College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2022 NEWSLETTER

INDUSTRIAL & SYSTEMS ENGINEERING

SHAPING THE FUTURE OF WORK

Greetings from Madison!

It's my favorite time of year. The leaves are changing colors, the Terrace is buzzing, and students have arrived, ready and eager to take on another year of learning. This autumn marks the beginning of my second year as chair of the Department of Industrial and Systems Engineering. I continue to be impressed and amazed by the students, faculty and staff that surround me at this incredible university we call home.

I'm happy to report that our department is thriving. In the past year, we've taken a close look at our strategic plan, and are beginning to implement a variety of initiatives that will support our vision of improving society through world-leading research, community service and exceptional education experiences for all students. For example, we established a new inclusion, diversity, equity and access (IDEA) committee, which launched a distinguished IDEA speaker series in the spring. We also initiated a special alumni speaker series entitled "Welcome Back, Badger" that invites alumni at all career stages to share their journeys and advice with the next generation of ISyE Badgers.

Our research teams are hard at work investigating ways in which to make the world a better place. From the use of drones for delivering life-saving equipment to best practices for collaborations between humans and robots, we're pleased to highlight some of their recent work in the following pages.

It's nice to see members of our department community be rewarded for their passion and hard work, too. Many of our faculty have recently been recognized for research excellence through best paper awards and prestigious publications. And our students are thriving, as evidenced not only by the research grants and honors they received, but also by the exceptional placement they earn as they graduate from our programs, whether in industry or academia. We have a lot to brag about!

With all this activity, it's no surprise that the department continues to grow. This fall we welcomed Assistant Professors Tony McDonald and Hantang Qin to our faculty. Professor McDonald's research focuses on human factors, healthcare systems and data analytics, while Professor Qin researches advanced manufacturing and industrial artificial intelligence. Their expertise strengthens the department's leadership in engineering data analytics.

We are grateful for your continued interest in, and support of, our department. If you find your way to campus in the coming months, we'd love to have you stop by and visit us in person. Until then, please feel free to reach out by phone or email.

On, Wisconsin!

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Submitted photo

Welcome Back, Badger

Students earning a degree in industrial engineering have no shortage of options when it comes to choosing a career path. And what better way for the next generation of Badger Engineers to learn about those options than hearing from those who have come before them? We are proud to introduce the "Welcome Back, Badger" alumni speaker series.

ISyE has alumni in every field imaginable, including health systems, supply chain management, manufacturing, finance, academia and more. And whether those alumni have only been out of school for a few years or are leaders in their field with years of experience, current students can benefit from learning about their journey.

So far, we have welcomed three speakers to share their stories with our student body. Maria Palma (BS '07) manages an international investment firm that funds startups around the globe. Jake Birrenkott (BS '17) works in manufacturing, helping to increase the efficiency of production lines through the integration of automation equipment. Michelle Ranavat (BS '03), our 2022 Engineers' Day Early Career Achievement Award recipient, is an entrepreneur who uses her industrial engineering skills to source materials for her internationally renowned line of beauty products.

Every ISyE graduate has a story to tell. We're excited to invite more of them back to campus to share their experiences with current students.

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By working with industry collaborators and visiting manufacturing plants, Robert Radwin ensures his work can tangibly improve real jobs.

Robots as co-workers?

Professor Robert Radwin is devising strategies for introducing collaborative robots into manufacturing jobs

A future in which robot-powered automated manufacturing lines endlessly pump out products across industries sounds like a boon for efficiency and productivity.

It also feels more than a little dystopian, triggering fears of human workers being replaced by machines at an unprecedented scale.

But from Robert Radwin's perspective, that vision is neither realistic nor prudent.

"Researchers are beginning to realize that a future workplace dominated by robots and completely devoid of human workers is not only impractical but undesirable, for a number of reasons," says Radwin, the Duane H. and Dorothy M. Bluemke Professor who's studying how to best integrate robots into manufacturing industries. "We envision a workplace where workers won't be replaced by robots, but rather where robots will assist workers in their jobs. That's our goal."

Radwin is working on several projects to devise strategies for introducing collaborative robots (or "cobots") into manufacturing jobs in ways that enhance work—boosting overall productivity while reducing physical and mental workloads for human workers. To do so, he's collaborating with companies like Wisconsin-based Mercury Marine, General Motors and Boeing, and teaming up with UW-Madison researchers in industrial and systems engineering, computer science, mechanical engineering and labor economics to consider the technical challenges, ergonomics considerations and employment policy issues.

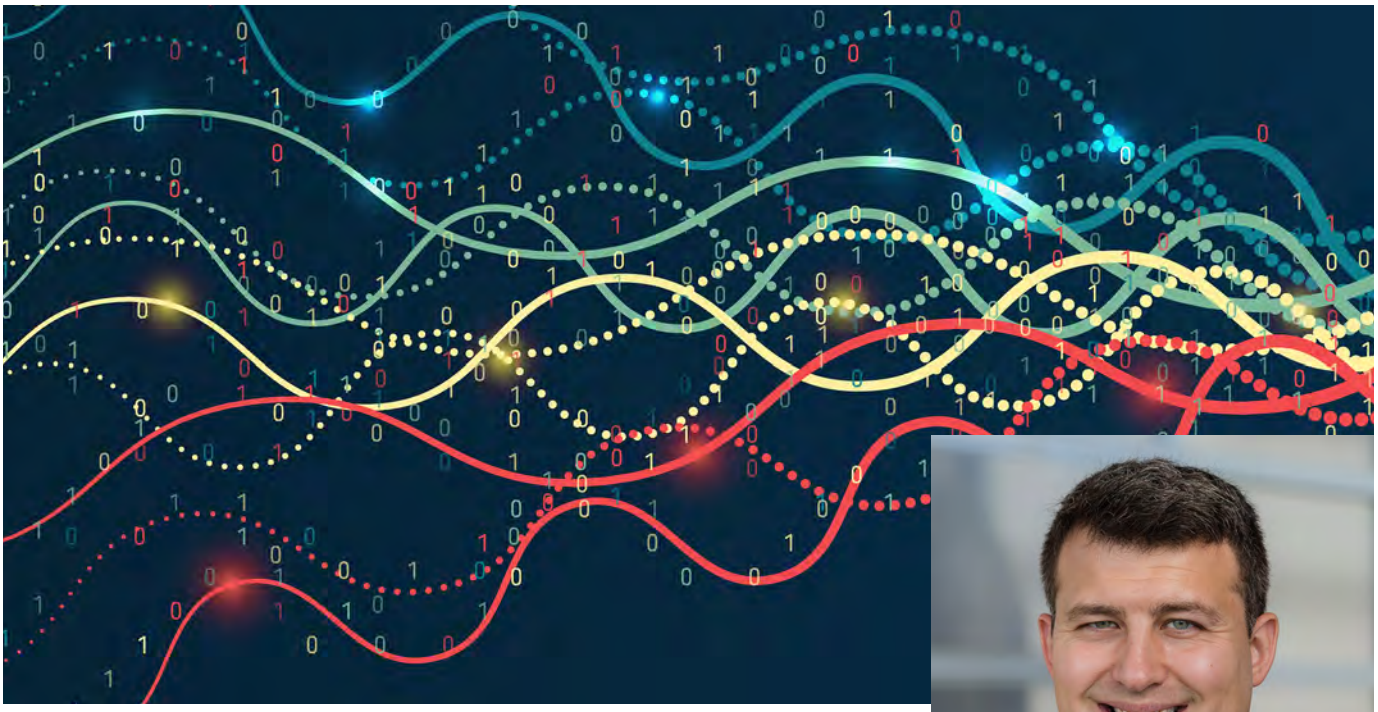
As opposed to colossal industrial robots that function explicitly separate from human workers because of safety considerations, cobots are designed to operate in concert with humans. They move slower, deliver less brute force and include more sensors to avoid causing injury. Yet they can endlessly perform repetitive motions, relieving physical stress for human workers.

In order to maximize cobots' potential, though, companies need to strategically integrate them into manufacturing workflows in ways that truly optimize productivity and reduce both physical and mental strain, rather than unintentionally adding complexity. That's where Radwin and his UW-Madison colleagues come in.

Through a series of National Science Foundation grants, Radwin is leading an effort to apply a data-driven methodology for evaluating jobs for human-robot collaboration—outlined in a paper in the journal *Human Factors*—to real roles at Mercury Marine's foundry and die-casting plant in Fond du Lac, Wisconsin, and a General Motors assembly line. The research, part of NSF's Future of Work at the Human-Technology Frontier program, will take a multidisciplinary approach with the help of Professors Bilge Mutlu (computer sciences), Shiyu Zhou (industrial and systems engineering) and Timothy Smeeding (public affairs), and Assistant Professor Lindsay Jacobs (public affairs).

Radwin is also part of a NASA-funded project led by Mutlu to apply a similar approach to aviation manufacturing with industry partner Boeing. Michael Zinn, an associate professor of mechanical engineering, is a collaborator, as is Michael Gleicher, a professor of computer sciences.

"Today employers are challenged to find employees," says Radwin, who has a long track record of using his ergonomics research to assist industry partners. "Right now, there's a shortage of workers. It's natural to think of trying to substitute workers with robots. But we think that, in fact, we can gain productivity and some of the benefits that employers are seeking by creating a better match between existing employees and automation."



FOCUS ON NEW FACULTY

McDonald integrates human factors into machine learning

Tony McDonald has a vision for bridging the fields of human factors engineering and machine learning, allowing them to inform each other and work in concert to create a safer world.

But we're not there yet.

As artificial intelligence techniques like machine learning have spread across nearly every industry, their propagation has outpaced much-needed consideration of human perspectives, says McDonald, who joined ISyE as an assistant professor in fall 2022.

"We really need to start thinking about how humans will use, interact with or interpret these systems," he says, pointing to issues such as baked-in biases in data and algorithms. "There are things we can think about very early on in the process, so it's not just that we implement a machine learning algorithm and realize the performance is much different for men than it is for women, for example. We need to be thinking about that very early on when we're sampling the data and developing the situations we use to train the algorithms."

McDonald aspires to facilitate connections across that disciplinary gulf while also applying his research to solve tangible problems like drowsy driving and improving human interaction with autonomous vehicles. He returns to UW-Madison, where he earned his PhD in 2014, after spending nearly five years as an assistant professor at Texas A&M University.

There, he created the infrastructure for collecting naturalistic driving data, in part while studying driver fatigue among nurses and assessing machine-learning-based interventions such as a camera and alarm system. He's begun to expand that work into the context of hospital patients following stays in the intensive care unit, when many experience cognitive decline. And he's refining models of driver behavior to incorporate contemporary cognitive theories, which could be particularly useful in testing autonomous vehicle technology.

McDonald says he's thrilled to be back in Madison, where the energy around campus and the spirit of the Wisconsin Idea inspired him as a graduate student in the lab of Emerson Electric Quality & Productivity Professor John Lee. And working about a mile from the School of Medicine and Public Health and the School of Nursing will be a boon to his collaborative research efforts.

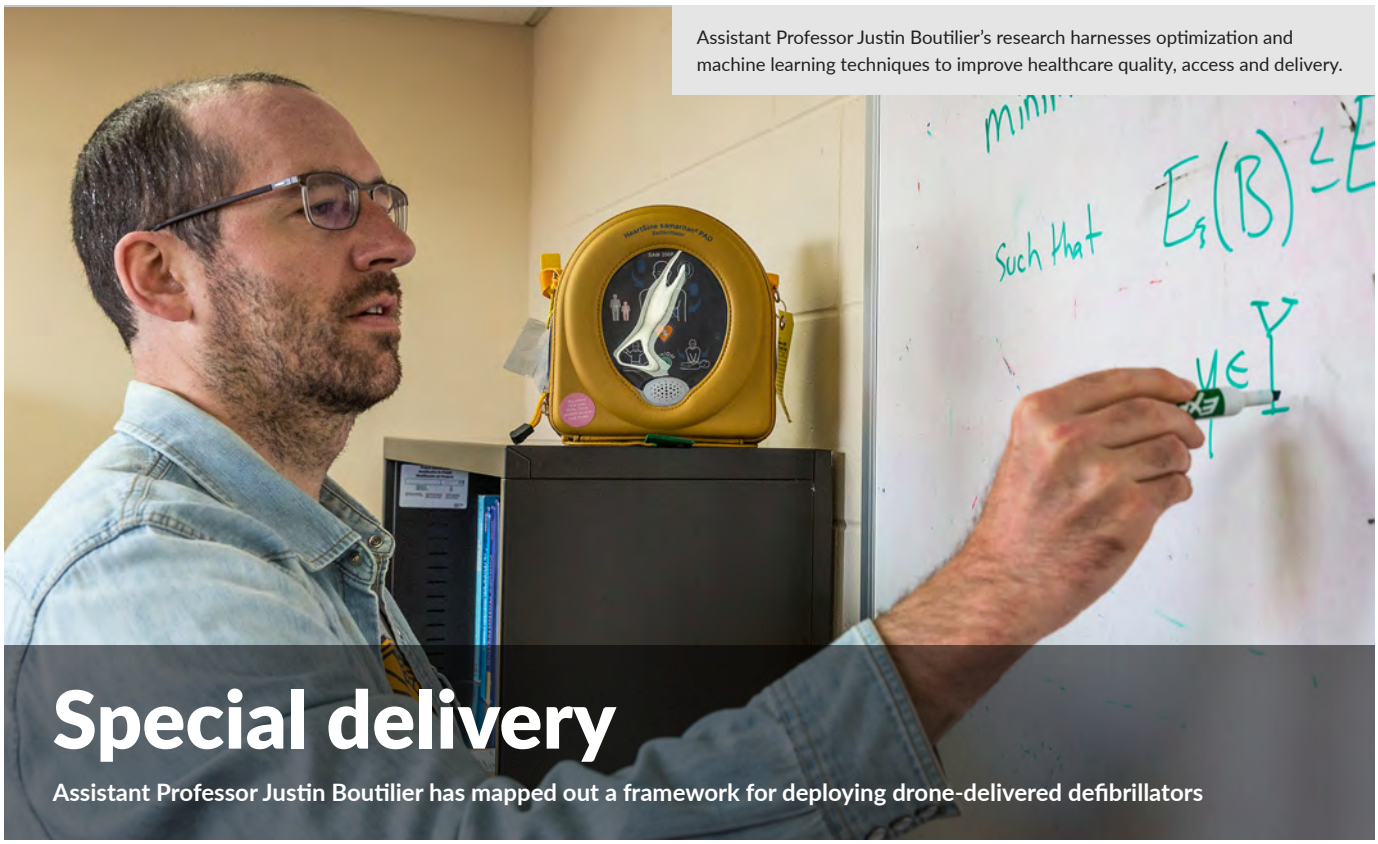
"In the ISyE department, there are so many people that I've looked up to for a very long time and see as kind of the pinnacle of the field," says McDonald, whose office is just a few doors down from Lee on the third floor of the Mechanical Engineering Building. "I feel like I can really learn a lot from them. The entire faculty has a standard of excellence that I feel will be really motivating for me and that will open up many opportunities for diverse collaborations."

McDonald also brings industry experience, having spent three years at software giant Oracle following his PhD. He quickly moved into a leadership position, managing software development for part of an enterprise cloud computing product. But he found he most enjoyed mentoring others and conducting machine learning analysis, and felt academia would allow him to focus more explicitly on those areas.

In that vein, he's eager to help expand ISyE's machine learning curriculum while using the latest research on teaching approaches to deliver an inclusive learning experience for all students.

"I have a strong belief in the land-grant institution mission, educating all to the best of their ability, so I try to focus on that and on making the course as equitable as possible," says McDonald, who is teaching ISyE 516: *Introduction to Decision Analysis* in fall 2022.

"I also plan to build in a substantial amount of writing and critical thinking to my courses. Those are the skills that I observed were the most important to my success at Oracle, so I try to emphasize them with my students."



Assistant Professor Justin Boutilier's research harnesses optimization and machine learning techniques to improve healthcare quality, access and delivery.

Special delivery

Assistant Professor Justin Boutilier has mapped out a framework for deploying drone-delivered defibrillators

As a kid, Justin Boutilier would sometimes get roped into helping his dad, a paramedic and firefighter, perform automated external defibrillator demonstrations in and around his hometown of Niagara Falls, Canada.

"If a kid can use an AED, so can you," he says, recalling one of his dad's messages during those visits to local office buildings or hotel conference rooms.

Two decades later, Boutilier, now an assistant professor, is trying to help reimagine how AEDs can save more lives.

In a paper published in the journal *Manufacturing & Service Operations Management*, Boutilier detailed the framework for designing a network of AED-outfitted, autonomous-flying drones, which could allow the life-saving devices to more quickly reach people experiencing cardiac arrest. In out-of-hospital cardiac arrests, survival rates drop by 1-10% each minute that passes without treatment, according to a previous analysis coauthored by Boutilier.

"Ambulances are not fast enough for this, especially in non-urban areas, so drones are just such a good fit," says Boutilier. "They're super fast, with straight-line flight. And then AEDs are a relatively light payload, so it suits the drone. The best applications for drones in healthcare are things that are light and where time is of the essence."

The idea of drone-delivered AEDs may sound futuristic, but it's slowly gained traction since Boutilier and Timothy Chan, his PhD advisor at the University of Toronto and coauthor on the paper, first saw a video of a team from Delft University of Technology in the Netherlands showcasing a prototype in 2016.

In January 2022, an off-duty doctor used an AED delivered by an autonomous drone to save a 71-year-old man's life in Sweden—the first such documented successful rescue—as part of a nascent program in the Scandinavian country. The company Drone Delivery Canada has also conducted tests with simulated cardiac arrest situations in Ontario in recent years.

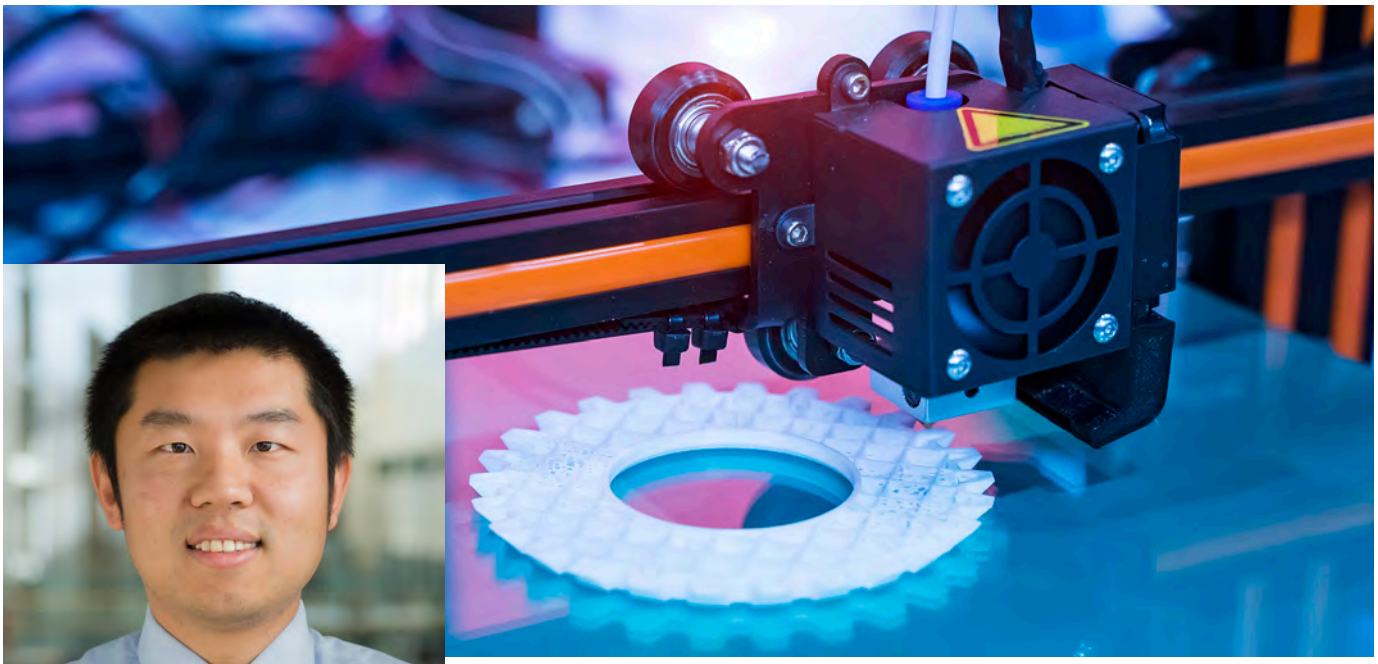
Boutilier is hopeful research like his, which draws on cardiac arrest and emergency response time data from a more than 10,000-square-mile area around Toronto, will help nudge the technology closer toward mainstream implementation.

In the paper, he and Chan present system designs for either improving average response time or curbing the range of slowest response times. Between those two options, they estimate that such a drone network could produce a 42-76% higher survival rate among people experiencing out-of-hospital cardiac arrests, with up to 144 lives saved each year within that geographical area. And, they note, a modest number of drones can have a significant effect; per their analysis, one base with three drones could improve average response time in Toronto by one minute.

Boutilier says policymakers will need to consider both moral dilemmas—prioritizing average response time would lead to a larger concentration of drones in urban areas—and logistical hurdles such as flight regulations and navigational challenges in crowded cities.

He is pursuing funding with collaborators at Purdue, the University of Illinois, the University of Pittsburgh and the University of North Carolina to investigate more models for system designs while also exploring ways to ensure people can effectively use drone-delivered AEDs.

"I think there are still a lot of questions about the design of drones, what's the best way for a human to interact with a drone both safely and efficiently, so people are comfortable with it," he says. "Historically, AEDs have seen such limited use, even when they're put in public places. I think we need to be careful with drones to make sure we don't end up in a similar situation, that we figure out what we need to do to make these usable by bystanders."



FOCUS ON NEW FACULTY

Qin taking 3D printing to new heights

To test the 3D printing technology he hopes will one day reach the International Space Station or even Mars, Hantang Qin loads his novel equipment onto an airplane for a parabolic flight that simulates a zero-gravity environment.

Beyond the enormous technological challenges in perfecting such machinery to work in space, Qin must contend with one fundamental inconvenience: He can't actually observe its in-flight performance firsthand, because he has motion sickness.

But that minor hindrance isn't deterring Qin's ascent toward his goal of seeing his technology travel to—and successfully operate in—space. That's just one of the practical results Qin hopes to deliver through his research, which spans 3D printing techniques, rapid prototyping methods and tools, autonomous robots, and quality assurance in emerging micro- and nanoscale manufacturing systems.

Qin has brought his work to ISyE as an assistant professor, after five years on the faculty of Iowa State University.

He says he didn't initially set out to develop technology for in-space manufacturing while earning his bachelor's degree in electrical engineering from Zhejiang University in his native China, or later, while pursuing his PhD in industrial engineering at North Carolina State University. But he saw a natural fit between his work and NASA's desire for a system that could autonomously print new electronic components for the array of sensors on spacecraft.

"Those sensors, they are consumables, so sometimes they don't function after being used for a while," he says. "So making new sensors would be essential for deep-space efforts. However, for NASA, they don't want to bring backup sensors for each and every type. Instead, they want to have a manufacturing technology that can make each type of sensor."

As part of his collaboration with NASA and industry partners, Qin, colleagues from Iowa State and a team of students have twice traveled to Fort Lauderdale, Florida, for parabolic test flights over three largely sleepless days. These roller-coaster-like maneuvers yield a series of 20- to 30-second windows that mimic a zero-gravity environment, allowing Qin's team to test and refine its tools for printing conductive inks, including silver and barium titanate, onto glass. Qin is currently planning a third test run for late 2023 or early 2024.

"In the lab, everything is stable. Every environment is controlled. Well, over there, nothing is as expected," he says. "That's why, even for industrial and systems engineering, experiments are important, because we will never learn everything without doing the experiments ourselves."

Qin is also using a grant from the U.S. Army Corps of Engineers to build an autonomous robot capable of scanning damaged concrete surfaces and then printing materials to make repairs. He envisions departments of transportation deploying the robots to fix surface damage to roads and the U.S. Army using them to safely repair buildings and bridges in areas of conflict.

And through a U.S. Army Research Laboratory grant, he's developing a new inline monitoring system for manufacturing at the micro and nanoscales, where optical methods reach limitations. Qin's method employs laser diffraction to gather data used to monitor quality.

He's bringing his 3D printing and prototyping expertise into the classroom in fall 2022 through a new course in biomedical design and manufacturing (initially offered as a special topics course, ISyE 604). In it, students create computer-aided design models of human bones, 3D print them, and work with medical data. Qin plans to also bring in guest speakers from biomedical manufacturing companies to expose students to industry insights.

Qin also began using virtual reality modules to allow students to interact with manufacturing tools when labs were closed early in the COVID-19 pandemic. He sees the technology as a potential avenue to remotely connect students from technical colleges to world-class facilities.

As the son of two high school teachers, inspiring the next generation of engineers is part of what drew him to academia in the first place.

"Making an impact, educating people, putting them onto a successful career path is something that satisfies me," he says.

Faculty News

Duane H. and Dorothy M. Bluemke Professor Robert Radwin received the 2022 Boeing Excellence Award for Collaboration in Productivity, Workplace Safety and Ergonomics from the Institute of Industrial and Systems Engineering. The award honors outstanding quantifiable, innovative contributions to the fields of productivity, safety and ergonomics through academia-industry collaborations.

Four ISyE faculty members landed 2022 American Family data science research grants. Professor and David. H. Gustafson Department Chair Laura Albert has received a grant to apply optimization methods to improve machine learning tools for insurance industry applications. Harvey D. Spangler Professor Jeff Linderoth and Professor Jim Luedtke will pair up to develop a new model and algorithms specifically tailored to complete matrices with heterogeneous data, with important applications in recommender systems, computer vision systems for processing and analyzing visual images, data inference, and outlier detection. Jane R. and Jack G. Mandula Assistant Professor Gabriel Zayas-Caban is part of a grant that seeks to develop a causal inference framework for estimating the effects of intervention on certain systems and providing algorithms to guide their use of risk prediction models in their operations.

Assistant Professors Justin Boutilier and Carla Michini, along with PhD student Zachary Zhou, earned a best paper award at the 19th International Conference on the Integration of Constraint Programming, Artificial Intelligence, and Operations Research. In their paper, they detail a new and more effective mixed-integer programming approach for learning optimal decision trees.

Professor Douglas Wiegmann received the Franklin V. Taylor Award from a division of the American Psychological Association in recognition of his work in human factors engineering. Wiegmann and doctoral students Demetrius Solomon and Laura Wood also earned the 2022 John C. West Writing Excellence Award at the annual American Society for Health Care Risk Management.

Student News

PhD student Hanna Barton is the lead author in an August 2022 publication in *Pediatrics*, a journal published by the American Academy of Pediatrics. The article identifies in-home testing pitfalls and strategies that facilitate high-quality COVID-19 rapid antigen testing.

PhD student Valerie Odeh Couvertier published her research evaluating advanced imaging in the emergency department in *Academic Emergency Medicine*. Her work was supported by the 2021-2022 Wisconsin Institute of Healthcare Systems Engineering Graduate Award.

Alumni News

Alumni Meghan Meredith (BS ’20) and Eleanore Scheer (BS ’21) received the prestigious National Science Foundation Graduate Research Fellowship, which provides three years of financial support toward their graduate training. Graduate student Eric Stratman earned honorable mention status.

Three recent PhD graduates have begun the next leg of their professional journey as tenure-track professors. Minhee Kim is an assistant professor in the University of Florida’s Department of Industrial and Systems Engineering. Jaesung Lee is an assistant professor in Texas A&M’s Department of Industrial & Systems Engineering. Akash Deep is an assistant professor in Oklahoma State University’s Department of Industrial Engineering and Management.

Congrats to our 2022 Engineers’ Day award winners

Ernest Nicolas (MS ’05) is ISyE’s 2022 Distinguished Achievement Award winner as part of the College of Engineering’s annual Engineers’ Day celebration. He has established himself as a keen manufacturing systems engineer and business leader adept at creating transformative approaches for agile and resilient supply chain management. Nicolas is currently the chief supply chain officer for HP Inc.

Our 2022 Early Career Achievement Award winner is Michelle Ranavat (BS ’03), the founder and CEO of the global skin and haircare line RANAVAT. She has leveraged her engineering skills to create a company that honors and celebrates South Asian culture and beauty.

Support a STAR Scholar

Effective solutions to today’s challenges arise when we bring the brightest people to the table. When you make a gift to our STAR Scholarship fund, you’ll help our college recruit the nation’s best students so that they can become tomorrow’s problem-solvers and difference-makers. Thanks to a commitment from The Grainger Foundation, there’s also matching support available—meaning that you can double the impact of your support.

We need your help growing this important scholarship fund. To make a gift, contact Kyle Buchmann, senior managing director of development, at kyle.buchman@supportuw.org or (608) 630-1679.

Learning options for working Badgers

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Graduate students work to bolster diversity in operations research

As a Black woman pursuing her undergraduate degree in electrical engineering and now a PhD focused on operations research, Carmen Haseltine has seen and experienced plenty of the forces that dissuade aspiring scientists and engineers from traditionally underrepresented backgrounds.

So it's understandable she would like to counter those dynamics.

"If there are going to be people who deter people, why not have people who are like, 'Hey, this is completely doable'?" she says.

Haseltine and three colleagues are doing their part to spread that message through a high school outreach project funded through the Institute for Operations Research and the Management Sciences (INFORMS).

Haseltine, ISyE PhD student Veronica White, recent graduate Elizabeth Scaria (PhD '22) and Mary Ogidigben, a PhD student at Pennsylvania State University, have created a workshop and materials to introduce students from traditionally underrepresented backgrounds to the broadly applicable yet opaque fields of operations research and management science.

"Really when you get down it, there's just not enough underrepresented students in our programs," says White. "And the only way to do that is to reach them at a younger age and reach more of them."

The foursome is holding a mix of in-person and virtual events throughout 2022. By talking about her own research on police response to the opioid crisis, or Haseltine's work on election infrastructure protection, White hopes the group can show students that operations research can help address serious pressing challenges.

PhD students Veronica White, left, and Carmen Haseltine are creating outreach materials that other INFORMS members will be able to use.

And, given numerous studies have shown diverse teams are more effective than homogenous ones, who better to solve societal issues than a STEM workforce that better reflects the wider world?

"People's life experiences gear them for how they solve problems," says Haseltine. "I think that's something we really don't talk enough about: The benefit of diversity and inclusion is not just to be a good person; it's also to be more productive, to do better research."