ISE Sheet Folding Theory Brings Advances to Vehicle Air Filter Industry

Professor E. A. Elsayed is providing a mathematical model and the platform for mass production

The lowly engine air filter in today's motor vehicles is being ordered to step up its game.

Vehicle manufacturers need to shoehorn these filters into increasingly cramped engine compartments, yet the filters need to deliver just as much—if not more—particle-free air to keep engines running efficiently and reliably.

A major engine filter manufacturer has devised an innovative way to fold filter paper to maximize the surface area that flowing air encounters inside a small filter package. But the company still had one challenge—how to mass-produce the small, tight, and exact folds.

“The company's R&D people came up with a very innovative filter, but they built one unit,” said E. A. Elsayed, professor of industrial and systems engineering, when the company first contacted him. “They asked me if Rutgers could help them scale it for mass production.”

The company approached Elsayed because they had read about his patented sheet folding theory and equipment that folds cardboard into three-dimensional patterns.

“The United States Army used our folding designs to make boxes that they dropped from low-flying aircraft without parachutes,” Elsayed.

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While a big research university like Rutgers is making incredible contributions through investigation, discovery, and innovation, at our core we are first and foremost an academic institution dedicated to educating students. With that in mind, we have designated this issue of our ISE newsletter as a showcase for our students’ talents and achievements. I hope you will enjoy reading about the research they are contributing to as doctoral students, their advancement to professorships at universities, and exciting career opportunities they are pursuing.

We are particularly excited to tell you about Pedro Gerum’s selection as one of only eight international students to be selected for a NASA internship where he will employ AI and data analysis to develop algorithms to help detect exoplanets. According to Pedro, he was selected because of his expertise in data science and optimization and because of his research alongside Professor Melike Baykal-Gürsoy, his doctoral advisor.

Among our undergraduates we have two students who are members of the prestigious Rutgers Honors College. Both students have also conducted research alongside faculty member James Luxhøj in the area of using drones to determine the degree of relief needed in emergency situations when getting humans on the ground to assess situations is compromised.

We also include faculty news and an update on our Laboratory for Energy Smart Systems (LESS) projects that are helping advance the State of New Jersey toward a more sustainable future that includes renewable and clean energy.

And finally, our lead story features Professor Elsayed who has made some exciting industry connections for his innovative paper folding patent. Your car may soon include an air filter that has a direct connection to Rutgers’ IE department!

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

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Pedro Gerum, a fourth-year doctoral student working under the direction of ISE professor Melike Baykal-Gürsoy, will be joining NASA Ames in Mountain View, California as part of a partnership between the Brazilian Space Agency and NASA. Gerum joins the TESS (Transiting Exoplanet Survey Satellite) Mission where he is developing machine learning algorithms to discover exoplanets, planets located outside of our solar system. TESS is a space telescope designed to scan an area of the sky that is 400 times larger than the one covered by the Kepler mission.

“My job is to automate this detection process by implementing an algorithm that can detect exoplanets and has all the necessary human knowledge embedded into it,” says Gerum, who is one of only eight international interns to have been selected from around the world.
ISE Sheet Folding Theory Brings Advances to Vehicle Air Filter Industry (continued from page 1)

Each year, industrial and systems engineering seniors bring all that they’ve learned as undergraduates to the table in a culminating capstone project. This year’s design projects, presented in December, included original ideas conceptualized by students as well as those related to faculty research. The scope and impact of the 15 projects presented reflect the versatility of an industrial and systems engineering degree, says professor and department chair Mohsen Jafari.

“In today’s fast moving business environment, industrial engineers are increasingly in demand for their valuable system-of-systems thinking approach, quantitative decision making, and depth of knowledge in data analytics, optimization, and automation and control. Our department and field of engineering encompass the areas of quality and reliability, advanced manufacturing, and smart systems—components that are reflected in the projects presented today.”

The range of projects for the 2018 cohort of students introduced engineering innovation in the areas of agriculture, traffic congestion, retail shopping, robotics, warehouse distribution, and security breaches, among others.

Jafari gave the students near free reign on their project selection, while challenging them to push boundaries. They had to fully believe in their innovation and move forward with determination that their concept was viable, he said. The result was a lot of fresh ideas.

For example, the MiBag team tackled a problem that was the result of a real life scholastic catastrophe when team member Suraj Rathod found himself without his calculator before an Elements of Electrical Engineering exam. He was sure it was in his backpack before leaving home after an all-nighter studying, but it was not.

The team developed a smart bag that keeps track of items through a Bluetooth beacon module, Arduino microcontroller, and radio-frequency identification (RFID) reader and tags. Items are tracked and monitored via a cell phone, with settings controlled by the user.

The Ping! aquaponic system brings innovation to the field of sustainable farming. The project combines data processing with a monitoring system that tracks and stores vital information related to aquaponic bays, sending data to a live monitoring website. The system not only saves time, but also money in the event of a fluctuation in temperature, oxygen, or pH levels of the water tanks that house the 50 koi that provide the fertilizer and water purification that run the farming operation.

See a full list of projects: ise.rutgers.edu/news/2018-senior-design

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said. “They delivered ammunition, drinking water bottles, IV medicines, even Humvee engine parts for troops in Afghanistan. The folded cardboard cushioned the impact; there was no damage to the contents.”

While filter folding would require smaller and more exacting patterns than his earlier work, Elsayed believed he could apply his earlier theory and technique to this new application. He entered a one-year joint research agreement with the company in September of 2017 and renewed it for a second year.

Elsayed worked with Joseph Lippencott, ISE department specialist, to build a prototype machine that presses pleats into a roll of filter paper, parallel to the paper’s edges. Then at regular intervals, every three inches or so depending on the filter package dimensions, it impresses a diamond-shaped pattern across the pleats to create a folding point. Once folded back and forth, accordion-style, the block of paper essentially has several three-inch tubes with air entering at one end of the block, flowing through the paper into adjacent tubes before exiting the block at the opposite end.

Elsayed is quick to note, however, that the machine itself is not the “deliverable” of his research contract; rather, it is a platform for the company to see how its advanced paper formulations hold up to the stress of manufacturing, to modify the pleating and folding process to fit different sizes and shapes of packages, and to scale the process for economical manufacturing.

“Some papers are forgiving—we can bend and twist them and still be okay,” he said. “Others bend and break.” He steams the paper before it goes through the pleating rollers and the diamond-shaped dies to give it flexibility, yet some formulations split at the sharp creases that the dies impress on the paper to make it fold.

The real deliverables, he explained, are the mathematical models that describe the processes, which, in turn, will be used to implement full-scale equipment. Once in production, Rutgers will earn royalties from this intellectual property.

Elsayed is satisfied with the collaborative nature of the research program.

“I was extremely impressed by the effort and thought the company put into this concept,” he said. “We work with their engineers; they participate in our discussions. The goal is a flexible process that they can use for many products.”
student spotlight: doctoral

Mengmeng Zhu, Ph.D.’18
Assistant Professor
Department of Textile Engineering, Chemistry and Science
North Carolina State University

My research interests include computational data analytics and mathematical models and methods development for system reliability engineering, software reliability, and transportation infrastructure deterioration. My work also has applications in system health monitoring and control, software development and performance evaluation, energy, healthcare systems, and transportation systems.

During My Time at Rutgers...
I learned how to do research, communicate, and teach. The faculty members in ISE department were excellent role models both as academics and people. Every moment that I spent at Rutgers was very precious to me. I enjoyed all the meetings and conversations with my advisor, faculty members, and colleagues.

Where I am Today
At NC State University, I will continue to focus on research and teaching. The goal is to apply my research to various industries to help build more reliable and secure systems. Also, I would like my students to recognize and understand today’s problems, but more importantly, think and discover within a wide range of possibilities to solve problems.

Behnam Tavakkol, Ph.D.’18
Assistant Professor, Business Studies
Stockton University

My main focus of research during my doctoral studies was the development of new and comparatively more accurate data mining algorithms for different applications. I spent the majority of my time developing data mining algorithms for performing tasks such as classification and clustering of uncertain data.

During My Time at Rutgers...
I really enjoyed my time at Rutgers and in particular the ISE department. I worked with different faculty on different research projects and I learned a great deal. The ISE program is one of the best in the country and a university with the size and research budget of Rutgers is ideal for doing doctoral studies.

Where I am Today
I began a tenure-track assistant professor position in business analytics at Stockton University in September. I look forward to further expanding my research and teaching portfolio in the coming years.

facultly & student news (cont. from p. 2)
Rutgers ISE doctoral student Jian Zhou was awarded the 2019 Hans Reiche Scholarship by the Society of Reliability Engineers (SRE), to support his attendance at the 2019 RAMS (Reliability and Maintainability Symposium) in Orlando. RAMS is the most prestigious and well-known reliability conference in the world and Jian has previously presented his research work at this conference.

Jian’s research focuses on reliability and resiliency of complex systems, such as the electric power grid during extreme weather events and/or cascading failure events. He already has published two papers in prestigious journals, with several more in preparation. His doctoral degree adviser is David Coit.

ISE associate professor Melike Baykal-Gürsoy has been using game theory—the study of mathematical models of conflict and cooperation between intelligent decision makers—in her research related to combating security threats. In the Game Research for Infrastructure SecuriTy (GRIST) Lab, Baykal-Gürsoy and her students are developing game-theoretic models (with multiple players interacting against each other) to study security problems against man-made threats to communication networks, public transit, and other soft targets.

Doctoral student and GRIST member Abdolmajid Yolmeh was recently awarded a $150,000 fellowship from the National Institute of Justice. This award provides up to three years of funding for Yolmeh to continue to work on his dissertation entitled “Game Theory Applications in Security.” Yolmeh’s research is also supported as part of Baykal-Gürsoy’s National Science Foundation grant entitled “Collaborative Research: Network Protection Games.”
Dennison Adad, MEng’18
Industrial Engineering Consultant
Allstate

Where I am Today
I’m an industrial engineering consultant at Allstate’s corporate headquarters, working with enterprise resources at the operational level to drive process improvements. A lot of people think because I work at an insurance company—I work with insurance—when that couldn’t be further from the truth. I don’t ever touch insurance directly during my day-to-day. Instead, my team and I go behind-the-scenes understanding the company’s business processes and often play a hand in the development, execution, and leadership of projects across areas, such as claims, contact centers, and agencies. As a result, my work impacts how the business understands itself, how it subsequently operates, and how it provides and improves the Allstate customer experience.

During My Time at Rutgers...
As a Rutgers ISE graduate, I had the honor and fortune to be exposed to not only an eclectic curriculum that covers concepts applicable to work, but also a faculty that invested in student successes outside of academia.

I learned traditional engineering and the soft skills to be able to collect and turn data into a relatable story, while cultivating organizational and networking skills through the Rutgers Institute of Industrial and Systems Engineers chapter. I often think back to what was taught in my first course in the ISE curriculum—Work Design and Ergonomics—and how one should think of the bigger picture when engineering and the people your work affects. As a student I thought that should be common sense. But now that I am where I am, I realize that that course and the courses that followed made all the difference, turning common sense into how I work, how I’ve succeeded at Allstate, and how I will continue to succeed moving forward.

Rui Song, M.S.’18
Quality Analyst
Tiffany & Co.

Where I am Today
During my internship, I provided support to the labor-management department through the application of core analysis and industrial engineering techniques, including process flow design and mapping, productivity measures and time studies, data collection, and computational analysis.

I studied supply chain processes within a distribution warehouse facility through classic work measurement assessments, including data collection and documentation. I was then able to recommend workflow, equipment, or other changes based on analysis to improve material flow, storage and processing capacity, cycle time, and productivity. I also developed analytical and statistical tools, process flow documentation, database queries, reports, and related items to aid this effort.

The core functions of my new position include managing all aspects of an audit from planning, fieldwork, and reporting in accordance with the company’s compliance and regulatory guidelines.

I will also be designing the processes and the control tools of incident management and conducting comprehensive reviews to identify root causes, analyze risks, identify opportunities for improvement, and provide value-added recommendations.
student spotlight: undergraduates

Curiosity, Knowledge, Purpose: ISE Rutgers Honors College Students

Now in its fourth year, the Rutgers Honors College is a living-learning community for high achieving students across all disciplines. It is a place where social innovation and collaboration balance academic pursuits.

We recently checked in with ISE students Victoria McKeown and Priti Kantesaria, who are among the class of 2020 Honors College students studying industrial and systems engineering, to learn more about their experiences.

Priti Kantesaria, B.S.’20

Priti Kantesaria rounds out her academic life as a member of a number of student organizations, including the Rutgers chapter of Engineers Without Borders where she is leading the Tanzania Project. This effort is aimed at supplementing an arid community in Tanzania that is deprived of water during certain times of the year with a sustainable and self-sufficient water supply.

“It’s not about fixing a community, it’s about serving a community. Knowing that even though we come from a position of privilege to have resources and opportunities to help other people out, it’s not about solving their problems for them it’s about working with them and making sure that you can put in a sustainable solution that’s going to help the community in the long run,” Kantesaria said.

She credits ISE professor and undergraduate director James Luxhøj with encouraging her to pursue industrial engineering and inviting her to join his research team, studying aviation safety and risk.

“He’s the one who really got me interested in ISE research my freshman year. I remember I reached out to him to promote National Engineers Week and he came back and said ‘hey do you want to join me for my research project?’... I learned a lot from him about getting involved in the industry and applying for internships,” Kantesaria said.

Victoria McKeown B.S.’20

Like Kantesaria, Victoria McKeown is also part of Luxhøj’s research team.

“Our research is based on a notional scenario that models the post-hurricane scenario of Hurricane Maria which took place in Puerto Rico in September 2017,” says McKeown.

“Such natural disasters call for humanitarian relief and in our research we consider the use of Unmanned Aircraft Systems and a Hurricane Response Helicopter to lead in surveying the land after the hurricane has occurred to determine the degree of relief that is needed.”

McKeown applies the values of the Honors College—Curiosity, Knowledge, and Purpose—in approaching her research:

• Curiosity, because before joining Dr. Luxhøj’s team, I had little to no previous knowledge of the world of aviation and UAS technology.
• Knowledge, because every part of my research is centered on one objective—to learn.
• Purpose, because we conduct this research not only for our own exploration of the risk involved in aviation, but for the opportunity to produce discoveries and results that could be very useful in humanitarian relief.

McKeown’s interests are in a variety of different subjects, including math, science, language, and literature. So when it came time to choose an engineering discipline, IE felt like the right fit to match her inquisitive nature.

“I knew that my strengths were most definitely in the STEM fields, but I have a curiosity to keep learning about different subjects,” she said. “I could not choose one strict engineering discipline to pursue because I have an invested interest in each one. As IE is a very interdisciplinary major, it is the perfect fit for me.”

The diverse industrial engineering curriculum includes many courses that are found within other majors, such as Elements of Electrical Engineering, and courses that are specific to the major, like Probabilistic Models in Operations Research.

“The IE department at Rutgers provides students with an immense support system and a push to excel,” said McKeown. “For me, Dr. Luxhøj has been a role model and mentor who has challenged me to pursue research and to explore different areas within the IE profession. I am excited to see what the future holds.”
LESS Takes on State-wide Energy Projects

Rutgers’ Laboratory for Energy Smart Systems (LESS) is a multidisciplinary research and resource center established in 2014 to work with public agencies, private industry, and communities to build sustainable and resilient energy solutions through the use of technology and analytics. The LESS team, under the direction of industrial and systems engineering (ISE) department chair Mohsen Jafari, is currently involved in a number of state-wide energy projects, investigating clean and renewable energy as it relates to vehicles, public utilities, and storage. Total funding for these projects is nearly one million dollars.

Energy systems cover a broad range from demand side to power generation, and they constitute the most important sectors in terms of economy and societal benefits, says ISE doctoral student Ali Ghofrani, whose interest in heat transfer, thermodynamics, and energy conversion led him to Rutgers and, in particular, Jafari’s innovative research.

“As the complexity of these challenging systems dramatically increases, analytic frameworks and decision-making support tools become more crucial,” he says.

To that end, LESS has developed analytical platforms and modules for energy systems with extensive applications for built environments, building communities, microgrids and distribution level, and transmission level.

“The objective at LESS is to develop methodologies to save energy, decrease emissions, and improve service quality and resiliency for end-users, authorities, and private sectors,” says Jafari.

Working with partners, including the State of New Jersey, LESS is implementing a number of projects with important implications within the energy sector.

LESS Doctoral Student Ali Ghofrani: In His Own Words

My passion for energy systems started in my undergraduate studies and I was influenced by family members who were engineers in the field. I was mesmerized by heat transfer and thermodynamics equations and how they actually work and make sense in the real world. I started my undergraduate studies in mechanical engineering and I have a master’s degree in mechanical engineering (energy conversion). Since I started learning more about industrial engineering and analytics in this field, I found out that I could better deploy my knowledge as an industrial engineer and contribute more. I got familiar with Dr. Jafari’s innovative research and reached out to him, and he accepted me as his Ph.D. student.

Since then, we have been incorporating different scientific aspects in physics, statistics, operations research, etc. to develop new solutions for more energy efficient systems. Every day, we are dealing with new research topics and trying to push the boundaries. These topics actually have extensive applications in the real world and we are working with several institutes.

Current Projects

LESS, Rutgers Energy Institute, Ramboll Group, and the state are developing a strategic plan for offshore wind power generation that will result in New Jersey generating enough offshore wind energy to power 1.5 million homes by the year 2030. Rutgers’ contribution to this project focuses on grid integration and economic analysis.

LESS is also leading a project funded by the New Jersey Board of Public Utilities (NJBPU) to analyze the state’s energy storage needs and provide the data needed to achieve the energy storage targets set by the Clean Energy Act of 2018. Energy savings will provide emergency back-up power for essential services to offset peak loads, stabilize the electric distribution system, and benefit the ratepayer.

LESS will perform a gap analysis and survey existing system architectures, implementation plans, and infrastructure readiness based on a connected/electric vehicles survey by Rutgers’ Center for Advanced Infrastructure and Transportation.
Cindy Ielmini Says Farewell to the Department and Rutgers

After nearly 25 years on the job, department administrative assistant Cindy Ielmini retired at the end of 2018. As word spread of her retirement, emails, cards, calls, and even a bouquet of roses were sent from former students and faculty wishing her well as she begins a new chapter.

In her role at ISE, Ielmini supported faculty and students and managed the office alongside the department chairs—she worked under Mohsen Jafari, Elsayed Elsayed, Hoang Pham, and others. She was a troubleshooter who helped sort our students’ scheduling conflicts, she was a cheerleader encouraging students to keep going, and she was a friend to many colleagues and students.

“It’s been a wonderful experience,” she said. “So many former students still keep in touch, sending pictures of their weddings and children. It makes me happy that they remember me and appreciate what I did for them.”

“Cindy has a great sense of humor, which is an important quality when you’re dealing not only with students, but also faculty,” said department chair and professor, Mohsen Jafari, during Ielmini’s retirement party in December. “We’re going to miss her.”

The ISE department’s faculty and staff celebrate Ielmini, center, during the annual holiday party.