Industrial & Systems Engineering at Rutgers

ise news

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Since the 1980s, the U.S. industry and society as a whole have been shaken by transformative changes initiated by advances in computing, communication, and automation sciences. Rutgers' Department of Industrial and Systems Engineering is among the leading institutions that have made the integration of human, machine, and information common grounds for research and education. Emphasizing its core competency in reliability engineering, advanced manufacturing, and smart systems, the department is pushing ahead with new endeavors in emerging technical areas and focusing on educating the next generation of engineers and technology leaders.

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School of Engineering

Siemens Fellowship Winner to Combat Cyberattackers

Thinking like a hacker holds key to defending cyber networks

Today's cyber hackers and network defenders are engaged in a daily race against time. But, according to industrial and systems engineering doctoral student Andrew Benton, "in order to defend your system, you have to first understand how the cyberattackers operate."

Benton, who earned his bachelor's degree in industrial and systems engineering from Rutgers, recently received a competitive Siemens FutureMakers Fellowship that includes a year's tuition and a stipend for expenses. His winning proposal, "Reinforcement Learning for Software Defined Networks," focuses on training both cyberattackers—and defenders. "We're trying to secure networks and keep people safe from cybersecurity hacks by creating de-ceptive networks that prevent attackers from learning a network's true nature," the Arkansas native explained.

As an undergraduate, Benton was attracted to ISE because of its emphasis on the big picture. "I like knowing I'll be able to actually solve a real problem," he said. "I like finding real solutions. Other fields talk about small things, such as making circuits or a piece of software, but industrial engineering looks at how all the pieces fit together to interact and work as a whole system. That's something I really enjoy."

To Benton, his Siemens FutureMakers project exemplifies this kind of big picture thinking,

Researcher and author **Eric Rosenberg** joins the ISE department as a full-time visiting professor, following a career studying networks at Bell Labs. He is teaching undergraduate courses in Work Design and Ergonomics and Probability Methods in Operations Research, and looks forward to working with students on projects and research.

A Rutgers team led by ISE evaluated multiple energy storage targets to find the best ways to achieve a 600 MW of energy storage capacity by 2021 and 2.3 GW by 2030. Working at the request of the **New Jersey Board of Public Utilities** and under landmark clean energy legislation signed by the governor in 2018, different applications of energy storage were investigated and bundles were developed to achieve the mandates in the areas of energy storage technology, analysis, and cost-benefit.

Weihong "Grace" Guo was among 14 manufacturing engineers, age 35 and younger, to receive the *2019 Barbara*

Message from the chair

Industrial and systems engineers devise ways to make products and services better, safer, easier to use, less expensive, and more energy efficient. Our students, faculty, and alumni are all working in their own way to advance our field across so many different areas. That is the exciting thing about industrial and systems engineering. We apply what we learn to areas as diverse as thwarting terrorist attackers by learning how they operate as Prof. Melike Baykal-Gürsoy is researching with doctoral student Andrew Benton, and fraud control at corporations like American Express where doctoral degree alumnus Dr. Di W. Xu is leading a team as vice president of machine learning and customer risk modeling and risk management. Dr. Xu has also created a fellowship program between American Express and Rutgers, advancing student learning.

We're also preparing our students beyond the field of engineering with a required course in engineering economics. Prof. Elin Wicks, who received her bachelor's and master's degrees from Rutgers, has joined our faculty as a full-time teaching professor where she is instructing students in applying the principles of economics to the business of engineering. New faculty member Ahmed Aziz Ezzat brings expertise in engineering-driven data science, renewable energy analytics and forecasting, and physics-informed statistical learning with applications in energy, manufacturing, and materials.

We also share with you in this newsletter issue updates on a recent graduate, Gavin DeAngelis, who is working as a systems engineer at Lockheed Martin, and Lydia Prendergast, who earned her master's and doctoral degrees in industrial engineering and is now an assistant dean at the School of Engineering. And be sure to check out the photos from our networking meet-and-greet last spring where we honored alumni Stanley Makadok and Peter Manzetti. If you haven't attended this annual event, I encourage you to join us as it is a fun night to reconnect with old friends and make new ones!

Sincerely,
Mohsen A. Jafari, Ph.D.
Chair, Department of Industrial and Systems Engineering

Siemens Fellowship on Security Applications (continued from page 1)

Photography: Brian Alden

as he is looking at a real problem from two opposing perspectives—that of the attacker and that of the defender.

"The defender's job is to protect the network by changing the location of things on the network to keep an attacker from knowing what the network looks like," Benton said.

"Using network reconnaissance, the attacker tries to learn about the network and determine how to attack it. What we care about is making good defenders for enterprise networks. But in order to do this, we need to understand the cyberattackers, whether they are nation states or teenagers at their computers."

Using cyber deception as a means of combating network attackers has been a focus of Benton's advisor, ISE associate professor Melike Baykal-Gürsoy, who encouraged him to submit a proposal for the prestigious fellowship in fall 2018.

According to Baykal-Gürsoy, cyberattacks pose a potential threat to national security. Industrial systems—from water systems to energy systems—are particularly vulnerable to such attacks. "The goal of this research is to create a prototype of a deceptive network to learn

about attackers—and ultimately slow them down," she explained.

"It's a real race between hackers and networks. Andrew is trying to outsmart the adversaries who constantly look for vulnerabilities in your system. By creating the smartest adversaries, and in turn, the smartest defenders, a network is ready to stop hackers," Baykal-Gürsoy added.

Benton is working on transforming his Future-Makers proposal into reality by developing a prototype that he will present to Siemens in spring 2020. While his work is likely to be part of his dissertation, he is also in the process of co-authoring with Baykal-Gürsoy. "There will be papers coming out of this," she said. "There will be real academic results to report. It's not just going to be a prototype that we can demonstrate." ∎

Engineering Economics Course Prepares SoE Students for Future Success

This academic year, all entering School of Engineering students are required to take Engineering Economics, a 3-credit semester-long course taught by industrial and systems engineering assistant teaching professor Elin Wicks.

For Wicks, the course is essential preparation for future success. "I want to give my students the ability and confidence to learn, adapt, and contribute when they get into the workforce," she said.

"Teaching professors like Elin Wicks, who is focused on teaching and not research, bring value to a School of Engineering education by helping to fulfill our mission of providing our students with a top-quality, relevant education," said School of Engineering dean Tom Farris.

Wicks, who joined the ISE faculty last year, earned her bachelor's and master's degrees in industrial engineering from Rutgers, and her doctoral degree from Virginia Tech. A contributing co-author of the popular textbook, Engineering Economy, Wicks taught at the University of Missouri before retiring to raise a family.

"I'm both an old teacher and a new teacher," said Wicks, who teaches three sections of the course each semester, as well as a summer section. "I'm in a continuous improvement phase and hopefully always will be."

Class enrollment has doubled from 220 to 440 students since last year. In two weekly 80-minute lectures, Wicks' students learn to apply principles of engineering economics to evaluate the economic merits and consequences, as well as profitability measures, of engineering solutions.

"I tell students they can design the most fantastic thing in the world, but if it doesn't make money for the company they work for, and if they can't show the financial benefits of what they're doing, their company won't stay in business," Wicks explained. "They'll need to evaluate the economic consequences of what they're doing. It's a tool they need—both in business and in life."

Sophomore Kimberlee Sibilia agrees. "This class puts you in a position you could find yourself in the future. You not only have to make decisions as if you were a project manager, but you have to back them up," she noted. While Sibilia took the course last spring, as a course learning assistant, she is currently helping Wicks facilitate classroom activities and mentor students.

Fellow learning assistant and senior Omer Yucel also found the course tremendously helpful. "My biggest takeaway was learning the time value of money, and how an engineer should work with money," he said. "This is an important course because engineers with money management skills will be viewed as more valuable to companies."

Wicks hopes lessons learned will extend beyond the classroom and workplace. "One of the things I love about the course is that it also teaches them about personal finance applications—such as how to measure the time value of money for the loan value of a car—that are relevant to their lives," Wicks said. "Unless they are independently wealthy, they can't get around the personal benefits of this course."

Working in teams, students draw on engineering, science, and math principles to assess the viability of sophisticated engineering solutions. "The course encourages students to cross boundaries between departments," said Wicks. "After all, they'll have to be able to work with other people. At some point, a good engineer has to become a manager and apply the same skills it takes to develop machines to managing a product line or even a company." ■

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department news (continued from page 2)

M. Fossum Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers (SME) for exceptional contributions and accomplishments in the manufacturing industry. Guo's research focuses on the fusion of advanced statistical and domain knowledge to develop methodologies for modeling, monitoring, diagnosis, and prognostics for complex manufacturing systems.

The **Material Handling Society of New Jersey** awards scholarships annually to college students pursuing studies in material handling, engineering, and supply chain related fields. This year's honors went to two Rutgers industrial and systems engineering undergraduate students, **Victoria Mckeown** and **Joseph Palmer.**

Di W. Xu, Ph.D.'01

Vice President, Machine Learning and Customer Risk Modeling, Risk Management
American Express Company

My doctoral research focus was on multivariate statistical process control and robust optimization. At Rutgers, I valued being part of a closely-knit family with a highly reputable faculty that paid attention to students.

During My Time at Rutgers...
My SoE education helped me create a solid foundation in statistics and optimization—the two pillars for any machine learning research. I gained problem solving skills that help me strike the right balance between theoretical research in the long run and solving practical problems in the short term.

Where I am Today
I develop cutting edge machine learning research to drive its adoption and best practices for risk management and am responsible for customer risk models globally. I enjoy many learning opportunities in this role and the ability to interact with young talents who drive machine learning innovation. I've recently helped create a long-term fellowship/internship program between American Express and Rutgers that is spearheaded by ISE. ■

Read our longer Q&A with Di at ise.rutgers.edu/news/di-xu

Gavin DeAngelis, B.S.'17

Systems Engineer, Lockheed Martin Rotary Mission Systems

Believe it or not, I'm working as one of the few systems engineers at Lockheed Martin with a background in systems engineering. When I came in, our processes were standardized, but outdated and inefficient. With my background in industrial engineering, I've had an integral part in finding those "low hanging fruit" that are ripe for improvement.

During My Time at Rutgers...
I valued the close connections with professors. My senior design project team met regularly with professors to understand expectations and work towards solutions to logistical and technical problems. I use these same skills as a systems engineer working with customers to understand their needs—and working with other engineers to develop solutions to those needs.

Where I am Today
My job responsibilities include the traditional aspects of systems engineering. I stay connected with ISE: I actually completed a research project working with Professor Elsayed, which was altered to fit our needs and will be coming into our main architecture soon. ■

Gavin, photographed aboard the HMAS Brisbane, is currently undergoing combat system qualifications with the Royal Australian Navy as part of his work with Lockheed.

Lydia Prendergast, M.S.'98, Ph.D.'13

Assistant Dean for Academic Services and Instructor of Pedagogy for Learning Assistant Program
Rutgers School of Engineering

In the past 18 years, as a dean in Academic Services, I've advised undergraduate engineers on degree planning, career development, and more. As an instructor of pedagogy, I also help prepare undergraduate classroom learning assistants.

During My Time at Rutgers...
I received quality training in engineering amongst a globally diverse population. As a three-time alumna, I gained a full picture of the engineering student experience and what initiatives support success and retention in engineering.

Where I am Today
Since I work at SoE, I maintain regular contact with ISE students and faculty—including my graduate research advisor Dr. David Coit. What I most enjoy is being able to contribute to the success and retention of our students. Working with students is like watching flowers blossom. This is an awesome thing. ■

ISE Alumni Gather for Networking Event

More than 85 ISE alumni, faculty, and friends turned out in May for an ISE Alumni Networking Event honoring alumni Stanley Makadok, MS'64 and Peter Manzetti, BS'82.

Makadok, the recipient of the 2019 Distinguished Alumnus Award, is president and founder of Century Management Consultants, Inc., which provides strategic planning and management guidance to leading national and international companies and organizations.

As a long-time friend and generous supporter of the department, he has donated in-kind equipment and shared his work experience with students in a campus presentation. A member of the board of directors of the Rutgers Alumni Association and the School of Graduate Studies Dean's Advisory Council, he currently serves as chair of the ISE department's Industrial Advisory Board.

Peter Manzetti—a principal in the Governance, Risk and Compliance Services Practice at

Friedman LLP—received the 2019 Outstanding Alumnus Service Award. He and his wife Kathleen generously funded the department's Manzetti scholarship for undergraduate students. He has taken part in student events as a panelist and speaker.

Committed to helping make a difference for children in New Jersey, Manzetti has served as a trustee with Big Brothers Big Sisters of Northern New Jersey, Inc. and Clothes for Kids' Sake, Inc. ■

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Student Achievement

Rutgers students win the data challenge in the 2019 IISE Annual Conference

Industrial and systems engineering doctoral students Shenghan Guo and Changxi Wang won the Quality Control and Reliability Engineering (QCRE) Data Challenge at the 2019 Institute of Industrial and Systems Engineers (IISE) Annual Conference. The IISE Annual Conference joins leaders, up-and-comers, and students in the industrial engineering field to network, gather new ideas, and learn about innovative tools and techniques. This year's QCRE Data Challenge called on students to predict a rarely-occurring paper break in a paper milling machine and find out the root cause using data from multiple sensors placed in different parts of the machinery.

According to Wang, this data challenge belongs to a big category of problems called "the early classification of multivariate time series data," which remains an open problem.

"If we can achieve even a five percent reduction in paper break events, this will result in significant cost savings for a mill," he says.

The same problem also arises in other fields such as healthcare, where EEG/ECG patients are continuously monitored and the doctors need to be alarmed when the anomalies of the patients are identified. Currently, however, the research on early classification of multivariate time series is sparse and the extreme imbalance of the data also adds difficulty to the problem.

Among the 100 teams participating, Guo and Wang developed a machine learning model based on logistic regression, vector space model, and symbolic aggregation approximation, which had the best paper break prediction accuracy among all the participants.

"It was a great pleasure to be the winner out of so many competition participants. The whole experience was fun, exciting, and inspiring. The data were complex, common in practice while the problem motivated by the data was novel and unique. Finding the solution to the problem actually inspired my research interest into some method branches in big
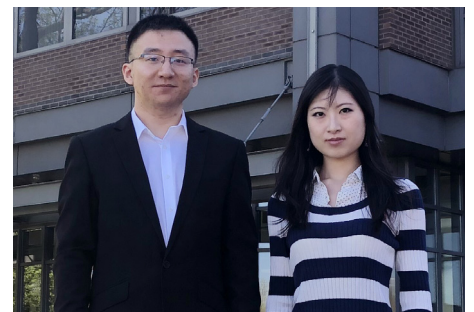
data that I hadn't explored previously. So, overall I am grateful and happy about winning the competition," said Guo who attended the conference for the first time.

Wang, who first attended the conference in 2018, was also nominated as the finalist in the QCRE best paper competition for his paper entitled "Stochastic Modeling of Degradation Branching."

"The IISE annual conference is a place where great ideas shine. It was my great honor to interact with so many outstanding researchers from various disciplines," says Wang. ■