2021

UNIVERSITY OF UTAH
COLLEGE OF ENGINEERING

RESEARCH REPORT

FROM THE DEAN

Just 16 months ago, we joined the nation in bracing for impact as Covid-19 upended traditional ways of working, learning and living. While we continue to combat the pandemic, there is plenty of reason for optimism. As Utah's flagship engineering program, we are surging ahead on a wave of positive economic news.

When the Santa Monica-based Milken Institute released their 2021 rankings of "Best-Performing Cities: Foundations for Growth and Recovery," Utah cities took three of the top ten places, more than any other state. No other state had more than one city in the top ten. The think tank ranked cities across the nation by aggregating factors like jobs, wages, and high-tech growth.

U.S. News & World Report ranked Utah as the top state for economy in 2021, followed by Colorado, Idaho, Washington and Massachusetts. And, at his February 21 news conference, Gov. Spencer Cox announced that Utah was one of only two states coming out of 2020 with a net positive job growth. Furthermore, the unemployment rate in Utah is currently 2.8%, less than half the nationwide unemployment rate. Looking ahead, the state's gross domestic product is expected to grow by about 6.2%.

As the top producer of engineering and computer science graduates in Utah's statewide system, this is good news for the College of Engineering. Unlike schools facing shrinking enrollments and budget cuts, our greatest challenge is keeping up with unprecedented growth in student demand and a burgeoning job market. The college experienced a 4.3% enrollment increase last fall.

According to CompTia Cyberstates 2021, Utah has 8,197 "Tech Business Establishments," with 35,035 employer job postings, led by software, programmers, WEB, and quality assurance, with growing demand in cybersecurity, systems analysis and data science. These companies depend on the College of Engineering to prepare the technology leaders of the future.

As important, they rely on the College of Engineering's entrepreneurial faculty for the breakthroughs, innovation, and technology commercialization that are part of our academic DNA. I hope you enjoy reading about a few of them in the following report. I am excited to see what the new year will bring!

Richard B. Brown
Dean, College of Engineering

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Dean, College of Engineering: RICHARD B. BROWN
Associate Dean for Research: KEVIN WHITTY
Excecutive Director, External Relations and Development: JOSH GRANT
Senior Advisor, Development: MARILYN DAVIES

Research Report Editor: VINCE HORIUCHI
Photography and Graphic Design: DAN HIXSON
Contributing Writer: MARILYN DAVIES
Additional photos and illustrations provided by Adobe Stock

STAYING STRONG

There is no question it has been a tough year and a half for college students, faculty and researchers as the Covid-19 pandemic has disrupted every aspect of life. But for the University of Utah and the College of Engineering, like many others, it has also proven our resiliency in the face of hardship.

For the duration of the pandemic, rigorous sanitation and social-distancing policies have been in place for all U engineering campus buildings, student areas and labs. Students and faculty have remained diligent in following university guidance on wearing masks, and there have been no reports of widespread breakout infections in the labs since the pandemic began, said Kevin Whitty, College of Engineering Associate Dean for Research.

"We did really well," he said. "We didn't completely shut down, and I can't think of any cases where people consciously violated policy. Things are pretty much getting back to normal at this point, which is great because we all want a productive summer."

While the world is still far from being out of the Covid-19 danger as the widely reported delta variant continues to spread, the University of Utah remains vigilant in monitoring and preventing infections.

Covid Testing – During fall 2020, the U led all Utah higher-ed peers in offering start-of-semester testing for residential students, randomized testing, and by late fall, rapid testing for all students. Positivity rates on the U campus consistently remained lower than peer institutions, in large part because of campus safety messaging, testing, and efficient contact tracing, said Cameron M. Wright, Program Manager for the campus Covid-19 testing.

Contact tracing – A campus-dedicated contact tracing team was set up last year and has been critical in quickly quarantining exposed individuals.

Vaccinations – General campus vaccine willingness and vaccination rates on campus exceed those of the rest of the population in Utah. For example, more than 62% of students enrolled in classes for the summer semester have been vaccinated, according to the University of Utah Student Health Center, as opposed to 41.7% of Utahns age 19 to 29. The campus has held one major vaccination event in the summer and has more scheduled for the beginning of fall semester.

As we prepare classrooms and research labs this summer for the return of students for in-person instruction, the health and safety of everyone on campus remains our top priority.

THE LEADING EDGE

The University of Utah's College of Engineering continues to break new ground in its ongoing research of technologies that benefit the world around us. Here are examples of our researchers pushing the boundaries in engineering. Go to www.coe.utah.edu to learn more about these projects.

GEOTHERMAL LAB

Researchers with the Frontier Observatory for Research in Geothermal Energy (FORGE) at the University of Utah have completed the first of two nearly 11,000-foot-long wells that will be used to create a geothermal reservoir. The FORGE project, led by U engineers, is a $220 million geothermal energy laboratory developing the tools and technologies required for reservoir creation and management. Research at the lab near Milford, Utah, will lead to improved drilling techniques, methods for stimulating fractures from cased wells, and other technologies.

RECHARGE YOUR BATTERIES

Chemical engineering assistant professor Tao Gao has opened the door to creating a battery that can be recharged in just a fraction of the time of normal lithium-ion batteries. His research reveals the physics behind a phenomenon known as "lithium plating," a side reaction that happens when lithium ions are put into graphite particles too fast. With this new knowledge, he believes new technologies could create a car battery that could be fully charged five times faster than with current techniques.

BETTER BLOOD CLOTTING

Blood clotting prevents excessive bleeding, and large cells known as megakaryocytes are a vital ingredient to ensure that clotting happens. Biomedical engineering assistant professor Tara Deans has discovered a simple way to isolate and enrich a rare population of immature megakaryocytes. She hopes this research will allow her to better understand the processes associated with megakaryocyte development and lead to diagnosing diseases more quickly. Ultimately, the goal of the lab is to alleviate the need for platelet donations in the future by producing viable platelets for transfusion in a dish, which will be especially helpful for chemotherapy patients or those born with certain conditions that produce lower platelet counts.

IDLE THREAT

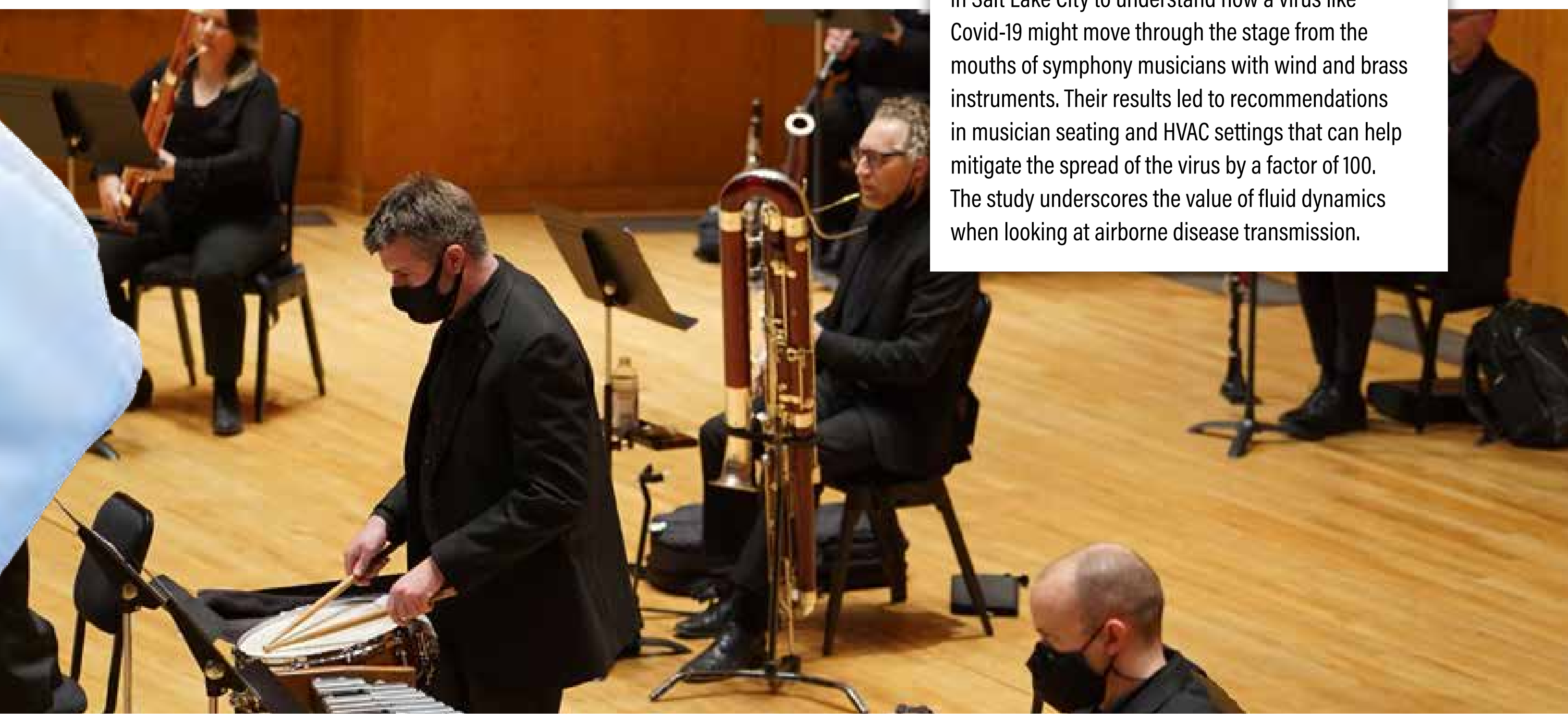
Chemical engineering assistant professor Kerry E. Kelly believes a dynamic display that alerts parked drivers to how their idling is affecting air quality could encourage them to shut off their cars. Similar to displays for speeding, Kelly is developing and testing a display system with air-quality sensors for places like airports and schools that shows real-time pollution numbers to help motivate motorists to turn off their engines while waiting.

LOWERING RISKS OF A FALL

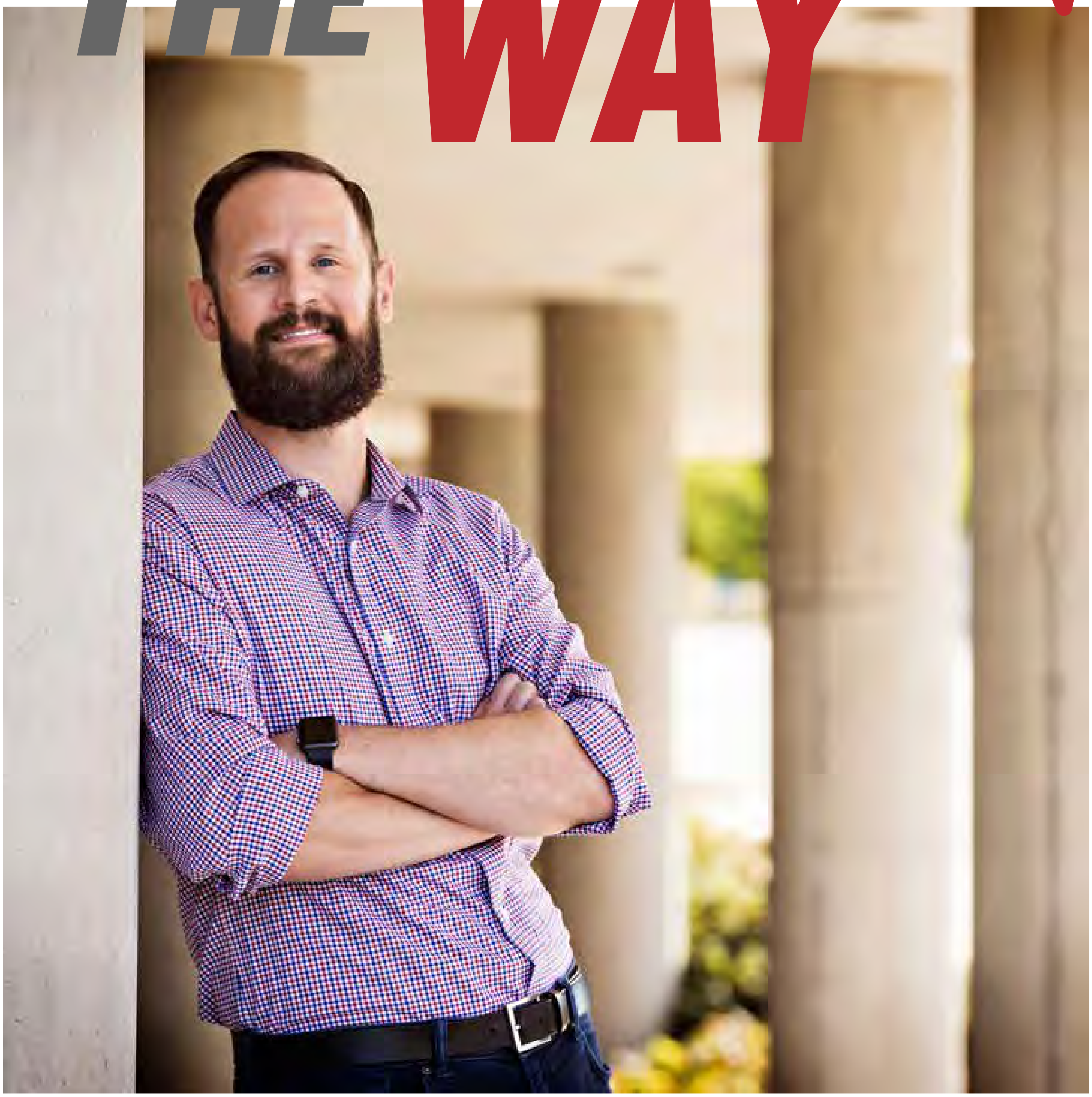
Mechanical engineering associate professor Andrew Merryweather and School of Computing assistant professor Tucker Hermans are creating a new computer algorithm they believe can reduce the number of accidental falls in a home, hospital or care facility. This unique software tool analyzes something that's never been calculated before – how environmental conditions such as furniture and the layout of the room might contribute to the risk of a fall. It then provides suggestions for better configurations that help lessen accidents.

BLOWIN' IN THE WIND

Chemical engineering professor James Sutherland and assistant professor Tony Saad conducted a study of the flow dynamics of two concert halls in Salt Lake City to understand how a virus like Covid-19 might move through the stage from the mouths of symphony musicians with wind and brass instruments. Their results led to recommendations in musician seating and HVAC settings that can help mitigate the spread of the virus by a factor of 100. The study underscores the value of fluid dynamics when looking at airborne disease transmission.



CLEARING *THE* WAY



For patients with heart disease, there is one cause of heart attacks that is difficult to predict – knowing when diseased tissue within the blood vessel or artery is likely to rupture, causing a dangerous blood clot to form.

While current imaging makes it possible to identify when plaque creates blockage in the artery and requires a stent to restore blood flow, it's more difficult for clinicians to anticipate when an artery might break under the stress of the plaque accumulation. But University of Utah biomedical engineering assistant professor Lucas Timmins believes there are telltale signs in the plaque and arterial tissue that can alert doctors if and when that might happen. The secret lies in knowing how stiff the artery becomes when diseased and understanding how much more mechanical stress the tissue can take before the plaque bursts.

"We're developing the method to quantify the material stiffness of the plaque directly from medical imaging data and using these data to identify the rupture risk of a given plaque," he said.

Coronary artery disease, which is the leading cause of death worldwide, is the accumulation of substances such as fat and cholesterol that can block the flow of blood in the arteries to the heart. When these obstructions form, the change in the mechanical environment can promote further progression of the disease and lead to a heart attack. Typically, doctors can analyze a patient's level of heart disease through procedures such as an EKG, CT or MRI scan, and routine blood test. However, the ability to predict a patient's risk for a heart attack is low.

"The holy grail in cardiology is determining what metric will provide clinical value in indicating when a plaque has high risk for rupture. We believe biomechanics is a key driver in being able to understand what will or will not rupture," Timmins said.

For a clearer answer, Timmins has turned to computational modeling to better understand the biomechanics behind arterial tissue and plaque.

He and his team of researchers, along with colleagues in the University of Utah's Scientific Computing and Imaging Institute, clinicians from the U's School of Medicine, and collaborators from Emory University School of Medicine in Atlanta and Cambridge University, are analyzing a large catalog of patient imaging data. By comparing those plaques that ruptured with those that have not from the patient database, his team is creating computational models of the tissue to predict the mechanical stress in the arterial wall. In 2020, he received a five-year $1.7 million grant from the National Institutes of Health to pursue this research.

"With this preliminary data, we've identified unique mechanical characteristics that have predictive value in identifying patients prone to rapid disease progression. That includes unique blood flow patterns and wall stress distributions in the coronary arteries," he said.

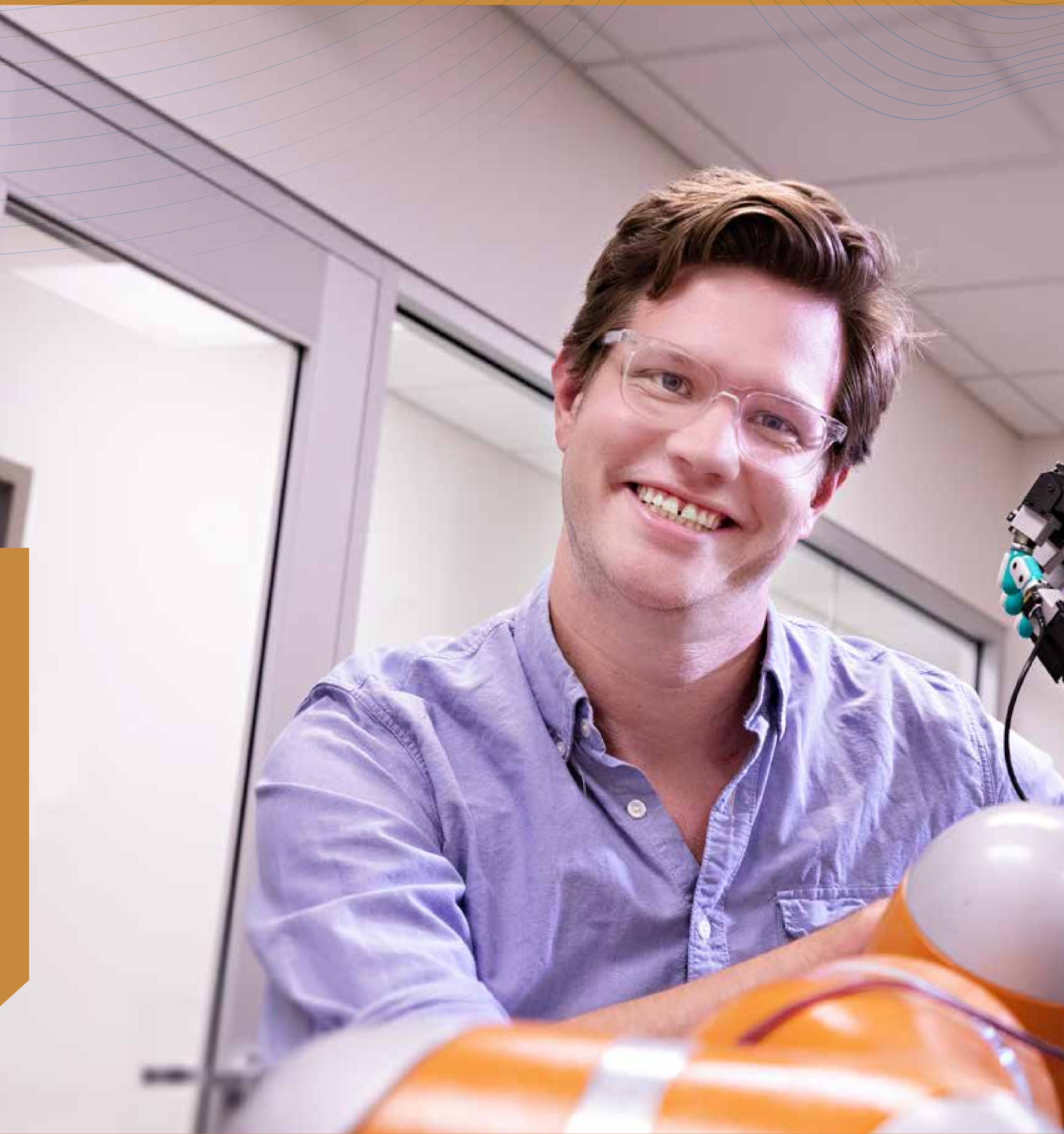
With this valuable knowledge, patients could undergo a coronary catheterization – the insertion of a catheter to diagnose a heart condition – and the results could be processed through the new computer models to determine how stiff the coronary tissue is and the risk of a break. Doctors could then develop more accurate treatment strategies such as what medications to use, how often to check the patient or what lifestyle changes need to be made.

Timmins said he and his three graduate students conducting the research – Jack Wang, Caleb Berggren and David Jiang – have "each made efforts on both the experimental side and computational side to really push the limits of our understanding of this unique medical problem."

"This can really advance the detection of these vulnerable plaques and aid our ability to detect rapid heart disease," he added.

It's this kind of multidisciplinary approach to medicine – utilizing innovations in engineering to aid in the advancement of medicine – that attracted Timmins to engineering and away from his initial plans to be a medical doctor. He received his Ph.D. in biomedical engineering from Texas A&M University.

"I've always enjoyed tinkering and taking apart and putting together things," he said. "And I've always had a passion for helping people, so I've always been drawn to medicine. I had plans to go to medical school but seeing how engineering can impact medicine was something that better suited my interest in serving society."



A HIRED HAND

Picking up a drinking glass may seem like a simple task. But in reality, the human brain goes through a tremendous number of neural computations in order to determine the best way the hand should pick up the glass without spilling.

University of Utah School of Computing assistant professor Tucker Hermans is researching how a computer can replicate those dense calculations so a robotic hand can perform the same function as a human hand. And he's making tremendous progress. The artificial intelligence he is creating can allow a mechanical hand to analyze an object and determine the best way to grasp it in a fraction of a second.

"Most robotics research on grasping has focused on simple robot grippers, like two-fingered hands," said Hermans, who received his Ph.D. in robotics from the Georgia Institute of Technology's School of Interactive Computing. "We're interested in how we can manipulate with more dexterous hands."

Programming a robot to grasp objects the same as a human would revolutionize a variety of industries from home health care to online retail and mining.

"The robots we have today, they're capable of doing amazing things but they don't have the software – the intelligence – in these machines to do certain things in our daily lives," he said. "So the focus now is to figure out how we provide that intelligence."

The goal is to teach the robot hand to pick up an object it has never seen before by analyzing it with cameras and other sensors and then calculating the proper way to pick up and manipulate it. To do that requires artificial intelligence that can quickly determine which grasp to use based on the object's size, shape and what the robot is told to do with it.

"Imagine picking up a rock if you want to throw it. You hold it with your entire hand like a baseball. That's a 'power grasp,'" Hermans explains. "That's in contrast to a 'precision grasp' where we can imagine that same rock as a piece of flint with a specific shape. We can hold it with fingertips and impart more specific forces on it."

To understand that, the robot has to "see" the object with its cameras and sensors and determine the best grasp for the job. In the past, roboticists would input a complete 3D model of the object beforehand in order for the robot to detect it. But Hermans says robots can do that with just a partial view of the object using depth cameras that instantly create a map of points on the item and the environment it's in. The robot assesses thousands of attempted grasps to quickly figure out the best one for that object and for what the user wants done with it.

"It gives us a big data set of inputs of grasp configurations and camera configurations and outputs of binary labels of whether it will be successful," Hermans said. "That's what we need to train deep neural-network classifiers."

That trained neural network is then used in the robot

to successfully pick up and manipulate the object. "We want to find the grasp that is most successful, so we take some initial guesses at a grasp then pass that through the neural network and we get a score," he explained. "What the optimization does is it figures out that if the hand moves this way or that way, will the score go up. It does this all very quickly to find the best score for a successful grab."

More dexterous robots could be used at online retail fulfillment centers to pack products into boxes more efficiently. Hermans also envisions robots helping the disabled or the elderly at home by performing normal household tasks as simple as bringing a cup of coffee.

Hermans doesn't believe the role of robots would eventually take away jobs but rather be assigned chores that nobody else would want to do. They also could be given jobs that are deemed too dangerous for people, such as in mining or manufacturing.

"The quick term for that is 'we want robots to do jobs that are dull, dirty, or dangerous,'" he said.

Hermans wasn't interested in computer science when he first attended college and was instead studying math and philosophy. It was not until he joined the university's RoboCup League, a robotic soccer competition, that he became fascinated with programming for robots.

"I started working on RoboCup as a sophomore, and it quickly took over my life," he said. "Seeing my code come to life in a robot and not just in a computer – that totally changed my view of computing. That's what got me excited."

As a leading researcher in robotics, Hermans is also a faculty member of the Utah Robotics Center at the University of Utah, a multidisciplinary research center involving faculty from the U's School of Computing, Department of Mechanical Engineering and Department of Electrical and Computer Engineering. One of the top centers of its kind in the country, its faculty members and students address a diverse range of topics in robotics including intelligent agents, hybrid mobile robots, medical robots, humanoid robots, haptic interfaces, and personal assistive devices.

The university's College of Engineering has been at the forefront of robotics research, including early noted researchers such as the late mechanical engineering Distinguished Professor Stephen Jacobsen, a co-developer of the world's first wearable artificial kidney. He was also part of the team that developed the Utah Artificial Arm, a mechanical prosthetic that translated electrical pulses from muscles into arm movement. Jacobsen later launched the Utah-based robotics company, Sarcos, which designs wearable powered exoskeletons for industry and the military.

Hermans is now part of a team at the U that is taking Jacobsen's legacy and adding new and exciting innovations to the field of robotics.

"In addition to computer graphics, we have a long history of robotics at the University of Utah," he said. "We've created this interdisciplinary center where students can learn all aspects of robotics. The U is clearly one of the top programs in the United States."

As the need for coal continues to fall due to a rising interest in renewable energies like wind and solar, researchers are finding other important uses for this otherwise abundant black sedimentary rock.

University of Utah mechanical engineering assistant professor Roseanne Warren believes what's inside coal is an extremely low-cost ingredient for another source of energy – rechargeable batteries.

She and chemical engineering professor Eric Eddings are experimenting with coal char, a byproduct of coal when you heat (not burn) it. They are using the char to create anodes for sodium-ion batteries, a rechargeable battery under development that is cheaper to produce than the standard lithium-ion battery.

Warren, who specializes in new nanomaterial structures and advanced nanofabrication techniques for battery energy storage, believes sodium-ion batteries will be a promising form of rechargeable batteries for power grids for wind or solar farms that serve cities and small communities. Sodium is significantly cheaper than lithium, and the U.S. has vast reserves of soda ash or sodium carbonate (the main source of sodium ions for sodium-ion batteries), while the availability of lithium for lithium-ion batteries is more limited.

"Sodium-ion battery anodes have been made of other carbons as well as alloys and phosphates," she said. "Using coal char would be a thousand times cheaper than using these other materials like typical battery carbon materials."

A battery cell consists of two electrodes – an anode and a cathode – electrolyte, separator, as well as inactive components like packaging. In a sodium-ion battery, sodium ions move back and forth between the cathode and anode during charging and discharging, and the electrons move through whatever device is being powered.

To produce the anode, the char – which is in the form of a black powder – is mixed with a binder material that holds it together. A proprietary form of graphite is then added to improve its conductivity. This is coated on a sheet of metal that provides an electrical connection to the battery cell.

So far, Warren said the process has had good results when producing anodes with just standard char. But she is experimenting with different treatments for the char to increase the battery's energy storage capacity.

"We are doing some acid washing of the coal to try and create micropore structures and remove the ash materials," she said. "We're also trying different ways of heating the char to change its properties."

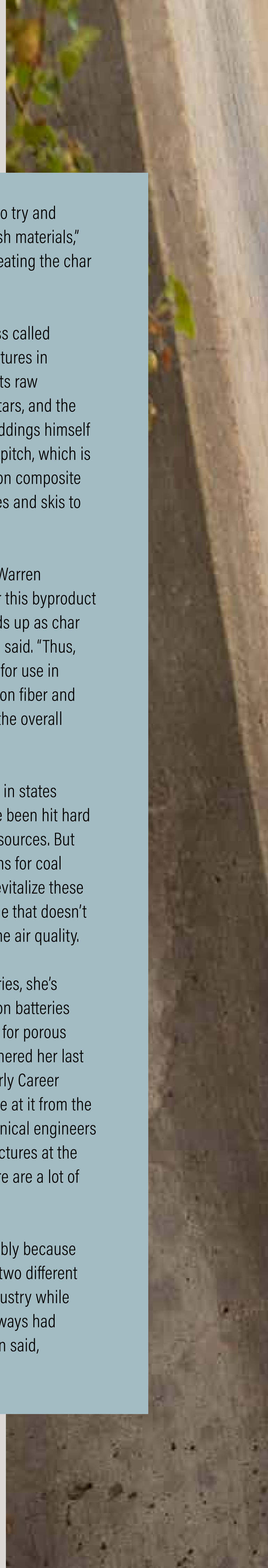
The char is derived from coal through a process called pyrolysis, when coal is heated at high temperatures in the absence of oxygen and broken down into its raw components: gases, light liquids, heavy liquid tars, and the char. Another valuable use for coal is the tar. Eddings himself is developing a process to convert the tar into pitch, which is then treated to produce carbon fibers for carbon composite materials for products from lightweight bicycles and skis to automobile parts.

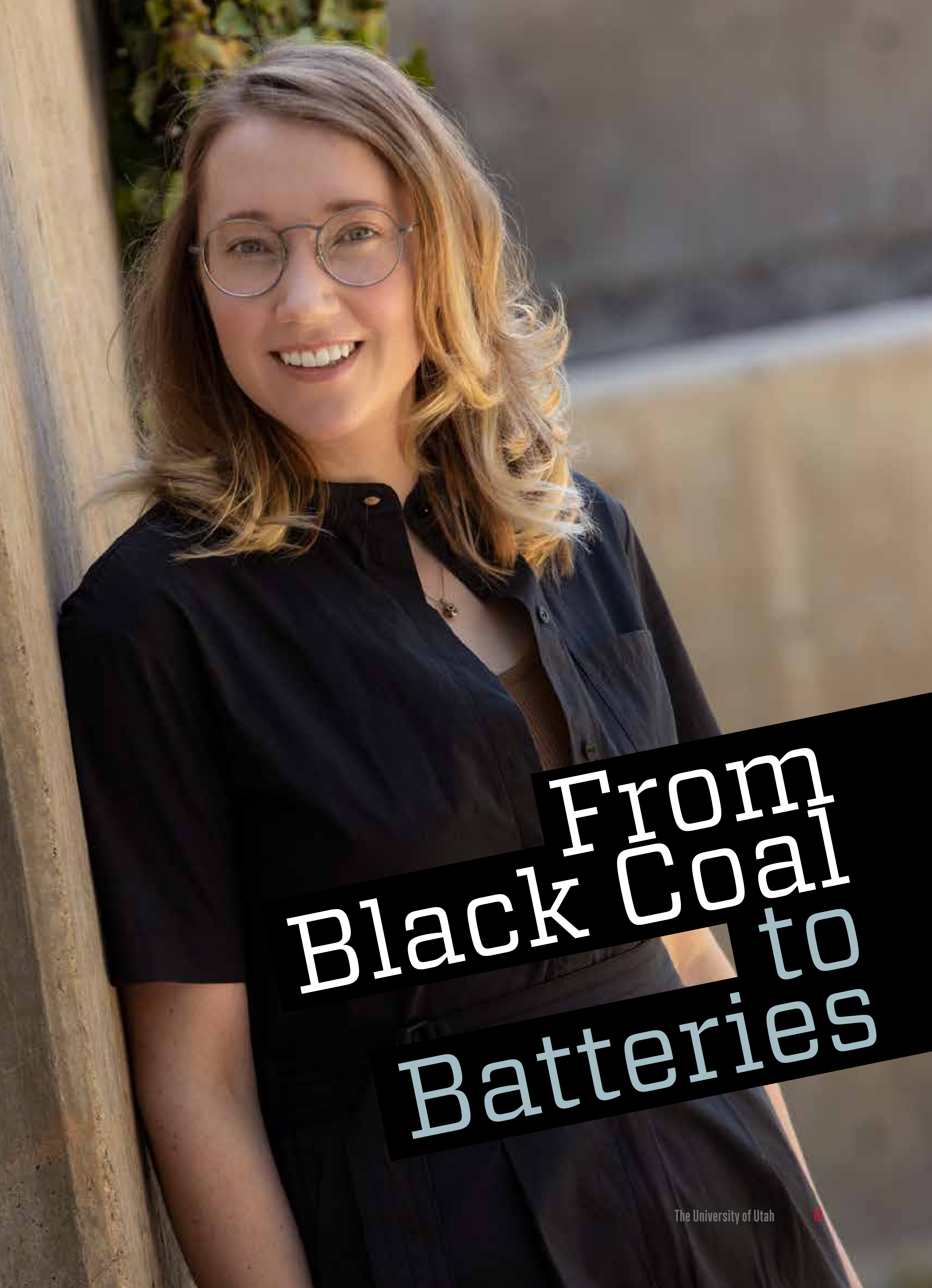
"We started exploring this research with Prof. Warren because we wanted to find a beneficial use for this byproduct char. Roughly half of the initial coal weight ends up as char during traditional coal tar production," Eddings said. "Thus, the production of coal-derived carbon anodes for use in batteries is a great parallel product to the carbon fiber and would help increase the economic viability of the overall process."

For more than two decades, coal communities in states such as West Virginia, Kentucky and Utah have been hit hard by the transition to cleaner renewable energy sources. But Warren believes the new promising applications for coal she and Eddings are researching could help revitalize these rural areas and provide a new economic engine that doesn't involve burning coal, which is detrimental to the air quality.

While Warren is researching sodium-ion batteries, she's also working with the more common lithium-ion batteries by developing a better manufacturing process for porous materials used by them, a project that has garnered her last year's National Science Foundation Faculty Early Career Development Program (CAREER) award. "I come at it from the nanofabrication perspective," she said. "Mechanical engineers can think of cool new ways to produce architectures at the nanoscale and how to manufacture them. There are a lot of applications in battery storage."

Her interest in the sciences came easily, probably because both her mother and father were chemists for two different companies – he worked for the oil and gas industry while she studied drinking-water treatments. "We always had experiments going on in the basement," Warren said, laughing. "I was absorbing it all by osmosis."





From Black Coal to Batteries

SAFE AND SECURE

Researchers at the University of Utah's College of Engineering are developing innovative solutions with AI and machine learning that could help protect the nation's infrastructure from cyberterrorists.


VIRUS ALERT
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For everyday people, a cybersecurity breach might just mean stolen credit card data or identity theft from an online store.

But stolen data and cyberattacks against ordinary citizens are just some of the disastrous consequences of a world living in a digital domain. A greater threat on a global scale are attacks from hackers that target important infrastructure systems such as oil pipelines, power grids, water treatment plants or defense department facilities. These forms of cyberwarfare are now becoming some of the most pressing national security issues of the day.

Researchers at the University of Utah's College of Engineering are developing groundbreaking technologies with artificial intelligence and machine learning to protect critical systems while also identifying cyberterrorists who attempt to infiltrate them.

LONG-TERM HACKS

U School of Computing associate professor Mu Zhang is working to stop a destructive assault known as an "advanced persistence threat," or APT attack. This is when hackers take much longer than traditional attacks – sometimes years – to sneak into a system undetected.

To find vulnerabilities in the control system for a transportation grid or a manufacturing or water treatment plant, for example, the attackers will perform internal reconnaissance to decide what to target. Then they find a way to move from one computer or device to another to pinpoint the target, find its vulnerability, and launch malware to damage the system. This is similar to when Russian hackers initiated a ransomware attack last May on the Colonial Pipeline system that resulted in the oil pipeline's shutdown.

"This slow attack is hard to capture," Zhang said. "If you look at the individual steps, they are careful not to trigger strong signals that cause an alarm to go off."

To detect if such an attack is occurring, Zhang and his team are using complex machine learning software that analyzes the cyber-physical systems of a plant (the systems software that is connected to the physical systems such as conveyor belts, data entry machines or robots on the manufacturing line). His team can build a test bed to simulate attacks across these digital and physical domains and perform algorithms to automatically extract an attack pattern.

"Machine learning can help us to not only stop the attack we know of but also the variants we have not seen before," Zhang said.

Zhang is also working to enhance the security of another kind of infrastructure – high-performance computers for scientific research.

These super computers, which are used in scientific research such as weather forecasting, air quality monitoring, nuclear engineering, and the development of new drugs, can also be susceptible to software attacks. For example, supercomputers in the UK, Germany, Switzerland, and Spain – many of them used for research into Covid-19 – were forced to shut down last year after they were attacked with malware.

Zhang's team is working on a solution called "context-aware vulnerability detection," an analysis of a high-performance computer's workload manager such as Slurm. Using multiple techniques, Zhang's software analyzes both the computer's software and it's runtime environments as it searches for malicious code that creates vulnerabilities.

"This is a real problem because it's common practice to use scientific computing for discovery," Zhang said. "Everything is computerized because they've introduced this digital layer on top of a physical layer in supercomputers, and there can be a lot of vulnerabilities which people have not thought of before."

PROTECTING THE POWER GRID

America's electrical infrastructure is attacked by hackers daily. It has become such a crippling problem that in fact the U.S. Department of Energy announced earlier this year a 100-day plan to harden electric utilities' security systems against cyberattacks.

At the UtahSmart Energy Laboratory (U-Smart) in the U's Department of Electrical and Computer Engineering, research assistant professor Jairo Giraldo and his team have built a testbed to emulate the real-time physical systems of a working electrical grid. They then deploy simulated cyberattacks to better understand how hackers launch them and the potential impacts they can cause to the grid.

With this testbed, researchers can realistically recreate a power grid's behavior including protection relays and a communications network, elements that can't be recreated in a mere computer simulation. What also makes the lab's testbed standout is the use of an NVIDIA high performance computer that focuses on advanced AI and machine learning, Giraldo said.

"The real benefit of this test bed is to identify vulnerabilities and to generate real data by simulating a power grid's communications network," he said. "That will help us build the defenses necessary to protect the grid."

Meanwhile, Giraldo and the U-Smart lab, which is led by electrical and computer engineering associate professor Masood Parvania, are also developing tools that can help electric utilities detect problems in the grid, classify whether they are a fault caused by an accident or a cyber-attack, and locate where the problem is. These tools can also temporarily restore power by automatically tapping alternative sources such as batteries, solar panels, or other renewable energy sources.

"The power grid is a critical infrastructure," Giraldo said. "Being able to find faults or attacks in seconds is important, otherwise it will be a huge problem for a community."

KEEPING WIRELESS SIGNALS SAFE

Another vital piece of the country's infrastructure is its wireless communications spectrum. Because managing a wireless network relies on software and internet connectivity, it too is susceptible to hacking, said U School of Computing professor Sneha Kasera. His research is focused on monitoring the wireless spectrum for unwanted signals.

In projects with the Idaho National Laboratory and Nokia Bell Labs, Kasera is developing machine learning algorithms for software-defined radios (radio communications systems with functions performed in software instead of hardware) that identify unlawful signals, such as when a hacker tries to interrupt tower communications at an airport.

"We have state-of-the-art algorithms for localizing where the problem is," he said. "We use software-defined radios to look at the data and the strength of the data. Then we use the algorithms to locate the signal."

The ability to monitor radio jamming or the illegal use of a radio frequency is essential for first responders, air traffic control, industrial communications, national defense communications, and more, Kasera said.

"These are important problems to address for the future," he said. "People don't want to be tethered to anything, so it's all becoming wireless. We do this research in anticipation of these problems."

The world is becoming increasingly dependent on critical infrastructures that provide people with energy, water, and other valuable resources. Researchers at the University of Utah's College of Engineering are dedicated to developing new methods to ensure these systems run smoothly and remain safe from cyberattacks.

SUSTAINING UTAH'S TECHNOLOGY WORKFORCE

One of Utah's best-kept secrets is the College of Engineering's critical role in sustaining the state's technology workforce. After more than tripling its enrollment in the past 20 years to a record 6,000 majors, the college awards a whopping 46% of the BS, MS and Ph.D. engineering and computer science degrees in Utah's statewide system of higher education (USHE). Utah State University comes in second at 25%.

That means University of Utah's technical graduates are essential to Utah's booming economy, ranked number one by *U.S. News & World Report*. According to CompTIA Cyberstates, Utah's net tech employment is 152,000, or roughly 9% of the total workforce, and growing. According to the 2021 report, there are 35,035 employer job postings.

Utah's continued number one ranking hinges on the college's capacity for future growth. Luckily, student demand is strong. In 2004, roughly 7% of the University of Utah's first year students were opting for engineering or computer science degrees. That number has since risen to as high as 23%. These students represent a diverse group of academically excellent undergraduates who are committed to improving their communities.

Perhaps most important is the exceptional quality of the graduates. With a rigorous undergraduate curriculum, the College of Engineering attracts the highest performing students on campus. In addition to classroom instructions and labs, students are immersed in research beginning at the undergraduate level. By their junior and senior year, capstone projects teach students the process of applying engineering fundamentals to address real-world problems.

A high percentage of College of Engineering students choose to enrich their educational experience by participating in the Engineering Entrepreneurship Certificate program, the annual Bench-to-Bedside competition and the Lassonde Entrepreneur Institute. One in five of the Honors students come from the College of Engineering. They share a common desire to use their technical skills for the benefit of their community.

One such group includes students Matt Mattucci, Jamie Hughes, Brock McCloy, Adam Ervin, Aaron Killpack, Jamie Law, and Zack Roberts, whose capstone project for mechanical engineering involved creating a portable ophthalmic eye examination station for doctors working in remote areas. Key components of their field equipment included: a sturdy flat table, a frame to support patients' heads and keep them stationary during eye examinations and charging options for a portable electronic slit lamp. The project was completed in collaboration with physicians at the U's Moran Eye Center.

Leo Geng and his team of two electrical and computer engineering graduate students and a mechanical engineering undergrad collaborated on creating a virtual reality device adapted for physical therapy for autistic persons and/or those with other disabilities. This adaptive device could provide therapeutic and educational opportunities for persons who may be unable to use conventional VR equipment.

Biomedical and mechanical engineering undergraduates Andrew Eyre, Tayt Cooper, and David Doane worked together on a smart shoe sensor array insert which, when paired with an app, coaches wearers into correct posture and gait when lifting, running, etc. The insert could one day help construction workers, delivery drivers, athletes and others reduce or prevent injuries due to incorrect lifting techniques.

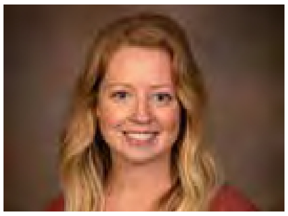
Some student projects help to extend advances in research in areas that are already well-established and ongoing. Kai Pruyn's team of students from materials science and engineering and biomedical engineering have been working with faculty and other researchers on the Utah Bionic Leg, which takes prosthetic leg technology to the next level. The goal is a robotic leg prosthesis that replicates key biomechanical functions of the biological leg while matching the weight, size, and robustness of conventional microprocessor-controlled prostheses. The leg enables individuals with above-knee amputation to walk, climb stairs, cross over obstacles, squat, lunge, sit, and stand while moving easily from one activity to the next.

College of Engineering graduates are in high demand among companies both locally and nationally. And, thanks to the college's entrepreneurial environment and reputation for technology commercialization, students are entering the workforce well-prepared to succeed and to lead. Not only are they finding jobs in Utah industry, many are working on technologies that turn into products and companies.

Going forward, the Utah economy and lifestyle will rise, or fall, on access to a highly skilled, technical workforce. As the state's primary provider of highly skilled, technical graduates, the College of Engineering must remain mission-focused. And, it will continue to foster ingenuity, creativity and innovation as if our lives depend on it.

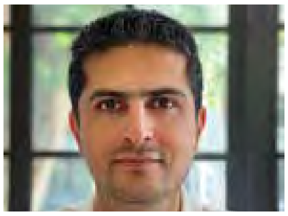
NEW FACULTY

The University of Utah's College of Engineering is well known for its renowned faculty members who are not only top educators but also world-class researchers. This year's group of new tenure-track faculty members will bring innovative ideas that push the boundaries of scientific research.



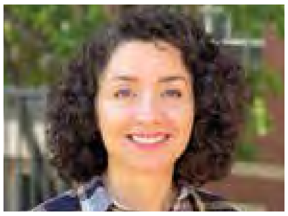
EMILY MARRON

ASSISTANT PROFESSOR CIVIL AND ENVIRONMENTAL ENGINEERING



KAMI MOHAMMADI

ASSISTANT PROFESSOR CIVIL AND ENVIRONMENTAL ENGINEERING



SHAHRZAD ROSHANKHAH

ASSISTANT PROFESSOR, CIVIL AND ENVIRONMENTAL ENGINEERING

DAN SCOTT DREW

ASSISTANT PROFESSOR, ELECTRICAL AND COMPUTER ENGINEERING

JACOB GEORGE

ASSISTANT PROFESSOR, ELECTRICAL AND COMPUTER ENGINEERING

ELIYA COHEN

ASSISTANT PROFESSOR, ENTERTAINMENT ARTS AND ENGINEERING

ZLATAN AKSAMIJA

ASSOCIATE PROFESSOR MATERIALS SCIENCE AND ENGINEERING

CHEN WANG

ASSISTANT PROFESSOR, MATERIALS SCIENCE AND ENGINEERING

EDOARDO BATTAGLIA

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

TIANLI FENG

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

ASHWIN RENGANATHAN

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

HAOHAN ZHANG

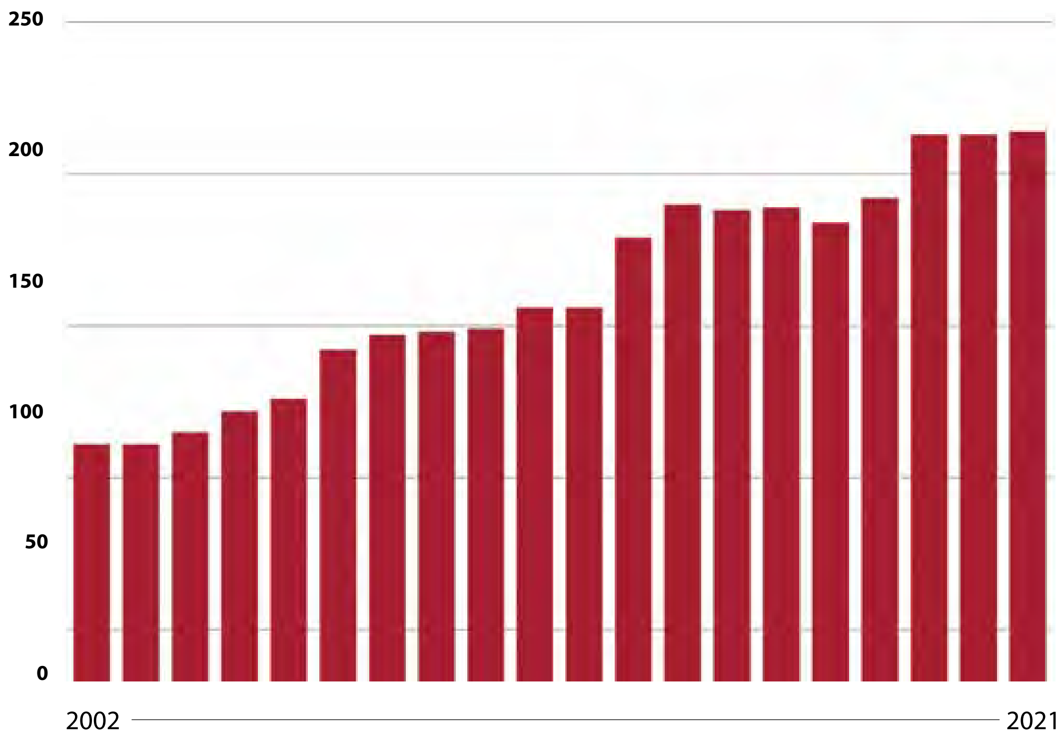
ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

SAMEER PATIL

ASSOCIATE PROFESSOR, SCHOOL OF COMPUTING

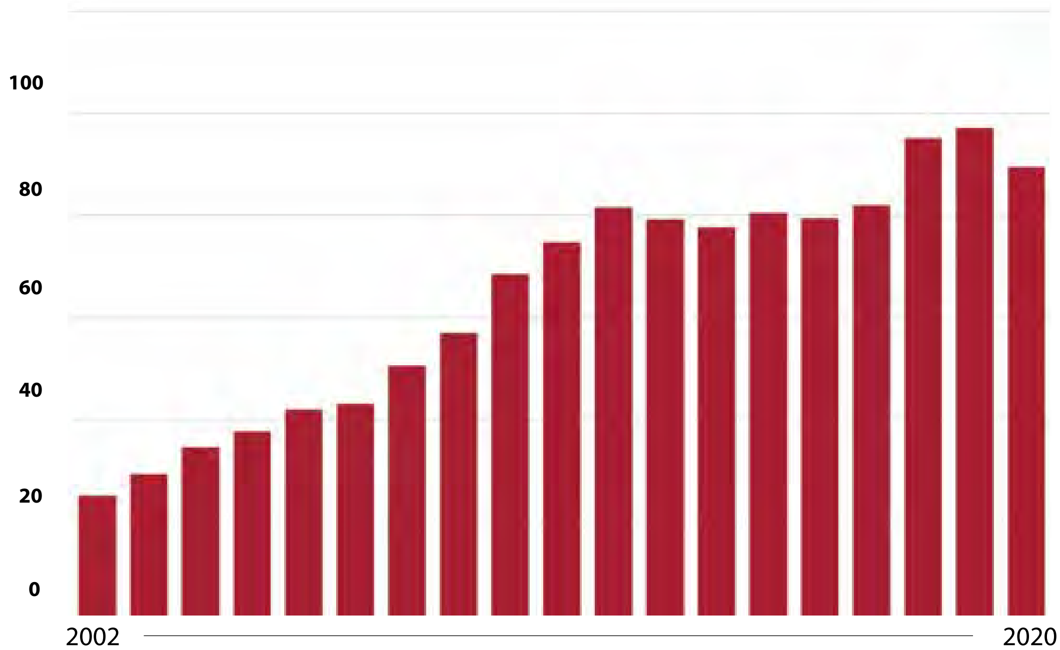
BY THE NUMBERS

TENURE TRACK FACULTY GROWTH



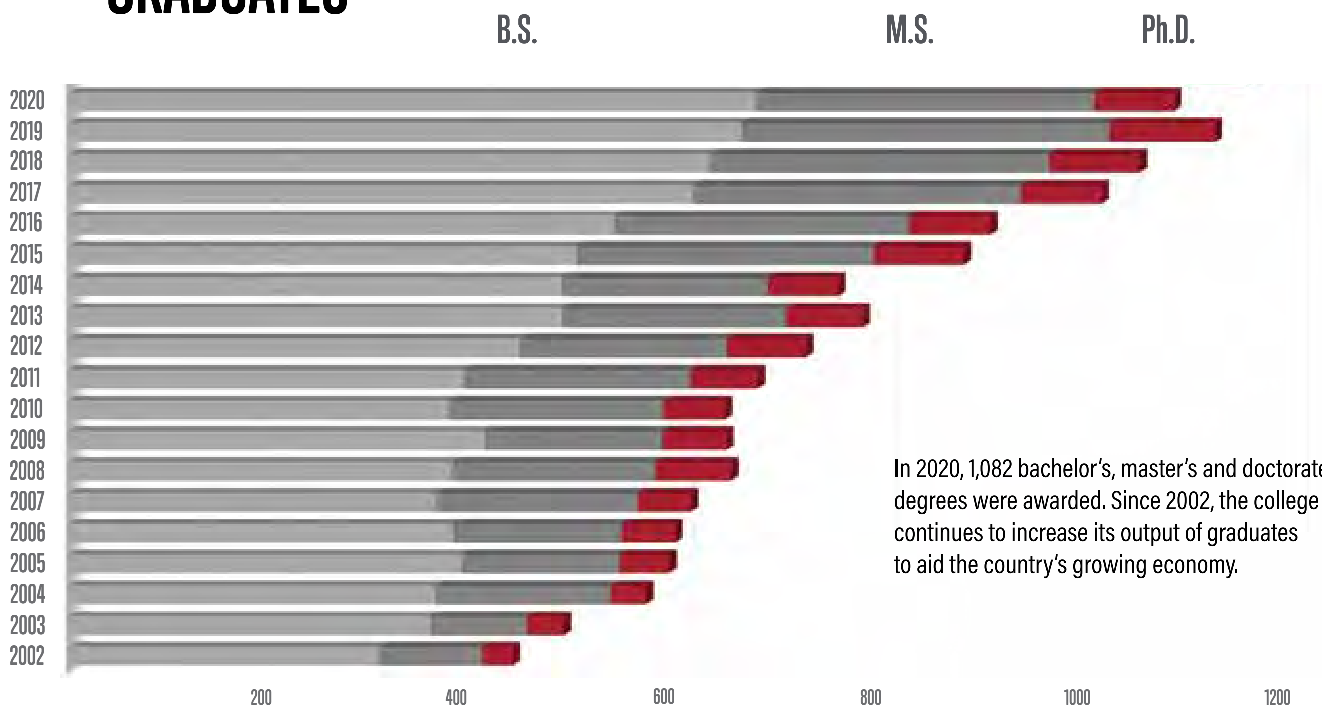
The College of Engineering is dedicated to hiring the world's finest researchers and educators. In a sign of its continuing growth, the college currently has 214 tenure-track faculty members, a 93% increase since 2002.

ENGINEERING RESEARCH EXPENDITURES AT THE U



Research is the lifeblood of the college, and despite the ongoing Covid-19 pandemic, faculty members continued to attract engineering-related research funding to further develop technologies ranging from medical devices to methods that improve air and water quality. In 2020, the college generated $89.4 million in research expenditures (including sub-awards).

GRADUATES



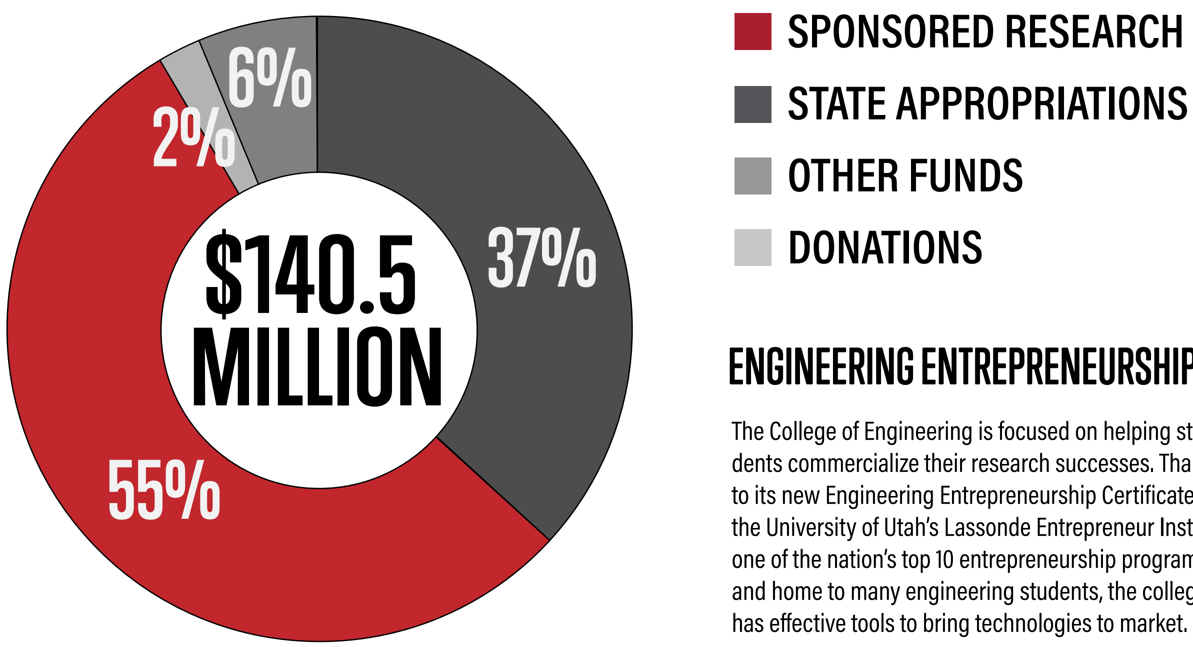
In 2020, 1,082 bachelor's, master's and doctorate degrees were awarded. Since 2002, the college continues to increase its output of graduates to aid the country's growing economy.

RANKINGS

The College of Engineering is viewed favorably around the country for its continued commitment to excellence. Here are just a few of its rankings according to the most current statistics from the 2020 Profiles of Engineering & Engineering Technology by the American Society for Engineering Education.

- Research expenditures — #41 (out of 214 schools)
- Engineering doctoral degrees awarded — #50 (out of 254 schools)
- Doctoral enrollment — #35 (out of 258 schools)
- Tenured/tenure-track faculty members #32 (out of 260 schools)

ENGINEERING BUDGET 2019-2020



ENGINEERING ENTREPRENEURSHIP

The College of Engineering is focused on helping students commercialize their research successes. Thanks to its new Engineering Entrepreneurship Certificate and the University of Utah's Lassonde Entrepreneur Institute, one of the nation's top 10 entrepreneurship programs and home to many engineering students, the college has effective tools to bring technologies to market.

ALUMNA PROFILE

JEANETTE HAREN

The story of Jeanette Haren's journey from receptionist at Evans & Sutherland (E&S) to vice president for product management for the nation's largest educational technology provider is a profile in courage, hard work and determination. A non-traditional, first-generation college student, Jeanette leveraged E&S 's tuition reimbursement program with tuition benefits from an eight-year stint in the U.S. Army Reserves to fund her degree in computer science.

"Working around Dave Evans, and all of the other really intelligent engineers inspired me to want to become an engineer," Jeanette recalls. "I worked full-time at E&S while going to school full-time." And, while Jeanette's career path wasn't easy, she credits a difficult beginning with her willingness to take risks to achieve success.

Jeanette advanced from receptionist to computer analyst and was writing code for E&S in the 1980's when then Governor Michael Leavitt became fascinated by the "information highway." He predicted that the internet would transform educational delivery systems. Jeanette left E&S and joined the newly formed team, Utah Education Network (UEN), to execute on Leavitt's vision. UEN started as a broadband and digital broadcast network serving schools, libraries, universities and colleges throughout the state. As head of Software Development, Jeanette led a programming team that developed an internet education system that was integrated into all K-12 classrooms in Utah.

While there, she developed UTAP (Utah Technical Assistance Project), a software self-assessment tool that allowed teachers to benchmark their progress in adapting to new technology, and to get additional training when needed. "In those days, things were much different. We were helping teachers learn how to use email, for example, and conduct internet searches," said Jeanette. Next, she was recruited by Campus Pipeline (CP) as Director of Product Architecture, where she designed and implemented the company's higher education portal systems. Other states took notice of the UTAP system and wanted their own version.

Jeanette decided to rebuild the platform and license it to manage all professional development opportunities for teachers in K-12 school districts nationwide. When Campus Pipeline fell victim to the "Dot-Com collapse," Jeanette co-founded her own company, Truenorthlogic (TNL) and created a one-of-a-kind comprehensive approach to supporting the cycle of continuous educator improvement and its connection to student achievement.

For the next 15 years as TNL's Chief Product Officer and Chief Executive Officer, Jeanette worked with K-12 school districts across the country to customize professional growth systems. By 2012, she was leading the most successful Human Capital Management SaaS (software-as-a-service) company in K-12, with over 1,500,000 users nationwide and a triple-digit growth rate. Jeanette credits the well-rounded education in computer science she received at the U with her ultimate success as a business leader. As TNL's CEO, she was no longer writing code, but understanding the technology from the bottom-up helped her to make smart business decisions.

In 2016, Truenorthlogic merged with Performance Matters, with Jeanette overseeing the vision, architecture, and direction of products, including all of the educator effectiveness and student assessment products. Today, these assets are part of PowerSchool, the leading provider of K-12 education application technology supporting over 45 million students in more than 70 countries, with Jeanette serving as Vice President of Product Management.

PowerSchool's online tools took on new importance during the pandemic as schools and teachers are now trying to measure learning loss, particularly among disadvantaged students. "Today, learning management systems have moved from 'nice to have, to must have," she commented.

Working for such a large company, Jeanette is once again on a learning curve. "If you're not a little uncomfortable on your job," she says, "you're not growing. At PowerSchool, the numbers are just so big, you have to think of things differently. It's a different skillset where everything moves faster, and every moment matters."

Jeanette continues to support he College of Engineering as a member of the Engineering National Advisory Council and participates in student outreach activities when time permits. "I would love to see more girls choosing STEM careers because they bring a different perspective to engineering projects which ultimately leads to stronger solutions."

Throughout her career building and leading diverse teams, however, Jeanette never defined herself as the woman in the room. "I simply focused on the problem and what it would take to get the job done."

ENAC

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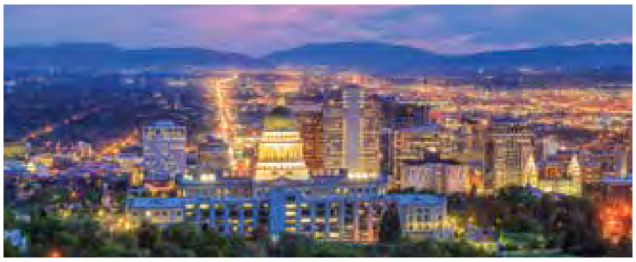
Information Security
and Compliance Officer
Tula Health

MULTIDISCIPLINARY RESEARCH CENTERS AND INSTITUTES

- Alliance for Computationally-guided Design of Energy Efficient Electronic Materials
- Biomedical Image and Data Analysis Center
- Cardiovascular Research and Training Institute
- Center for Controlled Chemical Delivery
- Center for Engineering Innovation
- Center of Excellence for Biomedical Microfluidics
- Center for Extreme Data Management Analysis and Visualization
- Center for Multi-Scale Fluid-Solid Interactions in Architected and Natural Materials
- Center for Neural Interfaces
- Center for Parallel Computing at Utah
- Energy & Geoscience Institute
- Global Change & Sustainability Center
- Intel Graphics and Visualization Institute
- Intermountain Industrial Assessment Center
- Manufacturing Extension Partnership
- NIH Center for Integrative Biomedical Computing
- NSF Center of Excellence for Large Facilities Cyberinfrastructure
- NVIDIA CUDA Center of Excellence
- Scientific Computing and Imaging Institute
- University of Utah Robotics Center
- Utah Center for Data Science
- Utah Center for Inclusive Computing
- Utah Center for Nanomedicine
- Utah Nanofab

LIFE IN UTAH



With its vibrant tech sector and unrivaled scenic beauty, Utah is the place where innovation thrives. Home to more than 8,100 tech-focused companies, the state has the second fastest-growing technology industry in the U.S. and has been called "the next Silicon Valley." If that weren't enough, it's also one of the greatest places on Earth to live and play. Here are recent accolades Utah and Salt Lake City have received from national media outlets.

UTAH

#1 Best Economy — 24/7 Wall St.
#1 Most Independent State — WalletHub
#1 Best State for Employment — U.S. News & World Report
#1 Best State for Entrepreneurs — Forbes
#1 State for the Middle Class — SmartAsset
#1 Best States to Start a Business — Seek Business Capital
#2 Happiest States in America — WalletHub
#2 Best Ski Vacations in the USA — U.S. News & World Report
#2 Best States for Winter Activities — GoAllOutdoors.com
#3 Best States for Business — Forbes
#3 Best Economy — Information Technology & Innovation Foundation
#4 Top State for Business — CNBC
#4 Top Ski Resorts in North America (Snowbird and Alta) — USA Today

SALT LAKE CITY

#1 Best Cities for Millennials — Rent.com
#1 Best Place to Start a Career — WalletHub
#1 Most Fiscally Fit Cities — State Farm Insurance/Best Places
#3 Best Cities to Start a Career — Zippia
#4 Best Cities for Singles — WalletHub
#4 Most Attractive City (Salt Lake City) — Travel & Leisure
#5 Best-Looking Cities — Total Beauty

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