Rensselaer

2017-2018

ise

where i means interdisciplinary

Industrial and Systems Engineering

John T. Wen
Head, Department of Industrial and Systems Engineering

Message from the Head

Industrial and Systems Engineering (ISE) became a department at Rensselaer in 1987 (the precursor program, management engineering, started much earlier in 1933). The world has changed a lot since then. Breathtaking technological advances are accompanied by new natural and human-made challenges—extreme weathers, energy sustainability, skyrocketing healthcare cost, income inequality, disinformation, terrorism, and a slew of others. In this increasingly complex and cacophonous world, ISE's grounding in evidence-based, data-driven reasoning and decision making is more relevant and critical than ever before.

Industrial and systems engineers today address highly interconnected societal systems consisting of engineered and human components, with distributed decision making based on huge amounts of disparate data. ISE faculty are at the forefront of the field—conducting innovative and impactful research, and at the same time bringing their insight and

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discovery into the classroom. To name just a few examples:

- Jennifer Pazour is leading the charge on the supply chain of the future, which integrates resource sharing, user preference, and real-time information. She has been honored with a trifecta of prestigious awards: the National Science Foundation (NSF) Faculty Early Career Development Award (CAREER), the Johnson & Johnson Manufacturing Scholar Award (part of the Women in Science, Technology, Engineering, Math, Manufacturing, and Design (or WiSTEM2D) Scholar Program), and the IISE Dr. Hamed K. Eldin Outstanding Early Career IE in Academia Award.
- David Mendonça, in his role as the program director for the infrastructure management and extreme events program at NSF (2015-2017), has been shaping research in community resiliency.
- Al Wallace analyzes behavior in social media in disaster events through funding from the Department of Homeland Security, the Army Research Office, and NSF.
- Tom Sharkey's innovative virtual office hour was recognized by the Institute of Industrial and Systems Engineers (IISE) Operations Research Teaching Award.
- Sergio Pequito, a new ISE faculty member, is expanding the boundary of ISE by applying his research on large complex systems to neuroscience and biomedicine.
- Cheng Hsu's patent on natural language interface has ushered in the advent of voice-based search such as Siri. The settlement with Apple has enabled the establishment of an ISE department endowment fund.
- ISE graduate students have been garnering multiple awards, from the Department of Defense Fellowship to scholarships in professional societies to best paper awards in conferences.

As a testament to the recognition that our faculty and students have received, our U.S. News & World Report graduate school ranking has been at 17 in both 2017 and 2018.

The coming year will bring preparation for ABET accreditation, curriculum review to ensure adequate coverage of both fundamentals and contemporary applications, and expansion of the Arch program for sophomores in summer. We will also continue close engagement with the ISE Advisory Council, many of whom are our alumni, for internship/co-op opportunities, capstone design project sponsorship, research collaboration, and curriculum input.

To broaden our outreach, we have updated our website (http://ise.rpi.edu) and set up an ISE YouTube channel (click on the arrow on our homepage). Please check them out and let us know what you think!

When I was growing up in Taiwan, I was drawn by American idealism and activism. There was a whole set of daunting challenges then—from the civil rights movement to gender equality to the Vietnam War. The problems were hard, but there was always the commitment to continue to strive for a better world, "a more perfect union," and the belief that the effort is ultimately rewarding—the long arc of history bending towards justice.

I am honored to serve as the ISE department head and to have the opportunity to work with wonderful students, faculty, staff, and alumni. Let's collectively harness the idealism and actively strive for a better department, university, and society.

Best,

John

John T. Wen, Professor, Department Head

ISE YouTube Channel Launched

Check out the new ISE YouTube channel (click on the arrow symbol on ise.rpi.edu). The channel includes Jennifer Pazour's introduction to Rensselaer ISE, targeting high school students and incoming engineering students, and INFORMS interview of Dan Berg, in which he described the path to his illustrious career.

Jennifer Pazour Wins NSF CAREER Award

Jennifer Pazour
Assistant Professor

ISE faculty Jennifer Pazour has won the prestigious Faculty Early Career Development Award (CAREER) from the National Science Foundation (NSF) Division of Civil, Mechanical, and Manufacturing Innovation. She will use the five-year, $500,000 award to study "Distribution Resource Elasticity: A New Hierarchical Approach for On-Demand Distribution Platforms." The CAREER Award is given to faculty members near the beginning of their academic careers and is one of the most competitive awards given by the NSF to junior faculty. The award places emphasis on high-quality research as well as novel educational initiatives.

ISE Endowment Fund Established

The department has used its share of a legal settlement to establish a new endowment fund for ISE student and faculty excellence. Rensselaer and Marathon Patent Group brought the patent infringement case over technology used in the iPhone's Siri app—technology that originated in the invention "US 7177798 B2 Natural Language Interface Using Constrained Intermediate Dictionary of Results," developed by ISE professor Cheng Hsu and his former graduate student, Veera Boonjing. The case was settled in early June for $24.9M to be shared between Rensselaer and Marathon.

ise.rpi.edu

Check out our revamped website! Go to ise.rpi.edu for links to faculty talks and tutorials, information on how to stay connected to us with LinkedIn and Twitter, and how to support the department.

ISE Welcomes New Faculty Members: Sergio Pequito and Joana Coelho

Sérgio Pequito joined ISE as an Assistant Professor in fall 2017. Sergio obtained his Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University and Instituto Superior Técnico, through the CMU-Portugal program, in 2014. He was a postdoctoral researcher in the General Robotics, Automation, Sensing & Perception Laboratory (GRASP lab) at University of Pennsylvania from 2014-2017. His research consists of design, analysis, optimization, and control of large-scale systems, including applications to neuroscience and biomedicine.

Joana Coelho joined ISE as a Lecturer in spring 2018. Joana received her Ph.D. in Bioengineering from MIT-Portugal Instituto Superior Technico (IST) program. Her previous position was Data Scientist of Analytical Consulting at BNP Paribas, an international banking group. She has excellent background in applied statistics and machine learning, and extensive experience working with large-scale data particularly related to healthcare and life science.

ISE Rises to 17 in USNWR Ranking

The U.S. News and World Report best graduate industrial/manufacturing/systems engineering department ranking lists Rensselaer ISE at 17 in both the 2017 and 2018 rankings. This is an indication of the reputation and impact Rensselaer ISE faculty and students have in the ISE field.

ISE Advisory Council

The ISE Advisory Council provides input and advice to the department. They serve as the champion for the department and connect opportunities to ISE students and faculty.

The Advisory Council members are:

- James Birnby, VP in Technology Group, Ayco (Goldman Sachs)
- James Daviero, Director of IP Operations, AT&T
- Greg Dietrich, VP, Operations Eng. & Excellence, DXC Technology
- Bill Fosnight, Co-Founder and Chief Dev. Officer, Alert Innovation
- Robert Kewley, Head of Systems Engineering, West Point
- David M. Levermore, Lead Systems Engineer, MITRE
- Lori Parrott, Program Manger, Sandia National Lab
- William Rauch, Director of Analytics, Albany Medical Center
- Ravi Ravichandran, Director of Strategic Dev., BAE Systems (Chair)
- Colleen Shugrue, Manager, Learning Operations, UTC
- Rui Soares, Senior Manager, Deloitte Consulting
- Chris Vasiloff, Co-Owner Coolbreezecyclery and Trek Bicycle
- Peter Velez, Retired (Shell)

30 Years and Counting

A brief history—from DSES to ISE—and a forecast for a bright future

Dan Berg and Jim Tien

ISE Emeritus Professors Dan Berg and James Tien

The Department of Decision Sciences and Engineering Systems (DSES) was established in March 1987, after some 20 faculty—with a strong interest in decisions and systems—convinced then–President Daniel Berg and Provost James Meindl to form an interschool department with faculty from the Schools of Engineering, Science, and Management. The uniqueness and visionary aspect of the department was lauded by The New York Times. Although the new department reported to the deans of the three schools, Management Dean Bob Hawkins, was tasked with the major supervisory and coordination role. During the first year, Al Wallace was the department's acting chair while a national search for the department chair was conducted. Jim Tien from RPI's Department of Electrical, Computer & Systems Engineering was selected to be chair in 1988; he stepped down in 2007 when he was recruited to be the dean of engineering at the University of Miami.

The quantitative disciplines that underpinned the interschool department included operations research, statistics, industrial engineering, systems engineering, decision making, and others. The growth and success of DSES, especially in the early years, was very much due to Bob Hawkins; he vigorously supported the department and facilitated our interactions with Engineering Dean Dwight Sangrey and Science Dean Hal Raveche. Although Rensselaer went through some difficult years, DSES remained a financially viable department, mostly due to our growing research activities and our ability to attract distance learning, MS-level students. The department, for example, was instrumental in working with General Motors, IBM, Ford, United Technologies, and other organizations to establish a popular curriculum in the management of technology.

The interdisciplinary and interschool nature of DSES became a challenge, especially when budgetary concerns materialized over time. With the departure of the initial administrative group of DSES supporters, the department became less important as an interschool entity and more integrated with the School of Engineering, mostly because of common research interests. Finally, in 1997, under then–President Byron Pipes and Management Dean Joe Morone, the 10-year old department was told to dissolve and the faculty members were asked to return to their pre-1987 departments.

However, President Pipes did allow faculty members to vote and make their individual decisions. And so they did: the faculty unanimously decided that DSES should remain as an academic entity, within the School of Engineering. Moreover, except for a couple of faculty who felt more at home in the Lally School of Management, all the remaining faculty decided to stay in DSES.

The department continued to strengthen by broadening its research endeavors, enlarging student enrollment, and obtaining a new professorial chair (the Yamada Corporation Chair), which was funded by the sale of a table on which the peace treaty to end the (early 1900s) Russo-Japanese war was signed. The Yamada Chair has been held by Jim Tien and Al Wallace.

In 2007, Charlie Malmborg stepped in as department chair when Jim Tien left Rensselaer. With the support of the dean of engineering, the department was renamed and is now focused on Industrial and Systems Engineering as its unifying theme. More recently John Wen became chair. He continues to hire new faculty including Wei Xie, Jennifer Pazour, and Sergio Pequito to replace some of the faculty who left from prior years.

The department has always been blessed with energetic faculty with a common quantitative focus. The faculty have continued to innovate. The department's recent academic rankings have improved. Noteworthy in this recent period was Rensselaer's winning a major patent financial settlement based on a Cheng Hsu patent.

Given the department's strengths in decision-making methodologies, the future holds many opportunities for ISE.. With the advent of mass customization, autonomous vehicles, artificial intelligence, big data, and the internet of things, the best is yet to come for the department and its graduates. Rensselaer's heritage of "application …. to the common purposes of life" continues unabated.

RESEARCH HIGHLIGHT

Before–and After–Disaster Strikes

ISE's current research in community resilience continues its tradition of leadership and innovation

When you watched the news from Puerto Rico after Hurricane Maria last year, you probably weren't thinking about the rosters of debris removal teams. Or how the number of tweets about the hurricane could predict fundraising efforts for recovery. Or how system x cannot be restored until system y is back up and running.

ISE researchers have thought about all that. In fact, they're in the vanguard of research on improving the resiliency of interdependent networks.

Their work builds on a long and distinguished record. Professor William "Al" Wallace is renowned for his research on New Orleans levees following Hurricane Katrina. In the wake of 9/11, Wallace, ISE Associate Professor David Mendonça, and others collaborated on one of the earliest, most comprehensive studies of interdependence and resiliency. Senior Research Scientist Martha Grabowski recently led the National Academy of Sciences team researching oil spill response in the Arctic. All in all, ISE faculty members have investigated and published research on many of the most significant disasters of the past 30 years, from Hurricane Sandy to the Exxon Valdez spill.

Their most recent work covers a dizzying array of areas related to resiliency. In quite a few cases, the words novel and unique apply. Here is just a sampling of their research.

A Model of Interdependency

Often, in the wake of a disaster, people in the affected area can't get water because the water system is damaged. The water system can't be fixed until the power system, which runs key components of the water system, can be fixed. That can't happen until the debris is removed.

In short, the systems we depend on are massively complex and just as massively interdependent. The more decision makers know about these systems and plan ahead, the more efficiently they can respond when disaster strikes.

That's why models and other tools have become a major focus for several ISE researchers.

"Our goal in this work is to provide prescriptions for decision makers responsible for all phases of emergency management: preparedness, response, recovery, and mitigation," Wallace said. "The approach has been to develop mathematical models that would serve as decision aids to help ensure community resilience."

As it turns out, community resilience can be effectively studied in a community that isn't real. Wallace, together with Associate Professor Thomas Sharkey and others, have created an infrastructure dataset for a fictional community—CLARC County, a hurricane-prone coastal area with half a million residents—that decision makers can use to model and analyze their disaster preparedness. The dataset is unusual in including not only civil infrastructures but their social counterparts, such as healthcare and critical consumer goods like food and drugs.

Wallace has applied his emphasis on social infrastructure to another model as well: CRISIS (Civil Restoration with Interdependent Social Infrastructure Program), which can help decision makers identify the best community response for a given disaster. The model is predicated on the idea that, as Wallace wrote, "the rapid restoration of social infrastructure should drive priorities for civil infrastructure repair and service restoration."

Sharkey, meantime, has devised new classes of games that model interdependent infrastructure restoration (IIR). "This is unique," he said, "in that it allows decision makers from multiple agencies to determine the single best overall solution from a societal perspective."

The decentralized nature of disaster response makes such a game—and much of ISE's work in resiliency modeling—invaluable.

"Each infrastructure owner schedules the repair of damaged components within its own system. It's focused on how well the services provided by its system come back online," Sharkey explained. "However, the social objective is how well the entire set of services comes back online, since society requires all of these services to return to normal."

In terms of unique, Sharkey has also introduced a new term into the field of resiliency: restoration interdependency—a consideration from an outside source that must be factored into the infrastructure's restoration efforts. Debris removal required to reach a power substation would qualify as a restoration interdependency. So would competition for the same restoration resources from multiple infrastructures. Sharkey's research focuses on identifying and classifying the restoration interdependencies that arose after Hurricane Sandy.

Modeling can also reveal insights about the human side of resiliency—including communication among multiple owners of interdependent infrastructures. Wallace, Mendonça, and others are collaborating to design and implement a computer-based synthetic environment

to study collaborative information seeking during a restoration task.

The Human Factor

That the aforementioned project includes Mendonça is no surprise: his body of work focuses on the human element in disaster response and recovery. One project, for example, tackles a little appreciated aspect of emergency response actions: the thinking that determines which tasks require conventional responses and which call for improvisation. A statistical analysis of two events—the Oklahoma City bombing in 1995 and the 9/11 attack—revealed that the thinking behind conventional response relates closely to recognition, while improvised behaviors link more directly with explicit reasoning processes.

In another project, Mendonça and Grabowski are studying how the size and turnover of debris removal teams drive overall system performance. The findings could have substantial impact, due to the continued high costs of debris removal operations after hurricanes and other events.

The research uses data from a recent tornado event to identify potential improvements in debris hauling. "The data enable a detailed (and objective) examination of team performance," Mendonça wrote, "overcoming many shortcomings of retrospective methods such as questionnaires."

Wallace and Mendonça are also prototyping interactive systems that allow decision makers to solve restoration problems in real time. Unlike conventional algorithmic approaches, Mendonça said, these systems factor in human intelligence and behavior, providing far more flexibility in dealing with changing conditions and shifting priorities.

Away from the disaster site, Wallace has investigated the use of social media to predict collective behavior in two cases: donations to emergency response efforts and participation in protests. The results can help organizations like NGOs and law enforcement agencies to allocate resources in the wake of an unexpected event. In one finding, the value of post-disaster donations is proportional to the square of the number of tweets related to the event.

Sharkey sees the focus on the human element as setting ISE apart. "The recognition that humans are fundamental to resilience is critical in our overall focus," he said. "We conduct research into several related areas: 'physical resilience,' human contributions to overall resilience, and the connections between the two. That makes us quite unique."

From the Law to the Arctic

Some of the department's research has focused on specific concerns in the resiliency field—such as oil spills in the Arctic. Grabowski's leadership in the NAS research falls into this category.

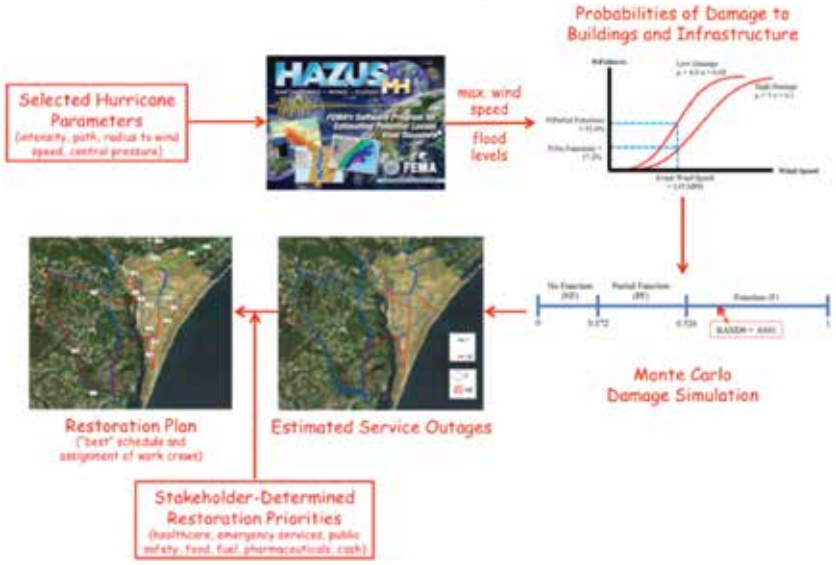
"Oil spill response operations in the Arctic can be hampered by a lack of existing infrastructure, limited pre-positioned response equipment, and the possibility that the equipment might not arrive in time to mitigate the impact of a spill," she said. "We modeled a mixed integer linear program, consisting of two interrelated constraint sets, to minimize response time for a set of potential spills."

Research from Sharkey, meanwhile, aims to ease infrastructure limitations by determining when, where, and how to make investments that improve emergency response. A key to this research is input from local residents on ways in which the research can benefit their communities.

Another facet of Sharkey's research takes him into an entirely different realm: law enforcement. His IIR games find application in the disruption of transnational smuggling networks—an area, like disaster recovery, in which multiple decision makers in multiple agencies must coordinate their efforts toward a larger objective. Sharkey has also developed a novel technique to improve law enforcement's response to drug smugglers by several orders of magnitude. The same technique can be used in analyzing vulnerabilities to cyberattack as well.

In summarizing the department's work in resiliency, Sharkey recalled its heritage in shaping the heart of current research.

"We have to emphasize the intellectual leadership of Al Wallace and John Mitchell (Rensselaer professor of mathematical sciences), starting immediately after 9/11, in modeling the interdependencies of infrastructures to explore how to repair the set of systems so that society can effectively recover," he said. "This has broadened to thinking about how decision makers across infrastructures interact with one another after an event—and how even sharing information between them can greatly move towards a 'societally optimal' recovery plan."



Efficiency on Demand

Jennifer Pazour is finding ways to streamline supply chains in the new collaborative economy

Jennifer Pazour started early on her quest for optimal efficiency.

"I really enjoyed organizing my room as a kid," said the ISE assistant professor. "I have just always liked efficiency."

The lifelong fascination recently led to two of engineering's most prestigious awards—and perhaps a better life for Uber drivers, Meals on Wheels volunteers, and others who inhabit on-demand supply chains.

Early this year, the National Science Foundation awarded Pazour a Faculty Early Career Development (CAREER) grant. More recently, Johnson & Johnson honored her with its Manufacturing Scholar Award, given as part of the WiSTEM2D Scholar Program (Women in Science, Technology, Engineering, Mathematics, Manufacturing, and Design).

The research behind the accolades has to do with Pazour's signature focus: the seismic shift from centralized to on-demand and collaborative distribution.

"Modern distribution systems need to fulfill a wide variety of requests quickly with little warning in small units to many dispersed locations at low costs," she wrote. "This is fundamentally different than yesterday's demand, which aggregated at fixed (store) locations. Thus, today's supply chains are optimized for yesterday's customers."

In the face of this disconnect, Pazour's team is rethinking supply chain design to meet the demands of modern distribution. That involves researching new ways to move supply chain networks from fixed and static to collaborative, dynamic, and agile.

One aspect of this research involves underutilized resources and how organizations might obtain them. To understand it, consider cars and what they do—or don't do—all day.

"The things we own have extremely low utilization rates, spending the majority of their useful lives idle," Pazour explained. "When you're at a stoplight, count the empty seats in the vehicles around you. When you're in a parking lot, think about the fact that most of the surrounding cars get an hour of use a day. Or consider the duplication of effort when both you and your neighbor make individual grocery trips. These examples all represent underutilized capacity, and with the right algorithms and models, companies could start accessing these underutilized resources."

But there's a challenge in the way. "We need to entice the owners of these resources to provide access," she continued. "On the one hand, the centralized model doesn't allow for decision making by the owners, so it dampens their participation. On the other, a fully decentralized system leads to myopic decision making: no one supplier has the whole picture of the marketplace, which results in reduced system performance because some requests receive multiple selections and others are left unfulfilled."

The CAREER award-winning research aims to combine the two in what Pazour calls a hierarchical approach, which gives suppliers "recommendations" to help them make efficient decisions. She used Meals on Wheels volunteers as an example.

"Millennial Millie gets a notification on her phone asking if she'd like to deliver groceries to shut-in residents," she recounted. "Millie clicks yes. Two requests appear. She chooses the one that fits with her plans that day. What the platform did—without control or knowledge of Millie's plans—was to provide choices estimated from her past behavior. Before this example can become a reality, research is needed to discover new ways to provide choices and quantify the impact of those choices on suppliers and demand requests."

As part of the Johnson & Johnson award, Pazour will create new data-driven models to address several specific challenges in on-demand distribution, including novel research in pharmaceuticals.

Another element of the Johnson & Johnson and CAREER research dovetails with Pazour's dedication to her profession. Working with Rensselaer's Engineering Ambassadors program, she will mentor undergraduates to create active learning modules, inspired by her research, and use them with K-12 students.

"I want to gain more exposure for the field, and inspire more young people to get involved," she said. "The world needs more industrial and systems engineers. We are wired to think systematically about complex problems, which exist in all sectors of society. Yet too few incoming Rensselaer students even know what we do. That needs to change."

RESEARCH HIGHLIGHT

Real Teamwork in a Virtual World

League of Legends has proved a treasure trove of the data needed for teamwork studies

It's impossible to observe and analyze every aspect of teamwork in the real world. So David Mendonça has turned to a virtual world instead.

That world would be League of Legends, one of the world's most popular online games. Two five-player teams attempt to capture each other's "nexus," or home base, employing a dizzying array of powers and tactics to do so. Each participant takes on the role of a "champion" with assigned strengths and personal traits for use in service to the team.

Each game generates an ocean of data—and millions of games take place every day. Therein lies Mendonça's fascination.

"The continual challenge in team studies is the difficulty of scaling up traditional research methods to yield enough data in enough detail," said Mendonça, an associate professor in ISE, who collaborates on this research with professor Wayne Gray in Rensselaer's Cognitive Science Department. "Besides being costly and time-intensive, traditional methods like surveys are obtrusive and happen after the fact. Even simulations are typically limited, in that they don't provide a direct understanding of what happens within teams, moment by moment. That makes big, detailed data on meaningful tasks the Holy Grail."

By generating data from every game—even every move—as it happens, League of Legends allows researchers to gain an objective, measurable picture of each team's inner workings, including its myriad choices and their effects.

Most recently Mendonça, Gray, and their research partners zeroed in on the importance of two potential contributors to team performance: the working history of team members and the role played by so-called critical team members. The research found that the loss of a critical player can have a decisive effect on the team's performance.

Their research found that the loss of a critical player can have a decisive effect on the team's performance.

David Mendonca
Associate Professor

These research methods, and their implications for the measurement of "real world" teams, could extend into many industries and professions, including the military (the Office of Naval Research is funding the research).

"In League there's a lot of movement of players among teams," he observed, "and that's certainly true of military branches, since frequent redeployment is a fact of life. Under what conditions does this turnover help or hinder performance? When should it happen in order to maximize the benefits to team performance? A study of this scale can begin to address these questions."

A parallel line of work, funded by the National Science Foundation, is exploring similar issues in an entirely different domain—the multi-billion-dollar world of post-disaster debris removal operations. "Over time, debris removal teams establish their own ways to load the debris onto a truck, "Mendonça explained. "Introducing a new member can degrade the productivity of the team. Decisions on staffing and restaffing the debris teams can lead to big gains or losses in the productivity of these operations."

Ultimately Mendonça seeks to contribute to general theories of teamwork from the mass of findings that Big Data can facilitate. At the same time, he knows his research must consider the nature of the work as well as the circumstances that surround it.

"We're not studying environments in which there is one right answer," he said. "In League as in many areas of life, circumstances are constantly shifting, and a high degree of creativity is required. That is why analyzing performance in relation to the specific task is important. We need more research on expert teams that looks at moment-to-moment interactions over a long time period in various task environments."

In a way, Mendonça observed, his research harks back to the earliest days of industrial engineering. "The field got its first real traction with time-and-motion studies in industrial settings, looking at ways to optimize human performance, machine performance, and the interface between the two," he said. "Over time, data on machine performance outstripped data on human performance in scale, scope, and affordability. We still have a ways to go in equalizing the balance, but the future looks very bright."

RESEARCH HIGHLIGHT

Your Brain as a Network

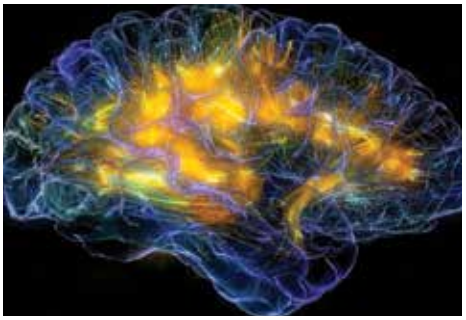
When network science meets neuroscience, Alzheimer's patients—and many others—stand to benefit

To understand the importance of Sergio Pequito's brain research, look at the map of a midsize city. Note the location of the interstates, the state routes, the county roads. Can you estimate how much the infrastructure influences the volume of traffic on each road, relative to the others? Well, you can, but only within certain limits.

Pequito has broken through those limits.

"We wondered if it was possible to map the structural and functional elements of the brain together," explained Pequito, ISE's newest assistant professor. "Previous research could only justify the relationship between structure and function to 40 percent, and it was assumed that 50 percent was the natural limit. We used network science and optimization to justify the relationship to 90 percent."

The stakes are high for such an advance: it could help the millions of people with neurological diseases like Alzheimer's, where changes in brain structure impede brain function. By mapping the two together, Pequito and colleagues can use the structural pattern—as seen via brain imaging technologies like magnetic resonance imaging (MRI), for instance—to infer the functional pattern. That could provide critical insights into how these deadly diseases evolve.



This figure shows the white matter fibers (i.e., the brain highways) that underpin the brain activity.

> "I wondered how I could contribute to solving problems in the field. Then I sat in a neuroscience class during my postdoc, and suddenly I was collaborating with bioengineers and physicians."

Sérgio Pequito
Assistant Professor

Applying network science to neuroscience is the common theme behind much of Pequito's research.

"Understanding the brain as a network enables us to leverage several intuitions and methods available in operations research. It allows us to rethink the brain," he said. "How can we optimize the brain to perform a specific task? Ultimately, we can learn what the brain network is doing right, why it works so well, and how it malfunctions."

In another project, Pequito's team uses mathematical tools to extract data from electroencephalograms (EEGs), capturing brain waves of patients with epilepsy. The goal is to create a model for analyzing, forecasting, and controlling the disease—a model that can improve the performance of electrical stimulation technologies in mitigating seizures.

When discussing the epilepsy research, Pequito stressed one challenge of his work: not just using systems thinking, but then translating it to the neuroscientists and physicians with whom he must collaborate.

"In a systems approach, the systems engineer would need to collect data about the system, in this case from an MRI or EEG," he explained. "Then the idea would be to model the problem and optimize it. But we need to be creative in describing the model so it makes sense to the bioengineers and physicians. We have to learn some language that refers to the symptoms that physicians diagnose."

Pequito's investigations do not stop with brain disease. Indeed, his research has taken him into one of the most talked-about areas of innovation: the brain-computer interface, which Silicon Valley leaders have touted as key to such inventions as Facebook's "typing by brain." Here too, according to Pequito, a systems approach can overcome limitations encountered by neurophysiological research.

Pequito's interest in the brain is a lifelong affair.

"I have always been fascinated by the brain and how it works," he recalled. "I wondered how I could contribute to solving problems in the field. Then I sat in a neuroscience class during my postdoc, and suddenly I was collaborating with bioengineers and physicians."

Brain research holds a great deal of promise for up-and-coming systems engineers. "The field is really cool, and it is one of the important future job markets for us," he said. "With Silicon Valley exploring brain tech for all sorts of applications, there is a need for systems engineers to connect the different areas of expertise required to make it happen. Fortunately, connecting things is what we systems engineers do the best."

Flipped Classrooms and Forecasting Competitions

For two ISE professors, active learning methods create a more engaging in-class experience

The test scores confirmed that Thomas Sharkey was on to something.

Some years ago, as part of his Operations Research Methods course, Sharkey and his team created a series of supplementary videos that, in his words, "filled the gap between classwork and homework." The videos freed up class time for more active learning.

And the active learning changed the scores. "I saw a significant improvement in the answers that related to the active learning modules," said Sharkey, now an associate professor with ISE.

Active learning—in which students spend class time engaging the material and one another—has gained currency in recent years. According to the 2013-14 Higher Education Research Institute (HERI) Faculty Survey, nearly half of respondents are making greater use of group projects, 60 percent use cooperative learning more frequently, and more than 80 percent facilitate class discussion in most or all courses.

"With information being so readily available online, teaching methods have had to change," said Jennifer Pazour, ISE assistant professor and a frequent user of active learning techniques. "How do we make connections between course content and people and reach them where they're at?"

For Sharkey, that has involved "flipped classrooms," which forms the framework for his Optimization Algorithms and Applications course. Students watch Sharkey's video lectures on algorithms in their free time. In the next class, they complete exercises based on the video lecture, implement the relevant algorithm, and receive a "challenge" that introduces the concepts in the next video lecture.

This model proved particularly effective with one difficult concept.

"Students tend to struggle with the abstract nature of pseudocode while designing and analyzing an algorithm for a particular problem," Sharkey explained. "They understood the high-level steps involved in the algorithm but struggled to see how each line of pseudocode related to those steps. It would have been ideal to work through an example in class, but in a traditional classroom we had no time. In a flipped environment, however, we could look at an example for every algorithm, and I believe students gained a deeper understanding."

Flipped classrooms have also provided benefits to students in another area: time management. "They are able to accomplish the learning objectives more quickly," Sharkey explained. "The time they spend in reviewing the text and class notes is down to about two hours in an average week. With all the demands on student time, this is an important advantage for them."

Meanwhile, Pazour has used polling and response systems to get real-time feedback from students in Design & Analysis of Supply Chains, which she now teaches. The feedback enables her to adjust her presentations on the fly, based on student need.

Polling systems play a role in other active learning modules that Pazour uses during the course. In one activity related to stochastic inventory and forecasting, students first play the role of stochastic demand by recording their choices among a set of consumer products. Each student then predicts the class's aggregate choices and makes inventory management decisions accordingly.

Jennifer Pazour working with students

"We end up discussing inventory tradeoffs, and the laws of forecasting," Pazour said, "especially the first law: that all forecasts are wrong."

Pazour also created a forecasting competition, in which students had to make predictions based on older data from an existing dataset—without knowing what the dataset represented. Students submitted their predictions via Google Forms, after which Pazour compared the student forecasts with real data for the time period involved. Only on the day of the competition were the rankings revealed, as well as the source of the data (NASA's Land-Ocean Temperature Index).

According to Pazour, it makes sense that ISE faculty would work with active learning techniques. "It's in our nature to design systems with people in them," she said. "Classrooms are a perfect example of such a system. So designing and adapting active learning methods is a matter of doing what we do well."

Recognition for ISE Faculty and Students

Jennifer Pazour receiving the IISE Award at the IISE Annual Conference

Jennifer Pazour Honored by Multiple Awards

ISE faculty Jen Pazour has been honored with multiple awards: the NSF Faculty Early Career Development Award (CAREER), the Johnson & Johnson Manufacturing Scholar Award, the IISE Dr. Hamed K. Eldin Outstanding Career IE in Academia Award, and National Academy of Science Early-Career Research Fellowship by Gulf Research Program.

David Mendonça Will Serve on Board of Governors of IEEE SMC

David Mendonça has been elected to serve a three-year term on the Board of Governors of IEEE's Systems, Man and Cybernetics (SMC) Society. IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE's SMC Society is a world-leading society for the advancement of theory and application in systems science and engineering, human-machine systems, and cybernetics.

Mark Embrechts Awarded Patent

ISE faculty Mark Embrechts received a U.S. patent on the "Use of machine learning for classification of magneto cardiograms."

Dan Berg Medal Established

The Daniel Berg Medal was established in the International Academy of Information Technology and Quantitative Management Conference in honor of the lifelong contribution of ISE Emeritus Professor and former Rensselaer President Dr. Dan Berg.

Tom Willemain Publishes Memoir

ISE Emeritus professor Tom Willemain published a book on his experience working at the National Security Agency (NSA), *Working on the Dark Side of the Moon.*

Seyed Mofidi Receives Multiple Awards

ISE Ph.D. students Seyed Mofidi was honored with E.J. Sierleja Memorial Fellowship and John F. Fargher Scholarship by IIS, and Tomkins International Honor Scholarship and St. Onge Company Honor Scholarship by MHEFI.

2017 IISE Honorable Mentions

ISE Ph.D. students Uzma Mushtaque and Orkun Baycik each received Honorable Mention at IISE Doctoral Colloquium at the IISE annual meeting.

Aaron Rowen Awarded ASEE SMART Fellowship

ISE Ph.D. student Aaron Rowen was awarded the highly competitive American Society for Engineering Education (ASEE) Science, Mathematics, and Research for Transformation (SMART) fellowship sponsored by the U.S. Navy Space and Naval Warfare Systems Command.

2017 IISE Best Track Paper

ISE MS student Felipe Ortiz and ISE faculty Tom Sharkey received the Best Security Engineering Track Paper Award at IISE annual meeting.

Rack Manufacturers Institute/John Nofsinger Honor Scholarship

ISE Ph.D. student Ni Ni was awarded the Rack Manufacturers/John Nofsinger Honor Scholarship for the 2017-18 academic year from the Material Handling Education Foundation.

2017 INFORM Best Student Paper Finalist

ISE Ph.D. student Bo Wang was a finalist for the 2017 INFORMS Best Student Paper Award in the Quality, Statistics and Reliability section.

The Transition to Come

David Mendonça

The field of Industrial and Systems Engineering (ISE) is in the midst of a major transition towards methodologically innovative yet problem-focused research, enabled through a combination of recent developments in human-centered aspects of engineered systems, ubiquitous "Big Data," and changes in Federal funding priorities.

My perspective on this transition is informed by the two years I recently spent on leave to the US National Science Foundation (NSF)--the country's main funder of basic research in science and engineering--as well as a career equally divided between Industrial Engineering and Computer Science. At NSF, I worked with colleagues in engineering, computer science and social science to manage a variety of programs that provided funding for cutting-edge, competitive research. (Of course, the opinions expressed here are my own, and are not meant to represent those of NSF or any other agency.)

I see the transition in our field as being driven by three interrelated, ongoing changes.

First, we are now able to measure and monitor human performance at scales ranging from milliseconds to months and beyond. Improvements in technologies such as eye-tracking, virtual worlds, and computer-based tools for collaboration are accelerating this trend in any ways, including through the capture of accurate, objective data. While challenges exist, these data are enabling us to explore the integration of human and technological elements of industrial and other systems. In parallel, the nation's top Industrial Engineering departments have been hiring aggressively in areas such as modeling and simulation of human cognition and behavior, with applications in human/robot teaming, autonomous systems, distributed intelligence, among others. While challenges remain, this work promises bold new insights into how humans and machines cooperate and collaborate in a wide variety of systems.

"ISE, perhaps more than any other field, holds a strong prospect for interpreting "Big Data" in a systems context in order to drive decisions that improve system design and performance."

David Mendonca
Associate Professor

Second, the common ground between ISE and Computer Science is expanding, driven in part by accelerating growth in society's production of "Big Data." While it has long been recognized that addressing complex societal problems requires integration of multidisciplinary perspectives, this integration has always been elusive. Commonly-held, large-scale data may help. ISE, perhaps more than any other field, holds a strong prospect for interpreting "Big Data" in a systems context in order to drive decisions that improve system design and performance. But to do so, it must more fully engage the language and tools of computing--such as algorithms, data, and interactive systems--within a broader systems engineering perspective. It must also place a higher premium on sharing data (Big and otherwise) to support larger-scale research endeavors and more robust results.

Third, an impending distinction, perhaps even a bifurcation, between problem-focused and theory-focused advances is evident in the ISE research community. NSF's recent redefinition of its Operations Engineering program is one such example; others may be found in basic and applied research programs in other Federal agencies. ISE was born and has thrived as a field seeking new, societally significant problems that require substantial methodological innovation to solve. Yet it is no great secret that the ISE field has been criticized in recent years for an over-reliance on purely methodological advances as an indicator of progress in the field as a whole. ISE's historical roots suggest that, fundamentally, the field is and should be much broader and comprehensive, with a focus on "hard" modeling problems that have strong societal implications.

These observations carry a number of implications for research, training and practice in ISE. Current and future ISE students at all levels will benefit considerably from training in data management and modeling, while not losing touch with the field's strong focus on decision making in a systems context. A renewed focus on human/machine integration promises a major leap forward in ISE, with strong implications for the design of future work systems in a broad array of fields. Finally, given ISE's rich and interdisciplinary history, the field is poised to lead engineering and related disciplines towards improvements in the performance of human-centered systems that contribute to our quality of life.

In Their Own Words

For these two alumni, the impact of an ISE education has been immense

Colleen Shugrue'05

Associate Director
Learning Operations
United Technologies Corporation

Whenever I tell people that I'm an alumna of Rensselaer, I'm always returned with a surprised look. I don't think it's because people don't believe that I graduated from a prestigious engineering school – I think it is because I'm not a "typical engineer". I received my BS in Industrial and Management Engineering and immediately started working at United Technologies right after graduation. My career path has been an interesting one, and I have a lot to be thankful for as I reflect back on my time at RPI, what I learned, and how it brought me to where I am today.

"My career path has been an interesting one, and I have a lot to be thankful for as I reflect back on my time at RPI, what I learned, and how it brought me to where I am today."

Colleen Shugrue

Until recently, I've spent most of my career working in Operations. While I could list all my different experiences in detail, I think there are two key areas that stick out in my mind that an IME degree has helped me differentiate myself from my colleagues. First, as an IME student I really learned to think in a process-based, systems-centric way. When I'm faced with a problem, I really start to think about all of the dependencies and processes that are impacting what is happening. The second area is in my ability to communicate my messages to all levels of the organization. Through my coursework I was constantly writing reports and presenting – all things I have needed to do on a daily basis with every job I've had.

Currently, I'm working in Human Resources and I'm focused on the operational side of Learning and Development. I need to understand complex systems, vendor management and facilities management. My degree in IME has definitely helped me better understand some of the complexities that were hidden to my predecessors.

I'm very passionate about the importance and promotion of IME degrees. I feel that IMEs really can work in any industry and have so many opportunities out in the workforce. My degree has given me a great baseline of knowledge and the ability to think systematically, and I'm very thankful for it.

IISE Regional Conference

The RPI Student Chapter of IISE hosted the Northeast Regional Conference on March 24 - 26, 2017. The theme of the conference was: 21st Century Efficiency in Northeast: Engineering Tomorrow's World Today. There were 42 students from different schools, including Buffalo, RIT, Northeastern, Rutgers, and the University of Pittsburgh. For the Technical Paper competition, Zach Shearin, under the supervision of Jennifer Pazour, won second prize. Three recent ISE alumni, Monica Ricci, Casey Burnham, and Brian Keating, participated in the students panel.

The chapter's officers are Carlos Elizondo,Conrad Dorn,Brooke Ramlakhan, Anurag Kelkar, and Kanu Mallick.

Top: IISE Student Chapter President Carlos Elizondo and Chapter Advisor Mohamed Aboul-Seoud; Bottom: Jennifer Pazour presenting her research to the audience.

David Levermore, Ph.D. '95, '05

Lead Systems Engineer
Data Management Integration & Interoperability
The MITRE Corporation

My journey to Rensselaer was a long one but ultimately the best decision I made in my career. I grew up in Kingston, Jamaica, and when it was time for College I made my way to Howard University in Washington, D.C. to pursue a Bachelor's in Mechanical Engineering. After graduation, I started full-time with the Boeing Company, but also applied and was accepted to pursue a Master's in Mechanical Engineering at Rensselaer. I pursued my Master's in the Fall semester of the same year and graduated three semesters later, where I again continued full-time employment with Boeing Defense and Space. It was at Boeing that I fully appreciated the application of the interdisciplinary approach to engineering. I participated in collaborative engineering efforts that combined planning, design, analysis and manufacturing to produce aircraft components that contributed to the final aircraft product. I wanted and needed to learn more and thought of my experiences at RPI and what more I could learn there. There was no question of any other learning institution! I started the Decision Sciences and Engineering Systems (DSES) program at Rensselaer three years after leaving with my Master's.

"My journey to Rensselaer was a long one but ultimately the best decision I made in my career."

David Levermore, Ph.D.

From the start of the program I was challenged to think differently. Information Systems and Operations Research came easy, but Statistics and Math were different from what I knew in Mechanical Engineering. But with time and hard work I was successful, graduated, and hired again into Boeing, but this time in the Research and Technology division, where I was part of a small team tasked with exploring the integration of design and analysis technologies. The application of what I learned in DSES was fundamental to my work and research into reliability analysis, structures design and analysis, and the development of applications to integrate design and analysis systems and data.

Now I work for a different company, the MITRE Corporation, where we have the wonderful benefit to serve the public interest. We have grown beyond solely a Systems Engineering company, but these fundamentals are still essential to our day-to-day business. Every sponsor engagement demands a systems-thinking approach: What is the fundamental problem? Is a technical solution appropriate? Is a solution available for purchase? Do we need to develop a prototype? Et cetera. The training I received from DSES prepared me well to do the required analysis to answer such questions, and to do the work to provide our sponsors with accurate recommendations. I have supported several sponsors across the Government – civilian and military agencies – in various capacities, from an individual contributor, to leading projects, and performing internal MITRE research to solve our sponsors most difficult challenges. In all, DSES equipped me with the tools to be adaptable, a quality that I learned over my career is rare but extremely advantageous to possess.

ISE welcomes new Ph.D. students

Mustafa Can Camur

Joshua Eaton

Orlando Romero

Yeming Shen

Kaan Unnu

Bo Wang

ISE Commencement Awards

Del and Ruth Karger Doctoral Dissertation Prize is awarded to a Ph.D. graduate in ISE whose dissertation is deemed outstanding.

2016: Yulia Tishchuk (Advisor: Al Wallace) Dissertation Title: Modeling Human Behavior in the Context of Social Media during Extreme Events Caused by Natural Hazards

2018 (co-winner): Uzma Mushtaque (Advisor: Jennifer Pazour) Dissertation Title: Context-Dependent Discrete Choice Models and Assortment Optimization for Online Retail

2018 (co-winner): Hongtan Sun (Advisor: Tom Sharkey) Dissertation Title: On Approximation Algorithms and the Cost of Decentralization for Problems in Network Restoration

The Del and Ruth Karger Outstanding Master's Thesis Award is awarded to a Master's graduate in ISE whose Master's efforts - including project or thesis - are deemed outstanding.

2016: Brendan Howell (Advisor: Tom Sharkey) Thesis Title: Implications of unmet demand within the context of supply chain restoration

2017: Felipe Ortiz (Advisor: Tom Sharkey) Thesis Title: Modeling the impact of government resource allocation on the illegal drug trafficking supply chain

2018: Joan Climes (Advisor: Jennifer Pazour) Thesis Title: Analytical Models for Retrieving and Repositioning Items in Dense Storage Systems and Optimizing the Location of an Open Square

ISE Ph.D. Meritorious Service Award

Aaron Rowen: awarded for his outstanding service to the department, especially those efforts that foster a sense of community between students, faculty, staff, and visitors. In particular, Aaron has served as an outstanding campus host and guide for visiting faculty and students.

The Ray Palmer Baker Prize (1937) is established by bequest of Vjera C. Ricketts, widow of President Ricketts. It is awarded at Commencement to a senior in management engineering who has demonstrated outstanding ability in academic work and gives promise of outstanding professional success.

Alexandra Sakorafos, 2016

Joan Climes, 2017

Omar AlShaye 2018 co-winner

Zach Shearin 2018 co-winner

ISE Graduate Student Research Award: This award is to recognize the research excellent among RPI ISE graduate students.

2017: Yuan Yi: awarded for the lead author for the paper "An Efficient Budget Allocation Approach for Quantifying the Impact of Input Uncertainty in Stochastic Simulation," ACM Transactions on Modeling and Computer Simulation (TOMACS), 27(4), Dec., 2017, by Yuan Yi and Wei Xie

2018: Orkun Baycik: awarded for outstanding theoretical contributions as lead author of the paper "Interdicting layered information and physical flow networks" IISE Transactions, 50(4): 316-331, 2018 by N.O. Baycik, C. Rainwater, and T.C. Sharkey and that was featured in the March 2018 issue of the ISE Magazine

2018: Ni Ni: awarded for outstanding modeling contributions as lead author of the paper "Modeling the impact of unmet demand in supply chain resiliency planning" by N. Ni, B.J. Howell, and T.C. Sharkey that is forthcoming in Omega: The International Journal of Management Science

Long Time ISE Staff Mary Wagner Retires

It was an end of an era for ISE on October 21, 2016 — the departmental administrative coordinator, Mary Wagner, retired after 32 years at RPI (29 years with the department). Throughout her career, Mary has been consistently excellent in managing departmental operations and providing assistance to students, faculty, staff, and visitors.

ISE held a luncheon on October 19, 2017 to celebrate Mary's contribution to ISE and RPI and her next phase of adventures.

Mary Wagner with ISE graduate students during farewell luncheon.

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IME Graduates Enjoy Outstanding Placements in 2017

Graduates of the IME program enjoyed another year of outstanding industry placements in 2017. Marquee corporate names appearing on this year's placement list include Johnson & Johnson, IBM, Deloitte, BAE Systems, Northrop Grumman, Goldman Sachs, ebay, P&G, GlobalFoundries, and many other recruiters representing an impressively broad range of industries and economic sectors. A number of ISE graduates continue on to graduate schools at Georgia Tech, Virginia Tech, and others.