I-Corps program were particularly helpful, he said.

"The energy and dedication of the students has been amazing," Delson said. "Regardless of the success of the company, I am confident that the real-world lessons they are learning are invaluable."

At the Moxie Center at UC San Diego, the Hush team received access to workspace, tools, equipment and supplies, including 3D printing, several machine shops and electronics fabrication. They also received mentoring from business professionals, legal assistance on incorporation and patents, and were introduced to investors and the EvoNexus incubator.

"The Hush Technology team came into the Moxie Center with an exciting business idea and a passion to make it work," said center director Jay Kunin. "They took full advantage of our technical and business resources, and I'm particularly proud of how Daniel, Daniel and Daniel have supported their fellow entrepreneurs in the Moxie Center and across UC San Diego."

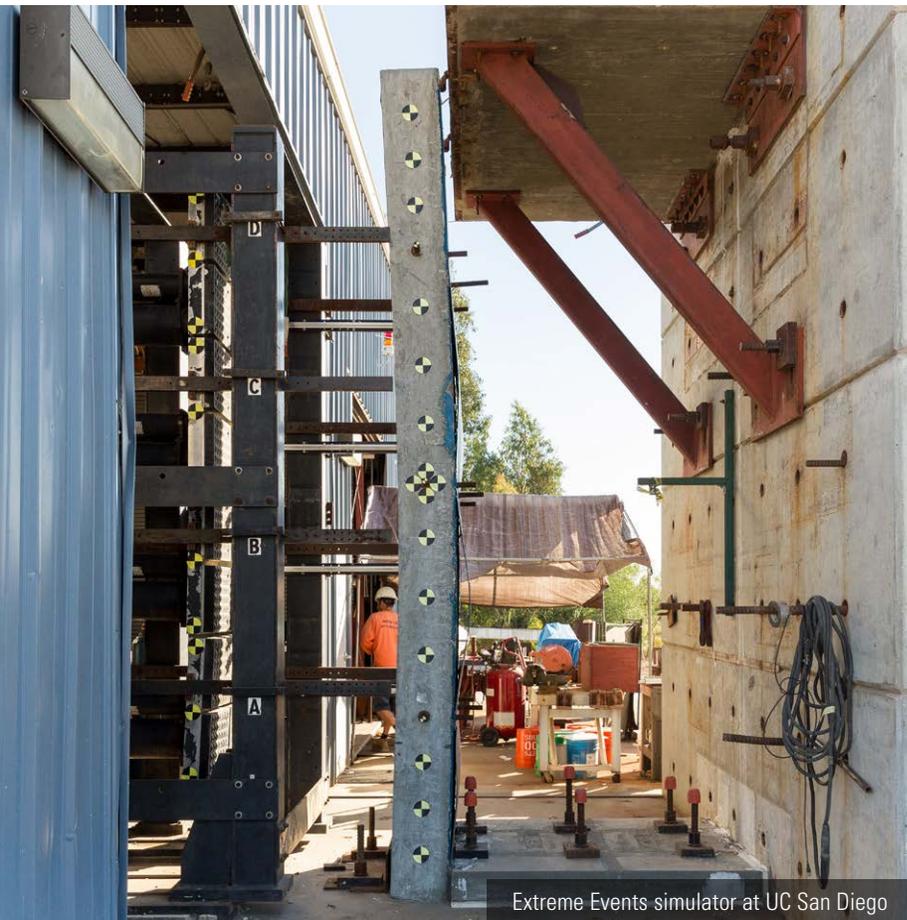
The three Daniels also offered great customer support on their Kickstarter page, answering more than 292 comments from backers. They decided to offer a one-year limited warranty after backer feedback. One typical example: "@Pan Totally legitimate concern! We have a backup alarm which you will be able to hear if your earplugs fell out!"

More on hush.technology



Hush co-founders (L-R): Daniel "Ewok" Lee, Daniel Synn, and Daniel "Chesong" Lee

Extreme Events: Prepare. Protect. Respond.



Extreme Events simulator at UC San Diego

The Center for Extreme Events Research leverages world-renowned expertise in experimental and computational methods to develop better ways to prepare and protect entire built infrastructures, as well as humans, from extreme events such as blasts from terrorist attacks and mining explosions, car crashes, sports collisions, and natural disasters such as landslides. Center researchers also develop tools for rapid damage and vulnerability assessments.

Visit [CEER.UCSD.EDU](https://ceer.ucsd.edu)

When a landslide or an earthquake strikes; when a blast tears through a building, two essential questions arise: How can we protect buildings and their occupants better? And how can we predict the damage these extreme events will cause? Researchers at the Jacobs School of Engineering have launched a new research center to answer these questions. Their goal is to protect the built infrastructure, as well as the human body, from events such as blasts from terrorist attacks, mining explosions, car crashes, sports collisions and natural disasters such as landslides and earthquakes

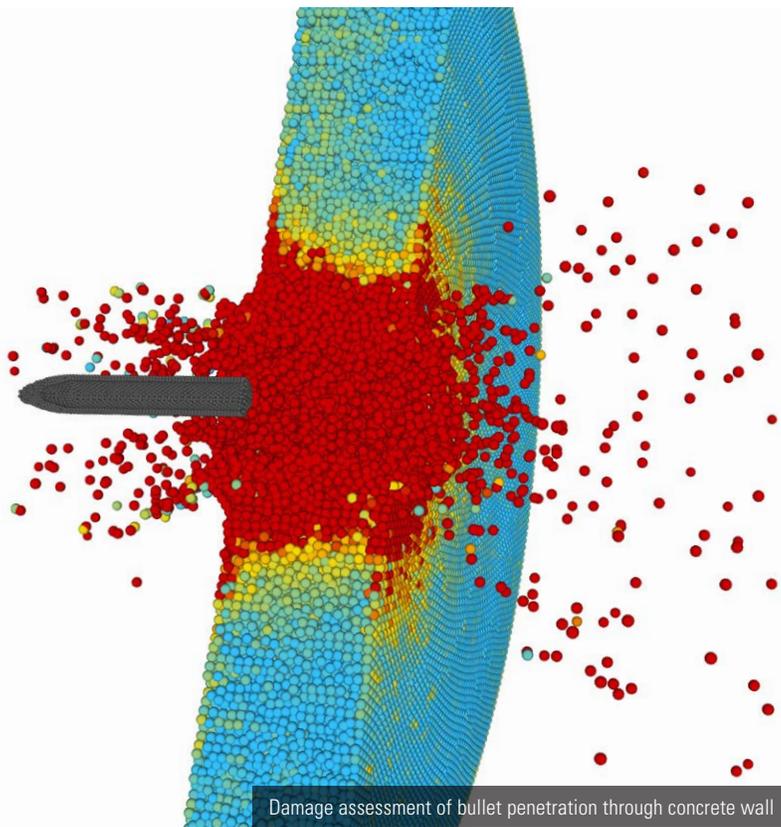
The Center for Extreme Events Research (CEER) brings together a unique combination of experts in experimental and computational research. As a result, faculty will be able to develop sophisticated simulation tools and validate them experimentally.

“We need to be prepared for the next generation of threats,” said J.S. Chen, the center’s director and the William Prager Professor of Structural Engineering at the Jacobs School. “My role is to bring together the fantastic expertise we have here at UC San Diego, especially in the field of assessment and mitigation of extreme events.”

The center is home to the Extreme Events simulator, the only facility of its kind in the world (pictured left). It is capable of replicating everything from blasts generated by car bombs to damage due to hurricane-force winds. The simulator uses the high-speed motion from several actuators to replicate the shock wave created by a blast or other type of impact, without a fireball. The damage can be captured with high-speed cameras and other sensors. Gil Hegemier, a Distinguished Professor of Structural Engineering at the Jacobs School, is the center’s associate director and leads its experimental efforts.

“We want to provide outcome-oriented results to benefit society,” Hegemier said.

An expert in blast and earthquake damage assessment, Hegemier was called to the site of many natural and man-made disasters, including the World Trade Center after Sept. 11 and the San Francisco Bay Bridge after the 1989 Loma Prieta Earthquake. He designed the blast simula-



Damage assessment of bullet penetration through concrete wall

tor in collaboration with former Jacobs School Dean Frieder Seible and MTS Corporation.

The center also brings together experts in high-end simulation methods, such as finite element analysis, isogeometric analysis and meshfree modeling. Meshfree modeling uses points such as pixels in an image as data points for computer simulation and is Chen's field of expertise. The method is especially adept at simulating blasts because it can track fragments from damaged materials and the impacts they cause. Chen's group has also expanded the use of meshfree simulation methods to biomechanics.

Yuri Bazilevs, an expert in finite element analysis and isogeometric analysis and an associate director of the center, leads efforts in the field of computational simulation. He works on problems ranging from the simulation of offshore wind turbines in rough sea conditions to modeling of cardiac assist devices that save patients' lives. His most recent research interest lies in the modeling of blast-structure interaction events in collaboration with J.S. Chen.

The Center for Extreme Events Research also has a crucial educational mission, in addition to the cutting-edge research. "We need to prepare the next generation of engineers to deal with these disasters," Hegemier said.

Short Courses for Industry Professionals

The Center for Extreme Events Research is developing short courses to provide industry and research partners with focused, cutting-edge professional training in the topics that matter most. Topics under development include:

- Experimental and Computational Investigation of Extreme Events
- Meshfree Methods
- Isogeometric Analysis

PARTNER WITH US

Joining the Center for Extreme Events Research provides access to UC San Diego faculty, researchers, and graduate students who are transforming the field of extreme events engineering.

<http://ceer.ucsd.edu>



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Nineteen New Professors Joined the Jacobs School in 2014–2015

Engineers who transform medicine. This is one of our exciting growth areas.

What do the nooks and crannies of a cell tell you about its health? And more importantly, can we build mathematical models to predict when cells are about to get sick, based on their geometry? These are the questions that Padmini Rangamani is tackling. She joined the Department of Mechanical and Aerospace Engineering at the Jacobs School in fall 2014. Rangamani has a unique perspective on these issues: she has a Ph.D. in biology and a master's and bachelor's in chemical engineering.

"We need to keep the conversation going between physicians and engineers," she said.

Rangamani is one of 19 new faculty hires at the Jacobs School for the 2014–15 academic year—a record in the school's history. More than half a dozen of these new hires work at the intersection of engineering and medicine.

Here at UC San Diego, she is partnering with several researchers at the School of Medicine to examine how a particular protein affects cells responsible for aging and heart disease. The ultimate goal is to find mechanisms that could lead to better drugs.

"If we want effective treatments, we need to understand how cells behave," Rangamani said. "There are a lot of forces and mechanic principles at work, in addition to chemistry. If we can target cells better, we can design therapeutics better."

Rangamani's goal is not easy: she wants to use mathematics to elucidate the design principles at work behind biological systems. Her team starts with a simplified mathematical system focusing on a cell's geometry, not only its size and aspect ratio, but also its local variations, its nooks and crannies. Then the researchers add more data, such as the cell's proteins and their interactions. Next, they attempt to make some predictions to validate their model. If the predictions don't mesh with real-life experiments, the system gets modified, or even scrapped. "My assumptions can be shattered during experiments," Rangamani said.

Future Faculty Hiring

In the coming years, faculty growth at the Jacobs School will be focused through cluster hires—in robotics, materials and energy, advanced manufacturing, information sciences, engineering and clinical medicine, and more. In robotics alone, the school plans to hire four additional professors in the next two hiring cycles (see Tolley on p. 11 for this year's robotics hire). The Jacobs School is on track to hire 16 to 21 new faculty during the current 2015 recruitment cycle. The faculty roster is growing to meet intense demand for engineering education programs at the Jacobs School.



Padmini Rangamani is an assistant professor in the Department of Mechanical and Aerospace Engineering. She was a postdoctoral fellow at UC Berkeley and received her Ph.D. from the Icahn School of Medicine at Mt. Sinai in New York City. prangamani@ucsd.edu



NUNO BANDEIRA

Associate Professor
Ph.D. UC San Diego

Bandeira works at the epicenter of a seismic paradigm shift in computational mass spectrometry. Instead of interpreting each spectrum in isolation, he develops algorithms for so-called “spectral networks.” His goal is to collect and organize all mass spectrometry data in the world and make it searchable and accessible to a social network of researchers in order to enable discovery of new drugs.
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Science &
Engineering

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YI CHEN

Assistant Professor
Ph.D. Purdue University

Chen builds DNA nanostructures to deliver therapeutic agents and functional biological components. Beyond its genomic properties, DNA is also recognized as a novel material. Chen’s group uses DNA strands as building blocks that self-assemble into highly structured materials with specific nanoscale features such as rationally designed DNA 3D crystals and autonomous nanomachines.
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NanoEngineering

Previously: Postdoctoral Fellow, MIT Cancer Center



JIUN-SHYAN “J.S.” CHEN

William Prager Endowed Chair Professor
Ph.D. Northwestern University

Chen is a leader in computational mechanics and specializes in developing mesh-free computer simulation methods using image pixels as data points. His research team applies advanced computational methods to fragment-impact processes in homeland security applications, landslides, natural-disaster prediction, manufacturing processes modeling and biological systems simulation.
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Structural
Engineering

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AARON DREWS

Teaching Professor
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Drews develops and improves core undergraduate chemical engineering laboratory courses with an emphasis on active classrooms that promote self-directed learning and increase the quantity and usefulness of teacher-student interactions. A 2014 Teaching Fellow for the Chemical Engineering Department at Penn State, Drews is passionate about excellence in engineering education.
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NanoEngineering

Previously: Ph.D. Pennsylvania State University



DAVID FENNING

Assistant Professor
Ph.D. Massachusetts Institute of Technology

Fenning designs and develops materials and technology for solar energy conversion and storage. His research centers on modeling, characterizing, and controlling defects in solar cells to raise efficiency and on developing new materials and device architectures for solar-to-fuel conversion for energy storage.
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NanoEngineering

Previously: 1366 Technologies



STEPHANIE FRALEY

Assistant Professor
Ph.D. Johns Hopkins University

Fraley studies the multiscale physical and molecular contexts that drive complex cellular behaviors. Her research aims to improve our understanding of disease progression in cancer and sepsis. She works to develop new technologies for early detection and personalized interventions. Fraley received a 2013 national Burroughs Wellcome Fund Career Award at the Scientific Interface.
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Bioengineering

Previously: Postdoctoral Fellow, Johns Hopkins School of Medicine



JAMES FRIEND

Professor

Ph.D. University of Missouri

To develop new biomedical devices, Friend combines fundamental and applied studies of the interaction of electromechanical fields in novel materials and across various interfaces at the micro and nano scale. His team created several medical technologies, including a new pulmonary drug delivery system and a robot capable of swimming inside human arteries. jfriend@eng.ucsd.edu

Mechanical
& Aerospace
Engineering

Previously: Professor, RMIT University, Melbourne



JESSE JOKERST

Assistant Professor

Ph.D. University of Texas at Austin

Jokerst engineers nanoparticles for molecular imaging and in vitro diagnostics. His focus includes ultrasound imaging, which has broad clinical utility and high spatial and temporal resolution, and photoacoustic imaging for high-contrast imaging. Current projects include tools to image stem cells in cardiac regenerative medicine and increase the specificity of ovarian cancer screening. jokerst@gmail.com

NanoEngineering

Previously: Postdoctoral Fellow, Stanford School of Medicine



DANIEL M. KANE

Assistant Professor

Ph.D. Harvard University

Topics of Kane's published papers include algorithms for big data, results on writing numbers as sums of primes, and the structure of polynomials in many variables. He has diverse research interests within mathematics and theoretical computer science, particularly in the areas of combinatorics, number theory, derandomization and Boolean functions.

Computer
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Previously: Postdoctoral Fellow, Stanford University



PRASHANT MALI

Assistant Professor

Ph.D. Johns Hopkins University

Within synthetic biology and regenerative medicine, Mali's long-term focus is on developing tools for enabling gene- and cell-based human therapeutics. Over the years, he has developed a range of genome and stem cell engineering technologies. In particular, he pioneered the development of the CRISPR/Cas systems for eukaryotic genome engineering. pmali@ucsd.edu

Bioengineering

Previously: Postdoctoral Fellow, Harvard Medical School



JULIAN MCAULEY

Assistant Professor

Ph.D. Australian National University

McAuley focuses on the linguistic and temporal dimensions of opinions and behavior in social networks and other online communities. He is perhaps best known for having analyzed 42 million Internet product reviews consisting of over five billion words written by 10 million users, including Amazon reviews posted through early 2013, to predict product ratings more accurately. jmcauley@ucsd.edu

Computer
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JOHN MCCARTNEY

Associate Professor

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McCartney solves problems that arise when geotechnical engineering systems such as foundations, retaining walls, and landfills are used as geothermal resources; and he investigates ways of using heat to improve their behavior. He explores the fundamental response of unsaturated soil layers to seismic shaking, temperature changes, wetting and drying, and compression under high stresses. mccartney@ucsd.edu

Structural
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MIA MINNES

Teaching Professor
Ph.D. Cornell University

Minnes' research and teaching expertise is in theory of computation and foundational mathematics. She is a founding faculty member of the Summer Program for Incoming Students and faculty sponsor for the Summer Internship Symposium in the UC San Diego computer science department. She studies the effect of randomness on computational power and models of efficient online computation.
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Computer
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Assistant Professor
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Porter reduces barriers to developing, deploying and managing applications that process massive amounts of data while ensuring the resulting systems are practical, low cost and energy efficient. He focuses on improving networks for data-intensive clusters and data centers to support a new generation of applications and data sizes that are an order of magnitude greater than state of the art.
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Computer
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Porter identifies core course concepts essential to student success; develops pedagogies to facilitate student engagement; and creates assessment instruments to evaluate student learning. He works to improve diversity by using pedagogies fostering community among students. His research includes multicore, multithreaded computer architectures and scheduling in high-performance computing.
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Computer
Science &
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RAVI RAMAMOORTHI

Professor
Ph.D. Stanford University

Ramamoorthi creates realistic images – or renderings – in computer graphics and studies scene appearance in computer vision. He has received many awards, including a White House Presidential Early Career Award. His results are widely adopted in movies such as Avatar and Monsters U., and in games including Halo. He taught the first open online course in computer graphics.
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Computer
Science &
Engineering

Previously: Associate Professor, UC Berkeley



ANTONIO SANCHEZ

Professor
Ph.D. UC San Diego

Sánchez focuses on multiscale research problems that involve the interplay of fluid mechanics, transport processes, and chemical reactions, in particular those emerging in practical combustion systems. Applications include clean combustion technologies, aerospace propulsion devices, and safety hazards in the built environment.
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Mechanical
& Aerospace
Engineering

Previously: Professor, Universidad Carlos III de Madrid



MICHAEL TOLLEY

Assistant Professor
Ph.D. Cornell University

Tolley focuses on the design and fabrication of bioinspired robotic systems that inherit beneficial properties from natural systems: e.g. resilience and self-organization. He developed origami-inspired print-and-fold methods for rapid robot fabrication and deployment; untethered soft robots that walk or jump; and systems that employ fluid forces for self assembly.
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Mechanical
& Aerospace
Engineering

Previously: Postdoctoral Associate, Harvard University

Security Vulnerabilities

A team of researchers has discovered several security vulnerabilities in full-body backscatter X-ray scanners deployed to U.S. airports between 2009 and 2013. The research brought together scientists from the Jacobs School, the University of Michigan and Johns Hopkins University.

In laboratory tests, the team was able to successfully conceal firearms and plastic explosive simulants from the Rapiscan Secure 1000 scanner. They were also able to modify the scanner's operating software so it presents an "all-clear" image to the operator even when contraband was detected.

The researchers attribute these shortcomings to the process by which the machines were designed and evaluated before their introduction at airports. "The system's designers seem to have assumed that attackers would not have access to a Secure 1000 to test and refine their attacks," said Hovav Shacham, a professor of computer science at the Jacobs School. However, the researchers were able to purchase a government-surplus machine found on eBay and subject it to laboratory testing.

Many physical security systems that protect critical infrastructure are evaluated in secret, without input from the public or independent



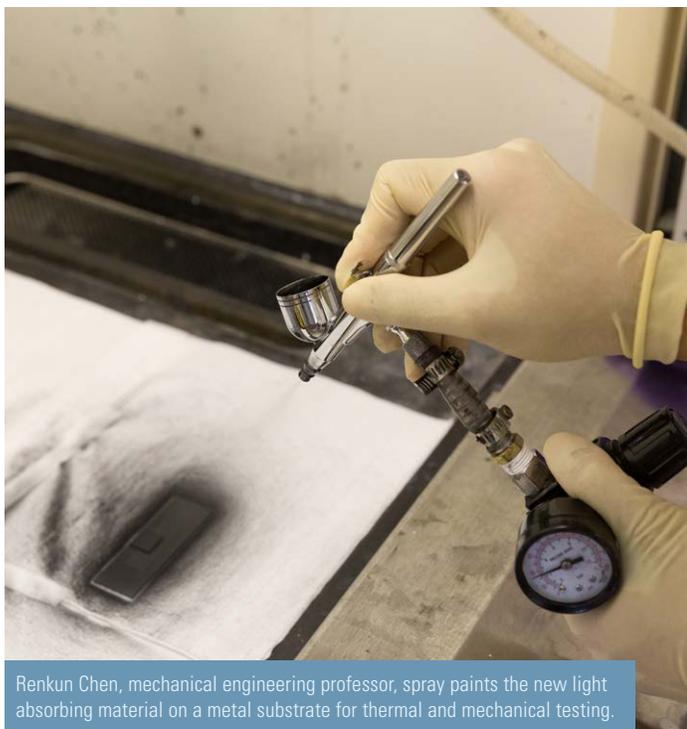
Keaton Mowery, PH.D. student, and Hovav Shacham, professor of computer science (L-R)

experts, the researchers said. In the case of the Secure 1000, that secrecy did not produce a system that can resist attackers who study and adapt to new security measures. "Secret testing should be replaced or augmented by rigorous, public, independent testing of the sort common in computer security," said Shacham.

The researchers have suggested changes to screening procedures that can reduce, but not eliminate, the scanners' blind spots. Secure 1000 scanners were removed from airports in 2013 due to privacy concerns, and are now being repurposed to jails, courthouses, and other government facilities.

Learn more: radsec.org

From Light to Heat

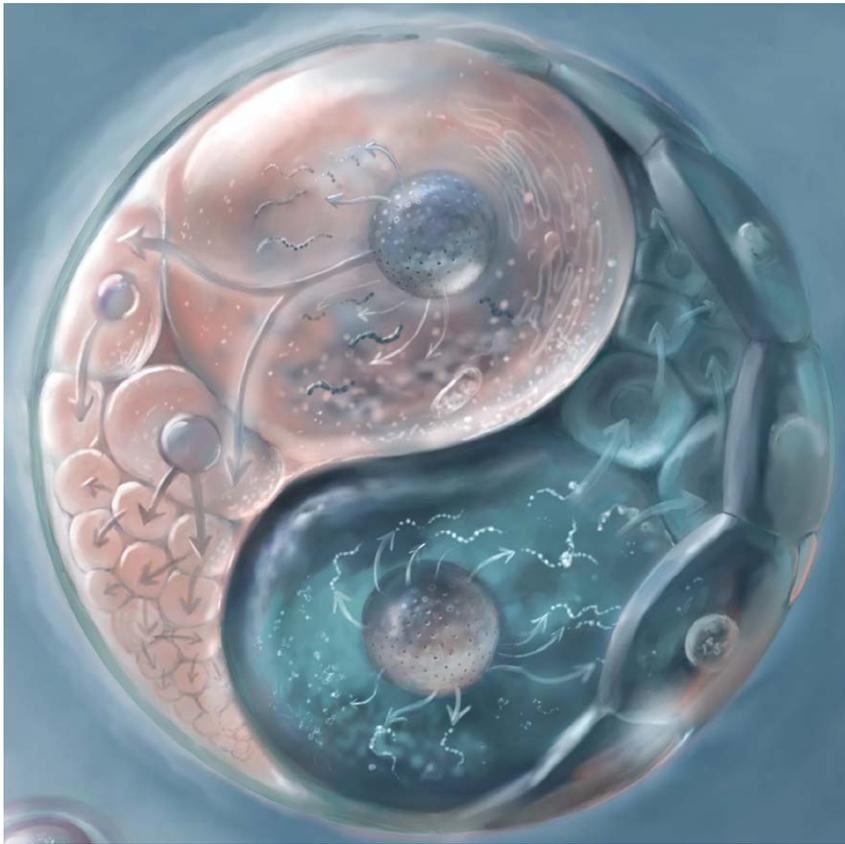


Renkun Chen, mechanical engineering professor, spray paints the new light absorbing material on a metal substrate for thermal and mechanical testing.

Engineers at the Jacobs School have developed a nanoparticle-based material that converts 90 percent of captured sunlight to heat and could be used in concentrating solar power (CSP) plants. The idea is to create a material that absorbs sunlight and doesn't let any of it escape, a kind of "black hole for sunlight." Concentrating solar power (CSP) plants create steam to turn turbines by using sunlight to heat molten salt. They are an emerging alternative clean energy market that produces approximately 3.5 gigawatts worth of power at power plants around the globe—enough to power more than 2 million homes.

One of the most common types of concentrating solar power systems uses more than 100,000 reflective mirrors to aim sunlight at a tower that has been spray painted with a light-absorbing black paint material. This material usually degrades after a year and needs to be removed, which means expensive downtime for the power plant. The new silicon-boride-coated nanoshell material from UC San Diego is designed to be longer lasting and operates at temperatures greater than 700 degrees Celsius, higher than the temperature limit for current materials.

The interdisciplinary research team at the Jacobs School developed the multiscale-structure material, which has particle sizes ranging from 10 nanometers to 10 micrometers. The work is funded by the U.S. Department of Energy.



Embryonic Cells Start Talking Early

Bioengineers at the Jacobs School are using single-cell RNA sequencing to get an unprecedented view of the gene expression of mouse embryos in the earliest stages of development after fertilization. The findings could upend the scientific consensus about when embryonic cells begin differentiating into cell types. The work could also provide insight into where normal developmental processes break down, leading to early miscarriages and birth defects.

Led by professor Sheng Zhong, the team identified a handful of genes that signal to each other at the two-cell and four-cell stage, which happens within days after an egg has been fertilized and before the embryo has implanted into the uterus.

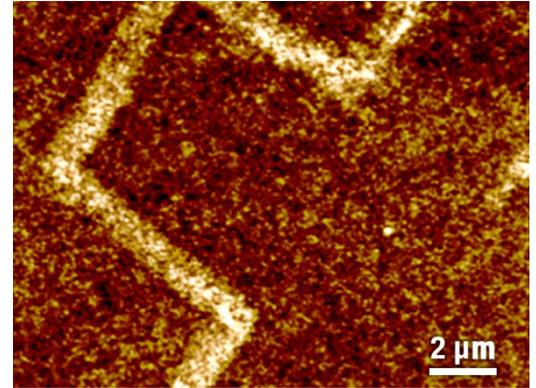
The first major task for an embryo is to decide which cells will begin forming the fetus, and which will form the placenta. The prevailing view until now has been that mammalian embryos start differentiating into cell types after they have proliferated into large enough numbers to form subgroups.

This work, published in *Genome Research*, was funded by the NIH and the March of Dimes Foundation.

In a separate paper published in the journal *PNAS*, the Zhong lab presented their methodology for “time-course” single-cell data analysis, which enabled their findings about cell-fate decision making. The method involves measuring every gene in the mouse genome at multiple stages of development to find differences in gene expression at precise stages.

Artwork ©2014 victorleshyk.com

Nanomotor Lithography



Picture nanorobots swimming over the surface of a light-sensitive material. The nanoscale robots create complex surface patterns that form the sensors and electronics components on electronic devices. This is “nanomotor lithography”—a technology that may offer a simpler and affordable alternative to the high cost and complexity of current state-of-the-art nanofabrication methods such as electron beam writing. The technology, developed in the labs of nanoengineering professor and chair Joseph Wang, was described recently in the journal *Nature Communications*.

Electron beam writing is used to define extremely precise surface patterns on substrates used in the manufacture of microelectronics and medical devices. Today, as scientists invent devices and machines on the nanoscale, there is new interest in developing unconventional nanoscale manufacturing technologies for mass production.

The researchers developed two types of nanorobots: a spherical nanorobot made of silica that focuses light like a near-field lens, and a rod-shaped nanorobot made of metal that blocks the light. Each is self-propelled by the catalytic decomposition of hydrogen peroxide fuel solution. Two types of features are generated: trenches and ridges. When the photoresist surface is exposed to UV light, the spherical nanorobot harnesses and magnifies the light, moving along to create a trench pattern, while the rod-shaped nanorobot blocks the light to build a ridge pattern.

Photo above: AFM image of remote, magnetically guided writing of ridge lines.

Orion's San Diego Spirit

A San Diego company co-founded by Jacobs School alumni made 1,000+ parts for Orion, NASA's new space capsule designed for travel to deep space.

When Robert Kolozs, a Jacobs School structural engineering alumnus, toured the Kennedy Space Center in Cape Canaveral in early December 2014, he had a sudden revelation: if everything went well, the spacecraft parts his company manufactured would someday share an exhibit with the space shuttle and the Saturn V, a rocket used during the Apollo missions.

Kolozs is president of San Diego Composites Inc., a company he co-founded in 2004. The company built and tested more than 1,000 parts for NASA's Orion spacecraft, from windows

to light composite elements connecting the spacecraft's inner and outer shells. The company also manufactured a key component of the system that will allow Orion's crew to eject in an emergency.

Attending the launch and seeing parts that his company made blast off into space was an amazing experience, Kolozs said. "This is as close as you can get to your childhood dreams of being an astronaut and going into space," he said. "It's awe-inspiring."

This is San Diego Composites' first big project with NASA. Headquartered in San Diego, the company designs, manufactures and tests a wide range of products, including missile systems, space structures, propulsion systems and aircraft structures.

"We are a small business and we are employee owned," said Kolozs. "Our goal is to grow as a business and provide people here ownership of that growth."

Many of the staff are UC San Diego alumni, including half of the senior staff and more than half of the engineering staff. The company recruits interns at the Jacobs School's DECaF career fair—many of whom then land full-time jobs.

"I equate a lot of what we do to a more technical version of Mythbusters," Kolozs said. "We develop designs for spaceships, airplanes and missiles, then we test them by blowing them up."

Kolozs got his first introduction to the world of composites as an undergraduate student studying structural engineering at the Jacobs School between 1993 and 1998. He took classes from structural and aerospace engineering professor John Kosmatka and wound up working for him at the Powell Structural Research Laboratories. His job was to run vibration tests on a composites bridge being designed to withstand earthquake loads. The data he collected was later used in a Ph.D. student's thesis. "That was a unique opportunity," Kolozs said. UC San Diego did a great job at exposing structural engineers to a wide range of specialties within the discipline, including civil and aerospace engineering and defense-related work, he added.

He then earned a master's from the University of Texas at Austin and worked for another small composites company in San Diego before starting San Diego Composites. "We wanted to provide something unique to aerospace and defense industries by bringing together our expertise in high-tech engineering and lightweight composites," he said.



On Dec 5, 2014, NASA sent its Orion space capsule (above) on a successful, unmanned test flight. San Diego Composites, a company co-founded by Jacobs School engineers, built and tested many parts including windows and composite elements connecting the spacecraft's inner and outer shells.

Charles Bergan

Vice President of Engineering
Qualcomm

The engineering community doesn't do a very good job explaining engineering or computer science careers.

Charles Bergan (B.S. '87 computer engineering, M.S. '88 computer science) made this comment during a wide-ranging conversation in his office at Qualcomm in Sorrento Valley, where he oversees both software and robotics at Qualcomm Research, the research arm of Qualcomm.

"My friends who are MDs understood pretty well what they were getting into...and the rewards for the work. It was a long road, but they knew it was going to be great at the end," said Bergan. While interest in engineering and computer science degrees is surging at the Jacobs School and across the nation, diversity challenges as well as misconceptions about engineering careers remain.

In school, Bergan noted, engineering students are traditionally tested as individuals. They are tested on "what is X?" But that almost never happens in the engineering workplace, where jobs are completely open book. "You can 'phone a friend' at any moment," said Bergan. "You can go talk to the person who can do all the math in her head."

Bergan laments the fact that he still meets interns who are shocked to realize that working as an engineer is not about being tested on how much of the class materials you can learn. "It's about how you and your team can move together to get across the finish line."

Bergan's career advice for engineers is simple: "Try to be the most prepared person in the room. You often can't be the

smartest person in the room, and that's especially hard to do at Qualcomm. But you can be the most prepared."

***"Try to be
the most prepared person
in the room."***

When Bergan hires team leads, he looks for people who can keep others inspired even while telling them that they are on the wrong track.

As a volunteer and board member for the San Diego Festival of Science and Engineering, Bergan gets face time with young people, including kids from backgrounds that are traditionally underrepresented in engineering. Robotics is a tool he uses to engage kids in engineering and computer science. He also tries to get young students to see that they can make a positive difference in the world through engineering.

With older kids, he adds a dose of pragmatism when trying to get them to seriously consider taking on the hard work required to earn an engineering or computer science degree.

"Many kids are shocked that a six figure salary out of school is possible," said Bergan, who is quick to caution that you must be fully engaged. "If you don't like it...it's not worth it." For some prospective engineers, once they see the life they could have, "suddenly the whole thing will come into focus and taking compiler construction is not so bad," Bergan noted with a smile.

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What's your final frontier?

Orion is NASA's new space capsule which might one day carry humans to Mars. On p. 14, learn how alumni from the Jacobs School at San Diego Composites are involved.

Photo credit: NASA/Radislav Sinyak

Orion is going to Mars. What's your target?

Who are you mentoring and inspiring along the way?

Connect with Jacobs School students and fellow alumni.

Learn more: jacobsschool.ucsd.edu/alumni