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Industrial & Systems Engineering at Rutgers

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, quality engineering, and systems engineering, the department is pushing ahead with new endeavors in emerging technical areas and focusing on educating the next generation of engineers and technology leaders.

ise.rutgers.edu



Safer and More Reliable Lithium-Ion Batteries Using Prediction Modeling Techniques

Lithium-ion batteries power devices ranging from handheld smartphones to Tesla sedans. Their lightweight and high-energy density have propelled them to serve more than 85 percent of today's energy storage needs.

There's only one problem. Lithium-ion batteries can be finicky. Sometimes dangerously so.

Exploding batteries in Samsung's Galaxy Note 7 smartphones were front-page news in 2016, leading airlines to ban passengers from using the popular phones in flight. A few years earlier, the Federal Aviation Administration ordered U.S. airlines to ground their newly delivered Boeing 787 Dreamliners after batteries that power the aircraft's advanced electronic systems overheated or caught fire in a handful of planes.

Industrial and Systems Engineering professor Zhimin Xi is working to tame these incredibly useful but sometimes temperamental batteries. He is applying modeling and prediction techniques that will enable battery management systems to detect abnormal or unreliable operation and take actions that minimize the occurrence and severity of failures.

"Batteries cannot be exhaustively tested in the lab," Xi said. "We have to develop methodologies to make batteries resilient – to recover quickly from failure modes."

There are several failure modes that lead to "thermal runaway" – the formal term Xi and other experts use to describe uncontrolled overheating that sometimes ends in fires or explosions.

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Faculty News

ISE department chair **Mohsen A. Jafari** was the guest speaker at an event organized by Smart Cities NYC17 on transportation challenges facing large cities.

Tugrul Ozel, ISE associate professor, received an award from Taiho Kogyo Tribology Research Foundation to conduct an inverse analysis of high-speed cutting simulations and experiments to identify variable friction on micro-textured tool surfaces whether coated or uncoated. The research will include high-speed cutting experiments followed by 3D finite element simulation to understand stress distributions and variables.

Zhimin Xi, ISE assistant professor, is the recipient of a DARPA Young Faculty Award for his research related to control design errors resulting from model errors. The award includes a \$400K grant.

Xi was also awarded \$275K from the National Science Foundation for his research related to lithium-ion batteries in electric vehicles.



Message from the chair

Each year during Senior Design presentations, I am reminded that the field of industrial and systems engineering provides so many opportunities for study, research, and employment. For the 2017-2018 academic year, students' team-based projects tackled a host of divergent problems with originality and intelligence using analytics, mechanics, optimization algorithms, 3D printing, and UAVs, among other tools. The photos of student projects in this newsletter give a sense of the versatility.

Our department continues to advance exciting research and program depth through meaningful partnerships with Lockheed Martin and the New Jersey Board of Public Utilities. We sustain and support each other's expertise to improve not only the academic experience, but contribute to important energy initiatives for New Jersey and disaster resiliency both natural and manmade.

This newsletter issue includes an article featuring research by Zhimin Xi, ISE assistant professor whose research related to the safety and reliability of lithium-ion batteries was rewarded by the National Science Foundation. Zhimin was also recognized by DARPA with a Young Faculty Award for control design research.

We feature two alumni within these pages—Bill Amann and Heidi Taboada—to showcase the success and diverse careers of our graduates. Staying connected as alumni is very important to me as department chair and I've encouraged engagement through events like our annual meet and greets, mentoring opportunities, evaluators and judges for capstone projects, and career fairs. Any alumni or industry partners looking to become more involved, please feel free to contact me. Engagement is a two-way street that I'm sure you will find rewarding to your life and beneficial to your career.

I hope you enjoy this issue of the ISE News and I look forward to connecting with you over the coming months in person or via our Rutgers ISE LinkedIn group.

Mohsen A. Jafari, Ph.D.

Chair, Department of Industrial and Systems Engineering



Join our ISE community on LinkedIn. This is a closed group for ISE alumni and friends where we can share news, information, and opportunities.

Visit LinkedIn and search **Rutgers Industrial and Systems Engineering (RISE)** to join.

research

NJ Board of Public Utilities and Rutgers LESS Resiliency Collaboration

Working in partnership with New Jersey's public utilities, School of Engineering researchers and graduate students are planning for our state's energy future with both careful consideration and cutting-edge innovation. As part of this effort, the Rutgers Laboratory for Energy Smart Systems (LESS) is working with the State of New Jersey on the evaluation of several microgrid initiatives that the state is undertaking as part of its resiliency program.

The New Jersey Board of Public Utilities has provided funding for LESS on various aspects of distributed energy resources analysis. Addi-

tional funding will be geared toward analyzing microgrid initiatives, including resource mix optimization, and load management. This project will also include developing tools for the state to address issues that are pertinent to the expected growing penetration of electric vehicles across New Jersey.

According to Mohsen A. Jafari, LESS director, "This important partnership between New Jersey's public utilities and Rutgers is bringing together research and industry experience to build more resilient and sustainable energy systems." ■

Meet Lana Sharp ENG'18 from Ocean City, NJ



Why ISE?

I first chose industrial and systems engineering as a freshman because I liked the versatility. We take classes from manufacturing and probabilistic and deterministic models to simulation and accounting. It offers the opportunity to learn about a variety of things and really spark curiosity in students. Overall, I think ISE is a great major for students who have questions, who look at things or processes and wonder how or why they work or maybe even how they could be improved.

Internships

After sophomore year I interned at Giant Eagle, a grocery store chain in Pittsburgh. I was a continuous improvement consultant on the business systems team. We were the problem solvers of the organization, helping departments or stores find opportunities for improvements. Last summer, I had a totally different experience as an intern at Mars Wrigley Confectionery in their marketing finance department. I did a lot of data analysis, trying to understand the story behind financial data and trends.

On Campus Involvement

I have been involved in the Society of Women Engineers (SWE) and I'm currently the president of the Rutgers chapter of the Institute of Industrial and Systems Engineers (IISE).

Senior Design Project

Senior design is the culmination of all of the classes we take as undergrads so, for me, it was definitely one of the most rewarding experiences. My group made a highly mobile intelligent tennis ball collector that was capable of collecting tennis balls while playing a match. We used a variety of hardware and software, including Raspberry Pi, Arduino,

Python, OpenCV, and Flask App. There's a great support system throughout the process with our advisor, technicians, and TAs.

Career Plans

I have accepted a business technology analyst role at Deloitte in their federal consulting practice in Washington, DC. ■

Student News

Industrial and systems engineering doctoral student **Abdolmajid Yolmeh** was named the winner of the INFORMS New Jersey Chapter Annual Student Research Contest for his work on "A Two-Stage Invest-Defend Game: Balancing Strategic and Operational Decisions." This research was conducted under the direction of his advisor Melike Baykal-Gursoy, ISE associate professor, and funded by the National Science Foundation.

Lithium-Ion Batteries (continued)

"These include overcharging, rapid discharging, lack of heat dissipation, and structural flaws in individual cells," he said. "If we can detect overcharge, we could stop charging. If we detect rapid discharge, we could limit it."

Earlier this year, Xi received a \$400,000 grant from the National Science Foundation to study uncertainty management and proactive maintenance of lithium-ion batteries in electrified vehicles – both hybrid and plug-in electric.

"Current battery management systems perform tasks such as estimating the battery's state of charge and state of health, but their actual capability is often lower than expected," he said.

As a result, today's battery packs have to be overdesigned by anywhere from 20 to 100 percent to provide the safety and reliability needed in a practical vehicle. That, in turn,

means higher prices and a limited market for electric cars.

The modeling work Xi is undertaking seeks to accomplish three goals: making more accurate battery models, understanding uncertainties remaining in these models, and developing "adaptive resiliency," or ways to detect and overcome potential faults.

The first and second goals may seem contradictory, but Xi explains that the best model, known as a "full order electrochemical model," is too complex for the computational power of a vehicle's battery management system to handle. Therefore, simpler models that carry some uncertainty are necessary. So the second goal of characterizing these uncertainties "improves the accuracy of a low fidelity model so battery performance estimation can be conducted more effectively."

The third goal seeks to sense abnormalities in individual battery cells and take steps to

correct the abnormality or take the cell out-of-service before a major failure. If one cell is always in a higher state of charge or another is running hotter, intelligent cell balancing or smart heating and cooling techniques might help.

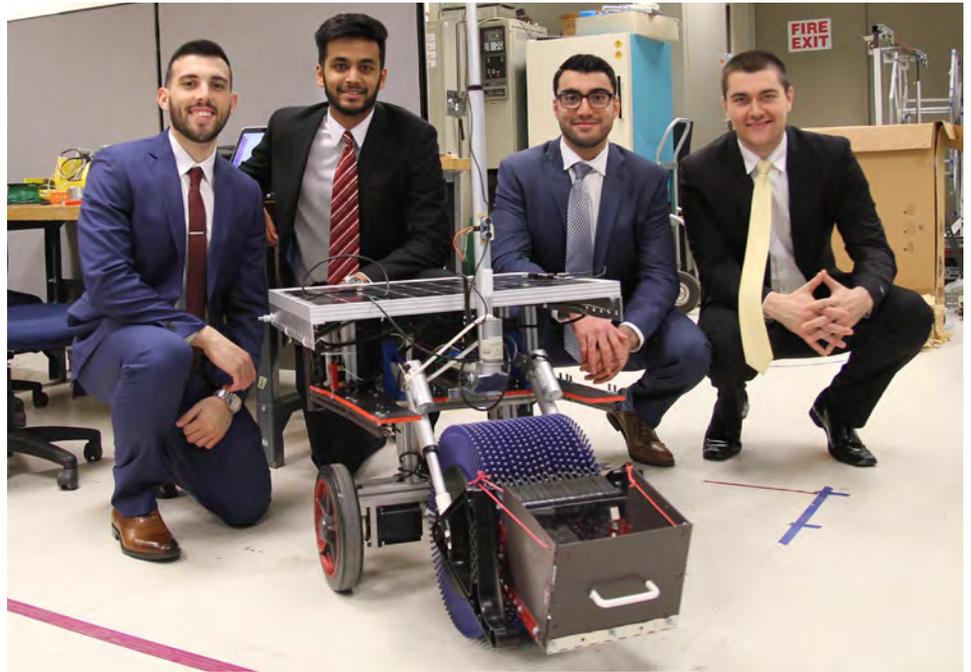
"We have those actions now, but they are applied to the whole system," said Xi. "But typical failure is because of a few cells."

Xi sees the benefits of his work extending beyond more affordable and reliable electric vehicles.

"Renewable energy resources such as solar and wind aren't steady and predictable," he said. "Grid-scale energy storage can make these sources more useful."

Lithium-ion battery packs that maintain their integrity and health could be recycled from used electric vehicles and deployed in the grid, which would give these vehicles more residual value. ■

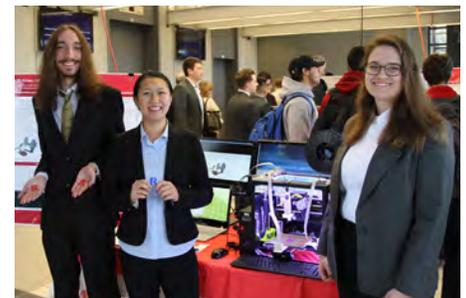
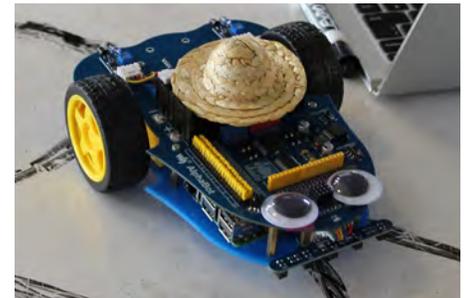
ISE Undergraduate Students Present Senior Design Projects



The 2017 *Design of Engineering Systems* course is a required capstone learning experience for graduating students. Work on a unique, challenging design problem begins during the spring semester of the junior year and culminates with team-based projects presented in December to a panel of industry and faculty judges.

This year's design projects addressed challenges related to autonomous factories, safe and efficient shipping ports, wild animal protection in game preserves, automated pipeline inspection, energy smart communities, railway traffic flow, manufacturing quality control, and predictive analytics to reduce hospital readmission, among others. Fifty-eight students participated in teams with direction from faculty members and mentors.

While many engineering departments assign capstone projects during the first and second semesters of the senior year, Professor Hoang Pham explained the ISE schedule as providing students plenty of time to pursue job opportunities during their final semester and the design projects give the students "something to talk about during the interview process." ■



ISE Alumni Spotlight: William (Bill) Amann ENG'79



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When you love what you're doing, you never work a day in your life.

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Why did you choose the School of Engineering?

I took a tour and sat down and chatted with Dr. Burbridge, who picked up a phone, called someone and said, "You're in." I'd looked at Fordham and Newark College of Engineering and liked being out in the country more than in the Bronx or in Newark.

What attracted you to industrial engineering?

I was into music and thought I'd design stereos for Marantz, so I first went into electrical engineering. I was living in Davidson Hall and talked to seniors across the hall who were in electrical engineering and told me to improve the stereo system in my car, they would need me to write the calculus equation. I quickly changed my major to a five-year industrial engineering degree for business because it seemed to cover a lot without being industry specific. I'd also read that Fortune 500 CEOs who were engineers were mostly industrial engineers.

How did you end up in energy?

In the spring of my senior year, two things happened. *The China Syndrome*, with its story about a nuclear plant emergency, opened. Twelve days later, the Three Mile Island nuclear reactor accident occurred. This set me on a

different direction, as I realized I could spend my whole career trying to make a difference in how we expend energy.

With more than 35 years of experience in energy systems, M&E Engineers president **Bill Amann** (BS/BA ISE and Economics '79) is a national leader in green building design and energy efficiency. His personal and professional dedication to energy conservation and environmentally sound construction practices has earned him the prestigious designation of LEED Fellow. Passionate about developing and implementing practical sustainable energy solutions, he has been involved in more than 20 LEED projects and over 100 Energy Star Buildings. A member of the board of the New Jersey chapter of the U.S. Green Building Council and chair of the Somerset County Energy Council, Amann is a man with a mission and strives to educate the industry and general public about green initiatives.

different direction, as I realized I could spend my whole career trying to make a difference in how we expend energy.

Did your Rutgers education prepare you for this career shift?

Those seniors across the hall terrified me with stories about thermodynamics. But it was the best class I ever took—and an indication that I might be good at that. As the "Berkeley of the East," Rutgers offered a cool elective class in solar energy. So—at that point, I knew how to heat a house with solar energy.

Has Rutgers kept pace with the times?

When I graduated, nobody really cared about energy—cheap energy was all that mattered.

Things have changed. Through the U.S. Green Building Council—the organization that created LEED building certification—there's a new LEED program for cities. Newark was the first to register. I've put industrial and systems engineering chair Mohsen Jafari in touch with Dr. Vatsal Bhatt who runs this program. There is a real potential for Rutgers to take a lead, if they do the modeling of measurements for this project. I'm happy to have made that connection for them and happy to see my alma mater really make a difference.

What does it mean to you to be a designated LEED Fellow?

You can get all sorts of letters after your name that don't mean much. But this means a lot, as very selective criteria were applied in how we make a difference when we build buildings. There are only three of us in New Jersey—I'm proud of us.

What projects are you most proud of?

I'm proud of the projects we've done for Wyndham Worldwide, including helping

to design its LEED Silver certified Parsippany headquarters, and helping the company to earn an Energy Star Score of 99.

I'm also proud of work done for the Willow School in Gladstone, New Jersey, which has achieved net zero water, net zero energy, and net zero waste—and which is one of only 14 buildings worldwide to achieve Living Buildings certification.

What can individuals do to make a difference?

Switching to LED light bulbs makes a huge difference. If everyone made the switch, a lot of our coal plants could be shut down.

Why is this so important to you?

Business and the general public need to hear about the benefits of energy efficiency from experienced practitioners. Engineers tend to be good technically, but not so great at communicating. I like to explain things in plain English so people can understand the benefits.

What advice do you have for students who want to follow your footsteps?

Buildings are responsible for about 40 percent of carbon emissions, and make a huge impact on climate change. It is really, really important to continue to develop new solutions. It's a motivating, challenging, and extremely important field. But it's one that if you like what you're doing, you'll never work a day.

It's an incredibly exciting time. It's exciting to use the Internet of Things to connect people to buildings through their phones. New energy storage technologies are making a difference, but so much more needs to be done. ■

Second Annual ISE Alumni Networking Event

More than 110 Industrial and Systems Engineering alumni, faculty, and friends joined Dean Tom Farris and department chair Mohsen Jafari to celebrate the second annual ISE Alumni Networking Event on May 11, 2017, at Battellos Restaurant in Jersey City.

Special recognition was paid to Binnur Altioik and Stephen (ENG'98, GSNB'03) and Kerry Bray along with the students who are benefiting from the generous scholarships they established for the ISE department.

Congratulations to Marc Block (GSNB'92), recipient of the Outstanding Contribution Award for his efforts in student education and training. ■





Heidi A. Taboada, Ph.D. (GSNB'05, '07)

Heidi Taboada was recently appointed associate dean for research and graduate studies at the University of Texas at El Paso where she is also an associate professor of industrial, manufacturing, and systems engineering.

Why did you choose Rutgers for your graduate education?

I decided to pursue my graduate education at Rutgers over other top universities because it is a premier research institution with an internationally recognized ISE program, world-class faculty members, excellent location, and remarkable university history. The education I received gave me a solid foundation for a career in academia. I am proud to be a Rutgers alumna.

What drew you to the industrial and systems engineering field?

ISE is a unique engineering discipline, and that is what I like about it. It integrates the quantitative engineering approach with qualitative insights of human behavior. It is a very versatile degree that gives you the opportunity to make an impact in people's lives.

What is your current position and what are your main responsibilities?

I am the associate dean for research and graduate studies in the College of Engineering at the University of Texas at El Paso. My main responsibilities are to oversee the growth and quality of our current graduate programs. At the UTEP COE, we offer 17 different masters programs, and 6 Ph.D. programs. The most important part of my job is to provide strategic leadership for developing and refining our College of Engineering's research activities, enabling interdisciplinary research collaborations, growing our research portfolio, and supporting continuous faculty development.

How did you get into the position you have now?

I completed my Rutgers M.S. and Ph.D. degrees in industrial and systems engineering in 2005 and 2007, respectively, under the direction of my advisor David W. Coit. Right after graduation, I was immediately hired as an assistant professor at the University of Texas at El Paso where I have spent my academic career. During my time here I have worked very hard to secure federal funding for my university. I have been the principal or co-principal investigator for over \$10

million in successful grants from agencies such as the United States Department of Agriculture, the United States Department of Education, the Department of Homeland Security, Department of State, 100K Strong in the Americas Foundation, and industry. My experience securing extramural funding and leading multi-disciplinary teams, along with my willingness to continue learning, were important aspects for me to advance into my current position.

How do you describe your leadership style?

I strongly believe that a leader's vision is only real when it creates inspiration. My role is to inspire students, faculty, and staff and help them achieve their career and professional goals. My commitment is to lead by example, inspire, motivate and empower colleagues, and serve in my current position with passion, dedication, and sincerity.

What is your favorite quote?

I find particularly inspiring the following quote by Pelé, a world famous soccer player: "Success is no accident; it is hard work, perseverance, learning, studying, sacrifice and, most of all, love of what you are doing." In my opinion, this quote describes what every student should do every single day at school. Hard work is what helps you achieve your dreams.

Any recommendations for graduating students?

My personal advice is that they should never stop learning, become the hardest working employee in your organization, maintain connections with Rutgers, and never underestimate the power of networking. ■

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I strongly believe that a leader's vision is only real when it creates inspiration.

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Reliability, Resilience, and Prediction Drive ISE/Lockheed Martin On-going Collaborative Partnership



Lockheed Martin, designer and developer of complex defense systems, and Rutgers are teaming up on a collaborative project to investigate multi-hazard disaster resilience assessment. Recent natural and manmade disasters along with cyber-attacks on companies, university campuses, airline reservations, operating systems, and other incidents illustrate the importance of designing

resilient systems that can withstand disasters with minimal interruptions to operations and rapidly recover from those interruptions.

Elsayed A. Elsayed, ISE distinguished professor, and researchers from Lockheed Martin are investigating critical systems with dependencies between multiple units and interdependencies where there are bidirectional links between several units.

Generic methods for resilience assessment under natural hazards and manmade hazards are also being developed and validated to improve resilience via redundancy and proper allocation of resources during the recovery process.

Lockheed Martin also supports the Rutgers Engineering academic program by offering a course in reliability engineering in conjunction with the Department of Industrial and Systems Engineering open to undergraduate students across all engineering majors.

Students study the principles and practice of reliability engineering while working in multidisciplinary groups on complex projects such as the reliability of rotors of unmanned aerial systems. They also conduct reliability testing of the rotors, reliability modeling and estimation of hard drives made by different manufacturers, and reliability of autonomous vehicles, as well as investigate approaches to assess and improve reliability of complex systems. ■