FALL 2019

INDUSTRIAL AND SYSTEMS ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

MODELS THAT MATTER:

RESEARCH OPTIMIZES CYBERSECURITY, HEALTHCARE AND MORE

CHAIR'S MESSAGE

Greetings!

This fall, we are excited to welcome our newest faculty member, Justin Boutilier, who joins us after earning his PhD from the University of Toronto and completing a postdoctoral appointment at Massachusetts Institute of Technology.

Justin will help us continue our long-held leadership position in engineering-oriented approaches to address society's largest health systems challenges. You can read more about Justin's work on page 6.

We are also thrilled to welcome 13 new PhD students to the department this fall. This record incoming cohort will surely turbocharge the department's research efforts for years to come and build on our excellence in graduate education. *U.S. News & World Report* ranked ISyE sixth in the nation in its 2020 edition of "Best Graduate Schools."

To help our new PhD students succeed, the department will offer a new colloquium series. The colloquium will introduce students to the breadth of research opportunities available in ISyE, teach them best practices for research and work-life balance, and foster a sense of community among all our graduate students.

As you'll read in the newsletter, our faculty continue to lead groundbreaking research, land large-scale federal grants, and earn named professorships and national awards. I encourage you to follow ISyE news throughout the year on our Facebook (@ISyE.UWMadison), Twitter (@uwisye) and LinkedIn pages (linkedin.com/groups/138818).

Thank you for everything you do to support our faculty, staff and—most of all—students. ISyE enthusiastically participated in the very first "Day of the Badger" campus-wide giving event in April 2019 and "punched above our weight" in terms of donations. We sincerely appreciate everyone who gave—and ISyE is looking forward to taking down civil and environmental engineering and mechanical engineering in the competition in 2020!

Please feel free to drop me an email, give me a call, or stop by our new ISyE office in 3107 Mechanical Engineering if you are back on campus. I look forward to connecting with you soon.

ON, WISCONSIN!

Jeffrey Linderoth, Professor and Chair
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Technology and teamwork: CQRM adds new leadership

Professor Leyuan Shi sees immense potential for improving production efficiency in the manufacturing industry. She's hoping to help drive that progress as the new director of the Center for Quick Response Manufacturing (CQRM).

Shi has developed "smart manufacturing" technology that allows companies to more precisely monitor and optimize their production scheduling, thereby reducing waste and boosting profits. Her work is well suited to companies producing low volumes of highly variable goods, making her a natural fit to lead CQRM.

"I bring the latest technology to the center, our students and to the industry," says Shi, who's worked with CQRM industry partners National Oilwell Varco and John Deere over the course of her career. "I think manufacturing companies, particularly in Wisconsin, should be aware of this kind of technology to help them improve their efficiency and lower their cost."

Professor Emeritus Rajan Suri founded CQRM in 1993 to bring together companies and academics to trim lead times and improve bottom lines. The center currently has 50 industry partners, most concentrated in the upper Midwest but some coming from as far away as California, Georgia, New York and Texas.

CQRM's new leadership team also includes alumna Charlene Yauch (PhD '00), who has returned to her alma mater as associate director. Yauch, who also holds master's degrees in manufacturing systems engineering and sociology from UW-Madison, has previously served on the faculty of Oklahoma State University and Milwaukee School of Engineering and worked as a practicing engineer. In her new role, she'll visit partner companies, lead workshops and training sessions, and recruit new members. She'll also teach *Design and Analysis of Manufacturing Systems*, a graduate course that gives students opportunities to work on projects for industry partners.

"I really like to see manufacturing processes and how materials are transformed into products, so I love getting involved in visiting manufacturing companies and seeing how they operate," says Yauch, who worked with CQRM as a graduate student. "I also like the challenge of trying to re-envision how to do it."

ALBERT BRINGS OPERATIONS APPROACH TO CYBERSECURITY

In an age of data breaches and malware attacks, cybersecurity is paramount to organizations that store troves of customer and employee information.

But companies, government entities and other large institutions have to consider more than just their centralized information technology infrastructures and policies to protect their data and cyber infrastructures, which rely on global supply chains comprised of third-party vendors and contractors. And any weak link in the chain can invite threats, as companies like Target or Home Depot or the U.S. Office of Personnel Management can attest. All have experienced major data breaches over the past six years from attacks that started with third-party vendors.

So how do organizations effectively safeguard their IT supply chains without completely exhausting their budgets?

Professor Laura Albert is among the pioneers in bringing operations research to cybersecurity. To start, she's examining supply chains to help organizations weigh the options—and tradeoffs—in these complex decisions.

Albert and former graduate student Kaiyue "Kay" Zheng (PhD '17) have published a series of recent papers—in the journals *Risk Analysis, Naval Research Logistics* and *IISE Transactions*—in which they propose optimization models to guard against worst-case risks and deal with adversarial attacks, where cyber assailants adapt to defensive measures. The National Science Foundation supported the research.

"A lot of the research out there focuses on real time decisions, which addresses the response side but not the planning side," says Albert, who likens establishing longer-term cybersecurity strategies and policies to building a fence. "It turns out with cybersecurity and infrastructure protection, you have to make many strategic defensive decisions over a long period of time. There are some real-time decisions, but frequently there are some really big decisions that you have to make about your infrastructure. These are not trivial decisions you can make on the fly."

Those protective tactics can range from physical measures such as replacing vulnerable hardware or requiring tamper-evident packaging to broader initiatives like training employees, regularly assessing vendors or tightening security requirements. But all organizations run up against budgetary ceilings and finite employee resources, and there is uncertainty about the effectiveness of all strategies. Some potential actions are also incompatible with each other or have overlapping capabilities, meaning decisions can't be made in isolation.

> **"These are not trivial decisions you can make on the fly."**
>
> **— Laura Albert**

Albert's models provide decision-makers with a quantitative way to assess their options and identify a portfolio of security controls that may work best for their organization.

Now, Albert is using a new two-year grant from the National Science Foundation to study how to protect critical IT infrastructure and university research systems in partnership with UW-Madison's Division of Information Technology. She's excited to apply her work in such a complex decision-making environment, with IT managers scattered across campus in different schools, colleges and units. The project represents yet another challenge within the larger emerging area of operations research on cybersecurity.

"I can't just take my previous models and apply them," she says. "We have to come up with these models. How do we take this real thing that I can observe in the IT center at UW-Madison and turn that into a mathematical abstraction that would tell me something useful? That's really humbling and challenging, but it feels good. It's fun research."

Professor James Luedtke and recent graduate Eli Towle (MS '18, PhD '19) were also authors on Albert and Zheng's paper in *IISE Transactions*.

TECH FOR TRAUMA

Grad student designing health IT

When Bat-Zion "Betsy" Hose walked into Union South for her student orientation—SOAR, in UW-Madison lingo—in summer 2011, she fully intended to major in biology.

But when the announcement came for engineering advising, she had a change of heart.

"I had teachers in high school who told me, 'You should do engineering.' At that moment, I was curious and thought, 'I'll try it at least for a semester,'" Hose recalls.

Eight years later, Hose (BS '16, MS '18) is a two-time ISyE graduate and is about a year away from earning her PhD. She's published as the first author on a scientific journal paper and presented at a major international conference.

"I can't imagine doing anything else," she says. "I think my brain really works as an engineer."

As part of Leon and Elizabeth Janssen Professor Pascale Carayon's team in the Wisconsin Institute for Healthcare Systems Engineering, Hose is using human factors and systems engineering methods to help develop information technology tools to support transitions in pediatric trauma care.

> **"Betsy's commitment to improve the quality and safety of care provided to hospitalized children is unwavering."**
>
> **— Pascale Carayon**

The project, supported by the U.S. Department of Health and Human Services Agency for Healthcare Research and Quality, aims to improve patient safety through technology that delivers timely and relevant information to the appropriate team members. In a hectic emergency department, such technology could improve efficiency and prevent critical information from being missed during staffing rotations or transitions to different hospital units.

"There's so much information throughout the electronic health record, so we're trying to pull it and organize it in a way that is useful, so that care team members can be on the same page about what's happening to the child," says Hose, who's worked on the project since its outset, initially helping to gather and understand the varied needs of different clinicians and staff.

Those interviews and subsequent analysis formed the basis for her paper in the January 2019 issue of *Applied Clinical Informatics* and her presentation at the triennial congress of the International Ergonomics Association in Florence, Italy, in August 2018.

"Betsy has gained self-confidence and developed her own unique research interest, with a focus on human factors design of team health information technology," says Carayon, an internationally respected expert in patient safety and healthcare systems engineering. "Betsy's commitment to improve the quality and safety of care provided to hospitalized children is unwavering."

Hose's dedication to her work comes, in part, from the memory of her childhood best friend, who died from a recurrence of brain cancer during her first semester of college in 2011. Hose says in the future she's interested in designing health IT for long-term care and disease management in settings like pediatric oncology.

"I think children are a priority population to study," she says. "They're a vulnerable population. If you think about adults going to the hospital, we can advocate for ourselves and we're constant in the care. But a child, maybe their parent's not there the entire time. So they're more vulnerable to patient safety issues and medical errors."

2020 WIHSE Conference

The Wisconsin Institute for Healthcare Systems Engineering is hosting its third conference, bringing together engineering and health sciences to enhance healthcare systems.

May 11

May 11, 2020
Union South, Varsity Hall

ABOUT TIME

App helps hospitals improve newborn screening efficiency

A prick on the heel is sure to prompt a few wails from a newborn. But the blood samples that poke yields are well worth the discomfort: Newborn screenings can alert doctors to serious genetic conditions, allowing them to promptly treat vulnerable infants and prevent developmental delays or, in some cases, deaths.

Of course, that's assuming those blood samples make it to the state laboratory for testing in a timely fashion, which doesn't always happen—despite a U.S. Department of Health and Human Services recommendation that samples should arrive at a lab within 24 hours of collection.

In fact, a 2013 investigative report from the *Milwaukee Journal Sentinel* exposed widespread delays in the handling of newborn screening blood samples across the country.

Assistant Professor Gabriel Zayas-Caban wants to help cut those delays. He and his collaborators have developed a web-based app that allows hospitals to test how changing variables in the screening and delivery process can impact arrival time at the lab.

Getting blood samples to the lab seems straightforward enough, but hospitals must consider a number of steps in establishing a process, such as the time distribution of births, pickup schedules, transit time to the lab, and lab hours.

"The hospital can input its characteristics," says Zayas-Caban. "And then it can test out what different strategies it could implement to reduce delays. If you change the hours of the state lab, for example, how much will that improve timeliness?"

The app grew out of a 2018 paper in *Maternal and Child Health Journal* in which Zayas-Caban and his collaborators found that adjusting the sample pickup time at hospitals could significantly boost the number of specimens arriving at the lab in a target time range.

Zayas-Caban's research draws on mathematical queueing models to improve workflow in healthcare settings. He also recently published a paper in the journal *Statistics in Medicine* outlining a framework for determining the impact of hospital admission decisions in emergency departments on patient outcomes.

MORE: go.wisc.edu/engrnews-061219

SMART SCREENING

A personal approach to mammography for women with Down syndrome

For most women, turning 40 brings an age-related preventative care dilemma: when, and how often, to get a mammogram to screen for breast cancer.

Luckily, their doctors can advise them by drawing on recommendations from national organizations and ample research. But for women with Down syndrome—or other chronic medical conditions, for that matter—no such guideposts exist.

Professor Oguzhan Alagoz hopes to provide physicians, patients and caregivers with the data to make informed decisions.

In a paper in the *Journal of General Internal Medicine*, Alagoz and collaborators used mathematical modeling to elucidate the potential benefits and harms of possible mammography screening strategies for women with Down syndrome.

"I'm hoping this paper will at least start a discussion. For these chronic conditions, modeling tells you that you have to do something differently," says Alagoz, who has been examining questions related to breast cancer for more than a decade. "You can't just do these one-size-fits-all blanket recommendations."

Alagoz is part of a National Cancer Institute-backed network of researchers employing statistical modeling to hone cancer interventions and inform policies.

Previous studies have shown women with Down syndrome have a substantially lower risk of developing breast cancer compared to the population at large. But as their average life expectancy has dramatically increased over the past three decades, aging-related questions such as mammography screening guidelines have come to light.

For their study, Alagoz and graduate student researchers Ali Hajjar and Mehmet Ali Ergun (MS '14, PhD '17) looked at a variety of mammography screening protocols. While no single strategy yielded a harm-benefit ratio for women with Down syndrome that was on par with that of the general population, a one-time screening at age 50 produced the best result.

Now he's interested in analyzing how screening guidelines function for people with more widespread chronic diseases, such as Type 2 diabetes.

MORE: go.wisc.edu/engrnews-081219

FOCUS ON NEW FACULTY

BOUTILIER BOLSTERS GLOBAL HEALTH THROUGH OPTIMIZATION

As a second-year PhD student at the University of Toronto, Justin Boutilier spent four weeks in Dhaka, Bangladesh, investigating ways to improve ambulance response times in the bustling capital of a developing country.

He quickly got a firsthand look at the scope of the challenge: The roughly 10-mile trip from his hotel to meetings in the city took about three hours.

"You could walk faster," he says, "but there's no sidewalk, so it's kind of dangerous."

Boutilier, who has joined ISyE as an assistant professor, uses optimization and machine learning to improve healthcare access, delivery and quality, particularly in low- and middle-income settings.

He's previously worked on projects to optimize emergency response times, such as the effort in Dhaka and drone delivery of automated external defibrillators in and around Toronto. But he's come to UW-Madison with an evolving research focus that's shifted toward applying the same operations modeling to screen and manage chronic diseases in underserved populations around the world.

Boutilier has partnered with several healthcare startups, including Hyderabad, India-based NanoHealth—the creator of a successful disease management platform and a former winner of the prestigious Hult Prize, the so-called "Nobel Prize for students."

Together, Boutilier and NanoHealth are building a diabetes risk assessment that's tailored specifically to a lower-income Indian population. Whereas guidelines from the American Diabetes Association would encourage a patient to visit a doctor for cholesterol testing and lipids panels to inform a diagnosis, those aren't feasible recommendations in the slums of India.

"Once we identify high-risk patients, then there are questions of how to manage them," says Boutilier, who is using the risk data to optimize visitation schedules of community health workers in the area. "A lot of these people lack education about healthcare."

He's applying similar methods to try to improve the efficacy of tuberculosis treatment in Kenya.

As Boutilier puts it, he grew up around healthcare. His dad, a paramedic and firefighter, showed him how to use an automated external defibrillator when he was in elementary school, while his mother was a nurse. But he didn't realize there was a way to connect his medical interests to his studies in math until late in his undergraduate schooling at Acadia University in Nova Scotia, where he was also a high-flying forward on the basketball team.

Now he's thrilled to join a premier research institution where industrial engineers have already forged deep links with researchers in the School of Medicine and Public Health, the School of Nursing and the School of Pharmacy.

"Wisconsin has such a long history of healthcare work," he says. "It's a nice environment to come into. People in the medical sciences already know about us and what we do."

In the classroom, Boutilier is adapting a course on machine learning—*Machine Learning in Action*—he taught as a postdoctoral researcher with the Center for Transportation and Logistics at Massachusetts Institute of Technology. The upper-level undergraduate course will take students through tangible applications of different machine learning methods, such as predicting decisions by Supreme Court justices.

"When you do research, the reward is typically far out. It's a long process, whereas teaching, you can see students learning, almost in real time," says Boutilier, who will also teach *Healthcare Engineering*. "That's such a cool and rewarding experience. I love being in front of the class."

He hopes to inspire students to follow his lead and take on global health challenges.

"I very much want to send my future students to India, to Africa, to Bangladesh," he says. "Go there, see it. It's such a life-changing experience, both personally and professionally."

CHESS ADDS REGIONAL SUBSTANCE-ABUSE PREVENTION EFFORT TO UMBRELLA

Through two decades of managing multi-state projects and effectively disseminating evidence-based practices to address health challenges, the Center for Health Enhancement Systems Studies (CHESS) has established itself as a leader in implementation science.

That reputation—along with its setting at a top-tier research university—has helped earn CHESS a prominent role in a new approach to improving mental health and addiction treatment and substance-abuse prevention across the United States.

The U.S. Substance Abuse and Mental Health Services Administration (SAMHSA) awarded the research center a five-year, $2.9 million grant to operate the Prevention Technology Transfer Center for the Great Lakes region, making CHESS home to the district's technology transfer centers for all three SAMHSA focus areas: mental health, addiction and prevention.

CHESS is one of just two institutions nationwide to house all three regional centers as part of SAMHSA's effort to move away from a nationally centralized model of training and technical assistance for organizations and workers. The administration believes that employing a regional model will allow each center to better understand and respond to the unique challenges facing its region's populations and broaden access to the latest evidence-based interventions.

Photo credit: Find Rehab Centers/Flickr.com

DEPARTMENT NEWS

Duane H. and Dorothy M. Bluemke Professor **Robert Radwin** is collaborating on an effort to improve the efficiency, flexibility and safety of the aviation manufacturing industry as part of a $3 million NASA-funded project. Radwin's spinoff company KineVid received funding from UW-Madison's Discovery to Product unit as part of the State Economic Engagement and Development Research Program. The startup is making an app that uses machine vision and artificial intelligence to analyze, evaluate and improve lifting ergonomics in the workplace.

Shiyu Zhou received a Vilas Distinguished Achievement Professorship, which provides five years of flexible funding. The award recognizes distinguished scholarship and standout efforts in teaching and service.

Assistant Professor **Alberto Del Pia** received a three-year, $356,773 grant from the Office of Naval Research to advance the design and analysis of algorithms for mixed-integer quadratic programming.

Associate Professor **Kaibo Liu** won the SME Outstanding Young Manufacturing Engineer Award, as well as the Dr. Hamed K. Eldin Outstanding Early Career IE in Academia Award from the Institute of Industrial & Systems Engineers.

PhD student **Changyue Song**, a member of Liu's lab, received a Wisconsin Distinguished Graduate Fellowship for the 2019-20 academic year.

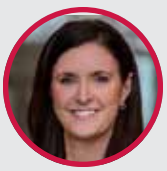
WORDS OF HONOR

The journal *Risk Analysis* celebrated Professor Vicki Bier's contributions to the field by profiling her career in its April 2019 issue.

"Vicki is often that voice in the back of my head offering essential advice," former student Jon Welburn (BS '10, PhD '16) told the publication.

To read the full profile, visit **go.wisc.edu/uk0oyz.**

DYNAMIC DUO



Tom Werner (BS '82) and **Nancy Spelsberg** (BS '99) are industry leaders in energy and transportation. They're ISyE's 2019 award recipients at the College of Engineering's annual Engineers' Day celebration.

Werner, chairman and CEO of the solar energy company SunPower, is a Distinguished Achievement Award recipient. Spelsberg, president and part owner of BCP Transportation, is an Early Career Achievement Award honoree.

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AN OFFICE ON WHEELS

If your car could drive itself for a chunk of your daily commute, what work could you take care of before arriving at the office?

John Lee, the Emerson Electric Quality and Productivity Professor, is identifying opportunities to use automated vehicles as mobile offices.

Lee, who studies human factors engineering in the context of automation and interface design, is part of a multi-university National Science Foundation project that aims to design systems that support productive work, safe driving and smooth transitions between the two tasks.

The four-year project, led by the University of New Hampshire's Andrew Kun, is most apt for a scenario in which an automated vehicle takes over driving control on a commuter road with limited cross-traffic, pedestrians, bicycles or other complicating factors.

Lee is working with economic productivity expert Raffaella Sadun at Harvard Business School to characterize and assign economic value to work tasks that could be completed in breaks between driving.

"If you've got these, say, 10-minute windows of time, what part of your day could you slot into that productively?" says Lee. "I think within the next five years, there probably will be viable options for converting some of the freeway time into work time, particularly in the very low-speed congestion situation, where you're stuck in traffic and you're crawling around at 5 miles per hour for half an hour."

The Driving Simulation Laboratory at UW-Madison includes 270 degrees of virtual simulation, thanks to a 24-foot wraparound screen with computer video projection, audio and car-tracking movements as small as one degree in any direction. *Photo: Jeff Miller, UW-Madison.*

Lee has researched distracted driving amid the rise of what he terms "infotainment" devices. He and former graduate student Ja Young Lee (PhD '18), now a quantitative user experience researcher at Google, published a paper in the *International Journal of Human-Computer Studies* detailing a computational model that simulates task-switching behavior among drivers. The work could inform how in-vehicle systems deliver and take in information such as text messages or directions.