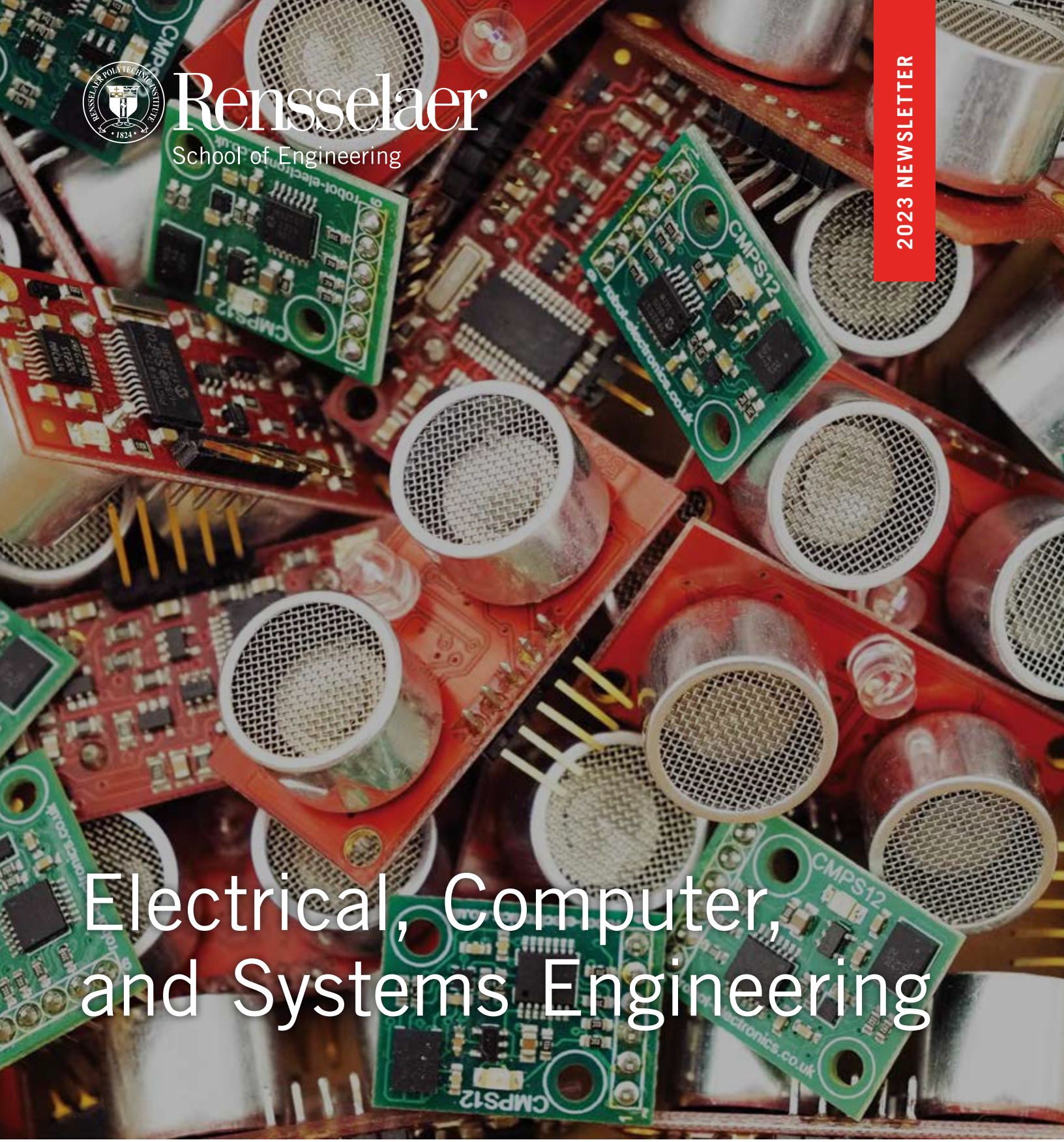
Rensselaer
School of Engineering

2023 NEWSLETTER



Electrical, Computer, and Systems Engineering

ECSE

Department of Electrical, Computer, and Systems Engineering
at Rensselaer

ECSE.RPI.EDU

A re-energized RPI & ECSE

It is wonderful to see our campus bustling with life once again. There is a palpable sense of renewed energy and optimism as RPI and ECSE take significant steps to strengthen and secure our position at the forefront of research and innovation.

After a decade of contraction, ECSE is embarking on an exciting multiyear faculty rebuilding initiative. This year, we successfully recruited three outstanding new faculty: Assistant Professors Zheyu Zhang and Esen Yel and Professor of Practice Muhsin Celik. We plan to continue expanding our faculty in the months ahead. Our new president, Marty Schmidt, is launching an ambitious strategic planning process, the Rensselaer Forward Plan, with input from the entire campus. This initiative focuses on five key themes: education, research, translation, regional engagement, and welcoming and inclusive community. ECSE is actively engaged in contributing ideas and shaping the agenda within each of these areas.

Alumni and other partners continue to be instrumental to ECSE's success and ability to provide a world-class education. A special mention goes to Doug Mercer '77, whose longstanding dedication to RPI and ECSE has led to the establishment of the Mercer Innovation and Exploration Laboratory, fondly referred to as the Mercer XLab. Under the leadership of Shayla Sawyer, its inaugural director, the Mercer XLab is now becoming more accessible to students, introducing new resources and expanding its physical footprint to enhance the student learning experience.

In our pursuit of providing students with cutting-edge real-world knowledge, especially in the field of semiconductor chip technology, we are leveraging our strong industrial partnerships. Under the leadership of James Lu, we joined forces with GlobalFoundries to offer a unique industry-focused course on microelectronics manufacturing. A follow-up course on materials, metrology, and equipment in semiconductor manufacturing brings together 23 experts from 9 companies and a partnering university. Capitalizing on RPI's strength in semiconductors, ECSE is introducing a new Master of Semiconductor Technology program to broaden the talent pool. Furthermore, we are working with Hudson Valley Community College (HVCC) to establish a Microelectronics Scholar program and a joint first-year robotics course to ignite interest in STEM at an early stage.

ECSE is energized by multiple new research frontiers and opportunities. We are actively participating in RPI's response to the CHIPS and Science Act, collaborating with industry partners like IBM, GlobalFoundries, and others. We are building a critical mass of people, facilities, and funding so we can be competitive in vital areas such as artificial intelligence (AI) and machine learning (ML), next-generation computing, advanced manufacturing, robotics, and power electronics.

The imminent deployment of the IBM Quantum System One computer at the Voorhees Computing Center promises to further invigorate the ECSE community. The IBM quantum programming tools are already accessible to the RPI community. Randolph Franklin has leveraged these tools in

John Wen
Russell Sage Professor and Department Head
Electrical, Computer, and Systems Engineering

his pioneering quantum computer programming course for several years. More quantum courses are on the horizon.

We are staying at the forefront of AI research, with a large team of faculty supported by the RPI-IBM AI Research Collaboration (AIRC), National Science Foundation (NSF), and other companies and funding agencies. ECSE has a strong AI/ML curriculum, including courses on machine learning, deep learning, distributed learning, and trustworthy AI. With generative AI such as ChatGPT and Midjourney all the rage, Rich Radke is offering a special topics course on Computational Creativity, exposing our students to the underlying algorithms. Increasing awareness of cases where AI has confidently asserted false information has spurred faculty research and courses on trustworthy, explainable, and safe AI (Ali Tajer, Meng Wang). Agung Julius uses AI mistakes as a teaching moment — asking students to identify fallacies in ChatGPT's attempts at mathematical proofs.

Our ECSE faculty actively collaborates with industry, contributing to translational research endeavors with partners ranging from large corporations, such as IBM, GE, Boeing, and GlobalFoundries, to smaller enterprises like Mosaic Microsystems, American GNC, Ross Precision, and Servo Robot, among many others.

We congratulate two long-time ECSE faculty members, Randolph Franklin and Paul Schoch, on their retirement. They both are staying active and continue to contribute ideas to ECSE and RPI. We bid goodbye to ECSE faculty emeritus Pankaj Das who passed away this year.

At ECSE, we take pride in fostering a supportive, inclusive community. The ECSE Webex space serves as a vibrant hub for community interaction and information sharing, boasting over 1,000 members and numerous subgroups. Whenever a question is posed, multiple responses are posted almost immediately. Beyond the virtual space, the Mercer XLab provides physical resources and a collaborative space for the ECSE community and others to test ideas, seek assistance, work in teams, and build camaraderie.

The expansion of our faculty, students, and education and research programs is generating excitement but also straining existing lab, office, classroom, and communal spaces. ECSE, and the School of Engineering, will need larger and more modern physical space to accommodate the growth trajectory. The most immediate needs are the renovation of the '87 Gym pool area to become a drone and robotics space (Agile Drone and Robotics Innovation Testbed, ADRoIT) and the renovation and outfitting of the Mercer XLab on the 6th floor of the JEC. We will need help from all of our alumni to support these endeavors. Please consider donating through https://ecse.rpi.edu/donate.

I am thrilled about the direction in which our department is heading. As we head into the RPI bicentennial celebration, I hope you share our enthusiasm, come back to visit us, and invite you to join us in shaping and celebrating our future. Together, we will continue to propel Rensselaer Forward!

The Mercer XLab: Where Cross-Pollination Fuels Innovation

Transformation is underway at the Douglas A. Mercer '77 Innovation and Exploration Laboratory, where a multi-million-dollar renovation and expansion is creating a space unlike any other on the RPI campus. Affectionately known as the Mercer XLab, the facility is designed to provide easy access to an array of technical tools in a setting that fosters experimentation, innovation, and collaboration.

Once complete, the new lab will be nearly three times the size of the original, which opened in 2012 on the sixth floor of the J. Erik Jonsson Engineering Center (JEC). Construction will be staged so students continue to have access to lab tools and equipment until the Mercer XLab officially opens in the spring.

The expansion will add significantly more work stations, a PCB printer for students to create their own circuit board prototypes, and a combination storefront/help desk with an extensive parts inventory to support student projects. A "break-it lab" will provide a safe place for students to experiment with and dismantle devices, and a "clubhouse" will ensure ample room for individual and group club gatherings. Glass walls will enable students to see what others are working on in all spaces at all times.

Two robots will be stationed on lower floors of the JEC to greet individuals as they enter the building and engage them in conversation about the lab. Those who show interest will receive a robot escort to the sixth floor.

User-driven design

At the recommendation of ECSE alumnus and major supporter Douglas A. Mercer, the updated lab will include a "failure wall" to showcase ideas and projects that didn't turn out as expected. A Fellow Emeritus of Analog Devices Corp., Mercer established an endowment to launch the original Mercer Laboratory for Student Exploration and Innovation. He recently made an additional endowment gift of $2 million for the renovation to the recently renamed Mercer XLab.

Other Mercer XLab features reflect input gathered during "design ideation" sessions with students, faculty, and staff. One session focused exclusively on meeting clubs' needs and encouraging cross-pollination.

"Everything is a result of that ideation and what students need for the types of projects they'd like to see," says ECSE Professor and Mercer XLab Director Shayla Sawyer. She cites a makerspace for course work and places to repair electronics, get instruction and guidance, and safely explore how things work.

"The Mercer Lab is for the curious," Sawyer says. "Do you want to learn how a capacitor works and by doing so blow up a capacitor? Do you want to take apart a drone to analyze its function? Go to the Use it-Break it-Take it lab to do this safely." Equally important, "It's a place where you're allowed to fail because it's OK to not get it right the first time. How else will you learn?"

That question is a driving force behind the Mercer XLab and Sawyer's approach to pedagogy: the art, practice, and science of teaching. A champion of hands-on, design-infused engineering education, Sawyer prefers a "call-and-response" approach instead of the traditional lecture. In the classroom, she encourages students to challenge her and each other. Her lab assignments offer multiple ways for students to demonstrate their mastery of the required material.

"My classroom is more like a learning community that fosters connections between both bottom-up and top-down thinkers," she says. In that environment, "You'd be amazed at the fascinating projects that come from students' imaginations. The Mercer XLab will facilitate and augment that."

RPI President Martin Schmidt '81 agrees. "There are so many different learning styles for success," he says. "The Mercer XLab will bring together students and faculty with vastly different backgrounds and experiences to explore, ideate, create, and even to fail sometimes. I am very excited to see how RPI's long history of innovative teaching and learning will be revolutionized."

Extraordinary potential and impact

For students like Amar Maksumić '24, the Mercer XLab will enhance both the academic and extracurricular experience. Maksumić spends up to 10 hours a week in the lab for course work and club activities, including working with other students this summer on building the "greeter" robots.

President of the RPI Robotics Club and powertrain lead for RPI Motorsport, Maksumić represented both clubs during the design ideation discussions. He is confident both will benefit from the additional space and capabilities of the Mercer XLab. "I'm excited about all the extra workspace and tools, but what I'm really looking forward to is the space where people from various clubs can get together and bounce ideas around," he says.

Sawyer shares that enthusiasm, especially for collaboration between students from ECSE and other departments. "Having space for that interaction is the point," she says. "And I'm confident it will happen."

She and others believe the Mercer XLab can provide a model for engineering education and, in the process, help spur innovation within and beyond RPI. "The world needs more engineers, specifically electrical engineers," Mercer says. "I see the newly expanded XLab as a place to question everything and assume nothing while exploring the proposition that the application of innovative technology can indeed improve how RPI educates engineers of the future."

RPI Science and Technology Studies (STS) doctoral student Jonathan Givan '26 sees opportunities to discover and document how the Mercer XLab's approach can influence learning styles and results.

"The Mercer XLab is breaking away from a more isolated engineering development culture and encouraging more diverse, inclusive, improvisational learning," Givan says. In keeping with that culture, he is working on a proposal for a future fellow program that would pair an STS/humanities student with an engineering student on a research project. Givan's proposed topic is "Exploring personal instrumentation as a heutagogical (self-determined learning) tool for improvisational learning."

Sawyer has perhaps the most far-reaching goals of all. In the short term, "I hope the XLab becomes a space where students, faculty, and staff can come together to actively pursue a revolution at RPI and push the boundaries of what it means to learn at an academic institution," she says.

Longer term, "A dream of mine is to use the lessons of the Mercer XLab to find ways to connect schools and cultures — and to see what groups of diverse students can accomplish when they work together."

Student Spotlight

Lauren Brady, *Class of 2023 (Ph.D.)*

Major: Electrical Engineering

Projects/Research: My thesis focuses on the development of a modular bioelectronic interface between genetically modified E. coli and a metal-reducing bacteria, Shewanella oneidensis MR-1. The goal is to detect multiple small-target molecules to improve biosensing capabilities in aquatic ecosystems. I have also been working on a project that utilizes S. oneidensis MR-1 as the primary mechanism to fabricate semiconductor nanomaterials in solution at room temperature.

In March, I was named a National Science Foundation (NSF) iREDEFINE fellow and participated in a workshop at the Electrical and Computer Engineering Department Heads Association (ECEDHA) Conference, which prepares fellows to pursue faculty positions in ECSE. At RPI, I have participated in the NSF Innovation Corps (I-Corps) Program as an entrepreneurial lead to explore the viability of commercializing technology in the areas of bacterial biosensing and nanofabrication.

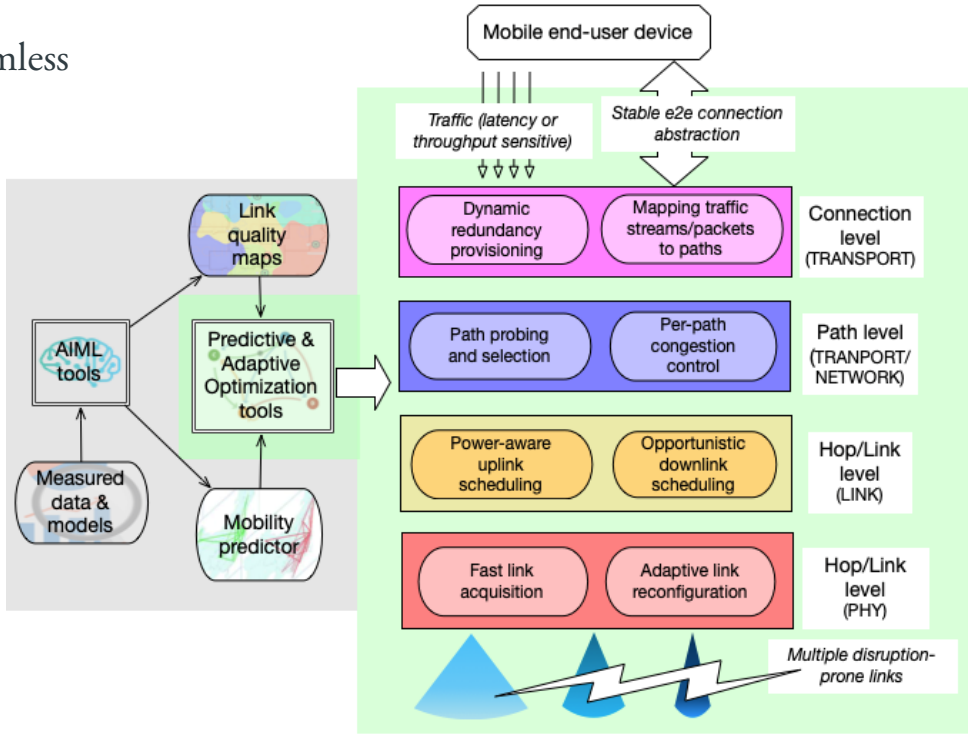
On-campus Activities/Organizations: I am a founding member of the ECSE Graduate Student Council and currently serve as president. I have also been a mentor in the ECSE Graduate-Undergraduate Mentor Program since its inception. Previously, I was a member of the Roots of Africa Music Ensemble, a percussion group focused on learning African, Afro-Cuban, and New World percussion rhythms.

Fun Facts About Me: I am a volunteer for the FIRST® (For Inspiration and Recognition of Science and Technology) Robotics Competition, the premier engineering challenge for high school students. I love playing and listening to music. I also enjoy traveling, and my research has taken me to Hawaii, New Mexico, Ohio, California, and home to my family in Ireland this year!

Seeking Multiple Paths to Seamless Connectivity on the Move

With its faster speeds and lower latencies, 5G millimeter wave (mmWave) technology (also known as the 5G FR2 Frequency Bands) is driving advances in indoor wireless communication. Cell phone carriers have been deploying 5G mmWave technology in airports, sports stadiums, and other high-density locations to increase bandwidth and dramatically improve the audio and video streaming experience.

Outdoor deployment has been slower, in part because mmWave signals have a shorter range and are more easily blocked by physical barriers, such as buildings, passing vehicles, and trees.



ECSE Professor Koushik Kar believes those disadvantages can be overcome by providing multiple, closely spaced access points and dynamically splitting data traffic among these access points. His research focuses on what he considers a bigger challenge in using mmWave in mobile environments: preventing connectivity disruptions by developing higher-layer protocols that can direct internet traffic via multiple access points and multiple paths.

mmWaves are electromagnetic waves that occupy the extremely high-frequency band – 30 gigahertz (GHz) to 300 GHz – of the radio-frequency spectrum. With this higher frequency comes higher bandwidth and the lower latency that is critical in ensuring the uninterrupted streaming required for gaming and video conferencing.

Kar sees enormous opportunity to tap the communications potential of mmWave technology, especially as users increasingly stream audio and video while on the move. His efforts focus on developing new networking protocols to enable data transmission over multiple paths, seamlessly and simultaneously.

In the future, he and others expect all public Wi-Fi access points to be complemented or even replaced by 5G, or possibly 6G, access points operating at mmWave frequencies. Because of the limited range of these high frequencies, access points will have to be densely deployed. As users move from place to place, their connection essentially will have to move with them and switch to the next access point without interruption.

That raises what Kar considers an interesting question: How should networking protocols work to prevent signal disruption?

Internet traffic typically is sent through a single access point via a single path. Kar is proposing and developing a solution that will smoothly, proactively change the traffic flow, diverting it through multiple access points and opening three, four, or more pathways through these access points at the same time. To accomplish this, changes must be made at the transport layer of the internet, which accepts data, divides it into smaller segments as necessary, passes them along, and ensures that all pieces arrive as planned at their destination, despite them getting reordered over multiple paths. It requires solving a number of related challenges across the networking protocol stack, done in a coordinated manner, as illustrated above.

It's a complex problem, given that switching from one access point or path to another is hardly seamless under current internet protocols, made more difficult by increasing user mobility and the shorter range of 5G/6G technologies. However, solving it could open the door to exciting applications, including the ability to attend video conferences in the autonomous vehicles that now appear likely in the not-too-distant future.

Research Highlights

Working With Communities To Detect Soil Pollutants

The toxic "forever chemicals" that are raising safety concerns about the nation's water supply also can be found in soil across the U.S. But in which communities and at what levels?

ECSE Professor Shayla Sawyer has received a nearly $1.2 million National Science Foundation (NSF) grant to develop novel tools to engage communities in answering those questions. The goal is to create a microbe-infused paper-based solution that community stakeholders can deploy in the field to sense arsenic and per- and poly-fluoroalkyl substances (PFAs) in the soil.

Often referred to as forever chemicals, PFAs include thousands of long-lasting synthetic compounds that pose risks to human health and the environment. PFAs have been found in the blood of people and animals around the world, as well as in water, air, and soil.

Sawyer's project, "Signals in the Soil (Sits) Socializing Soil: Enhancing Community CoOperation with Iterative Sensor Research," is both lab- and field-based. In the lab, researchers will investigate ways to use bacteria to create new testing strips to detect soil contaminants. The paper strips will be disposable, easy to use, and will meet Environmental Protection Agency detection standards.

In the field, investigators will consult with regulators, farmers, environmental justice activists and other stakeholders in communities affected by soil pollution. These consultations will include in-depth interviews, advisory board meetings, and citizen-science workshops that build on the model developed for RPI's Our Soil project, a previous NSF-funded community soil testing study.

Sawyer's research takes the unusual approach of originating with community stakeholders, transferring their knowledge to researchers, and then returning information from researchers back to the community, in what she describes as an "intentional reciprocated cycle throughout the project."

The cycle is designed, in part, to assess the potential impact of community engagement early in a research effort. Sawyer is especially interested in whether the greater community of interested stakeholders can influence the direction and application of research at the onset of innovation and whether community input inspires innovation in unexpected ways.

Student Spotlight

Josh Pratt, *Class of 2024 (B.S.)*

Major: Computer and Systems Engineering

Minor: Music

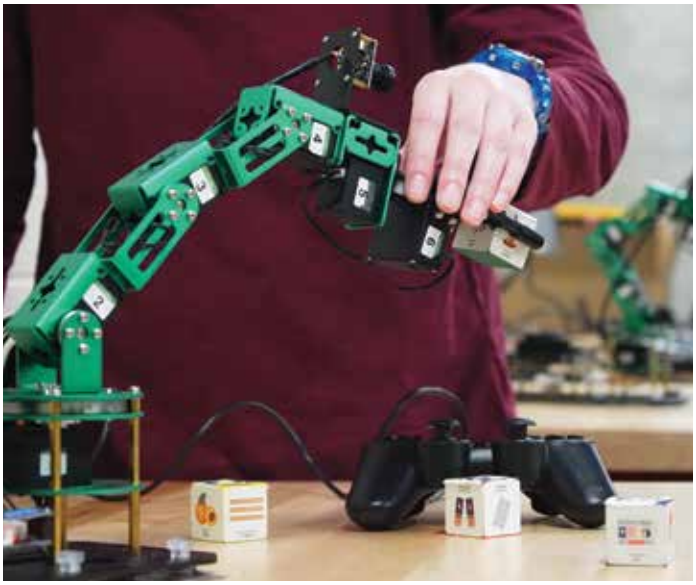
Work/Internship Experience: I spent my spring 2023 semester at MITRE in Bedford, Massachusetts, as a co-op student in digital communications engineering. The seven-month experience continued through August 2023.

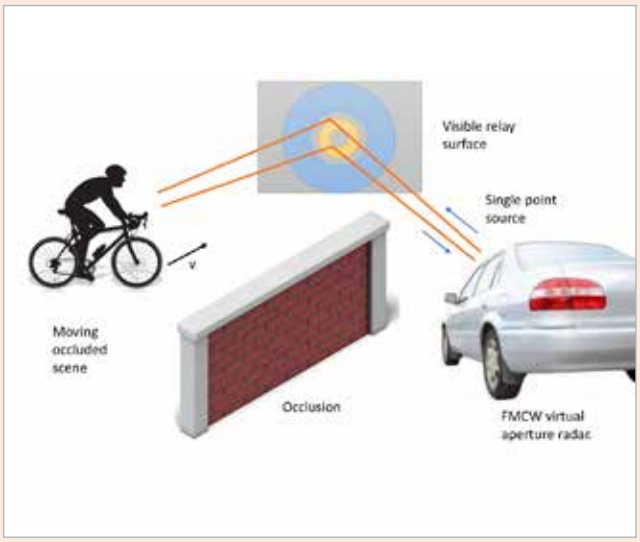
Projects/Research: Since my senior year in high school, I've documented five independent projects and a few coursework-related projects on my portfolio website (joshuapratt.net). I get a lot of inspiration from projects that others have posted online, such as on YouTube, and try to inspire friends and peers to pursue similar independent work, as well! I also was very fortunate to have the opportunity to conduct research part time with the Lighting Enabled Systems & Applications (LESA) Center at RPI during my Arch summer semester in 2022 and into the fall.

On-campus Activities/Organizations: I am a senior Engineering Ambassador, was president of the Phi Gamma Delta fraternity, was principal clarinet in the Rensselaer Orchestra and Chamber Music Ensemble, and play several intramural sports.

Future Plans: I began my senior year in fall 2023 and plan to spend spring 2024 as an audio hardware engineering intern at Tesla in San Francisco. I will then return to RPI in fall 2024 to complete my bachelor's degree.

Fun Facts About Me: My favorite artist is Kendrick Lamar. I have never owned a pair of jeans. I once flew in and out of Dallas from Albany in less than 24 hours for a meeting.





Computational Imaging

ECSE-4962/6962 | Taught by Birsen Yazici

This course introduces the field of imaging and its physical principles, methods, and applications within a unifying framework that integrates diverse topics that are presented separately in different science, mathematics and engineering courses. The course emphasizes the physics of wave-based imaging, adopting a linear systems-based approach to describe wave propagation in a medium and interaction with a target and in solving the resulting image formation problem. Statistical and matrix inversion techniques, as well as analytic inversion techniques, are covered. The course prepares undergraduate and graduate students in computational techniques in imaging applied to the broad domains of environmental, medical, biological, defense, civil engineering, and geophysics.

Topics in Microelectronics Manufacturing

ECSE-4961/6961 | Taught by James Lu

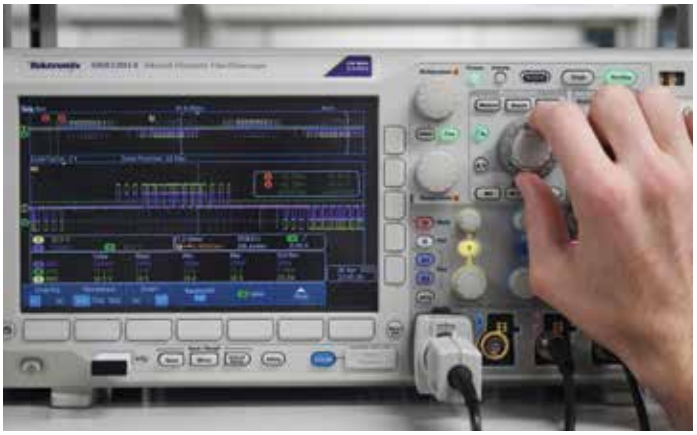
Semiconductor manufacturing is a specialized, highly skilled profession that draws from many disciplines including chemical engineering, mechanical engineering, electrical engineering, materials engineering, industrial engineering, physics, and computer science. This pilot course, taught by leading industry experts with over 300 years of combined experience, provides deep insight into key concepts driving the microelectronics industry. It is targeted toward advanced undergraduates and early graduate students who are interested in engaging with an industry that is changing the world. The course includes a tour of GlobalFoundries Fab8 in Malta, New York, where students see how all of these elements come together in one of the world's most advanced manufacturing facilities. A follow-on course, Advanced Materials, Metrology & Equipment for Semiconductor Manufacturing, continues the same mode of instruction.

Computational Creativity

ECSE-4964/6964 | Taught by Rich Radke

Creative applications of generative artificial intelligence have exploded in the past year, including image generation tools like Stable Diffusion and DALLE-2 and text generation tools like Chat-GPT. New algorithms are even generating music, video, and graphic designs. This course will survey the theoretical foundations of these tools, focusing on generative models and self-supervised learning, as well as explore the historical and ethical considerations involving the procedural generation of art. Students will apply cutting-edge tools for generating creative content and critique each other's work.

Research Highlights



Unlocking the Potential of THz Science and Technology

Over the next five years, 3 billion more smartphone users are expected to upgrade to fifth generation, or 5G, devices — and to overwhelm the world's data networks. Global mobile traffic is forecasted to reach 5G network capacity in 2028 and to exceed it by 2030. The resulting congestion will decrease both the speed and quality of communications.

The solution, according to ECSE Professor Michael Shur and other electronics experts, is to tap the promise of terahertz (THz) technology. The Patricia W. and C. Sheldon Roberts Professor of Solid State Electronics, Shur has made significant advances in understanding THz's properties and its potential to help power breakthroughs in mobile communications, medical imaging, and national security.

THz waves occupy space on the electromagnetic spectrum between microwave and infrared bands and have frequencies between 100 gigahertz (GHz) and 10 THz. Because these higher frequencies support ultra-wideband Wi-Fi, THz technology is widely considered the future of wireless communications. Other properties, including the ability to safely penetrate nonconducting materials, are driving research into THz applications for disease detection and treatment, food and drug safety, and a variety of other imaging-related uses.

Shur's research tackles key logistical challenges that must be addressed to enable these applications. Perhaps most significant, using the new physics of very small devices, Shur has demonstrated that it is possible to excite extremely small (3nm) transistors and get them to work in synchrony by matching them at their boundaries or corners. At these dimensions, plasmonics define the physics of electron transport.

Other key findings include:

- Electron fluid supports plasma waves, which are much faster than drift.
- Plasma waves can be used in field effect transistors (FETs) for novel electronic devices operating in a THz range.
- Short-channel silicon complementary metal oxide (Si CMOS) TeraFET plasmonic technology enables sub-THz and THz applications.

Because of its impact on the marketplace, THz's potential to enable 6G communications is generating the most interest. However, the technology and Shur's research have equally impressive implications, including advancing cancer detection, identifying homeland security risks, and spotting defective or counterfeit computer chips.

Shur's research is supported by the Office of Naval Research and the Air Force Office of Scientific Research.

Student Spotlight

Claire Olmstead, *Class of 2023 (B.S.)*

Major: Computer and Systems Engineering

Minor: Cognitive Science

Work/Internship Experience: The summer before my senior year, I was a college student tech spec for Lockheed Martin as part of the company's Naval Helicopter Program. During my Arch term, I also worked at the Union Ben & Jerry's.

Projects/Research: As part of the Magnetic Field Detection System Capstone Team, I helped create a portable electromagnetic interference (EMI) detection system that calculated a least-average EMI area for the ideal placement of portable MRI machines. We worked with the Icahn School of Medicine at Mount Sinai and were able to build a fully functional prototype by the end of the semester

On-campus Activities/Organizations: I was on the Panama Project Team of Engineers Without Borders. As a member of RPI Quadball, I organized RPI's first official home tournament for quadball, previously known as quidditch.

Future Plans: I plan to work for Lockheed Martin as a systems engineer and to play for two quadball teams: the Major League Quadball Boston Forge and the U.S. National Team Developmental Academy. I also plan to travel to New Zealand.

Fun Facts About Me: I like to hike, crochet, and knit in my free time. I have also visited the Hobbiton Movie Set in New Zealand!

Taking on the CHIPS Challenge

Rensselaer is poised to play a key role in U.S. efforts to reinvigorate and transform its semiconductor industry. Spurred in part by the passage of the CHIPS and Science Act of 2022, RPI is adding semiconductor-related courses and programs and strengthening relationships with industry, government, and academic partners.

The CHIPS Act is intended to help reverse a decades-long decline in the U.S. share of commercial semiconductor manufacturing — from 37% in 1990 to 12% today — by ramping up investments in production, research, and workforce development. As of July 2023, the Semiconductor Industry Association (SIA) projects a U.S. semiconductor technical talent gap of 67,000 workers by 2030 and a shortage of 1.4 million technicians, computer scientists, and engineers across the nation's economy.

"Addressing the talent gap is a monumental challenge," says James Lu, ECSE professor and curriculum chair. "We are responding by building on Rensselaer's history of excellence in research and education in micro- and nano-electronics and developing curricula and programs that will help power the U.S. semiconductor resurgence."

The university is also capitalizing on other assets: leadership and alumni's strong ties to the tech community, and RPI's location in a region that's fast becoming a center of U.S. semiconductor activity.

"Working across the entire institution, we are developing new research and education programs, forging new partnerships with leading companies in the field, and building Rensselaer leadership in microelectronics in the Capital Region and beyond," says Robert Hull, Vice Rresident of Research at RPI. "The ECSE Department is a key pillar in this enterprise."

Talent, content, and scale

RPI's strategy for workforce development addresses three critical issues: talent, content, and scale. The university is reaching out to students at all levels, from K-12 through doctoral programs; developing new courses, concentrations, majors, minors, and certificates; and partnering with colleagues in academia and industry to create a pipeline from the classroom to the clean room and research lab.

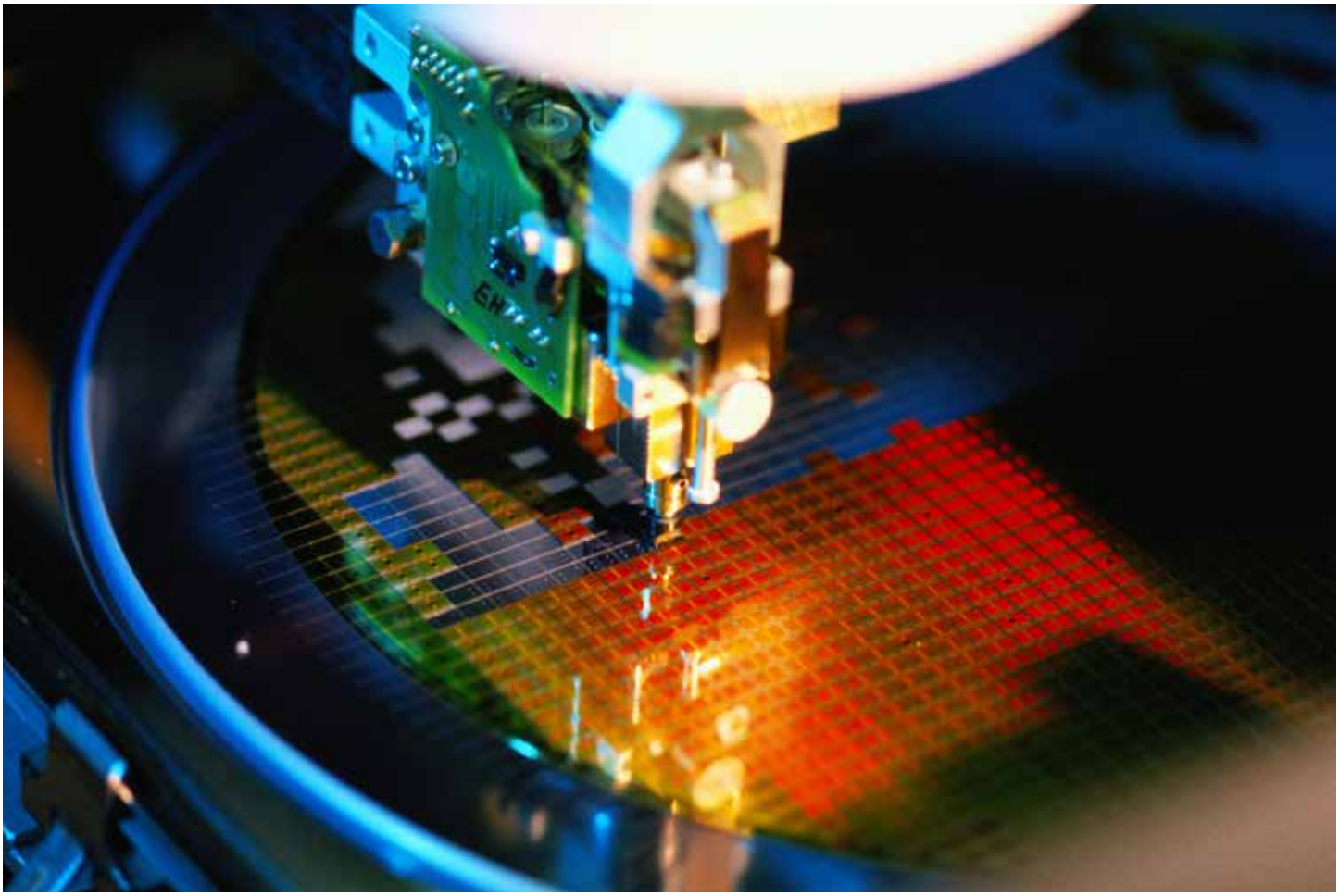
Annual events, such as National Manufacturing Day, Black Family Technology Awareness Day, and Exploring Engineering Day, as well as summer camps and other programs, bring young students from all communities to campus to spark interest in STEM-related subjects. RPI student ambassadors visit public and private school classrooms, help coach robotics teams, and volunteer at after-school and weekend clubs. In person and via virtual programs, ambassadors lead hands-on activities that demonstrate real-world applications of STEM topics and inspire young people to consider STEM-related careers — and an RPI education.

Those who attend RPI will find new courses designed with industry input to meet workforce development needs. Spring 2023 saw the launch of Topics in Microelectronics Manufacturing for advanced undergraduate and early graduate students. More than 70 students enrolled in the course, which was taught by Lu and industry experts from GlobalFoundries. A second course, Advanced Materials, Metrology, and Equipment for Semiconductor Manufacturing, debuted this fall. Lu was again joined by industry experts, this time from a number of semiconductor partners.

Lu also works on curriculum development with colleagues at other academic institutions to share best practices and anticipate — and address — future technical needs of the semiconductor industry. "We are collaborating to scale our impact through workshops, events, and digital programming that will extend our educational offerings beyond our individual institutions," he says.

Driven in part by SIA estimates that more than 18% of unfilled semiconductor-related positions — roughly 12,300 engineers — will be for master's-level graduates, ECSE is introducing a new Master of Science in Semiconductor Technology degree. The highly flexible degree program accommodates students with diverse STEM backgrounds and prepares them for successful careers in semiconductor and micro-nanoelectronics research and industrial practice.

To entice students at the associate and bachelor's degree levels, RPI has partnered with Hudson Valley Community College (HVCC) on the RPI-HVCC Semiconductor Scholars Program. During their two years at HVCC, scholars receive financial merit awards and have opportunities to visit RPI labs and facilities, be mentored by RPI faculty and advisers, enroll in RPI summer courses or internships, and participate in RPI research. Once they earn their associate degree, scholars can choose to start their semiconductor career or continue their education at RPI.



Either way, their education and connection to the Capital Region will provide an edge with employers who, increasingly, are "gravitating toward upstate New York. We are becoming a hub for chips research and development and, even, prototyping," says Shekhar Garde, RPI capitalize, I think and Elaine and Jack Parker Chaired Professor.

"Area employers — GlobalFoundries, Micron, and IBM — want to recruit graduates whose education includes experience in semiconductor labs and clean rooms and who want to stay in the area," he adds. "Those who attend HVCC and RPI know the region and are more likely to remain here." Garde is optimistic that the Scholars Program will continue to grow, attract more partners, and even be a model for other communities and institutions.

A comprehensive, collaborative approach

The curriculum and workforce development initiatives are part of a comprehensive push, involving leaders within and beyond the university, to apply RPI's innovation and expertise to the CHIPS challenge. Researchers and faculty, administrators and trustees, alumni, industry partners, and others with ties to RPI are leveraging their resources, expertise, and connections to offer additional opportunities to RPI students and to accelerate U.S. semiconductor research and manufacturing.

The progress and the potential are impressive.

In April, RPI became a founding member of the Northeast University Semiconductor Network, a partnership of 21 colleges and universities, Micron Technology, and the National Science Foundation. Chosen for their strong STEM programs, exceptional facilities, and track record of collaboration, the founding partners will develop the workers expected to fill the thousands of upstate New York jobs created by Micron's planned $100 billion semiconductor plant near Syracuse.

"Micron's investment in leading-edge memory manufacturing will require a workforce with the technical skills to support this critical work," says RPI President Martin A. Schmidt. "RPI is ready to play a role in preparing the workforce of the future through our clean room and other innovative teaching approaches."

Parallel to these developments, RPI and longtime research partner IBM announced an exciting collaboration that will make RPI the world's first university to house an IBM Quantum

Taking on the CHIPS Challenge (con't)

System One computer. A new approach to computing, quantum computing uses principles of quantum physics to solve complex problems much faster than classical computers. RPI's quantum computer, which is scheduled to be installed in 2024, will have transformative applications across the university's research portfolio.

RPI also has strong ties — often through alumni — to other companies, including AMD, Applied Materials, Onsemi, Pallidus, and more. In addition, alumni from ECSE and other departments serve as industry advisers for students, sharing insights one-on-one, reviewing resumes, and participating in webinars, panel discussions, and other activities that help create employment pathways.

Faculty members mentor and advise students and forge relationships with business and government entities to enrich the educational experience. For example, working with the Efabless Corporation and NY CREATES, ECSE Professors Mona M. Hella and Russell P. Kraft created IC Design & Testing, a pilot program that allows students of any level of expertise to design and fabricate their own chips. Efabless provides the open-source chip creation platform, and NY CREATES helps cover associated production costs.

The long-term goal of all these initiatives is for RPI to become a national powerhouse in semiconductor education and research — and to use that position to help the U.S. reclaim its leadership in semiconductors and microelectronics. "This is an opportunity to literally transform our enterprise and reshore semiconductor research and manufacturing," Hull says.

"To reach those aspirations, and receive substantial resources from the CHIPS Act, we will need very strong partnerships," he adds. "And we have them."

Student Experience

Senior Student Services Administrator Rama Hamarneh recently organized several hikes around the area for ECSE students, faculty, and staff. The group has visited Peebles Island State Park, Poesten Kill Bends Preserve, and most recently the Valentino Family Community Forest in Grafton, NY.

Amazon, Cisco Awards Recognize Machine Learning Research

ECSE Assistant Professor Tianyi Chen received two awards this past year that advance and acknowledge his contributions to machine learning, the branch of artificial intelligence (AI) that uses data and algorithms to imitate human learning.

In October 2022, Chen's proposal — "Automating Decentralized Machine Learning (DML) via Bilevel Optimization"— was selected for an Amazon Research Award. A month later, Chen was honored with a Cisco Faculty Award in recognition of his excellence in research.

The Amazon award provides one year of unlimited access to hundreds of Amazon datasets and other computer resources, including on-demand cloud computing, AI, and machine learning tools. Chen will use these resources to test a new framework for leveraging bilevel optimization toolboxes to automate the design and analysis of DML algorithms.

Known as BOOM (Bilevel OptimizatiOn for decentralized Machine learning), the framework has potential as an enabling technology that could reduce the need for human intervention. That, in turn, could speed the machine learning process and expand access for students, researchers, and other practitioners interested in deploying DML in their work.

With his Cisco award funds, Chen will focus on creating a large language model (LLM) that can be fine-tuned to tailor its output according to the needs and preferences of diverse populations, accounting for differences in geography, culture, socioeconomic, and other factors. The model also would incorporate safeguards for data privacy and security.

Student Spotlight

Burak Varıcı, *Class of 2024 (Ph.D.)*

Major: Electrical Engineering

Work/Internship Experience: In summer 2020, I was selected as an AI Horizons Scholar in the RPI-IBM AI Research program. Since then, I've been collaborating with IBM AI researchers and spent a semester as an AI resident at the MIT-IBM Watson AI lab in Cambridge, Massachusetts.

Projects/Research: Since spring 2020, I have been working under the supervision of Professor Ali Tajer on scalable methods for inferring cause-effect relationships in natural or physical systems. Specifically, I focus on advancing the use of interventional (experimental) data in various subfields of causality research.

On-campus Activities/Organizations: I've served on the ECSE Graduate Council for the last three years, currently as secretary.

Future Plans: I aim to use my expertise on causality, developed during my doctoral studies, to solve real-world problems and bring a causality perspective to machine learning frameworks employed by industry.

Fun Facts About Me: My last name means "arriver" in Turkish. I won an autographed book from my favorite basketball writer by naming all players in an old playoff game simply by viewing a play diagram.

Staff Spotlight

Picutured left to right: Bill Mnich, Rama Hamarneh, and Kelley Kritz.

Kelley Kritz
Senior Student Services Administrator – Graduate Students

Kelley Kritz is the senior student services administrator for ECSE graduate students, providing support from the application process through graduation and beyond. She is involved in admissions, funding, programming, alumni communications, and anything else related to serving the department's graduate student community.

Kelley came to RPI — and returned home to the Capital Region — after serving as an academic adviser for undergraduate computer science students at New York University's Brooklyn campus. Before that, she was an academic adviser for professional-level students at Long Island University's Brooklyn campus.

A graduate of SUNY Oneonta, Kelley also has a master's degree in college student services administration from The College of Saint Rose in Albany, New York.

Bill Mnich
Senior Academic Support Technician

Bill Mnich has been serving Rensselaer for more than three decades. Currently, he is a senior academic support technician, supporting ECSE labs and projects. His work includes fabricating robots and assisting with 45 robotic cars. Bill also has volunteered for the FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition.

He began his affiliation with RPI in 1978 as a field service engineer for Imlac Corporation, installing and maintaining systems for RPI's Center for Interactive Computer Graphics (CICG). He joined RPI in 1985 as an electronic technician, serving in that role for 23 years. During that time, Bill was instrumental in moving the CICG to the Low Center for Industrial Innovation, maintaining computers, and running extensive wiring in the Low Center for its Electronic Computer Service Center. He later moved to the Jonsson Engineering Center and became part of ECSE, maintaining lab equipment and playing a key role in launching the Embedded Control Lab. Early innovations included the "intelligent faucet," smart cars, and 15-foot indoor helium blimps.

Bill retired in 2008 and returned in his current role in 2022.

Rama Hamarneh
Senior Student Services Administrator – Undergraduates

As senior student services administrator for undergraduate students in the ECSE Department, Rama Hamarneh serves primarily as a staff adviser for students in their sophomore to senior years. She also is involved in student programing, admissions and alumni initiatives, and everything undergraduate within ECSE.

Before joining RPI, Rama earned doctoral and master's degrees in comparative literature from the University of Texas at Austin, where she taught language and literature for five years. She also has a bachelor's degree in comparative literature and Near Eastern languages and civilizations from the University of Pennsylvania.

Alumni Spotlight

David Doria B.S. ’07, M.S. ’08, Ph.D. ’12

Director of Engineering, Autonomous Driving, Magna Electronics

Since earning my Ph.D., much of my work has involved applying my RPI experience with LiDAR (light detection and ranging) to advance autonomous driving technology. Currently, as director of engineering for autonomous driving for Magna Electronics, I lead several teams in the design and implementation of advanced driver assistance systems (ADAS) features. These next-generation versions of consumer car concepts — adaptive cruise control, lane-keeping, etc. — rely on LiDAR to help make vehicles safer and more comfortable to operate.

Previously, as a senior software engineering manager at HERE Technologies, I used computer vision techniques to automate high-definition map-making for the autonomous driving industry. Before that, I worked in the Computation Sciences Division of the U.S. Army Research Laboratory, developing solutions to modern and future battlefield problems.

I spent almost a decade studying at RPI, earning bachelor’s, master’s, and doctoral degrees, all in electrical engineering. My Ph.D. research, with Professor Richard Radke, focused on image and LiDAR data analysis, including object detection, segmentation, and 3D hole filling. My M.S. research, with Professor Shivkumar Kalyanaraman, focused on wireless communication systems, particularly software models of worldwide interoperability for microwave access (WiMAX) standards.

Alyssa Partridge B.S. ’17

Electrical Engineer, BAE Systems FAST Labs

As an electrical engineer in the BAE Systems FAST Labs research and development group, I lead small teams to design, implement, and test signal processing algorithms in digital circuits on field programmable gate arrays (FPGAs). I have supported both lab and field tests and am part of an interdisciplinary team with software, mechanical, electrical, and systems engineers. Although my primary focus is on radio frequency (RF) applications, such as radar and communications waveforms, I have also done work in optics and image processing.

I also lead the BAE Systems New Hampshire Women in Technology (WiT) STEM outreach program. This 16-week program gives young women from area high schools the opportunity to come onsite to BAE Systems once a week to learn about an engineering discipline and work on a hands-on project related to that discipline. I really enjoy leading this program and introducing young women to the field of engineering!

I joined BAE Systems in 2017, soon after graduating from RPI with a dual B.S. in electrical and computer systems engineering. I had done an internship at BAE Systems the summer before and joined the company as part of its Engineering Leadership Development Program. While working full time, I earned a master’s degree in electrical engineering from Worcester Polytechnic Institute.

I currently live in southern New Hampshire with my husband, Matt. My hobbies include hiking and skiing across New Hampshire, Maine, and Vermont.

Interview with President Schmidt

A Brief Conversation with President Martin Schmidt

Dr. Martin Schmidt received his B.S. in electrical engineering at Rensselaer Polytechnic Institute in 1981 and an M.S. and Ph.D. in electrical engineering at Massachusetts Institute of Technology in 1983 and 1988, respectively. He joined MIT as a faculty member in 1988 and served as director of the Microsystems Technology Laboratories (1999-2006), associate provost (2008-2013), and provost until 2022, when he returned to RPI as the 19th president and a professor in Electrical, Computer, and Systems Engineering (ECSE). The following questions and answers are excerpted from his June 12, 2023, interview with ECSE head John Wen. The full interview is available at https://tinyurl.com/2z9upu4p.

John Wen

Hi Marty. You came to RPI in 1977 as a freshman and received your bachelor's degree in the ECSE Department in 1981. Could you describe a bit of your background and how you decided on electrical engineering?

Marty Schmidt

I grew up in northeastern Pennsylvania, a small town outside of Wilkes Barre. I think, at some level, anybody who goes to a place like RPI probably had a real affinity for science and math. That was true for me as well. But also, I really liked building things, building furniture, rebuilding cars, when I was in high school. So that made either engineering or architecture of interest. This was the time of the microelectronics revolution, shortly before the PC rollout. It just felt like computing and computers were really where all the excitement was.

John Wen

What are some of the things you remember about your RPI experience?

Marty Schmidt

There are professors that I remember very well: Bruce Carlson, he wrote several of our textbooks. And Ken Connor, I maintained connection with him for a long time. I remember taking John McDonald's course, I think it was called COLD (Computer Organization and Logic Design). Logics class, which was kind of neat because it put you right in the middle of computing. Back then you really didn't get into your major discipline at RPI until fairly late in your sophomore year, or possibly the junior year. So, I got to take fluid mechanics and all sorts of classes like that, even as an electrical engineering major. I personally benefited from that because that breadth helped me.

John Wen

You emphasize the importance of translational research, and you've been involved in seven startups. Can you tell us a little bit about your entrepreneurial experience? How did that square with your academic pursuits? What advice you would give our entrepreneurial students?

Marty Schmidt

My passion had always been seeing things that we created in the lab going out and being used to some benefit. What happened early on was that our sponsors — General Motors, Ford, Honeywell, 3M, Bosch — were big companies that had large research laboratories. The typical model was they would fund our research where they were interested in a particular way of making something in a micro setting, and we would develop it to a certain level, develop fundamental understandings of how the process works. Then we would hand it off to them, and they would run with it. … But then what happened was we saw the decline of corporate research labs, so a lot of the labs that we were partnered with no longer existed. It just became challenging for large companies to maintain the kinds of research laboratories that would facilitate the translation. When we started working with medium-sized companies, they expected much more engagement in the translation piece. A lot of times what that would mean is, when it was ready to go, basically, they would hire a

Ph.D. student, and that was the translation path. Then, eventually, even that translated more into startups as the vehicle to get things spun out.

John Wen

We're so glad that you're back here at your alma mater. What do you look to accomplish? What's the vision that you have for RPI?

Marty Schmidt

First of all, it's personally very meaningful to think that I can finish my higher ed career where it started. And, to the extent to which I can help move RPI in a positive direction and advance it, that'll be personally satisfying. What's interesting to me is coming from an institution that has a $25 billion endowment to another institution that is trying to execute the same business but with a much different financial structure. It's a fascinating challenge, too, because the world can't live just off the well-endowed private institutions. Organizations like RPI need to succeed and thrive. The exciting challenge is, what is our path forward? What is our future that creates a healthy and vibrant RPI? That's a lot of what I thought about leading up to the decision to give my application to the search committee. This process we're going through right now, strategic planning, has to lay that path out. At the end of the day, RPI has an amazing history, and I think it has a really bright future. We just need to figure out what that path looks like and move forward on it. The world needs institutions like RPI.

New Faculty Spotlight

Liu Liu
Assistant Professor

Liu Liu's research interests lie at the intersection of computer architecture and machine learning. He supervises the EPIC (Efficient, Parallel, and Intelligent Computing) Lab, focusing on topics in AI hardware and systems design. He also has a passion for teaching, especially for guiding students to discover the beauty of computer architecture through courses on computer hardware design.

Lui came to RPI from the University of California, Santa Barbara, where he earned a doctoral degree in computer science in 2022 and a master's in electrical and computer engineering in 2015.

Outside work, Liu enjoys playing basketball and video games, watching movies and sports, and rooting for his favorite teams: soccer's Real Madrid and the NBA Lakers. Liu looks forward to exploring upstate New York during the winter months and practicing his snowboarding skills with his family.

Kimberly Oakes
Lecturer

Kimberly Oakes traces her love for robotics and her decision to study engineering to a high school FIRST Robotics competition. She went on to earn bachelor's degrees in engineering and physics at Clarkson University in Potsdam, New York, where her undergraduate research involved using social robots to assist autistic children. Her current research interests include robot control systems and human-robot interaction.

Oakes earned a Ph.D. in electrical engineering from RPI in spring 2022, under the advisement of Dr. John Wen. Her research focus was control system design of robotic arms for satellite servicing.

As a lecturer, she strives to create a safe, stimulating environment that encourages all students to be engaged and to explore beyond the course material. Outside the classroom, her hobby is photographing nature in the Albany Pine Bush Preserve.

Alex Patterson
Lecturer

Alex Patterson's academic research interests focus on bridging the gap between theory and experiment in the realm of nanoelectronic and photonic devices. He develops new models and employs them as tools to better understand device behavior.

Before joining RPI, Patterson worked at Osram Opto Semiconductors in Regensburg, Germany, implementing advanced methodologies for electrical, thermo-electrical, and optical modeling of LEDs and developing in-house simulation tools.

Patterson has master's and doctoral degrees in electrical engineering from the Massachusetts Institute of Technology, where he was a National Science Foundation Graduate Research Fellow. His work involved modeling and simulating low-dimensional field electron emitter structures.

In his free time, Patterson enjoys playing music, music production, outdoor activities, and traveling.

Faculty Retirements

Professor Randolph Franklin

Professor Randolph Franklin retired and became a professor emeritus in summer 2023 after 45 years at RPI. During that time, Franklin taught numerous courses, many in the software and computer engineering areas, including Computer Graphics, Computer Components and Operations, Parallel Computing, and Software Engineering. He developed multiple special topics courses to introduce state-of-the-art technology to RPI students, including terrain modeling and simulation, GPU-CUDA programming, and, most recently, Quantum Computer Programming.

Franklin received his B.S. from the Computer Science Department in the University of Toronto in 1973, followed by A.M. and Ph.D. degrees from Mathematica Accomodata in Harvard in 1975 and 1978, respectively. He joined RPI as an assistant professor in 1978 and was promoted to associate professor with tenure in 1984 and full professorship in 2008. He also had a joint appointment in Computer Science since 1986. He was on leave at the National Science Foundation (NSF) as a program director of the Numeric, Symbolic, and Geometric Computation Program from 2000 to 2002.

Franklin has published 24 book chapters, 43 journal articles, 29 conference articles in highly selective conferences, and 91 other refereed conference articles. He also has been involved in numerous conference organizations and journal editorial boards. Franklin supervised 71 master's students and 18 Ph.D. students, and many of his former students have gone on to distinguished careers in industry and academia. He was honored with the NSF Presidential Young Investigator (PYI) Award in 1984. He also received numerous NSF research grants, multiple DARPA grants, and industry support. In addition, he has developed multiple software tools and shared them with the community.

Professor Paul Schoch

Professor Paul Schoch retired and became an associate professor emeritus at the end of 2022. He spent his entire college and professional career with Rensselaer and ECSE. Schoch earned his B.S., M.Eng., and Ph.D. degrees from ECSE in 1976, 1980, and 1983, respectively. He went on to serve as a research associate (1983-1989), senior research associate (1989-1991), and associate professor with tenure (1991-2022). From 2010 until his retirement, Schoch was the director of the Center for Initiatives in Pre-College Education (CIPCE).

Schoch's research is focused on plasma diagnostics and instrumentation for fusion reactor applications. He served as adviser to four Ph.D. students and five master's students and supervised over 50 undergraduate research projects. But Schoch's true passion is in education. His contributions to the laboratory instruction in several foundational ECSE courses — including Introduction to Engineering Electronics and Circuit Analysis — led to the inclusion of hands-on laboratory instructional components in many of today's RPI courses (Introduction to ECSE, Circuits, Electronics, etc.). Schoch was part of the development team of Embedded Control and Electronic Instrumentation for Mechanical Engineering students, another course that continues to be offered today.

Schoch also was an early champion of studio classroom education, serving as a key contributor to studio circuits and electronics courses. In 2010, after the sudden passing of Les Rubenfeld, Schoch assumed the role of director of CIPCE, sustained the center for a decade, and established RPI as a leader in the Capital Region in K-12 STEM education through Lego League, FIRST Robotics, and outreach to teachers.

2022-2023 ECSE Awards

Faculty Awards

Shayla Sawyer, David M. Darrin ’40 Counseling Award

Joe Chow, Dr. Christoph Lackner and Dr. Denis Osipov, U.S. Department of Energy American-Made Digitizing Utilities Prize

Tianyi Chen, Amazon Research Award

Joe Chow, IEEE Herman Halperin Electric Transmission and Distribution Award

Paul Chow, IEEE Photonics Society 2023 Aron Kressel Award

Student Awards

Analog Devices Outstanding Student Designer Award

Nicola Altomare

Founders Award of Excellence

Syed Ahsan Raza Naqvi
Ming Yi

Allen B. Dumont Prize

Zijun Cui
Marcelo de Castro Fernandes

The Charles M. Close ’62 Doctoral Prize

Meaghan Podlaski
Ming Yi

The Henry J. Nolte Memorial Prize

Nicola Altomare
Chuizheng Kong

The Ricketts Prize

Allison Harry
Bennett Young

4.0

Michael Daegan Fuss

The Wynant James Williams Prize

Daniel Lennon
Zhemin Zhang

The Harold N. Trevett Award

Garrett Gagnon
Luke Williams

Jerry Dziuba Graduate Service Award

John Higham

Steve Dombrowski Undergraduate Service Award

Michael Awad
Sathya Ramesh

Constellation Energy Scholarship

Eric Carson
Francisco Sandoval

Dr. Alireza Seyedi ’99, ’04 Teaching Assistant Award

Hao Lu
Eric Segerstrom

ECSE Graduates and Students Enjoy Outstanding Placements in 2022-2023

Graduates and students of the ECSE program enjoyed another year of outstanding industry placements during 2022-2023 for post-graduation employment, as well as co-ops and internships. Marquee corporate names appearing on this year’s placement list include Lockheed Martin Space, Microsoft, Boeing, SpaceX, Mitsubishi Electric Power Products, and many other recruiters representing an impressively broad range of industries and economic sectors.

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