Spring 2024

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TAKING FLIGHT

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LEHIGH UNIVERSITY | P.C. Rossin College of Engineering and Applied Science

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LEHIGH UNIVERSITY

Driving impact through innovation

Welcome to the Spring 2024 issue of *Resolve*—a magazine dedicated to research and educational innovation in the P.C. Rossin College of Engineering and Applied Science at Lehigh University.

This issue gives us a chance to reflect on the rapid advancement of robotics at Lehigh and the investments made by the university, the college, and our community of supporters that made it happen.

Forward-thinking philanthropy led the way in transforming the massive Building C into a state-of-the-art technology hub and establishing our Autonomous and Intelligent Robotics Laboratory (AIR Lab) as a center for exploring the "science of autonomy."

In the six years since Building C opened its doors, our robotics faculty numbers have quadrupled, we have created five new student robotics competition teams, and our research community is staking its claim in aspects of the field with the potential for meaningful social and technological impact.

FORWARD-THINKING PHILANTHROPY LED THE WAY IN TRANSFORMING BUILDING C INTO A STATE-OF-THE-ART TECHNOLOGY HUB.

Our rapid growth in this area emulates the built-from-scratch drone pictured on this issue's cover. Each part of the design—building on existing faculty strengths and bringing in new expertise, investing in facilities, and engaging students from middle to graduate school—was integrated into something that is distinctly Lehigh. The building's unique high bay structure even contributed to making our campus the obvious choice to host a recent national-level university competition in aerial robotics.

As the AIR Lab and robotics at Lehigh continue their ascent, this issue of *Resolve* celebrates the accomplishments of this research community growing in Building C.

Research, after all, is all about impact. So I am delighted to also report on some recent recognition of our efforts to nurture and promote research endeavors that translate into real-world application.

In December, the National Science Foundation granted Lehigh a four-year, $6 million award to increase the scale and pace of advancing academic research into solutions that benefit and serve the public. The 16-member team behind the proposal, led by John Coulter, senior associate dean for research, represents all five Lehigh colleges and includes four co-principal investigators and 11 senior personnel.

Lehigh was one of five institutions, out of 18 awardees, to secure full proposal funding—an indication that our team was among the best in the country at putting forth a university-wide plan with a truly interdisciplinary focus.

The award will help us speed up and scale our research activities in engineering, health, biological sciences, humanities, business, education, and myriad other areas to generate products and services for the general good. Lehigh is also innovating in associated graduate-level academic programs, training graduate students and postdoctoral scholars in translational research and commercialization who work closely with companies seeking to solve technical challenges.

Elsewhere in the issue, we delve into intriguing work—connecting our college and Lehigh's College of Health—that is improving accessibility of indoor spaces for people with vision and mobility challenges. We also catch up with Kathleen Taylor '87, a tireless supporter of the Rossin College throughout her years at Johnson & Johnson and, most recently, Kenvue.

I hope you enjoy this edition of *Resolve*; please drop me a line with your thoughts and comments.

Stephen P. DeWeerth, *Professor and Dean*
P.C. Rossin College of Engineering and Applied Science
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THIS PAGE: RYAN HULVAT; OPPOSITE PAGE: CHRISTA NEU

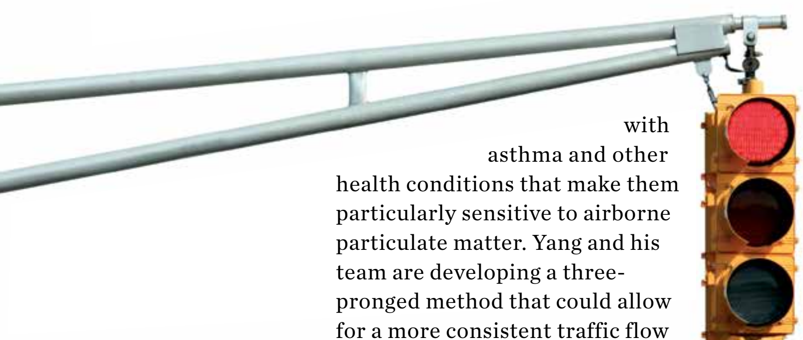
Driving change in urban air quality with machine learning

After a summer that broke all sorts of dismal records in terms of cataclysmic wildfires across North America, there is now an even greater awareness of poor air quality—its myriad health impacts and the overwhelming need for sustainable solutions.

To that end, Yu Yang, an assistant professor of computer science and engineering, is leading two research projects, with new support from the National Science Foundation, ultimately aimed at improving the air we breathe.

The most recent award will fund his work using machine learning techniques to develop socially informed traffic signal control systems to reduce air pollution caused by vehicle emissions.

In dense urban areas, cars and trucks idling at stoplights can contribute to localized air pollution. It's a problem for everyone—but especially for people



with asthma and other health conditions that make them particularly sensitive to airborne particulate matter. Yang and his team are developing a three-pronged method that could allow for a more consistent traffic flow with fewer and/or shorter stops to minimize polluting emissions.

They will first develop a low-cost, mobile air-quality sensing system to identify areas of high pollution and collect the social requirements of different areas. An area with a hospital, for example, might harbor large numbers of sensitive individuals.

"We'll use those data to then develop a spatial-temporal graph diffusion learning model to determine the traffic situation in our test bed city of Newark, New Jersey," says Yang. "In other words, what is both the traffic and the air pollution like at different points of time in different locations?"

Finally, the researchers will use a reinforcement learning method that will incorporate traffic signals around the city and simulate how traffic signal control helps improve air quality.

"Ours is the first project of its kind to incorporate a social component into a traffic control system," says Yang. "We are taking both a technical and a social perspective to solve this real-world problem."

Ultimately, Yang envisions a traffic management system that would enable city transportation officials to control signals in real time, along with a web-based system that would show city residents location-specific air quality levels so they can make informed decisions about what activities they do and where they do them.

Yang's work on traffic management for improved air quality extends to other modes of transportation, namely electric bikes and scooters. In a separate project, also supported by NSF, he is looking at how to make micromobility systems—shared systems where users rent these types of alternative vehicles for transportation—more efficient.

"Cities can have thousands of these vehicles, and so the problem becomes managing them and making sure the location of the vehicles satisfies the demand for them," he says.

He and his team are designing an algorithm to determine the best strategy for ensuring that, on a daily basis, sufficient numbers of these types of vehicles are located in areas of high demand, and that those vehicles are sufficiently charged.

Their approach will also consider human-system interaction, like how people actually select and interact with the vehicles, he says. "The existing work in this area assumes that people just randomly pick their ride. But that's not the case. People have preferences for things like how the bike or scooter looks and how much charge it has. Incorporating this kind of information will help us optimize our algorithm so it reflects how people actually use the system."

He envisions a system that will generate a daily strategy based on the current location and charge level of all vehicles. "Based on the optimal strategy, the operation center responsible for them can send out their employees and trucks in the night to both charge and transport the bikes or scooters to the areas that will satisfy the next day's demand."

In both projects, the human element plays a key role, says Yang. "These are real problems that citizens are experiencing every day, and by incorporating how people are affected by and affect these systems, we can make them better for everyone."

FROM TOP: PHOTO ILLUSTRATION BY KATIE KACKENMEISTER; JIM MILLS/ADOBE STOCK; MAYA2008/ADOBE STOCK

AI TOOL COULD LEAD TO A BETTER UNDERSTANDING OF BRAIN DISEASES

Breaking the mold for more sustainable concrete construction

Lehigh researchers have developed a method for concrete construction that combines 3D printing and topology optimization, a mathematical method of distributing material in an efficient way for a given design space.

"While using 'old' ingredients," says Paolo Bocchini, a professor of civil and environmental engineering (CEE), "this new manufacturing technology effectively gives us access to a new construction material, 3D printed concrete, which enables the creation of completely new geometrical shapes, exceptional structural efficiency, and superior environmental sustainability."

Xingjian Wang '19G '24 PhD worked on the technology, called 3D printing by selective binder activation, while a doctoral student under the supervision of Bocchini and CEE faculty members Clay Naito and John Fox. The team also includes architecture professor Nik Nikolov (College of Arts and Sciences), PhD student Urinrin Otite, and Buzzi Unicem USA.

The approach uses topology optimization to guide the design of structures.

Currently, structures often contain too much material in areas that aren't responsible for bearing heavy loads but exist to simplify construction. For example, rectangular cross sections, constant throughout the length of a beam, do not use material efficiently. Optimizing the design of such features can ensure materials aren't wasted, thereby minimizing the cost and environmental impact of building projects.

3D printing brings those optimized designs to life.

In traditional concrete construction, concrete is poured into a specially designed mold—often made of wood—called formwork. It holds the concrete until it's cured, but it's a resource-heavy and labor-intensive part of the process.

Together with his colleagues, Wang has helped develop a method that doesn't require such a mold. And, unlike other 3D-printing techniques in use for building large-scale structures (like bridges), their method does not extrude wet concrete paste, says Wang.

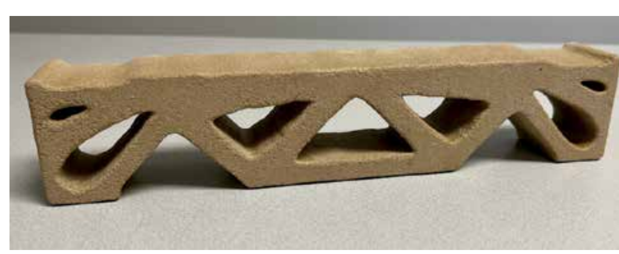
Instead, it deposits two materials separately onto a build platform. The first material is a dry powder of cement and fine sand. The second is called binder activator, which is about 95 percent water and serves to activate and hydrate the cement. The aqueous activator is deposited selectively onto a thin layer of dry powder forming the geometry of the structure. As the procedure is repeated, the structure is supported by the surrounding nonactivated powder and no external assistance is necessary.

"Using this technique, we can also print a structure with cavities and overhangs, which you can't do with typical 3D printing by material extrusion because wet concrete can't hang there without support," he says. "So we could print a wall with openings for windows and doors."

Designs produced via the technique are featured in an exhibit at the National Museum of Industrial History (pictured below) and appeared on a recent cover of *Structure* magazine.

Wang is inspired by the potential of the technologies to both reduce the carbon footprint of the construction process and drive creativity.

"This method gives you design freedom," he says. "You can create whatever you can imagine."



Learn more about 3D printed concrete in this video.

PHOTOS COURTESY OF LEHIGH CEE

Brain networks are often represented by graph models that incorporate neuroimaging data from MRI or CT scans to represent functional or structural connections within the brain. These brain graphs can be used to understand how the organ changes over time. Traditionally, however, these models treat the brain graphs as static, which can miss or ignore changes that could signal the onset of disease or disorders.

An NSF-funded research team led by Lifang He, an assistant professor of computer science and engineering, with collaborators from the University of Pittsburgh and Emory University, will develop new methods for modeling the dynamics of brain graphs using artificial intelligence that will generate more accurate, interpretable, and fair predictions when it comes to disease.

"A static graph represents a single point in time," says He. "In contrast, a dynamic graph represents multiple images taken at multiple points in time. We'll be using a new AI method called neural ODE, or ordinary differential equation, to analyze these dynamic brain graphs. The ODE is adept at capturing dynamics in continuous time that could unveil the progression of disease."

Neural ODE combines deep learning with concepts from ordinary differential equations, and it allows a neural network to model both continuous change and sudden discontinuous change that can lead to more accurate predictions. She says this AI tool will also facilitate the discovery of biomarkers—genetic traits, changes, or alterations associated with the brain—that can help detect disease or disorders.

The project could help reshape deep learning techniques for temporal data mining in bioinformatics and healthcare technologies.

The new methods, says He, "could revolutionize our approach to both diagnosis and treatment."

A trifecta of cover-worthy research

Journal covers highlighted the research of Lehigh chemical and biomolecular engineering teams several times in recent months.

Expanding the 'toolbox' for bioelectronics

A *Chemistry of Materials* cover (Nov. 14, 2023) illustrates the work of lead author Zeyuan Sun, a PhD student in the group led by Elsa Reichmanis, Professor and Carl Robert Anderson Chair in Chemical Engineering, and their team.

"Our research studied a distinctive class of polymers, known as organic mixed ionic-electronic conductors (OMIECs), that could efficiently conduct electronic charges and transport ions simultaneously," says Sun.

He says these materials show promise in the expanding field of bioelectronics—particularly in the development of organic electrochemical transistors (OECTs).

Ultimately, by unraveling the fundamental structure-property relationship associated with the complex interplay of ionic-electronic coupling, polymer properties, and device performance, Sun and his team have expanded the "synthetic toolbox."

"The growing field of bioelectronics, where electronics meets biology, could lead to the creation of innovative medical devices for treatment and diagnosis," he says.

Working toward more efficient catalysts

Bohyeon Kim, a PhD student in the group led by department chair Steven McIntosh, Zisman Family Professor of Chemical and Biomolecular Engineering, is co-lead author of the paper featured by *ACS Catalysis* (Nov. 3, 2023).

"In our study, we showed enhancement in production efficiency of 2,5-furandicarboxylic acid (FDCA) from hydroxymethylfurfural by using bimetallic catalysts," says Kim. "FDCA is considered as a promising monomer for bioplastic polyethylene furanoate as a replacement of petroleum-based plastic polyethylene terephthalate, or PET."

Kim says the design of the bimetallic catalysts is unique. "Unlike the conventional bimetallic catalysts, we applied Cooperative Redox Enhancement (CORE), whereby physically separated dissimilar nanoparticles electrochemically couple to provide a significant enhancement in reaction rate. The CORE phenomenon was recently discovered through collaboration between the McIntosh and Kiely groups at Lehigh and the Hutchings group at Cardiff University (UK)."

Their research, he says, addresses an electrochemical phenomenon that's common but poorly understood in thermocatalysis: electrochemical polarization in mixed thermocatalytic systems.

"By delving into the electrochemical coupling of catalytic sites and identifying the CORE effect, the study contributes to a deeper understanding of the mechanisms that drive catalytic reactions," he says.

An advance for 'E-ink' displays

Samuel Wilson-Whitford, a former postdoctoral researcher in the lab led by professor James Gilchrist, is lead author of the study featured on the cover of *Soft Matter* (Dec. 21, 2023).

"This research asked, 'Can you make little capsules of particles so that when the magnetic field changes, the amount of light going through the capsule also changes?'" says Gilchrist, the Ruth H. and Sam Madrid Professor of Chemical and Biomolecular Engineering.

The problem is relevant to what's known as "E-ink," or electronic ink, which is technology used in e-readers.

"E-ink displays can be slow to refresh, and they have electrodes that make them somewhat delicate," says Gilchrist. "We wanted to know if we could create magnetically responsive systems without electrodes that change how much light goes through the material, allowing a device to refresh faster and be more impact resistant."

Wilson-Whitford led the team in the design of a novel microencapsulation approach they coined "the soup dumpling process." Nanoparticles called Janus particles half-coated in iron oxide to make them magnetic were placed within a gel inside a capsule. The gel was then emulsified into the oil phase, which limited the particles' tendency to move and stick to the droplet interface.

Limiting that movement presented a "Goldilocks problem." They had to make the gel strong enough so that the particles couldn't move to the walls of the capsule, but weak enough so that when they applied a magnetic field, the particles could find each other through the gel, stick to each other, and make the chains that could then rotate their orientation. It had to be "just right."

"We designed the fluid on the inside to have these non-Newtonian properties that would hold the particles in place well enough while we form the capsules," he says, "but then allow them to rotate when we added enough magnetic force, which changed the amount of light going through them."

COVER ILLUSTRATIONS FROM LEFT: ELLA MARU STUDIO; NICOLLE R. FULLER/SAYOSTUDIO (2)

Unlocking hydrogen's potential

Hydrogen is the lightest, most abundant element on earth. It also serves as an energy carrier, and as such, holds great promise when it comes to decreasing reliance on fossil fuels. The problem is that current methods of storing and transporting the molecule can be unsafe, inefficient, and expensive.

A multi-institution, multidisciplinary group of researchers led by Lehigh recently received a $1.7 million grant from the National Science Foundation to fund the collaborative development of a new class of molecules, chemistries, and chemical processes to better store and transport green energy across the globe.

The team, which is led by Srinivas Rangarajan, an associate professor of chemical and biological engineering, includes investigators Dharik Mallapragada (New York University), Elizabeth Biddinger (City College of New York), and Daniel Resasco and Steven Crossley (University of Oklahoma). "This is a convergent effort where we're looking at this problem from the atomic scale all the way up to global supply chains," says Rangarajan.

Variable energy sources, such as wind and solar farms, can generate more electricity than is needed at any given time. If a system were to pass that energy through water, the water would split into oxygen and hydrogen, with the resulting hydrogen molecules containing the renewably generated energy. Those molecules could then be stored and transported to where power is needed—like a manufacturing or chemical plant, a university or school, or a community of apartments or houses—and later burned to harness the reserved energy.

"Hydrogen is one of the lightest energy carriers, which is good because the amount of energy per gram of hydrogen is very high," says Rangarajan. "But a gram of hydrogen also requires a lot of storage volume, unless you go to really low temperatures and really high pressure. So if you want to transport it over long distances, liquefied hydrogen has to be stored at cryogenic temperatures at hundreds of pounds of atmospheric pressure."

One technique currently in use to overcome this two-fold problem of transport and storage utilizes liquid organic hydrogen carriers, or LOHCs. Essentially, hydrogen is added to an organic molecule—called an hydrogen-lean molecule—that is liquid under ambient conditions to form another molecule which is also liquid, the hydrogen-rich carrier.

Rangarajan and his colleagues are investigating a new class of alcohol-based molecules, a new class of chemistries, and associated chemical processes that could potentially increase the hydrogen storage capacity of the LOHC technology and make the molecules safer to transport and handle. Their approach could also make the process more efficient by decreasing the energy penalty associated with the hydrogenation and dehydrogenation processes, steps in which some energy is normally lost.

"We're at a tipping point now with hydrogen," he says. "The U.S. is planning to spend $8 billion to build hydrogen hubs to produce hydrogen and use it to power transportation and industry. A breakthrough could open up new economies and create a global supply of renewable energy."

TOP: LYUDINKA/ADOBE STOCK; BOTTOM: HOLLY FASCHING '26

DETECTING CANCER CLUES WITH BIOSENSORS

An interdisciplinary team led by Anand Jagota, Lehigh's vice provost for research, with Brian Davison, chair of the Department of Computer Science and Engineering, will study DNA-wrapped carbon nanotubes as nanosensors that detect molecules such as biomarkers for cancer, or possibly other diseases. The project, which includes Memorial Sloan Kettering Cancer Center and the National Institute of Standards and Technology, is supported by a four-year, $2 million grant from the National Science Foundation.

Early detection of cancer, Jagota says, requires specific detection of low concentrations of biomarkers in biofluids. Researchers have found that single-walled carbon nanotubes wrapped with a DNA molecule will fluoresce differently in the presence of different biomarkers. Detecting whether certain biomarkers are in the blood can determine if a person has cancer, which is the initial focus of the project. In principle, he says, the process could eventually be used to detect other diseases.

To determine if a patient has cancer, a bodily fluid sample is exposed to several types of DNA-wrapped carbon nanotubes, and then the fluorescence of each nanotube is recorded. One of the project's objectives is to establish an automated disease detection system capable of receiving data related to a bodily fluid.

With many other molecules present in blood, it's essentially impossible for any single type of DNA-carbon nanotube to detect whether a cancer biomarker is present. To account for a mixture of molecules in the sample, many types of DNA-nanotubes are needed for collective analysis, Jagota says.

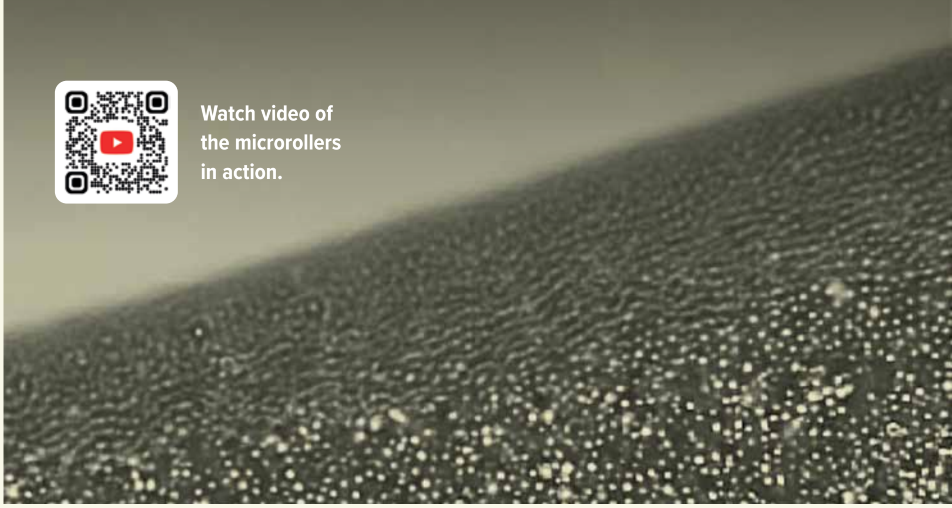
By identifying and using a number of sensors, researchers can be more confident they're finding what is associated with a biomarker and not something else in the blood, Davison says. That could lead to figuring out how to detect other characteristics or disease states in people. He uses the human nose as an analogy: Inside the nose, there are different receptors for scent, but it's not as simple as one scent per sensor. A collection of sensors activating is what allows people to recognize a particular smell.

The researchers don't want to have to rely on one sensor; they want a set of sensors detecting—or not detecting—a recognizable pattern. "A big worry for us is that we could have lots of conflicting compounds that are discoverable in blood that aren't what we're looking for, but similarly excite the sensors that we have," Davison says. The team seeks to identify the best set of sensors, which they expect need to be as diverse as possible.

Davison, who brings expertise in machine learning to the team, says building reliable prediction systems with limited data—likely just a few hundred data points because their dataset corresponds to real patients—presents a challenge.

Magnetic sand makes a counterintuitive uphill climb

Gravity-defying discovery in the study of granular flow could have applications in microrobotics



A time-lapse image of microrollers flowing uphill from left to right. A magnet rotates nearby applying torque to each individual particle resulting in a flow that behaves just as granular media does, but flowing uphill.

LABORATORY FOR PARTICLE MIXING AND SELF-ORGANIZATION

Impossible.

It was the first thought researcher James Gilchrist had as he watched his postdoc rotate a magnet beneath a vial of iron-oxide-coated polymer particles and the grains began to move—uphill.

"I went nuts," says Gilchrist, the Ruth H. and Sam Madrid Professor of Chemical and Biomolecular Engineering. "I was so excited because I'd never seen anything like it. Powders don't flow uphill."

Samuel Wilson-Whitford, who is now an assistant professor in engineering at the University of Warwick (UK), had made the discovery entirely by serendipity in the course of his research into microencapsulation. Wilson-Whitford is the lead author of a paper published in *Nature Communications* that proves the seemingly impossible.

"After using equations that describe the flow of granular materials," says Gilchrist, "we were able to conclusively show that these particles were indeed moving like a granular material, except they were flowing uphill."

After making their discovery, Wilson-Whitford and Gilchrist kept it under wraps for a while. The gravity-defying movement of the material—tiny, magnetically responsive particles that are similar to sand and are called microrollers—was so unexpected, they couldn't believe their eyes.

"These particles are really hard to make and scale up, so most people study a very small sample of microrollers, and, in fact, there's a body of literature of researchers who study single microrollers and how they move in response to a magnetic field," says Gilchrist. "We probably make more of these particles than any other group in the world, and that allows us to look at the bulk properties of what is essentially a pile of sand."

"I BASICALLY KNOW THE TITLES OF THE NEXT 14 PAPERS WE'RE GOING TO PUBLISH."

—James Gilchrist

For example, he says, when they pour the microrollers without activating them with the magnet, they flow downhill. But once they apply torque using the magnets, each particle begins to rotate. The microrollers also have an attraction to each other, creating temporary doublets that quickly form and break up. The result, says Gilchrist, is cohesion that generates a negative angle of repose due to a negative coefficient of friction.

"Up until now, no one would have used these terms," he says. "They didn't exist. But to understand how these grains are flowing uphill, we calculated what the stresses are that cause them to move in that direction. If you have a negative angle of repose, then you must have cohesion to give a negative coefficient of friction. These granular flow equations were never derived to consider these things, but after calculating it, what came out is an apparent coefficient of friction that is negative."

Friction matters a lot, he says. Increasing the magnetic force increases the cohesion, which gives the grains more traction and the ability to move faster. The collective motion of all those grains, and their ability to stick to each other, allows a pile of sand particles to essentially work together to do amazing, counterintuitive things—such as flow up walls and even climb stairs.

"This first paper just focuses on how the material flows uphill, but our next several papers will look at applications, and part of that exploration is answering the question: Can these microrollers climb obstacles? And the answer is yes."

The team is using a laser cutter to build tiny staircases and is investigating how the material ascends one side and descends the other. A single microroller couldn't overcome the height of each step, says Gilchrist. But working together, they can.

"It's similar to the tread on a tank," he says. "If you have one layer of particles rolling, there's enough friction on those grains to allow the next layer to grab on, and roll over the top of them and climb the stairs."

Potential applications could be far ranging. The microrollers could be used to mix substances, segregate materials, or move objects. And because these researchers have discovered a new way to think about how the particles essentially swarm and work collectively, future uses could be in microrobotics, which in turn could have applications in healthcare. Gilchrist recently submitted a paper exploring their use on soil as a means of delivering nutrients through a porous material.

"The article received widespread interest across many news outlets," he says. "We are studying these particles to better understand their collective motion. I basically know the titles of the next 14 papers we're going to publish."

Materials interfaces: A prime spot for innovation

The smaller the crystals, the bigger the possibilities.

So goes a motto of researcher Fadi Abdeljawad. The associate professor of materials science and engineering is developing theoretical and computational models that explain how materials behave at near-atomic-scale resolution.

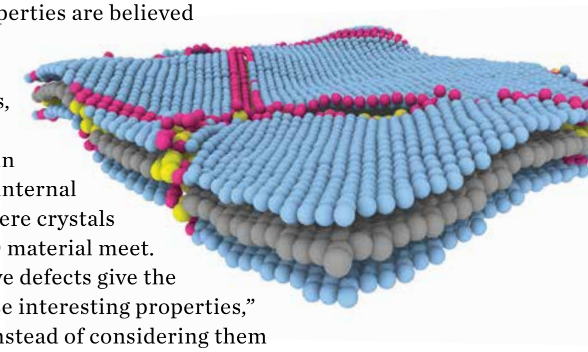
Among his research endeavors is a three-year effort funded by the Department of Defense and led by Professor Shen Dillon ’02 ’07 PhD at the University of California, Irvine. The project will examine how interfaces in nanoparticles evolve under extreme environments, such high temperatures and mechanical loads, with direct applications to additive manufacturing, or 3D printing. Abdeljawad will perform computational studies employing atomistic simulations, and his predictions will be experimentally tested by Dillon.

“We’re seeking to answer scientific questions that will ultimately enable us to control and tailor properties at the nanoscale,” says Abdeljawad, “so, essentially, building materials one atom at a time.” Such materials could play a future role in miniaturized devices, or in the aerospace industry, where materials have to withstand extreme environments.

Another project is a three-year collaboration with the Department of Energy’s Sandia National Laboratories that combines modeling and experimentation to examine the properties of two-dimensional (2D) materials.

Over the past decade, researchers have synthesized these 2D materials, which extend in two dimensions, but the scale in the third dimension is smaller by orders of magnitude—similar to a sheet of paper. For 2D materials, thickness is measured in nanometers.

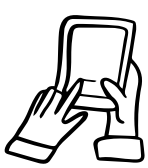
The materials have highly interesting engineering and functional properties. For example, they can be tailored for tribological applications. They have compelling transport and mechanical properties, too.



These properties are believed to come from defects, or imperfections, within what’s known as grain boundaries—internal interfaces where crystals within the 2D material meet.

“We believe defects give the material these interesting properties,” he says. “So instead of considering them as a detriment, we think of them as a design tool. If we can better understand these interfaces—these defects—we can tailor them to create materials with exciting properties.”

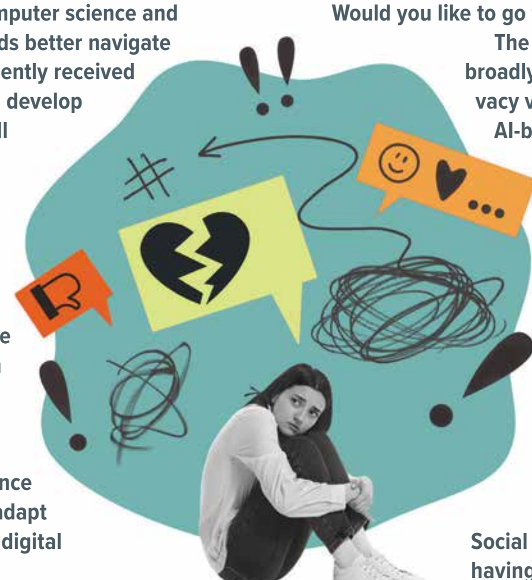
SAFER SOCIAL MEDIA—FROM SIMULATION TO REALITY



Like it or not, social media has become the new mall for kids. It’s where they want to be, and it’s a place they can easily go—often with no guidance, no oversight, and no guardrails. And when the content gets ugly or confusing or weird, it can be tough for them to know what to do.

Dominic DiFranzo, an assistant professor of computer science and engineering, has devoted his research to helping kids better navigate the perils of social media. He and his team have recently received two grants from the National Science Foundation to develop artificial intelligence tools and techniques that will ultimately help youngsters become savvier—and healthier—digital citizens.

Both grants build upon a digital literacy platform called Social Media TestDrive that DiFranzo developed in collaboration with Cornell University. “The platform teaches kids how to do things like spot cyber-bullying, recognize fake news, and create passwords,” he says. “It’s a social media simulation system, so it looks and feels like an actual site, but it’s not real. Kids can practice what they learn, and make mistakes in a safe environment.”

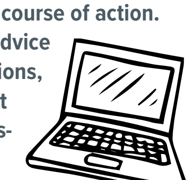


The team launched the platform in 2019, and since then, has partnered with Common Sense Media to adapt Social Media TestDrive into the organization’s K-12 digital literacy curriculum.

“Social Media TestDrive is now in middle schools across the country,” he says, “and more than 1 million students have used it so far. It’s been a really successful project, but we’ve been thinking of ways that we can leverage AI to scale it up and make it even more effective.”

DiFranzo will use one of the grants to leverage conversational AI tools like ChatGPT to help students stand up against bullying within social media. Such technologies will provide instant feedback and make the simulations on Social Media TestDrive more interactive. For example, if a student clicks on a troubling post, the system might immediately be prompted to say, “Hey, something doesn’t sound right here—what do you think you should do? Would you like to go through some scenarios of what you could say?”

The second grant will focus on digital literacy more broadly—how to confront risks like online aggression, privacy violation, phishing, and scams—using an innovative AI-based conversational intervention called Social Media Co-Pilot. The tool will simulate more complicated scenarios within Social Media TestDrive, in part through using characters of sorts—the bully, for example, or the victim of a scam—that would allow the student to interact with that character to determine the best course of action.



“And it will give students advice as they go through the simulations, similar to how an educator might offer real-time guidance in the classroom,” says DiFranzo.

There’s a long road of R&D ahead, but DiFranzo knows, through the success of Social Media TestDrive, that the work he’s doing is already having an impact. It’s giving kids the skills to better navigate their digital worlds. “As researchers, our work often ends up in a publication where a few people may read it, but it doesn’t translate into the field. My work is focused on building the next generation of responsible social media users and more empathic online communities,” he says. “It’s truly rewarding.”

TOP: FADI ABDELJAWAD; BOTTOM: MASTER1305/ADOBE STOCK; DOODLES: NATALIA/ADOBE STOCK

INTERVIEW BY **KATIE KACKENMEISTER**

EMBRACING CHANGE

Whether managing processes, people, or a high-stakes spin-off at Johnson & Johnson, industrial engineer Kathleen Taylor ’87 rises to the challenge

When Johnson & Johnson unveiled its plan to spin off its consumer health division, home to big-name brands such as Tylenol and Neutrogena, Kathleen Taylor ’87 found herself at a crossroads. “It was 2021 and I was running manufacturing for the Americas for the consumer division,” says the industrial engineering alumna. “Over the course of a weekend, I had to digest what was going on. *How was this going to affect the rest of my career?*” Having risen from a third-shift manufacturing supervisor to managing a plant in Mexico to directing global pharmaceutical and medical device supply chains—just a snapshot of her trajectory over 35 years with J&J—Taylor embraced yet another new challenge: leading the engineering and property services separation of Kenvue, now the world’s largest pure-play consumer health company by revenue. “It was a once-in-a-lifetime opportunity to set up essentially a multi-billion-dollar Fortune 500 company from scratch.” Newly retired from her post as Global VP of Engineering and Property Services, Taylor continues to channel her expertise back to the Rossin College through the Dean’s Advisory Council. “Re-engaging with Lehigh over the years and sharing my industry perspective has been so energizing.”

Q: What was it like to launch Kenvue?

A: I spent the past two years separating all of Kenvue’s real estate and facilities. This was a well-orchestrated effort across all aspects of the business that essentially required us to disentangle the consumer business from the rest of J&J. The experience was a unique opportunity to simultaneously build a new leadership team while also establishing the business needs and operating processes for Kenvue Commercial and Manufacturing facilities around the world. We had to set that all up, while keeping everything—customer service, facilities, engineering projects, and our workforce focused and safe during an incredible time of change.

"I gravitated toward industrial engineering," says Taylor, "because it was interdisciplinary, with a focus on optimization."

CHRISTA NEU

It was a fascinating experience, and one that I could have because of my confidence in getting out of my comfort zone and taking advantage of opportunities when they came up. A theme in my career has been doing things I maybe wasn't an expert in, but I felt I had enough experience and knowledge to be successful. When change happens, you might think, *This is terrible. This isn't what I wanted.* But mourning that is not productive. I was able to say: "How do I make this a learning experience and use my talent to help drive success?"

Q: Looking back, how does your career path compare to what you had envisioned as a new Lehigh graduate?

A: My approach hasn't been to set goals on specific positions. I've focused more on learning and building experience. I particularly wanted to live in different places and learn how companies and manufacturing worked.

My first job as a supervisor reinforced how much I loved to understand how machines work and how products are made. Manufacturing processes are fascinating to me, and that curiosity helped make me successful. I would learn how a product was made so that I could look at how we could do it better. I'd study how people worked, look for bottlenecks, and figure out how to help them be more successful. I was able to pivot from being an engineer and a supervisor in manufacturing to being a leader of people.

IT ISN'T ABOUT BEING SMARTER THAN THE PEOPLE YOU LEAD; IT'S ABOUT BEING SMART ENOUGH TO IDENTIFY HOW YOU CAN SUPPORT THEIR SUCCESS.

Living and working in another country builds greater awareness not only of other cultures but also your own. I wasn't really aware of my predispositions until I moved to Mexico or was living in Europe. All of a sudden you question: *Why do I think or do things that way?* I was initially very resistant to the idea of working in Mexico, at a time when lots of manufacturing was moving there. I had all these stereotypes in my brain. Working in Mexico opened me up to a whole new perspective. I feel very fortunate that I said yes to those opportunities and challenged myself to be uncomfortable, which is not a bad thing. One of the biggest dangers, especially in this work-from-home environment, may be that we are too focused on what's comfortable, versus recognizing the value of growth that's possible from being uncomfortable. In situations where I've had to change is where I've seen myself grow the most.

Q: What's different about leading a process like manufacturing versus leading people?

A: As an engineer, part of your value is what you know, your expertise. But I learned early on that it also had to do with how I worked with people who might know things I didn't. Often, they were manufacturing associates or maintenance staff, the electricians, the repair people in the shop. I further developed my technical knowledge by talking to people and understanding different perspectives.

As a people leader, your mentality shifts from "What do I know about that technology or science or process?" to "How do I learn what the people who work for me know about that? And how do I learn the value that each person brings to the table?" You can't be the expert in everything. You need to respect their technical or process or business areas of expertise. You need to piece together that puzzle for a team to be successful.

Leaders are often successful because they have technical expertise or a unique niche of knowledge. The challenge they face in moving up is learning how to rely less on that muscle in themselves and more on that muscle in others. It isn't about being smarter than the people you lead; it's about being smart enough to identify how you can support their success. That's a key difference. It takes humility to recognize you're not always the expert in everything. And the biggest failure is to think you have to be or to think you are when you aren't.

Q: How have advances in automation and technology played a role in your career?

A: I've seen automation take on jobs we thought required humans. Today, you'd never envision a person doing these tasks for safety, efficiency, or cost reasons. I was able to play a role in that transition. I spent a good part of my career at J&J in the manufacturing of medical products. I saw us automate so much. I was involved in implementing vision systems for inspection and automating packaging operations. We looked at how systems interfaced with equipment and allowed us to continuously optimize based on data and performance, whether making changes to raw materials or responding to demand in the marketplace. All of that has shortened the supply chain, from what we make to what we supply out to customers, and allows us to respond faster to how rapidly the world and what people want changes.

Artificial intelligence can give us insights and knowledge, and its future in industry is going to depend heavily on leadership's ability to use AI in spaces that really matter—like improving product quality, employee performance, and the consumer experience. Even anticipating and connecting the dots on what's going on in the world, whether it's weather patterns or consumer trends and behaviors, to how we manage supply chains. Companies that are able to harness AI and be first to get insights and respond are going to have an advantage.

Q: What advice would you give to early-career engineers?

A: People get hung up on "this isn't my dream job," but you can get something out of every job that you do. There certainly have been jobs in my career that weren't really what I wanted. But life is not linear. You've got to take a lot of turns and pivots. Sometimes that path can be surprising. The third-shift job I took after Lehigh was not the highest paying nor the most glamorous. It was hard work, and at times, there were people who were very open about telling me they knew way more than I did, and I was only a temporary blip on their radar screen. I matured a lot from that experience. Your learning and growth do not end with Lehigh. I'm currently taking an executive course on AI and business strategy at MIT, because I see the influence of AI in my day to day and the possibility that it could open up a new door for me. I may be retired from J&J, but I'm not done learning yet.

ADVANCIN AUTONO

“We’re constantly pushing the boundaries of what’s possible in the field,” says professor Nader Motee, pictured above with graduate student Guangyi Liu (left).

STORY BY **CHRISTINE FENNESSY** • PHOTOGRAPHY BY **CHRISTA NEU**

Lehigh engineers make their mark on the future of robotics through cutting-edge research and experiential learning opportunities

IF THERE’S A HOLY GRAIL IN ROBOTICS, it’s syncing what machines perceive and how they act on that perception.

“The ultimate goal for researchers is intelligent autonomy,” says Nader Motee, a professor of mechanical engineering and mechanics and director of Lehigh’s Autonomous and Intelligent Robotics (AIR) Lab. “And that means bridging the divide between what robots sense and the actions they take.”

The approaches that Motee, his colleagues, and students are taking—through research, competitions, classes, and clubs—are positioning Lehigh as a respected hub for the study of robot autonomy. AIR Lab members are tackling challenges involving robots’ ability to carry and manipulate objects, interpret information to make navigation decisions, and adapt to changing operating conditions and environments.

“We’re constantly pushing the boundaries of what’s possible in the field,” he says.

A ‘knot-so-typical’ approach

When we think about drones, we tend to think about Amazon. But their potential is much greater, and arguably far more important, than dropping off a box of laundry pods by lunchtime (an idea that’s struggled to take off since Jeff Bezos floated it more than a decade ago).

Aerial robots could be a huge asset, saving time, money, and workers’ well-being, in industries like construction where humans often have to heft materials up multiple floors, says David Saldaña, an assistant professor of computer science and engineering. They could also deliver lifesaving supplies in disaster areas. “The goal would be to get to a point where people don’t have to touch the robot at all,” says Saldaña. “Instead, we could just tell the robot to pick up that box of medicine and deliver it where it is needed.”

Traditional aerial systems in the literature have centered on robotic arms for autonomous grasping, which are heavy and hard to fly with as they change the drone's center of mass. Weight-saving solutions have included using an origami-like construction and very small motors. Saldaña and his team were recently awarded a three-year, nearly $600,000 grant from the National Science Foundation for an idea that takes an entirely different approach: using cables, knots, hitches, and often multiple robots to move objects in the air.

The project involves developing algorithms that will allow drones to overcome friction and actually tie a knot in a cable without getting entangled themselves. "We can't use the traditional reinforcement learning algorithms for this," he says. "We have to make our own because they have to learn very fast, since robots in the air need to operate fast."

The team will work with Subhrajit Bhattacharya, an assistant professor of mechanical engineering and mechanics, who will do the topological planning that will allow the robots to adapt to the specific requirements of securing individual items, like a chair versus a table. (Topology is the mathematical study of properties preserved through the twisting, stretching, and deformation—but not the tearing—of an object.)

The team will also use hitches. "We have a new concept called a polygonal hitch," says Saldaña. "Pairs of robots can make one side of the polygon, and are in charge of that side only. The polygon can be scaled up or down depending on the size of the object you're moving."

Assistant professor Subhrajit Bhattacharya researches motion planning and control of autonomous, intelligent systems.

While the ultimate goal is to create a more efficient approach to aerial delivery, the sheer number of problems that need to be solved first means that Saldaña will be happy to eventually perfect the transport of two items: a basketball and a solar panel. "Both will require a mesh where the cables are held together by friction, not with knots. And that means using multiple robots to interlace multiple cables, which is a very difficult task right now for robots. But this is a completely new way to look at transportation in aerial robots."

Road-testing algorithms

Self-driving cars must follow the rules of the road while avoiding collisions. But as with humans, robots have a harder time seeing things that are far away. They often receive only partial information from distant road signs and markings. Knowing at what point to react to that information—and whether the amount of information is sufficient to require

"IN A COMPETITION, YOU HAVE TO SHOW YOUR ROBOTS ARE ROBUST AND RELIABLE, AGAIN AND AGAIN. IT ADDS ANOTHER LEVEL TO THE RESEARCH PROCESS." —David Saldaña

the action—presents a complex challenge.

Cristian-Ioan Vasile, an assistant professor of mechanical engineering and mechanics, and his team recently published a paper outlining a framework for perception-aware planning in self-driving cars. "Our algorithms allow actions to be taken by the vehicle based on partial symbolic information," he says. "And using simulations, we saw a reduction in the risk of collision. The vehicle saw something, and while it may not have known exactly what it was, it knew enough to slow down."

The AIR Lab provides opportunities for both research and practice in an environment that encourages collaboration among students and faculty.

Formalizing their approach, however, wasn't easy.

"There's a discrepancy between perception coming from robot vision versus planning and control," he says, "where the expectation is either that perception is perfect and you can make whatever decisions you need to make, or you assume the worst and perception is very uncertain, which makes control very hard. If you expect too much from the perception system, it's going to lead to safety issues. On the other hand, if you try to take all possible uncertainty into account, your control algorithms will be very slow, and you risk veering at the last minute, or even colliding with obstacles. We had to construct a middle ground between the two."

The team extended their approach in another paper that focused on robots deployed to disaster scenarios and on Mars—simulations in which the goal was to efficiently explore an unknown environment where energy budgets are limited. In such cases, the framework they developed allowed the vehicles to operate autonomously despite receiving only partial information. For instance, they could pursue a search for victims who were more seriously wounded than others, and navigate terrain that could otherwise bog down or halt a space mission.

The next step, says Vasile, is to test their algorithms in a version of the real world. Beginning this spring, he and his team will run experiments using race cars in a miniature urban environment located in the AIR Lab. The platform was built by a team of undergraduates participating in Lehigh's Mountaintop Summer Experience program. The students have been working on the test bed since 2020, and it now features buildings, streets, traffic lanes and markings, and a localization system, similar to an indoor GPS. Vasile and his team (pictured, at right) will conduct their experiments using five miniature race cars equipped with sensors.

"We want to see how well the perception model and control algorithms we've been developing perform in urban scenarios where you have intersections, lights, and signs, and have to interact with other cars," he says.

The overall goal, however, is to ensure the safety of the newest fleet of technology to hit the roads. "The moon shot for this research is that it will allow us to connect guarantees about perception systems with guarantees about decision-making and control, so that together, we have guarantees about the behavior of robots and self-driving cars in particular."

Navigating with 'next best'

In the future, it may be common practice to use robots to deliver assets—medicine, supplies, tech of all sorts—to unknown places. There are the myriad issues around how machines will carry those items (the focus of Saldaña's research) and how they will interpret information as they travel (Vasile's work). On top of that, add the challenge of actually reaching their destination.

"When an asset-carrier robot navigates an environment using a perception model, there's often a level of uncertainty about its surroundings," says Motee, the AIR Lab's director. "This could be because the model was trained with a limited number of low-quality views. To mitigate the risk in decision-making and planning, the robot needs to enhance its perception of the environment. However, doing this in real time is a computationally demanding task."

"THE MOON SHOT FOR THIS RESEARCH IS TO CONNECT GUARANTEES ABOUT PERCEPTION SYSTEMS WITH GUARANTEES ABOUT DECISION-MAKING AND CONTROL." —Cristian-Ioan Vasile

Motee has developed a way in which robots work in tandem to help the asset carrier. These helper robots take samples and new views from the environment and feed the information to the carrier, allowing it to learn faster and update its perception of the environment.

"But then the question becomes: What is the next best view that a robot should use for improving its perception?" he says. "It's like when you're getting advice from several of your friends at once. You can't do everything, so you decide to follow the one piece of advice that sounds the most relevant to your goal. It's a similar situation with robots. They can't use all the different views because that would be computationally expensive and cannot be done in real time. They have to make a decision about which is the next best view."

Motee recently received funding from the Office of Naval Research to answer this question of control without trust. He and his team are combining computer vision with virtual reality to develop the algorithms that will help robots update their perception and reduce the uncertainty and risk posed by unknown environments.

"In an ideal scenario where we have complete knowledge about an environment, risk is nonexistent," he says. "However, uncertainty introduces the possibility that an incorrect action could result in failure. In real-world applications, robots need to attain a trustworthy understanding of their surroundings efficiently, while staying within their computational constraints. Given that all perception models inherently contain some level of uncertainty, robots capable of rapid online learning can significantly enhance their understanding of the environment. This improvement not only reduces their level of uncertainty and associated risks but also enables them to more effectively and efficiently fulfill their designated tasks."

Rising to the challenge

Accomplishing missions in the real world was the goal of last November's Defend the Republic drone competition (pictured, opposite page). The event was organized by the Swarms Lab (Saldaña's lab) and collaborators with the support of Lehigh's Institute for Data, Intelligent Systems, and Computation (I-DISC), the Department of Computer Science and Engineering, the Rossin College, and the Office of the Provost. It was Lehigh's first time as host, and the Mountaintop campus served as the main venue.

Teams from eight universities participated in a Quidditch-esque game (that's a Harry Potter reference for the unaware) in which autonomous aerial robots vied to capture floating helium balloons and deliver them to the opponent's goal. The competition is held twice a year at universities across the U.S. and aims to drive research and innovation in vehicle design, multi-agent control, swarm behaviors, and communication.

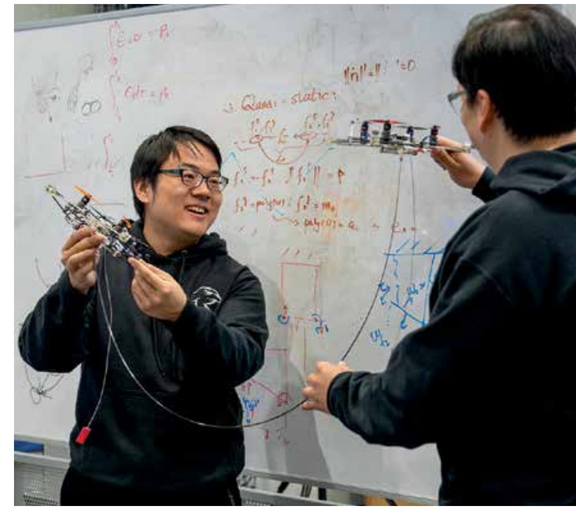
"Often in research, you run an experiment a couple of times, establish proof of concept, and that's enough to publish a paper," says Saldaña. "But in a competition environment, you have to really show that your robots are robust and reliable, again and again. It adds another level to the research process, and pretty quickly, you're able to spot your strengths and weaknesses."

Lehigh entered 21 robots into the competition, the largest contingent of any of the competitors, and ultimately made it to the final round, having experienced some glitches with their sensors reacting poorly to sunlight. (Teams from George Mason University, the University of Florida, and Baylor University took home top honors.) Such a show of technological strength was a testament to the Lehigh Aerial Swarms Robotics Club, a group Saldaña started in 2022. Although officially a club for undergraduates, Saldaña says that graduate students play a significant role serving as mentors.

"Students can pursue so many different interests within the club," he says. "They can build robots and compete, or if they're interested in research, they can join forces with our PhD students. We travel to events and conferences. The club is also connected with senior design projects and capstones, and it helps launch students into master's and PhD programs."

The group formed as an offshoot of a Mountaintop Summer Experience project Saldaña started in 2022 that explores using robots for social impact. In that project, students are studying how to use robots to deliver communication access points when typhoons cause widespread power outages.

"The students who are part of these clubs and projects are the engine behind so much of our success at events like Defend the Republic," he says. "When they come into a research competition like that, they can't have a simple idea. They have to think out of the box, and they need a clear goal. It's a unique experience for them."



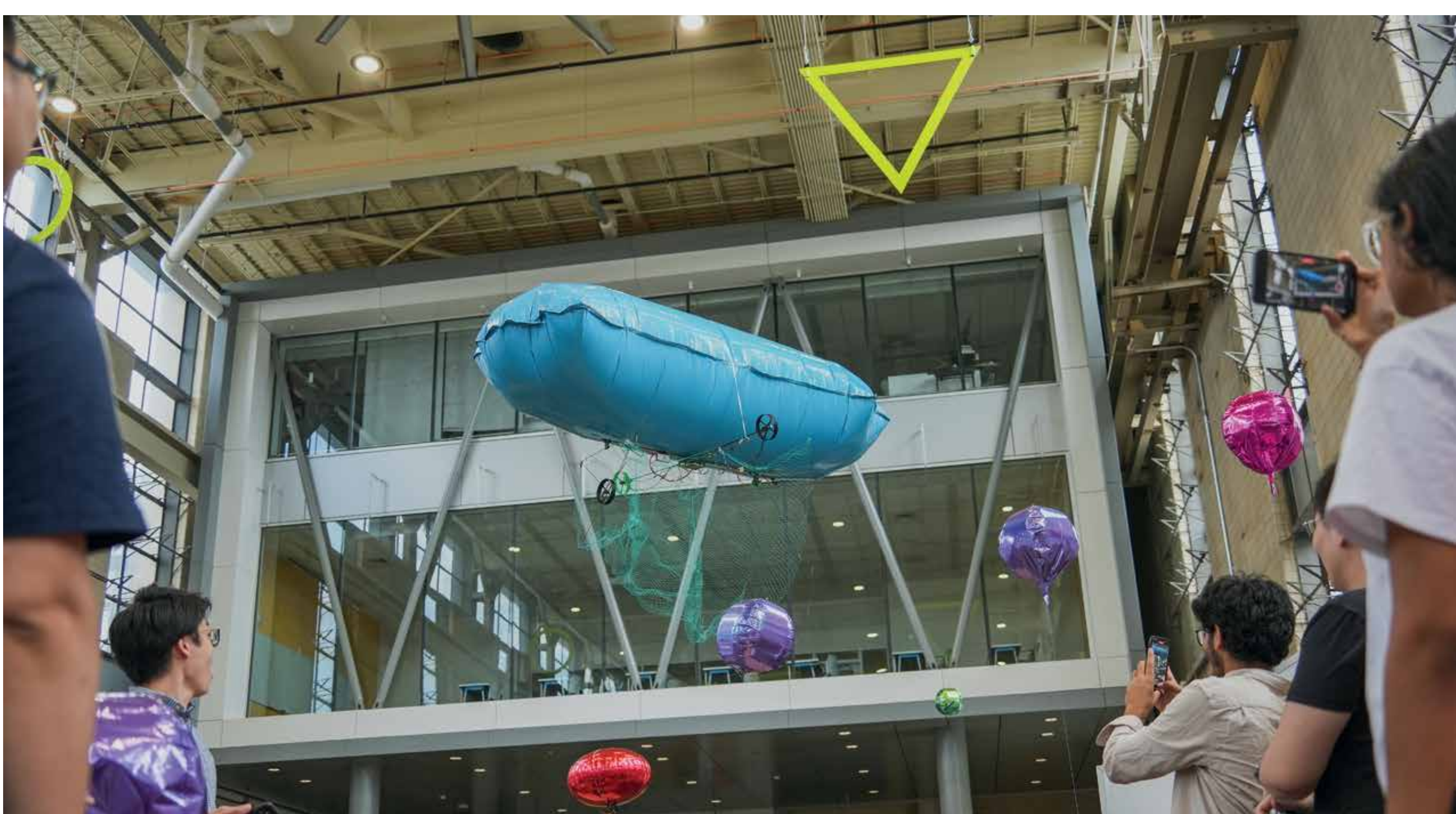
To further stoke excitement for the competitions and all they entail, Saldaña is teaching a new course in aerial robotics for undergraduate students this spring.

"Very few universities have a class like this because it requires a lot of infrastructure and support to make it happen," he says. "But thanks to the computer science and engineering department and Rossin College leadership, we're now one of the few."

Such opportunities across research and practice will help propel the next generation of students to further push the boundaries of robotics and narrow the gap to true intelligent autonomy, says Motee.

"That's really what the AIR Lab is about," he says. "It's about providing a place for collaboration and shared ideas for both students and faculty. The opportunities here are endless, and that's how Lehigh is setting itself up to be a leader in the field."

Watch drones compete at Defend the Republic.



RIGHT: HOLLY FASCHING '26

ART leadership team (from left): Dr. Dominic Packer (Arts and Sciences), Dr. Lee Kern (Education), Dr. Himanshu Jain (Rossin College), Dr. Henry Odi (Diversity, Inclusion, and Equity), and Dr. John Coulter (Rossin College)

PICKING UP THE PACE

Fueled by a noteworthy $6 million NSF grant, a cross-college team means business when it comes to transforming how Lehigh turns research into real-world impact

BY **CHRISTINE FENNESSY**

The goal of many researchers is to make an impact. But too often, their work gets stuck in the narrow confines of their lab and respective academic fields and fails to influence the real world. As a result, fundamental research ends up falling into what's known as the "translational gap."

"We're supposed to be taking basic research and delivering it to society in the form of something useful," says John Coulter, a professor of mechanical engineering and mechanics and the Rossin College's senior associate dean for research. "But there are a lot of reasons for why that doesn't always happen."

Those reasons tend to fall under a lack of funding and support—and insufficient connection to potential users in society.

"It's not uncommon for us to present our work at conferences, and afterward, hear from members of industry saying that while they love what we did, it doesn't quite solve their problems," says Coulter. "In those situations, it's clear that if we'd worked with people like them from the beginning, we could have conducted our research more efficiently, and ultimately, more effectively."

Forging those connections is at the heart of a proposal put forth last year by an interdisciplinary, university-wide team led by Coulter. In December, the National Science Foundation granted Lehigh a four-year, $6 million award through its Accelerating Research Translation (ART) program. The goal, according to NSF, is to increase the scale and pace of advancing academic research into solutions that benefit and serve the public.

The 16-member team behind the proposal represents all five Lehigh colleges and includes four co-principal investigators and 11 senior personnel.

"Specifically, we're talking about building capacity and infrastructure at all stages of the process," says Coulter, "so that research is conducted in a way that's quicker and targets real problems that people care about."

The award will help Lehigh speed up and scale its research activities in engineering, health, biological sciences, humanities, business, education, and myriad other areas to generate products and services for the general good. Lehigh will also train graduate students and postdoctoral scholars in translational research and commercialization pathways.

STORY PHOTOGRAPHY BY DOUGLAS BENEDICT/ACADEMIC IMAGE; GROUP SHOT: CHRISTA NEU

The interdisciplinary, university-wide team will build a research translation ecosystem at Lehigh to help graduate students, postdocs, and faculty get their work onto three impact pathways: venture creation, translation to existing industry, and social impact.

Three paths to impact

"When it comes to translating research, NSF is targeting three pathways," says Coulter. "The first is venture creation, meaning startups spawned by faculty and/or students."

The second, he says, "is delivering our research more quickly into the hands of established companies." That could be a company wanting to license a patent and sell products based on science that originated at Lehigh.

Another example, he says, is Lehigh's Pasteur Partners PhD (P3) program, in which doctoral students partner with industry to identify—and solve—real-world problems. Materials science and engineering professor Himanshu Jain, the T.L. Diamond Distinguished Chair in Engineering and Applied Science, is the key architect of the P3 model and a member of the ART leadership team.

"ART will help those students enrolled in the P3 program to further align their research for the benefit of society," says Jain. "It will also serve as a new tool for recruiting superior graduate students."

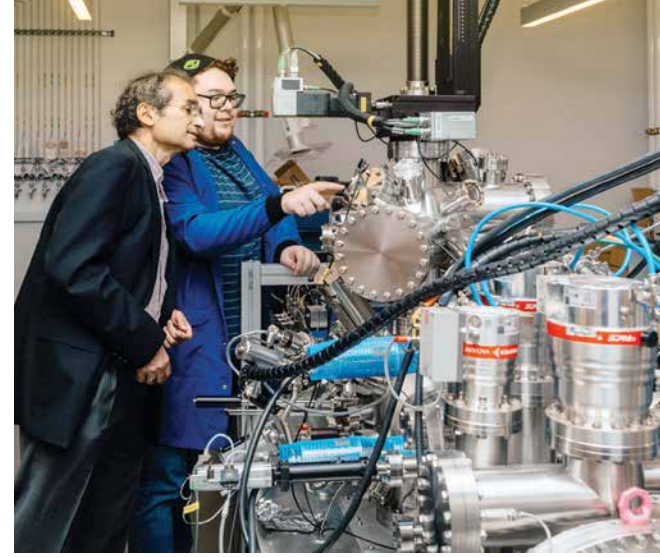
Ultimately, says Coulter, the idea is that students like those in the P3 program, whose research has been advised by both faculty members and industry partners, will go on to work for those industries. "And that research follows the student to that company," he says, "which is very effective translation."

The third translational area being targeted by the National Science Foundation is social impact.

"Some of the research we do within academic institutions isn't intended to have economic value. Think of a piece of open-source software, for example, that's useful to the world. It doesn't create revenue, but the impact is huge."

To better help graduate students, postdocs, and faculty get their work onto one of those three impact pathways, Lehigh has to flex its academic muscle. Coulter explains his team's vision using the metaphor of a gym.

"We want to create a campus ecosystem that provides the necessary capacity and infrastructure—the space, the equipment, and the expertise—for successful research translation," he says. The program will offer an experience akin to a "personalized, total-body workout," with educational and training opportunities focusing on building skills and nurturing an entrepreneurial mindset. Faculty members with related experience (such as Coulter, who holds multiple patents, including two issued in the past year) and external partners will serve as the trainers and coaches. And the



The ART grant will allow Lehigh to expand its infrastructure and capacity to better facilitate the translation of research to industry and society.

cross-college team will strive to create a diverse, inclusive, accessible community that breeds innovation and sparks a shift in the university's academic culture.

"We will optimize, incorporate, and enhance diversity, equity, inclusion, and accessibility in every piece of this ecosystem," says Coulter. "And we'll have regular assessment and continuous improvement of that system. Whenever we put a new policy on the table, there will be a team of people ready to vet it and ensure that it embodies those values."

Demystifying venture creation

To start and scale a successful company, first, you have to believe you can do it; then, you need the skills to pull it off.

"The curriculum in Lehigh's Technical Entrepreneurship graduate program offers a hands-on, industry-based, immersive educational approach to developing entrepreneurial knowledge, attitude, and skills, and this pedagogical approach will be utilized in the ART program," says Michael Lehman, faculty director of interdisciplinary Technical Entrepreneurship (TE), a professor of practice in the mechanical engineering and mechanics department, and the ART team's education and training lead.

"Lehigh was among the best in the country at putting forth a university-wide plan with a truly multidisciplinary team, and we are committed to making a real impact." —John Coulter

"Our goal with ART is to immerse emerging innovators—regardless of their educational background and experience—simultaneously into both technical product development and entrepreneurial venture creation," says Lehman, who has training as a medical doctor and also holds an MBA. He and his colleagues are adapting the TE curriculum to accommodate the rigorous demands of those pursuing translational research.

"What we've learned from past doctoral students is that a three-credit elective doesn't necessarily work with their schedules," he says. "So part of the ART grant will be utilized to develop flexible one-credit modules, ultimately offering 18 distinct, yet interrelated, topics."

Those modules will cover subjects including customer discovery and problem validation; the power of diverse teams; financing R&D to commercialization; business models for translating tech; and effective professional communication. A current summer TE course on intellectual property will be offered in two separate one-credit modules—one on core IP skills and one on IP strategy.

"These are interactive workshops with practical application," he says. "Students will be using databases available through Lehigh to map their industry's intellectual property landscape. They will engage with industry associations to craft effective partnerships. And they will develop a venture pitch, present it, get feedback, revise, and iterate."

Ensuring the university community can access this kind of training is critical. The lack of understanding around new venture creation is one of the roadblocks to translational research. For academics so well versed in every nuance of their subject matter, stepping outside of it can be uncomfortable. There's a tendency, says Lehman, to equate proficiency with deep knowledge. And when you consider just how many aspects there are to learn about when starting a company or translating an idea into global social impact, the prospect can be daunting.

"Many doctoral students and faculty have worked on technologies that could be commercialized," he says. "But to create a new venture, you also need to learn about product development, design, financing, licensing, scaling, etc. It can be overwhelming. The goal is to get them comfortable with the idea that they don't have to also be an expert in all those areas. But they do need to understand how they are all essential components that have to be addressed, either by themselves or by someone on their team."

And participants don't have to jump into all those areas at once. The modules are meant to provide a way to test the waters of potential.

"Someone may wonder, 'Is it reasonable to even think about commercializing my research?' Well, there's a module on feasibility analysis that could help them consider their research in a different way," says Lehman. "Another researcher might say, 'I believe that I'm onto something here, but I know nothing about sales or acquiring customers or negotiating.' That person could enroll in a related module to boost their confidence to take the next step."

A paradigm shift

The kind of big changes being promoted by an effort like ART will require a simultaneous shift in institutional culture. "Historically, PhD training has meant preparing a student to teach courses at any level, and training them to do cutting-edge research," says Hannah Dailey, an associate professor of mechanical engineering and mechanics. "But changes in industry now require that people go beyond a deep, technical understanding of their subject area. Employers are looking for people who also understand the innovation ecosystem and have leadership potential. It's not just about the science, it's about knowing what it takes to bring discoveries to market. We want students and faculty who are doing research to be thinking about translation from day one."

Dailey will lead that effort as coordinator of the "ART Ambassadors," and as co-leader of the group focused on culture change at the university. ART Ambassadors, comprising faculty and students at different stages of research translation around campus, will help foster engagement, connection, and dissemination at the local, regional, and national levels of the many ways in which ART is transforming how research is done at Lehigh. They will also help facilitate the culture change necessary to fully embrace an ethos in which research translation is rewarded and valued, and create an environment where researchers are excited and empowered to pursue the translational possibilities of fundamental work.

Such a transformation will require—among other things—changes in tenure, promotion, and evaluation processes.

"Right now," says Coulter, "if you're a junior faculty member trying to get tenure, you might be hesitant to start a company. And that's because you think your colleagues will vote against you, believing your company will take up too much of your time. Well, what if starting a company becomes something that helps you earn tenure?"

He says people such as Dailey—who started her own medical device company more than a decade ago—will also serve as mentors.

"Think of these people as coaches," he says, returning to the gym metaphor. "They're people within our ART team, as well as from other areas inside and outside the university, who have venture creation experience, industry experience, intellectual property and patent experience, social impact experience. These coaches are going to help students and faculty identify the particular skill or skills that they'll need to improve to work toward the goal of research translation. There's nothing like knowing a group of people who are starting or have already launched companies when you're trying to learn how to start one yourself."

Building an innovation ecosystem

Finally, ensuring that researchers can think about translation from day one requires expanding institutional capacity and infrastructure.

"We'll be doing everything we can to further establish Lehigh as a good partner for industry," says Coulter. "The more streamlined the approach to putting contracts and agreements in place, the more effective we'll be at technology transfer."

They're also proposing a physical research translation hub and prototyping facility. The hub, which Coulter envisions somewhere on the Mountaintop campus, would be a one-stop shop of sorts where researchers, entrepreneurs, mentors, and industry experts could gather for guidance and advice.

"It's not something we'll set up right away, but likely in year three or four of the grant," he says.

As Coulter and his team begin the work of rolling out the mission of ART, it's important to consider just what an award of this significance says about Lehigh as a research powerhouse. After all, the university was one of just 18 institutions across the country who received an NSF ART grant, and of those, only five received the full $6 million.

"The process was extremely competitive," says Coulter. "The fact that we were one of the five who got the full amount says that Lehigh was among the best in the country at putting forth a university-wide plan with a truly interdisciplinary team, and that we are committed to doing this well and making a real impact on our society."

Michael Lehman (center) is faculty director of Technical Entrepreneurship and the ART team's lead for education and training.

NAVIGATING THE GREAT INDOORS

Computer scientist Vinod Namboodiri envisions a more accessible future through smartphone technology with responsive interior maps and turn-by-turn directions

BY **CHRISTINE FENNESSY**

For some researchers, personal experience sparks innovation.

"Since childhood, I've had issues seeing in low light," says Professor Vinod Namboodiri. "And I always wondered about people who are completely blind: *How do they get around?* So as an academic with a background in computing, wireless communications, and networks, I knew I had the skills and the personal connection that could help me solve a problem faced by so many people with disabilities—how to confidently get from point A to point B when inside unfamiliar spaces."

Namboodiri, a faculty member in both the Rossin College and Lehigh's College of Health, recently received funding from the National Science Foundation's Convergence Accelerator program to advance from Phase 1 to Phase 2 of the program's Enhancing Opportunities for Persons with Disabilities track.

The computer scientist and his team—which includes partners such as Good Shepherd Rehabilitation, the Smithsonian's museums in Washington, D.C., and the American Foundation for the Blind—will use the three-year grant to build a prototype of a personalized, scalable app, called MABLE (Mapping for Accessible BuiLt Environments), that will allow people with a range of impairments to get turn-by-turn instructions when navigating indoor environments.

The award is part of a total investment of $30 million that NSF is spreading across six multidisciplinary research teams to develop systems, technologies, and tools to enhance the quality of life and improve the employment opportunities of those with disabilities.

Namboodiri's app builds upon work he began as a faculty member at Wichita State University after spending a sabbatical at Envision. The nonprofit, which is based in Kansas and Texas, serves people who are blind or visually impaired through employment, education, research, rehabilitation, and outreach.

"While I was there, I learned about the different challenges these people faced," he says, "and it became clear that while Google Maps and Apple Maps allowed them to find their way outdoors fairly easily, they really struggled once they walked into a mall or into a store."

Soon, however, he realized it wasn't just blind or visually impaired people who had a hard time navigating these types of indoor environments.

"Those who use wheelchairs often have a tough time locating the most accessible routes, like where the ramps or elevators are in a building," he says. "Similarly, older adults and those with cognitive impairments might get from point A to point B, but then have difficulty finding their way back to point A. It became clear that people with disabilities face a lot of anxiety when they visit new spaces, and so the question became, How can we use a computing and engineering perspective to solve some of these challenges?"

"THE ULTIMATE GOAL IS TO ALLOW PEOPLE WITH DISABILITIES, AND ANYONE ELSE, TO VISIT UNKNOWN SPACES MORE CONFIDENTLY."

—Vinod Namboodiri

Namboodiri plans to create a smartphone way-finding app that can be personalized to the specific needs of the individual user. But he and his team must first overcome two vexing problems: the absence of a universal positioning system—like the satellites that power navigation apps—and a dearth of maps for indoor spaces.

To address the former, Namboodiri deployed wireless devices called beacons within a single academic building as part of what he calls a "low-fidelity prototype" he developed while at Wichita State.

"We spread them around the building, and smartphones connected to them through Bluetooth. So as you got closer to them, the phone knew where you were, and in that way, it kind of mimicked the satellite system."

Such beacons may be the answer going forward, he says, but his team is also working on alternative methods of orientation, such as using the phone's camera or video capabilities.

"We don't want to marry ourselves to one approach because there may be some building owners who don't want to use beacons due to the need to add them to existing built environments," he says. "Camera-based approaches are increasingly viable due to greater computing capabilities, but some users do not want to use them due to extensive smartphone battery drain. Coarser positioning schemes based on Wi-Fi and inertial motion units may be sufficient for some users, but are inadequate for those who need more precise location and associated contextual information. So while this project started with beacons, we'll be pursuing a much broader range of possibilities that allows building managers to choose what they want to offer for their end-user base, and for users to voice their opinion on what they prefer."

The lack of comprehensive indoor maps poses a unique challenge. When floor plans do exist for a given building, it's rare that they contain the level of detail that would make them useful to those with visual, mobility, or cognitive impairments. Namboodiri and his team of collaborators plan to design scalable, automated approaches to convert floor plans to maps and then leverage crowdsourcing to enable users to contribute the information that will make the plans relevant to a diverse range of needs. And they'll be available not only within the mobile app, but online as well, all in accessible formats that can be personalized by a diverse set of users to meet their specific needs.

"The app will allow independent way finding," he says, "but say you're planning on going to a conference in a hotel. You'll be able to use your web browser to study the maps and plan out the best routes ahead of time, so when you arrive, you'll already know where you're going, in a sense."

He says the long-term vision is to provide a service in which the appropriate tools, software, and algorithms are available for purchase online by owners interested in making their buildings more accessible.

"So maybe there's a lower cost service for owners who can do everything on their own, and a specialist service they can hire for more complex buildings," says Namboodiri.

That future service could also become attractive to an even wider audience, like tourists and firefighters. That's because Namboodiri sees way finding as a base layer of sorts—once you have the ability to know where you are and to get routes within a building, the potential applications are vast. Travelers could use the service inside transit stations and get information on arrivals and departures in their own language. Firefighters could navigate when they're otherwise blinded by smoke. And it could be used in situations requiring emergency evacuations from a building when the typical exits are blocked.

"Once you have the core functionality of the map and the location, you can add so much on top of that," he says. "The ultimate goal is to allow people with disabilities—and anyone else—to visit unknown spaces more confidently."

It's a goal that is especially meaningful to him. And it's one that could have profound ripple effects on society at large.

"Within the U.S., around 25 percent of the population identify as having some kind of disability," he says. "If we can make it less stressful and easier for them to get around, not only will the quality of their lives improve, but it could also help increase their participation in the workforce. And that would be a huge boost to the economy."

DOUGLAS BENEDICT/ACADEMIC IMAGE (2)

MAKING THE ACADEMIC ASCENT

BY **CHRISTINE FENNESSY**

The Lehigh ISE Future Academic Career Experiential Training Program helps doctoral students connect the dots from PhD to professor

For some PhD students, the path to an academic career can feel like a black box of sorts. How exactly does one make the leap from teaching assistant to professor? From collaborating on research to leading it? From being funded to securing funding? Compared with going into industry, the process of entering academia can appear nebulous, daunting, and intimidating.

"For the most part, students know that if they go into industry, they're going to have a boss, and that boss is going to tell them what to do," says Frank E. Curtis, a professor of industrial and systems engineering (ISE) and director of graduate studies for the department. "But when it comes to academia, students often see faculty as people who are basically running small businesses—managing people and funds, teaching classes, contributing to committees, and things like that. It can seem like a very complicated, difficult job."

There's no question that academia is demanding. But it's also creative, intellectually stimulating, and rewarding. "As a professor, you have the opportunity to do research that's on the cutting edge and can put you on a path to make the next breakthrough in your field," says Curtis. "You're also in a position to make breakthroughs with your students, where you're able to help them get to a deeper understanding of complicated concepts."

In 2021, Curtis created the Lehigh ISE Future Academic Career Experiential Training (FACET) program, in part to shine a light into that black box and reveal the many possibilities of an academic career. All ISE PhD students are eligible to participate in FACET, and its purpose is to give them information, skills, and opportunities that will boost their confidence, enhance their resumes, and, ultimately, help them land positions in universities across the country and around the world.

At the heart of the program are monthly meetings with guest speakers featuring ISE faculty and alumni, as well as external educators. Topics tackle what it's like to work in a national lab versus academia; why a postdoc position can be a good bridge to a faculty position; how to apply for research funding; how to balance research, teaching, and service as a faculty member; and what makes for a good application for both postdoctoral and faculty positions. Each talk is followed by a Q&A session.

"With these meetings, we're trying to break down the process so it becomes clearer and doesn't feel so imposing," says Curtis. "And when it comes to their resumes, we're not only helping students understand how to make themselves stand out, but we're giving them the opportunities to actually do those things."

For example, ISE PhD students are now teaching (or co-teaching with a peer) some 400-level classes. "When our department has open faculty positions, we often get applicants who have no teaching experience beyond working as a TA," says Curtis. "Having our PhD students instruct their own classes goes a long way in demonstrating their interest and willingness to seek out additional experience—and that gives them an edge."

The program also helps students identify opportunities for additional research collaboration outside the typical PhD candidate-advisor partnership. "These relationships are important for a strong resume," says Curtis. "So we're here to help our students build them."

FACET also works with the Lehigh ISE Outreach Program (OutreachISE)—an initiative that aims to improve awareness of and promote research in ISE—to provide mentorship opportunities to undergraduate and master's students on research projects. "Students in FACET can also mentor younger kids in middle and high school during summer camps that are held on campus, and develop projects and games that introduce the kids to the basics of industrial and systems engineering," says Curtis. "It's a great opportunity for graduate students to get a sense of what the service component is all about in academia."

The overarching goal, he says, is to increase the number of ISE students securing postdoctoral fellowships and going into faculty positions. "We want our graduates to become part of the academy where they'll be making important contributions to the advancement of science and engineering," he says.

FACET has grown every year; it now includes one-third of the department's PhD students. One of them is Qi Wang (pictured with Curtis). When she came to Lehigh in 2020, she'd already spent several years working as a software engineer in China. She knew that she wanted to transition into research, but when she began her doctoral program, she wasn't planning on pursuing an academic career.

"My goal then was to work as a researcher in a company or institute," she says. "Back then, I didn't have the confidence to try for a faculty position. Academia is really competitive compared to industry, and I didn't think I could get hired. I was also intimidated by having to fund my own research as a professor. I just didn't think that I was good enough."

That mindset initially kept her from joining FACET. But in the second year of her PhD, a friend mentioned the seminars he'd attended. He explained how assistant professor Xiu Yang had talked about his experience working at a national lab and compared it with being on the ISE faculty at Lehigh. And assistant professor Karmel Shehadeh, he said, had walked through her transition from a PhD student to a postdoc to a junior faculty member.

These were exactly the real-world experiences Wang wanted to learn more about. "I regretted missing those talks," she says. "They would have clarified so much, and given me a better idea of what to expect, and what the application process is really like to become a professor. It would have helped me identify my strengths and what I needed to work on. I joined FACET immediately after that."

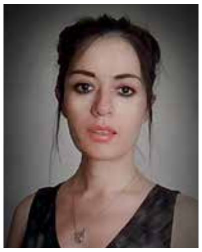
She's since attended talks on how to apply for grants as a junior professor, the pros and cons of doing a postdoc prior to applying for a faculty position, and how teaching can open up a range of creative possibilities to contribute to both students and the field as a whole. "That seminar made me realize just how fulfilling teaching could be," she says.

"GOING TO THE SEMINARS AND TALKING TO THE PROFESSORS AND OTHER STUDENTS HAS MADE ACADEMIA FEEL LESS INTIMIDATING. I'M MUCH MORE CONFIDENT NOW." —Qi Wang

Her time in FACET has directly affected her career trajectory. This spring, Wang, who researches nonlinear optimization, is co-teaching her first course: an operational research class for master's students. And next year, she plans to apply for a postdoctoral position, a step she feels—thanks to FACET—will give her more time to hone her research skills, expand her network of collaborators, and position herself to achieve her top aspiration of becoming a professor.

"Going to the seminars, talking to the professors, and talking with other students in the program has made academia feel less intimidating," she says. "I'm much more confident now."

ILLUSTRATION: GALIH/ADOBE STOCK; PHOTO: CHRISTA NEU



Aida Khajavirad's work with MINLPs has applications in data-mining techniques such as clustering.

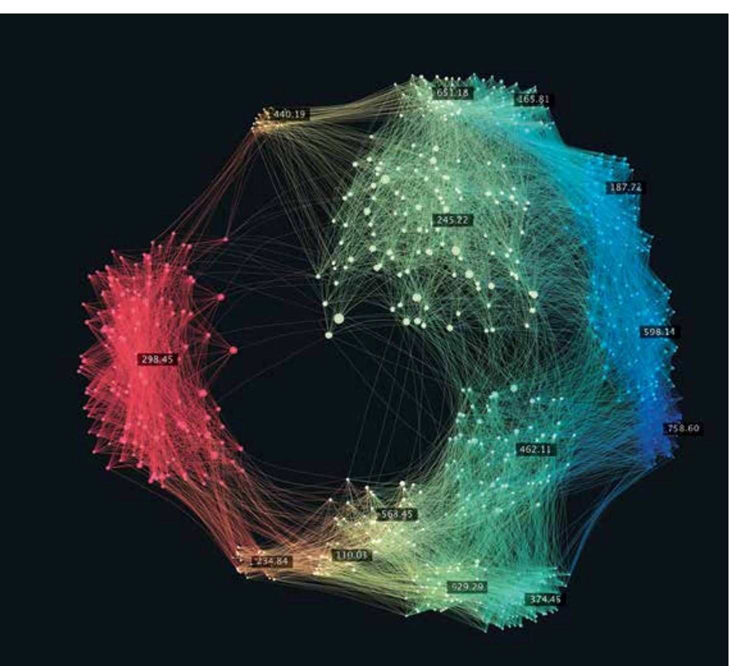
Minimizing trade-offs in mathematical optimization

ISE professor's work paves the way for efficient data-driven solutions to complex problems

Within applied mathematics, Aida Khajavirad, an assistant professor of industrial and systems engineering, researches the intricacies of mathematical optimization, specifically, Mixed-Integer Nonlinear Programming. MINLP aims to find the best values of variables to minimize a given function, a crucial task in solving real-world problems.

"My branch of research," says Khajavirad, "deals with optimization problems with a nonconvex objective function and both continuous and integer variables."

Khajavirad's work revolves around making the solution of these optimization problems more tractable, particularly when dealing with nonconvex objectives and a mix of continuous and integer variables. "Although many real-word problems can naturally be



formulated as MINLPs, solving such optimization problems is often very challenging," she says.

Khajavirad recently secured a three-year, $389,000 grant from the Air Force Office of Scientific Research. In collaboration with Antonio De Rosa, an associate professor of mathematics at the University of Maryland, she will address complex MINLP problems in data science applications, where locally optimal solutions often overshadow globally optimal ones, leading to computational inefficiencies.

The goal is to develop novel linear programming relaxations and scalable optimization algorithms with theoretical guarantees. This dual-pronged approach aims to overcome the hurdles associated with locally optimal solutions and extensive computation times in solving large-scale MINLP problems in data science.

> "MY AREA OF RESEARCH IS RELATIVELY NEW, AND THERE ARE MANY OPEN QUESTIONS THAT I ASPIRE TO ANSWER."
>
> —Aida Khajavirad

Khajavirad's approach puts the emphasis on providing both theoretical guarantees and reduced computation time. "To solve large-scale nonconvex problems in a reasonable time, existing methods either rely on heuristics, which provide good solutions but forego any guarantee on the quality of the solution, or use semi-definite programming relaxations, which do not scale well and are impractical for large-scale optimization."

The applications of her research span many domains, including computer vision, medical imaging, and finance, to enhance the efficiency and accuracy of data-driven processes.

"A variety of applications in data science can naturally be formulated as large-scale MINLPs, such as data clustering, image matching, and sparse regression," she says.

At a time when the demand for efficient and accurate data science processes is paramount, Khajavirad's work is critical.

"Many optimization experts believe that, in the case of nonconvex nonlinear problems, one must compromise either on the guarantee of solution quality or on the speed of solving the problems. My ultimate research goal is to minimize this trade-off by advancing the state-of-the-art in MINLP at theoretical, algorithmic, and software levels."

She also says that being at Lehigh has played a pivotal role in facilitating her research: "The Department of Industrial and Systems Engineering is a world-class center for research in mathematical optimization," she says. "It is home to several prominent optimizers in various fields, from quantum computing and applied operations research to data science and machine learning, and hence it provides a unique environment to do research in mathematical optimization."

The past year included a milestone for Khajavirad: She and University of Wisconsin–Madison professor Alberto Del Pia were awarded the 2023 INFORMS Computing Society Prize for their work on "convexifications for mixed-integer polynomial optimization" based on a series of seven papers. This was her second award from the Institute for Operations Research and the Management Sciences, having received an INFORMS Optimization Society Prize for Young Researchers in 2017.

Looking ahead, Khajavirad expects an expansion in research on nonconvex MINLP, and she seeks to address unsolved questions and tackle applications where current methods fall short.

"My area of research is relatively new, and there are many open questions that I aspire to answer," she says. "Research in nonconvex MINLP has witnessed significant growth at both theoretical and algorithmic levels over the last few years. While this class of problems has already made a remarkable impact on industrial and systems engineering, there are still numerous important applications that cannot be efficiently addressed using such a class, and these are the ones I want to work on."

As the landscape of data science continues to evolve, Khajavirad's work pushes the boundaries of mathematical optimization while paving the way for more efficient and accurate data-driven solutions that will ultimately facilitate decision-making processes across a range of industries.

OURS FOR THE MAKING

Lehigh's strategic plan, ***Inspiring the Future Makers***, will cultivate and support an environment where every mind can thrive and reimagine how we educate, innovate, conduct research, and work collaboratively to create a better future.

GO Beyond: The Campaign for Future Makers invites alumni and friends to play a critical role in achieving the plan. Your engagement and philanthropy support the initiatives designed to help Lehigh and the Rossin College lead in what we do best.

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GIVING BACK

"Engaging with Lehigh and sharing my industry perspective has been so energizing," says former Johnson & Johnson and Kenvue VP Kathleen Taylor '87.

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