SEEING THE BIG PICTURE

Experts across engineering and social sciences converge to tackle grand challenges

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LETTER FROM THE DEAN

Bridging disciplines, connecting communities

Welcome to the Spring 2023 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 of Resolve is dedicated to efforts that connect disciplines, and entire communities, in pursuit of common goals that are grounded in equity and sustainability. In particular, several emerging research initiatives on our campus underline Lehigh’s ability to contribute to scientific and technological discovery by bridging disciplines in novel ways to bring about real, lasting, consequential change.

This concept of convergence research animates the broader scientific community these days, as well. Convergence research is use-inspired scientific exploration driven by a specific problem or societal need that gathers an intellectually diverse set of experts to address a pivotal issue from all angles.

Global challenges that require this approach dominate news headlines: Think population health, sustainable energy, climate change, and the broader impact of online misinformation, for example. Sponsor agencies such as the National Science Foundation (NSF) increasingly prioritize convergence-driven projects in their solicitation efforts.

Convergence calls for interdisciplinary teams, and Lehigh is hardwired for endeavors of this nature. After all, applied, boundary-breaking research and education is the very foundation of our institution. Examples abound across our educational programs, the achievements of our alumni, and the research agendas of our faculty.

Since their inception, Lehigh’s Interdisciplinary Research Institutes (IRIs) have been a clear manifestation of our community’s convergence research mindset in action. They have nurtured discovery in areas such as infrastructure design and economics, materials science and health, and human-centered computing, to name a few. The IRIs encourage partnership that exposes us to new ways of thinking about our work as engineers, thereby throwing into sharp relief the human impact of that work.

Read on to learn about a new partnership arising from the IRIs that brings together researchers from the Rossin College, the College of Arts and Sciences, and the Institute for Indigenous Studies within Lehigh’s College of Health (page 10). The collaboration cuts across engineering, biology, data science, cognitive psychology, and population health in a groundbreaking effort to prevent the next pandemic among some of society’s most vulnerable groups.

Another emerging research partnership, this one among experts in computer science and journalism, seeks to better understand the source of social media in framing individuals’ beliefs and influencing their actions. It’s a fascinating exploration of how technology shapes cognition, emotion, and behavior.

This issue also highlights a string of winning bids to land Major Research Instrumentation support from the NSF (page 40). The secret to our considerable success rate in those proposals is, in fact, not so secret: Scores of faculty, hailing from a range of disciplines across Lehigh’s IRIs, joined forces to show how broadly these grants could be leveraged across our research community and beyond.

On page 16, we introduce three new faculty in the Department of Civil and Environmental Engineering whose arrival is another clear indication of the IRIs’ convergence mindset. Professors Farrah Moazeni, Gabrielle String (who holds a dual appointment in the College of Health), and Maryam Rahmehzor (who holds a dual appointment in computer science and engineering) bring with them innovative, outward-looking data-driven research. They draw upon expertise in artificial intelligence, smart devices and systems, and humanitarian engineering to address sustainability challenges involving water, energy, and infrastructure, and the associated social impact. Importantly, they also help to bring the department faculty’s gender balance into alignment with that of its students—an achievement in equity and inclusion that strengthens our research portfolio and our mentorship of the next generation of Lehigh engineers.

We also check in with Svetlana Tatic-Lucic (page 8), a Rossin College Professor and Dean of Engineering and the Rossin College. Svetlana describes how her experience at Lehigh prepared her to tackle this important role.

Thank you as always for your interest in Lehigh Engineering and the Rossin College. Please drop me a note with your comments.

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Unraveling the complexities of quantum dot synthesis

Research team uses low temperatures and water to create functional particles

Quantum dots are nanoscale crystalline particles that act as semiconductors. When exposed to UV light, they emit energy in the form of light, and the size of the quantum dot determines the color it emits.

“So by tuning the particle’s size, you can essentially tune its optical properties,” says Mark Snyder, an associate professor of chemical and biomolecular engineering (CBE), “which makes them interesting materials to use in applications like bioimaging.”

The problem, however, is that quantum dots are typically synthesized using toxic solvents, high temperatures, and hot injection methods. “All of which create challenges from the standpoint of sustainability and scalability,” says Snyder.

To overcome these challenges, researchers seek to create high-quality, nontoxic, functional quantum dots via green, scalable synthesis routes.

Snyder and his team recently published a paper in the Journal of Materials Chemistry B that outlines just such a synthesis method. The project was funded by the NSF’s Scalable Nanomanufacturing program, and was a collaborative effort among labs led by Snyder, CBE department chair Steven McIntosh, and Harold B. Chambers Senior Professor in Materials Science and Engineering Christopher Kibby. The lead author is Nur Onemli ’22 PhD, a recently graduated member of Snyder’s lab.

Earlier work by McIntosh, Kibby, and the University of Virginia’s Bryan Berger had explored a biomimORIZATION-based approach to synthesize quantum dots using low temperatures and aqueous conditions. BiomimORIZATION is the process by which bio-logical systems produce inorganic materials. “The question that Nur was addressing with this paper was how to use biomimORIZATION to synthesize quantum dots with greener and tunable compositions,” says Snyder. “She was able to show that she could do this in one pot, meaning, she could grow high-quality particles with tailored compositions in a single vessel. And under these aqueous conditions, the particles themselves are hydrophilic, so they can be used directly in aqueous applications without any complex purification steps. And they’re also easily functionalized—in this particular case, with antibodies that were specific to certain cellular systems.”

For this application, Onemli collaborated with co-author Shannon Collins ’21 PhD, who at the time was researching antibiotic resistance with Lehigh CBE associate professor Angela Brown. “I think this paper is an excellent example of student-driven research,” says Brown, who is also one of the paper’s authors. “I think it was over lunch one day that Nur was talking to Shannon about wanting to show that these quantum dots could be used for targeted imaging, and Shannon was able to help her do that.”

Brown says that, together, the students were able to show proof of concept. The quantum dots, functionalized with an antibody, could successfully target receptors for that antibody on specific cells.

“What’s so interesting about the quantum dots is that they can be made to emit different colors,” she says. “And so, in theory, you could look at multiple things on a cell, such as the presence or absence of a specific protein associated with disease or the distance between two different proteins to provide information about how those proteins interact with each other. There’s a lot of possibilities there in terms of identifying what’s going on with the cell—or is it healthy, is it dying, is it changing in some way?”

The synthesis process opens a number of doors. “Even though we looked at silver indium sulfide with zinc incorporation, the approach should be applicable to a whole range of other compositions in the metal sulfide class of materials,” says Snyder. “A broader materials palette could potentially now be accessible because of the work that’s been done here to unravel some of the complexities in the biomimORIZATION system.”

A ‘holistic approach’ to predicting Ebola outbreaks

Several years ago, a Lehigh team developed a predictive model to accurately forecast Ebola outbreaks based on climate-driven bat migration. Ebola is a serious and sometimes deadly infectious disease that is endemic, or enters, a human population via the wildlife. It is widely believed that the source of the 2014 Ebola outbreak in West Africa, which killed more than 11,000 people, was human interaction with bats.

Now members of the team have examined how social and economic factors, such as level of education and general knowledge of Ebola, might contribute to “high-risk behaviors” that may bring individuals into contact with potentially infected animals. A focus on geographical locations with high concentrations of individuals at high risk could help public health officials target prevention and education resources. “We started a survey that combined the collection of social, demographic, and economic data with questions related to general knowledge of Ebola transmission and potentially high-risk behaviors,” says Paolo Bocchini, a professor of civil and environmental engineering and one of the study’s leaders. “Our results show that it is indeed possible to calibrate a model to predict, with a reasonable level of accuracy, the propensity of an individual to engage in high-risk behaviors.”

The results were detailed in a paper published last year in PLOS ONE. Additional authors include Lehigh doctoral student Sena Mersel; recent graduates Nathaniel Altice ’22, Lindsay Stant’ 20 21, and Anna Smith ’22; and Javier Buceta, a faculty member at the Institute for Integrative Systems Biology in Valencia, Spain.

“The authors say their results point to the need for a holistic approach for any model seeking to accurately predict disease outbreaks. Their findings may also be useful for population health officials, who may be able to use such models to better focus scarce resources. ‘One has to look at the big picture,’” says Bocchini. “We collected satellite images that show the evolution of cropland-climatic data and combined them with biological and real-world models to map the spatial and temporal fluctuations of natural resources and the resulting continent-wide migrations of infected animal carriers. We strive at Lehigh to study the population’s social, economic, demographic, and behavioral characteristics, integrating everything to obtain our predictions.’

Only this ‘broad perspective and interdisciplinary approach can truly capture these dynamics,’” says Bocchini. “And with this line of research, we are proving that it works.”

To collect data, Bocchini and Buceta traveled to Sierra Leone with a delegation of undergraduate students from Lehigh with support from the National Institutes of Health and Lehigh’s Office of Creative Inquiry and in collaboration with nonprofit World Hope International.

Your phone already has an app that can tally your daily steps and log your maximum heart rate, but structural engineers have another type of well-tacker—one that monitors the health of bridges—in mind.

A research team, including Shamim Pakzad, professor and chair of Lehigh’s Department of Civil and Environmental Engineering, has demonstrated that GPS and accelerometer data collected from smartphones can be used to accurately detect modal frequencies from bridges. These vibrations can be used to assess the condition of spans, but are typically collected via special, fixed sensors attached to the bridges themselves.

In a paper recently published in Communications Engineering (a Nature publication), the researchers examined data collected from their own phones in vehicles driven over the Golden Gate Bridge in San Francisco and a shorter concrete bridge in Italy, as well as data crowdsourced from Uber drivers. In all three cases, the readings matched up closely with data gathered from the more sophisticated—and costly—stationary sensors.

While biennial visual inspections are still required by code for assessing bridge health, these new methods could allow for continuous monitoring of the most critical areas.

The lead author is Thomas Materazzo ’22 Q5 PhD, an assistant professor at the U.S. Military Academy at West Point. Sohail S. Estakhri ’20 PhD, now a senior machine learning engineer with Uber, is also a co-author. Both were advised by Pakzad at Lehigh. 
Designing a digital platform to make seniors savvy to online scams

Data from the FBI’s Internet Crime Complaint Center shows that in 2021, more than 92,000 U.S. adults aged 60 and over reported being victims of online scams. Their losses? Roughly $4.7 billion. To confront this problem, researchers from Lehigh and four other universities recently received a $85 million National Science Foundation award to create digital tools that help older adults better recognize and protect themselves from online deceptions and other forms of disinformation.

“Senior citizens are one of the most targeted and vulnerable groups when it comes to social financial scams,” explains Dominic DiFranzo, an assistant professor of computer science and engineering. DiFranzo is a collaborator on the Deception Awareness and Resistance Training (DART) project, which is led by University of Maryland professor Siwei Lyu, through UB’s Center for Information Integrity. The team also includes members from Cornell University, Clemson University, and the University of Illinois Urbana-Champaign.

The project is funded by the NSF’s Convergence Accelerator; at the agency launched in 2019 to support “basic research and discovery to accelerate solutions toward societal impact.” DART builds upon a $750,000 Phase I grant the team received in 2021, when they conducted afeasibility study.

Two researchers from Lehigh, DiFranzo and DiFranzo’s advisor, John McIntyre, are leading the project. The team’s overall goal is to create a digital platform to build awareness and resilience among older adults, including a wide range of online schemes. Older adults, many of whom are not tailored to older adults, which limits their effectiveness. DART aims to address this limitation by including a wide range of online schemes, with the team’s unique expertise.

For the past 20 years, Eugenio Schuster, a professor of mechanical engineering and materials science at Lehigh, has been part of an international team of scientists and engineers working at tokamaks, nuclear fusion reactors designed to produce energy, but to help researchers study the physics of the plasma. Their ultimate goal is to ensure the reality of sustained fusion of the sun, the ITER, the world’s largest nuclear fusion reactor, which is being built in France. The machine is the product of an international effort to essentially harness the energy-generating power of the sun.

Schuster leads a Lehigh team that recently received nearly $17.5 million from the Department of Energy (DOE) to continue their work in support of ITER and to help the United States establish its own nuclear fusion reactor within the next decade. The award is part of a $67.5 million effort the DOE announced this past October to fund research aimed at closing the gap in science and technology when it comes to making fusion energy viable.

Current tokamaks work in what’s called a pulsed regime, but they’re not created equal, says Schuster. Unlike the newer tokamaks, such as DIII-D and NSTX-U, those in the U.S. lack the superconducting coils necessary for extended operation. “So, for example,” he says, “with the DIII-D tokamak in San Diego, the pulse is around six seconds. So we run an experiment for six seconds, and then we have to wait for the machine to cool down before we can run another one.”

KSTAR and EAST are known as long-pulse machines, and can carry out experiments for at least hundreds of seconds, which makes them ideal for experimentation that could eventually be applied to ITER (which is also designed for long-pulse and eventual steady-state operation). Ultimately, says Schuster, for nuclear fusion to be economical, future reactors will have to operate in very long pulses (in comparison to the time between pulses) or in steady state.

Part of Lehigh’s DOE award will support research at KSTAR, where Schuster’s Plasma Control Group—together with the University of California, Los Alamos National Laboratory, and Princeton Plasma Physics Laboratory (PPPL)—will add critical research questions related to the development of ITER’s long-pulse scenarios and their active control. The remainder will fund research that Schuster’s group has planned for years, which includes teams from General Atomic, Lawrence Livermore National Laboratory, MIT, PPPL, and UCLA, to guide the design of a future fusion plant (FFF) in the United States.

“DOE asked the National Academies of Sciences, Engineering, and Medicine to determine what was needed here in the U.S. to really advance nuclear fusion, and in particular, to bring fusion energy to the grid,” says Schuster. “One recommendation was the construction of a fusion pilot plant. That’s why the DOE is funding American researchers to do this work abroad. It will help us learn from these superconducting tokamak machines so that eventually, we can build a long-pulse reactor—degree device here.”

Schuster says the goal is to design, develop, and begin producing energy within 10 years. “It’s a very aggressive time line,” he says. Indeed, especially considering that ITER—while its 16-year head start—is not yet operational. The difference, Schuster says, comes from continued investment and technology.

“If you want to make things much faster, you need to invest more heavily,” he says. “In the past, investors in nuclear fusion were exclusively governments, which are often constrained by budgets aligned with shorter-term priorities. But now, you have startup companies funded by billionaires, and they aren’t constrained in the same way. The DOE is presently developing partnerships with private investors to accelerate the development of fusion energy.”

The technological constraints have also changed dramatically. A “convergence” in computational power and advancements in superconducting coils capable of generating ever stronger magnetic fields to contain the plasma have pushed the field forward faster.

“We now have the capability to better predict the evolution of the plasma, thanks to more powerful computational resources, to understand the physics of the plasma more precisely after decades of studies, and to process the huge amount of data that comes from plasma experiments so that we can bet- ter learn from these experimental results,” he says. “So we do believe that we’re in a position to design and build this FPP much faster than we did with ITER.”

The promise of nuclear fusion is a big one: If achieved, it could provide a limitless supply of clean, safe, and reliable energy. And many of America’s entrepreneurial- ship behind it, the efforts of Schuster, and so many researchers like him, may finally be realized.

“This fusion pilot plant is what we’ve all been working on and waiting our whole lives for,” he says. “It’s the opportunity to develop a type of energy that comes with so many benefits in terms of pollution, climate change, and fuel security—right here at home.”
Advancing neurostimulation beyond the pacemaker

In a pharmaceutical approach to disease treatment, blood transports drugs throughout the entire body, sometimes producing undesirable side effects. Electroceutical or bioelectronic therapy offers a more selectively targeted approach, leveraging the electrical impulses that regulate the body's functions through the nervous system, with the goal of affecting only the organ of focus.

The research seeks to understand what nerve stimulation does to an organ, says Kothare and develops predictive mathematical models of behavior to help develop treatments.

Electroceuticals are not new. The pacemaker, which sends electrical signals to stabilize heart rhythms, was invented in the 1950s. However, nerve stimulation is not yet broadly approved to treat other diseases. Vagus nerve stimulation devices, for instance, have been approved by the FDA to treat epilepsy and depression.

Mayvahesh Kothare, B. R. L. McCann Professor of Chemical and Biomolecular Engineering, and his colleagues are investigating how the neurostimulation of peripheral nerves—the nerves located near various organs—could be used to treat other diseases, just as pacemakers are commonly used to help regulate heart function. With approximately $2.2 million from the National Institute of Health (NIH) through the Simulating Peripheral Activity to Understand Conditions (SPARC) program, the team is developing software and modeling tools for optimizing the delivery of neurostimulation signals to peripheral nerves to treat conditions such as cardiac arrhythmias, impotence, and stomach and bladder disorders.

Little research exists on the use of electroceuticals to treat such disorders.

“Nerves connect different organs,” Kothare explains. “There is a nerve connecting to the heart, and there is a nerve connecting to the stomach, and there is a nerve connecting the toxin to the bladder. So those nerves are the ones that control the function of each organ. We are looking at typical diseases that affect [the heart and stomach]. We are trying to develop technology and combining engineering and experimental approaches that would allow us to treat those dis- eases through stimulation.”

The team is working to determine how to generate the correct response to effectively treat the right problem, Kothare says. In the case of a pacemaker, wires are implanted in the heart and connected to an implanted chip so the pace of the heart can be monitored and adjusted as necessary, through the delivery of electrical energy. Similarly, Kothare says, common disorders of the stomach, such as constipation or irreg- ular rhythms of the stomach that cause chronic indigestion, could theoretically be treated by stimulating the gastric nerves to either change the contractions of the muscles of the stomach.

“The grand chal- lenge is how do you design those elec- trical signals so that they do what you want them to do?” he says. “Because if you send the wrong neural signal, it could create a worse symptom. Just like with drugs—a drug can have an effect or a bad effect.”

Kothare and Babak Mahmoudi, a machine learning scholar from Emory University, lead the project. Collaborators include Charles Horn, a neuroscientist from the University of Pittsburgh; Raj Vadgavis, a professor of pathology, cell biology, and anatomy from Thomas Jefferson University; and Gautham Kumar’12, MS, an assistant professor of chemical and materials engineering at Lehigh University, and his colleague, a retired Lehigh computer science faculty mem- ber, helped develop novel approaches to software and cloud-based simula- tions for the project. Students and postdocs from across the institutions are also collaborating on the work.

The group is using a two-pronged approach. Horn is collecting experimen- t data by implanting electrodes in the gastrointestinal system and then stimulating the gastric nervous systems. Team members are also analyzing exist- ing data, such as cardiac and gastric data collected from dogs by UCLA, which is where the modeling, machine learning, and cloud computing take place.

“What we are trying to do is to develop mathematical models of the behavior of the organ in response to different stimuli, and then use these mathematical models to develop a tool or ‘optimal’ signal that could elimi- nate the disorder,” Kothare explains. “So that requires us to have an under- standing of the underlying biophysics. How do the muscles contract? How does the contraction of the muscle move the liquid inside the stomach? What prevents the liquid from flow- ing out of the stomach continuously?”

These are the kinds of quantitative, almost engineering-like questions that we are asking to understand the underlying biophysical processes of each organ to achieve the intended function. How can we predict the behavior of organs in response to stimulation? When we don’t fully understand the biophysics, we employ data-driven machine learning methods to capture the observed behaviors.”

This story was adapted from the Lehigh Research Review (2022 Volume No. 7).

Making a dent in manufacturing emissions through materials optimization

While the jury is still out on the effectiveness of plastics recycling, the story with aluminum is generally regarded as a success. The material is infinitely recycl- able, meaning it can go through the process over and over, and doing so usually results in a product of equal or better quality.

The grand challenge, therefore, is to “rethink” recycling and develop new materials that will enable manufacturers to design and implement transformative systems that will underpin a circular economy.

An estimated 10% of aluminum manufactures, for instance, are looking for new ways to reduce the costs of aluminum recycling, according to Kothare. Challenges include finding new methods to purify recycled aluminum and to develop new materials that are more sustainable and recyclable.

“I think the main thing we need to focus on is what are the material properties we need to make the new materials?” Kothare says. “We need to make them more recyclable, meaning it can be sent into the recycling stream even if it has some impurities.”

This story was adapted from the Lehigh Research Review (2022 Volume No. 7).
Q: What are your duties at the NSF?
A: I make recommendations for future awards, manage the portfolio of existing awards, and participate in working groups outlining future solicitations. I also had the privilege of being a lead program officer for the Integrative Strategies for Understanding Neural and Cognitive Systems Program in the past year. It was a challenge and an honor to head this cross-directorate program as a brand-new program director, and I learned a great deal.

Q: How does your research expertise support you in this role?
A: The field of sensors, in general, is very interdisciplinary, because it assumes knowledge and understanding of various branches of engineering, physics, and chemistry. And in my specific field of interest, biology is needed as well. This breadth gives me a chance and irresistible allure, at least as far as I am concerned.

I’ve worked in interdisciplinary research since my first job, and my PhD thesis focused on applications of microdevices in neurosciences. I still remember that my fellow students were amused that I had to be cross-trained in biology. Back in the early 1990s, sessions on sensor applications in biology were poorly attended at major conferences. Many people moved to this field later because of more abundant funding, but I was there from the very beginning of my career.

Q: How do NSF program officers affect the direction and trajectory of STEM research?
A: Feedback from the review panel plays the biggest role in any funding decision. However, each program director submits a recommendation based on his or her insight into the field and what they see as the most promising venues of research, that is considered as part of the evaluation process.

Even more important, we have an opportunity to initiate and shape new solicitations and Dear Colleague Letters, which are special requests for research proposals, often tied to societal needs or unique circumstances like the pandemic. This was a black box for me prior to joining the NSF, and it has been interesting to peak behind the curtains and get to know the intricacies of the process.

Q: Why is it beneficial for researchers to serve a rotation as a program director?
A: From my first visit to the NSF, which was early in my academic career, I wished to one day have a chance and make a contribution. I believe it is beneficial for both researchers and their home institutions. This position gives you a big-picture view of where STEM research is going and insight into how you can contribute in your specific field, particularly as it applies to the NSF’s grand challenges. You gain an insider’s perspective into how proposals are processed and learn strategies to maximize the chances of securing NSF funding. Program directors return to their home institutions, they can pass that knowledge along by mentoring other faculty.

Q: Why did you choose this new path?
A: I see this job as a way to round out a full deck of experiences in my career as an engineer and scientist. I worked for an industry giant and a startup. I’ve made my way up the ranks as a professor and served as an administrator. Now I’m working in the government.

I think it is a royal flush of career experiences, and I am proud of my achievements. Not bad for a girl from a small town in a war-ravaged country in Southeastern Europe.

Q: What have you learned about the proposal process, and specifically about the NSF’s focus on convergence research, from sitting at the other side of the table?
A: It is very important that researchers are well-prepared and have an awareness of the opportunities and a wide-ranging network of possible collaborators. Communicating with the potential program director up front, to be sure that proposals are submitted to the right place, is critical. Convergence research is extremely impactful, but conducting research across different disciplines of science and engineering is far from easy. Flexibility is essential.

Q: You have been deeply involved in the Rossin College’s efforts to improve diversity, equity, and inclusion within the academic environment. How can similar goals be supported by funding agencies?
A: The NSF is very focused on making strides in these areas, specifically in regards to broadening participation in STEM. We are attempting to develop and implement innovative strategies to increase the participation of people from backgrounds that are under-represented in our fields. Other funding agencies have similar efforts, and in concert with what is going on in academia, I hope we will see some tangible results soon.
We live in a world that demands creative problem-solving. And such creativity is inevitably sparked when disciplines come together to look holistically at a problem. “Humans are facing challenges that are multifaceted and complex, and require an interdisciplinary approach for their solution,” says Anand Jagota, a professor of bioengineering and chemical and biomolecular engineering and Lehigh’s vice provost for research. “While incredibly important work continues within the confines of each discipline, innovation is occurring at the interfaces between them.”

That is the essence of convergence research, or what the National Science Foundation defines as work driven by a specific problem or societal need that brings together an intellectually diverse group of experts (in some cases, drawing from areas beyond traditional STEM fields). In recent years, the NSF has increasingly emphasized this approach—and supported it through an array of grants and workshops—as a way to frame research questions in new ways and spur discovery.

Boundary-crossing team science has long been part of the Lehigh research ethos. For example, The Humanities Lab weaves the study of history, language, society, and related fields into scientific pursuits. The Nano-Human Interfaces Presidential Initiative, which connects engineers with experts in human cognition, psychology, and education, seeks to redefine the interaction between scientists and their instruments. And the university’s three Interdisciplinary Research Institutes are developing research strengths across Lehigh’s colleges to address large-scale societal problems around materials and devices, data and computation, and infrastructure and energy.

All of these efforts use an interdisciplinary approach to advance knowledge and discovery. Creating and fostering that kind of collaboration is a function of both place and people, says Jagota. “A medium-sized institution like Lehigh really promotes interactions between researchers,” says Jagota. “But our real strength is our culture of collaboration. We want to work together, and we’re always looking for ways to do that, and do it better. At the end of the day, the goal is to make an impact with the work we do. And our chances of doing that are always greater when we approach it as a team.”

The NSF has supported a number of Lehigh’s interdisciplinary proposals that combine the university’s research strengths in new ways. Two of the most recent—both rooted in challenges borne out of the COVID-19 pandemic—reflect the depth of problems our researchers are joining together to solve, and the potential they have for creating a healthier, safer world.

Lehigh’s diverse expertise and culture of collaboration provide fertile ground for convergence research—with two unique cross-college projects taking root out of the COVID-19 pandemic.

STORY BY CHRISTINE FENNESSY | ILLUSTRATIONS BY SARAH HANSON
Imagine if researchers could predict the spread of a pandemic like they can the evolution of a hurricane. With the right data, they could help people stay out of harm’s way. Harnessing the ability that is the bold vision of a Lehigh team recently awarded a $1 million grant to examine pandemic dynamics from isolated and underrepresented populations.

The funding comes through the NSF’s new Predictive Intelligence for Pandemic Prevention (PiPP) program, which promotes convergent research by diverse, multidisciplinary teams spanning engineering, computer science, biology, and the social sciences.

“The call for proposals came out, we recognized that Lehigh had expertise in all of these areas,” says Jagota. “The institute gives us access to communities that, historically, have suffered disproportionally compared to the general population in every pandemic in modern history. Having this connection gave us a unique angle to look at the problem of pandemic prediction and prevention.”

Studying pandemic dynamics in Indigenous communities

Daley is an applied medical anthropologist who says she has been working with American Indian communities since 1995 on topics such as tobacco cessation.

“I spent my entire career trying to convince researchers to please, please, please come work with these communities—they need what you can deliver,” says Daley. “And I’ve been met with responses like, ‘They’re only three percent of the population, or it’s too hard to get to where they live.’ That’s the mindset you’re trying to respond to community needs. And for the first time, really ever, when I got to Lehigh, I met researchers who said, ‘Yes, I want to do that.’”

She credits that willingness, in part, to Lehigh researchers feeling comfortable with the unknown. Whereas in traditional research, investigators are continually building on what they know, committing to a project like this, she says, requires learning a new culture and working with colleagues who do science very differently.

“Working with a new community is a big step,” she says. “And it’s one that a lot of people aren’t willing to take because they see it as too different. You have to relearn things from a new perspective. But I think people at Lehigh are willing to take that chance like this because they can see the bigger picture.”

The team’s innovative collaboration cuts across the fields of engineering, biology, data science, and cognitive psychology, and their approach is organized around four research thrusts.

Falk (above) will study how viruses are transmitted from one cell to cell. Cheng (right), can develop point-of-care diagnostic devices.

The first will be led by Jessecare Marsh, an associate professor of psychology in Lehigh’s College of Arts and Sciences (CAS), and will establish the belief system around disease within Indigenous communities.

“So, how do these beliefs develop?” says Jagota. “How do they affect the progression of disease? How do they affect whether people get vaccinated?”

The second thrust will model virus spread and, and will be headed by Paola Bocchini, a professor of civil and environmental engineering.

“We’ll be using our Catastrophe Modeling Framework,” says Bocchini. “It’s a modeling approach that started with natural disasters, but we’re trying to push well beyond that now. In fact, we’ve been applying it to diseases like Ebola.” [See page 3] With the PiPP grant, we’ll work on modeling spread from animals to human and study the interactions, and lay the groundwork for probabilistic models detailing spread among the human population.

Lehigh’s strengths in data analytics “will play a particularly key role when it comes to studying American Indians,” says Daley. “When you have these very small populations, you need gigantic data sets to find these folks, and you need to use sophisticated statistical techniques that you usually have to develop yourself. And we have people here who can do all that.”

Xuehong Cheng, a professor of bioengineering and materials science and engineering, will lead the third thrust, which will focus on developing point-of-care diagnostic devices, as many of these communities are often located far from testing centers.

“The idea that her team member can simply make a device has been another really mind-blowing revelation for Daley. “I have always been the person who is looking for these devices,” she says. “But having engineers around telling me, ‘Oh, we can just make that; that’s pretty cool.’”

The fourth thrust has two aspects, says Jagota, and will seek to determine if researchers can detect the biological basis of why some people get sick and some people don’t and whether a person’s genetics or environment is “the main culprit.”

Biological sciences professor Matthew Falk (CAS) will examine how viruses are transmitted from cell to cell, and how that might lead to variability in the response to infection. Jagota will look specifically at the role of the glyocalyx, the protective layer that surrounds the cell.

“We hypothesize that this glyocalyx is very important in determining whether the virus sticks to the cell or not,” he says. “The cell membrane has a bunch of hairy molecules on its surface, which the virus has to get through, and so far, researchers have sort of ignored that fact. We’re pursuing the hypothesis that the variability with which the virus sticks may have to do with the variability of the glyocalyx, and that may have to do with your environment or with genetics.”

To that end, he’ll develop an assay to directly measure how strongly a viral particle sticks to a cell surface as the nature of its glyocalyx is manipulated.

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The ultimate goal is to secure funding in Phase II for the establishment of a formal research center.

“The idea is to create a center in which we’re able to use computational modeling, engineering, biology, and social science to predict pandemic spread and spread in underserved and isolated communities,” says Bocchini. “The hope is that what we learn will have relevance at the national scale, because protecting these communities is a way to protect all of society.”

There’s an additional element to this project unrelated to pandemic prevention, but very much in keeping with the NSF’s push toward promoting convergent science.

“Working with a new community is a big step. And it’s one a lot of people aren’t willing to take. But people at Lehigh are willing to take a chance like this because they can see the bigger picture.” —Christine Makosky Daley

The ultimate goal is to secure funding in Phase II for the establishment of a formal research center.
I think the most interesting research projects really happen at the intersection of various disciplines, so I find the idea of studying how we work together fascinating.

There's a tremendous amount of work to be done for the team to make it to the next step. But Jagota is optimistic. "We’d like to be able to contribute through surveillance, through measurement, through psychological work to predict the progression of a pandemic. Just the way we can predict the weather right now."

Examining social media’s role in framing facts, influencing behavior

The onset of the COVID-19 pandemic coincided with an era in which people the world over have the technology to document and share their experiences with and perceptions around the virus. "I was really moved by the personal storytelling I saw on social media," says CAS faculty member Marya Jia, an assistant professor of journalism and communication. "At the same time, I saw how those experiences were reflecting very different realities."

"The more she read, the clearer it became that such personal accounts were very much influenced by the information people were consuming. "As a media researcher, I was fascinated by this," she says. "I’m always trying to better understand how technol-

ogy shapes our cognition, emotions, and behaviors, and this was a unique moment playing out in real time."

That fascination has led to a nearly $1.2 million NSF grant that is funding an interdisciplinary team investigating the role of online media in framing processes—essentially, how individuals and communities develop their understandings of major events and, ultimately, act on that understanding.

In addition to Jia, the team includes two computer science and engineering faculty members—associate professor and lead researcher Eric P. S. Baumer and assistant professor Domenic DiFranzo. On the team is Amande Grewe, a former postdoctoral research associate in The Humanities Lab, who is now with the Center for Bioethics and Social Sciences in Medicine at University of Michigan Medical School.

The grant stems from the National Science Foundation's Information and Intelligent Systems division, which supports research that probes the intersection of people, computers, and information.

The kernel for the idea came from initial conversations between Jia and Baumer in the spring of 2020, and Jia’s realization that English-language, U.S.-based social media coverage of the pandemic reflected a very different reality when compared with coverage coming out of China. There are fundamentally different ways of organizing basic facts, says Baumer. “Taking the same exact facts and organizing them in a different way leads to different conclusions about what people should do—taking in a mask, for example. How we organize and give meaning to the events in the world draws on this theory called framing. And how we frame these events ultimately leads to what actions we take in the face of them.”

What’s interesting, says Jia, is that social media has upended who gets to do the framing. Yes, the main pur-

veyors of information—particularly around COVID—are public health departments, government entities, and the news media. But individuals and online communities are doing their own framing—puzzling together what most relevant issues are and the platform that makes the most sense to them, and ultimately influencing people’s reactions to and behaviors around the pandemic.

“What’s also unique here, is that while we often talk about news frames as fixed moments in time, the pandemic has been going on for years, which means the narrative around it has been changing," she says. “For example, take a person who may not have initially believed that COVID was a threat. If they lost someone in their family to the virus, that event might have changed their view completely, and they might be motivated to get vaccinated or be more willing to wear a mask. You can start thinking about framing as a process, and identify those things that trigger changes in people's understanding or framing of COVID." It’s not a purely academic exercise, says Baumer. The implications of their research could help inform public health communicators responding to crises.

"You can’t necessarily tell people how they should think," he says. "But you can control the kinds of resources that you give them for interpretation. The choices of language, the specific metaphors that are invoked, stereotypes, imagery. You can make conscious, intentional choices about the resources you make available to people to support their understanding of a pandemic, evolving crisis." To that end, the project will unfold in four phases, each reflecting the team’s interdisciplinary. The first phase will be led by Jia and Grewe and use qualitative methods from media studies, health humanities, and science and technol-

ogy studies to better understand how groups like community organizations, local leaders, and online communities describe their framing process. It will also involve content analysis of the groups’ social media, as well as information published by news organizations and governmental and health agencies.

Baumer, who studies human interactions with algorithmic systems, will lead phase two, which will involve computa-

tional analysis of much of that same content.

“We want to take the knowledge that we’ve gathered and understand how these framing processes play out in the kinds of language patterns that tend to co-occur with certain metaphors or visual imagery,” he says. “So the first and second phases will be in dialogue with each other, with each informing the other. That will allow us to see what’s going on, and the way that people are talking. But it doesn’t necessarily tell us anything about causal connections. That’s what the third phase is for."

That third phase will be led by DiFranzo, who will take the results of both the qualitative and computational analyses and formulate testable hypotheses. DiFranzo’s research focuses with computer interactions and “design interventions” that encourage pro-social behavior online. He also continues to develop new tools, platforms, and methods to help researchers study social media. (See page 4.)

“The idea is to develop web browser plugins where you can make subtle manipulations in the content that people see, for instance, on Facebook, on Twitter, on Instagram, or on Reddit, to test these hypotheses,” says Baumer. “If we change what people are seeing, does that change their perceptions? Their opinions? Their subsequent behaviors?”

The fourth phase will involve a process called reflexive engagement. Findings from the previous phases will be brought back to those groups who were initially interviewed, with the team synthesizing their draw on those results in a future health crisis, says Jia. "This is about making a real-world impact," she says. “We want to go back to these groups and say, ‘Here’s what we found, this is what we know about the facts of framing, what do you think?’—and they might then begin to look at their communication strategies from 2020, and identify where they could have done better.” It’s a project that could only be accomplished with the unique blend of expertise within the group, says Baumer.

“Because we each came at this from different disci-

plines, we each had a slightly different perspective,” he says. “And that’s allowed us to get to this point where we have a potentially novel way of thinking about and exam-

ining framing. Personally, I’m excited about the innovative computational methods that we’re proposing. I’ve done prior work collaborating with social scientists and human-

ists who are interested in using computational techniques, and so I’m really looking forward to expanding on that with this team.”

Such innovation and potential for impact could never happen without researchers being willing to step outside the comfort zone of their shared discipline. Again and again, Lehigh researchers are taking risks and engaging in fields far outside of their own to push the boundaries of cre-

ative problem-solving. Yes, it’s a mindset that is rewarded by the NSF, but it’s also a mindset with its own rewards.

"This team approach to research gives us the opportu-

nity to solve knotty problems, the kind that previously you might never have considered tackling," says Jagota. "And in the process, you inevitably find new fields of inquiry and make new discoveries. And so it becomes self-fulfilling, and something that, I think, will become the gold standard for how lasting impact is made."
Civil and environmental engineers are on the front lines of efforts to adapt to a changing climate, where natural disasters are more frequent and natural resources increasingly scarce.

Meet three new Rossin College faculty members who are taking innovative, data-driven approaches to sustainability challenges involving water, energy, and infrastructure—and their impact on people and communities.

STORY BY CHRISTINE FENNESSY
PHOTOGRAPHY BY CHRISTA NEU

FARRAH MOAZENI
SECURING MODERN WATER SYSTEMS AGAINST CYBERATTACKS

“Everyone should have equal access to water and to energy,” says Farrah Moazeni, an assistant professor of civil and environmental engineering. “Equity is the ideal, and so that’s our goal.”

Moazeni researches modern water infrastructure systems and how to make them more efficient and resilient. Water distribution systems comprise a vast, dispersed network that includes a water source like a reservoir or well, pumping stations that pressurize the water and allow it to travel long distances, and miles and miles of piping with countless valves that direct the flow to your faucet.

“Facilities and transport water—so the more water you use, the more energy you consume. Communication potentially can be leveraged to make both systems more efficient.”

“So another part of my work is the controlling of interconnected water and energy systems,” she says. “There are a lot of us involved in this research project because each of these systems on its own is so complex—highly nonlinear and highly uncertain. Now imagine trying to control and optimize them simultaneously while meeting both water and energy demand. It’s very challenging.”

Moazeni talks about working toward equitable access to resources, and leaving her life in Iran, on the Rossin Connection Podcast.

To meet that challenge, Moazeni is working with colleagues across civil and environmental engineering and electrical engineering to develop a framework called model predictive control that will help them coordinate the two systems.

The ultimate goal, she says, is to establish an urban system where water, energy, transportation, and building systems are all connected and optimized so that consumption, emissions, and costs all go down while access for all goes up.

“Imagine if you could do that for the entire United States,” she says. “You would have all these interconnected systems lending and borrowing from each other, depending on the need at any given moment, so that no matter where you live, you have uninterrupted, reliable, and resilient access to these resources.”
The idea is to train the next generation of students in a domain that bridges these two disciplines," she says. Rahnemoonfar has long worked at the intersection of the two fields. For the past decade, she has been leading a project using radar imaging to monitor changes in Arctic and Antarctic sea ice. The technique uses radio wavelengths to send out pulses of light and measures the strength and time with which those signals are reflected off an object to create threedimensional images.

"Radar is the only sensor that can penetrate the ice and the soil to give us information below the surface," she says. "The problem was that there were no advanced data analytics techniques to process all of that data. Our group was the first of its kind to develop the models to make sense of all of this data collected over the years. Ultimately, it will lead to a better understanding of the factors that affect sea-level rise."

She previously led a multi-institution, multidisciplinary team that established an inaugural National Science Foundation HDR (Harnessing the Data Revolution) Institute for Data-Intensive Research in Science and Engineering. The institute studies polar regions and their contribution to sea-level rise using a combination of machine learning and physical models. At Lehigh, Rahnemoonfar is leading a project to develop physics-informed machine learning algorithms for polar ice dynamics for the NSF-funded Leadership Class Computing Facility in collaboration with the Texas Advanced Computing Center at the University of Texas at Austin. She’ll be employing similar techniques alongside colleagues who are developing models to better predict situations like flooding after a hurricane. If experts can better predict such events, she says, they can better prepare communities or help them evacuate.

Her cross-disciplinary appointment is a natural fit for her strengths as a researcher, and her skills as an educator. It’s also directly in line with her passion.

It’s also directly in line with her passion. Rahnemoonfar is using computer science and environmental engineering “when you take an image with a handheld camera from the ground, you can see all the objects and their features, like the doors and windows of a house. But with overhead imagery, one can only see the roof of the house, features are tiny, and there’s no balance between foreground and background. So it’s very difficult to decide if the house is totally destroyed, or if what you’re seeing is actually part of the road next to the house.”

Rahnemoonfar uses a combination of computer vision (i.e., simulating with computers how the human eye and brain interpret the visual world), machine learning, and remote sensing to develop better tools to analyze aerial imagery. Her crossdisciplinary appointment will allow her to computer science students to work on a real-world problem, using advanced techniques not traditionally applied in civil engineering.

"The idea is to train the next generation of students in a domain that bridges these two disciplines," she says.
Uncovering ‘weak links’ in microstructures

Thanks to a nearly $1.3 million MRI grant awarded in 2022, researchers across Lehigh will soon be able to conduct experiments using a state-of-the-art plasma focused ion beam system, or FIB, together with the capability for in situ mechani- cal testing at various temperatures between minus 130 and 1000 degrees Celsius.

“We had 25 faculty members involved in this proposal, all of whom submitted projects requiring the FIB system, and many of them are associated with Lehigh’s Interdisciplinary Research Institutes,” says Masashi Watanabe, a professor of materials science and engineering and a major contributor on the proposal. “And they represent a range of disciplines. There’s just such a high demand for a machine like this.”

“The FIB system is a micro-nano-fabrication tool that is able to precision-machine samples in a rapid, efficient way, similar to woodworking, but at the micrometer or even nanometer level,” says lead researcher Helen Chan, New Jersey Zinc Professor of Materials Science and Engineering. “The feature that allows for mechanical testing in real time enables us to indent or put push on a material so we can see how it deforms. Even more exciting, we can study the effect of temperature on the deformation process.”

Chan says the EBSD (electron backscat- tered diffraction) capability is exciting because when certain materials are subjected to a stress, a phase or orientation change can take place, and this is detectable by EBSD. “These changes are often highly localized and are difficult to observe in bulk samples,” she says. “With in situ mechanical testing with EBSD analysis, we can observe these changes as a function of the stress and correlate with changes in the properties.”

The new instrumentation also includes an ultra-high-speed electron camera for acquisi- tion of EBSD patterns. “We’re targeting 2000 to 3000 patterns per second, which is incredibly fast. So during deformation, we’ll be able to see these crystal structures change as the change is taking place.”

“The system is very new,” he continues. “No research team on Earth has yet been able to achieve this.”

Such information will inform researchers on how cracks in structures initiate, says Chin. There may be “weak links” in the microstructure that could be alleviated by improved processing. “We would like to build ‘crack stoppers’ that make it more difficult for cracks to propagate throughout a structure,” she says. “The net result would be structures that exhibit higher toughness and longer lives.”

The Lehigh team behind the effort also includes Coulter and fellow MEM faculty member Natalia Vermaas, as well as Wojciech Z. Miseilek, the Lowey Professor of Materials Science and Engineering.

Getting technology closer to the action

Lehigh’s second MRI grant funded in 2022 received nearly $1 million, and it will also allow researchers to try something completely new. “No one else, to our knowledge, has tried to put such a high-speed computing cluster so close to the equipment in their labs,” says Yang Li, a professor of bioengineering and mechanical engineering and mechanics. “We believe the facility we’re proposing will have a huge impact on our campus by enabling big-data analysis and new science.”

Liu says the new platform will facilitate interdisciplinary teams pursuing next-generation research. “The facility will help circumvent latency and bandwidth challenges, and its proxim- ity to the data sources will allow for real-time analysis and control of optical, scanning probe, and transmission electron microscopy. Liu says the server will be installed in Lehigh’s state-of-the-art HST Building, with high-speed fiber connecting it to various labs.

“This platform will allow researchers across the university to make advances in fields like wireless communication, healthcare monitoring, advanced manufacturing, and multiantennary autonomous systems, and it will facilitate interdisciplinary teams pursuing novel research across the campus,” she says. “That will allow us to advance our research, which is incredibly exciting.”

TOOLS OF THE TRADE

Lehigh’s research infrastructure gets a boost through two National Science Foundation grants for instrumentation development and upgrades

— BY CHRISTINE FENNESSY —


It’s a wish list of sorts. But not the type you can fulfill on Amazon.

“Overall, receiving these grants signifies there’s a compelling need for the instrumentation, and that the university has the expertise and human capital to use it to tackle grand challenges and gain new knowledge that can make an impact on society in the long run,” says Coulter. “This latest investment continues to strengthen Lehigh’s internationally recognized capabilities in materials research and microscopy.”

Neutron probe. The technology allows researchers to study materials at high temperatures, complex chem- ical or multiagent autonomous systems, and radiation.

Nanocrystals Thermochemistry Laboratory. His work focuses on the fundamental understanding of nanomaterials and their behavior under processing and service in a variety of high-temperature, complex chemi- cal, and radiation environments.

Coulter’s research group seeks to understand nanoscale effects on electronic, mechanical, and chemical properties and how to optimally process materials to control these effects and influence nanoscale behavior. By using a combination of structural charac- terization techniques, including microcalorimetry and high-resolution electron microscopy, the Coulter group has advanced processing techniques to create samples with unique mechan- ical properties and tolerance to irradiation-induced defects.

Liu notes the Loewy Professor of Materials Science and Engineering and the University at California, Davis, leading the

ADDITIONAL EXPERTISE IN NANOATERIALS

Award-winning nanomaterials researcher Ricardo H.R. Castro will succeed Wojciech Z. Miseilek, the Lowey Professor of Materials Science and Engineering, as MSE department chair on April 1. Castro most recently served as the Chancellor’s Leadership Professor, Professor of Materials Science and Engineering at the University of California, Davis, leading the

Nanocrystals Thermochemistry Laboratory. His work focuses on the fundamental understanding of nanomaterials and their behavior under processing and service in a variety of high-temperature, complex chemi- cal, and radiation environments.

Coulter’s research group seeks to understand nanoscale effects on electronic, mechanical, and chemical properties and how to optimally process materials to control these effects and influence nanoscale behavior. By using a combination of structural charac- terization techniques, including microcalorimetry and high-resolution electron microscopy, the Coulter group has advanced processing techniques to create samples with unique mechan- ical properties and tolerance to irradiation-induced defects.

Liu notes the Loewy Professor of Materials Science and Engineering and the University at California, Davis, leading the
That means sometimes they fail, but they learn from things, doing experiments, and taking risks. Zheng calls “student centered.”

The Autonomous Driving for Underwater Drones project is also a creative way to give students hands-on experience with solving complex problems that span a range of engineering disciplines. Zheng leads the project, which is part of Lehigh’s Mountaintop Summer Experience. She also teaches a class on Autonomous Driving and Robotic Racing. Both the project and the course is what Zheng calls “student centered.”

“Experiential learning puts students in the driver’s seat,” she says. “They’re making things, doing experiments, and taking risks. That means sometimes they fail, but they learn more through trial and error. And then they get to compete with their vehicles. They learn so much by doing, and I think that’s what students really enjoy.”

Zheng started the Underwater Drones project in Summer 2020 with a small group of undergraduates. Each year, the goal is to build an autonomous underwater vehicle (AUV) capable of accomplishing a series of tasks in a pool. Students can continue work on the project through the academic year as part of a course led by Zheng. The project has also become a recognized Lehigh student club.

“Even if students aren’t in the course, they can still join the club and participate in weekly workshops,” she says. This past summer, the team took their first shot at RoboSub. The international competition (supported in part by the Office of Naval Research) promotes interest in underwater autonomous driving and wireless communication. Participants face simplified versions of real maritime challenges, such as object detection, localization and mapping, robotic arm manipulation, and underwater vehicle coordination. The August 2022 event attracted 39 teams to design, build, and compete virtually or in person at the University of Maryland.

To build their sub, the Lehigh team divided into four groups. The mechanical group designed the vehicle in accordance with the competition’s rule book; the electrical team focused on eight thrusters and ran the battery support system; the software team figured out how to use multiple cameras for image recognition and train the machine-learning engine; and the business team raised the money to pay for it all. Together, they“What’s Facebook to the classroom? But they ask questions, and take chances. Zheng offers students a different perspective inherent in programming. Some come to the course with little to no prior knowledge of coding, but Zheng has created an environment and a platform that allows them to be curious, ask questions, and take risks.

“And they learn to adapt because this is a field that’s constantly evolving,” she says. “There are always obstacles as we use the emerging new technologies transferred directly from research to the classroom. But they learn to work together and come up with solutions.”

Students in the Robotic Racing course are graded not only on how well they perform during in-house competitions but also on how they evaluate those performances and how much they participate as a whole, from recording races for their fellow team mates to sharing strategies and lessons learned. It all serves to reinforce the idea that they are the drivers of their own success, says Zheng.

“When they first come to my class, students always ask me, ‘What do you want me to do?’ I say, ‘I always turn that question around and ask them, ‘What do you want to learn?’”

For many of those students, it’s how to get over the intimidation factor inherent in

The pride of Lehigh’s Formula SAE team continues with the upcoming addition of an electrical branch. Formula SAE is a student-run club open to all undergraduates. Every year, the team designs, manufactures, and competes in an open-wheel race car. The Formula SAE Society of Automotive Engineers (SAE) competition. This year, team members will also begin the development of an electric motor.

While the goal is to create an EV prototype capable of competition in the spring and summer of 2024, going electric will be a challenge. “We support the effort, the college still provides students with a multidisciplinary safety training specifically geared toward working with high voltage and currents. The curriculum of two courses—one on electrical machines and another on power converters—has been revised to further support the initiative. Advisors, including Bill Maron (Composites Lab technician), Mark Motako (IT client support coordinator), and Javad Khazaei (assistant professor of electrical and computer engineering) will work closely with team members throughout the process.

“I have the capacity in my lab to allow these students to test the electrical components before they’re assembled in the car,” says Khazaei, whose research includes the integration of EVs into the electrical grid. “This is a fairly new research area, and so it’s going to be a learning process for all of us. But that’s exactly why I’m interested in this project. I think the knowledge we gain by designing this vehicle will apply to my lab’s current research efforts.”

As for the students, he says, their interest in this emerging technology is undeniable. “They are super motivated,” he says. “If it weren’t for the safety requirements, they would have designed the car already. They just want to race tomorrow.”
Up to speed

Wujie Wen tackles computing efficiency and security challenges on the cutting edge of artificial intelligence

“My philosophy is, maybe you publish a 100 or so papers in your career, but a few of them should have a direct and immediate impact on the real world,” says Wujie Wen.

As an assistant professor in the Department of Electrical and Computer Engineering, Wen puts that philosophy into regular practice. He researches how to improve computing efficiency and security, primarily for machine learning and AI-related applications that will play key roles in the future of autonomous vehicles, healthcare, and other fields.

Three of his most recent projects have all been supported by the NSF.

The first addresses the intense energy demands of running deep learning algorithms (the kind that power computer vision and language processing technologies). With traditional computer architecture, computation and memory are accomplished separately in hardware accelerators. “But if you look at neurons inside the human brain,” says Wen, “they can process and memorize at the same time. They’re much, much more efficient than the modern computer.”

Wen and his colleagues developed new compression techniques that are necessary for efficient AI processing in hardware. In this way, the resource overhead incurred by defense can be minimized.

Wen’s third project explores techniques to better harness AI for future applications, such as medical imaging diagnosis and edge computing. Images like CAT scans, for example, are enormous, and sending them to a processing unit—like an edge server—could take longer than the time it takes to compute the image.

“We’re thinking that in the future, you’re going to have a lot of resource-limited devices,” says Wen. “And these devices need to communicate with the server or with the cloud to do some kind of machine learning inference service.

Traditionally, the focus has been on the inference, or the computation side. But people have ignored the communication side. It can take more than 10 seconds to send data from your sensor to the processor unit, and if your computation in the cloud takes only 5 milliseconds, that’s a big issue. And we are actually the first ones to examine it.”

“The ideal, he says, is end-to-end latency, especially for real-time machine learning services, like collision avoidance applications in vehicles. So Wen and his colleagues developed new compression frameworks to dramatically reduce the latency between computation and communication.

“The existing image compression frameworks are not like that. We were the first ones to look at this issue by examining the image perception difference between human vision and machine vision. And we were able to develop a new compression framework that lowered the communication window by four to five times.”

It’s all work that has the potential to translate into regular use in the real world, exactly in line with Wen’s mission and philosophy as a researcher. His methods are inclusive of both hardware and software, and honing that range of expertise is something he stresses for his students.

“Computer engineering requires so much knowledge. It’s not just the programming. It’s learning both the software and hardware components,” he says. “That’s what I tell my students. And when they develop that level of expertise, they’re able to get hired by these big companies and solve practical engineering problems that have a real impact on society.”

In the Rossin College, future engineers grab hold of experiential learning opportunities that engage their interests and unlock their passions—whether that’s joining a competitive racing or robotics team or spending a summer engaged in community service, locally or abroad.

Together through GO: The Campaign for Lehigh, we can ensure that student-focused groups and organizations have the tools they need to provide vibrant experiences. Gifts to the Rossin College Student Experimental Learning Fund also help ensure that students of all backgrounds can reap the benefits of hands-on learning.

Strengthens the legacy of Lehigh Engineering by supporting this or other initiatives around interdisciplinary research and diversity, equity, and inclusion.

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DISSOLVING BOUNDARIES

With a shared focus on sustainability, new faculty members (from left) Gabrielle String, Maryam Rahnemaifar, and Farrah Moazeni expand Lehigh’s research footprint.

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