inside ECE

2021 Year in Review

ECE Strategic Plan

STRATEGIC PLAN

PEOPLE POWERING INNOVATION

ECE ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

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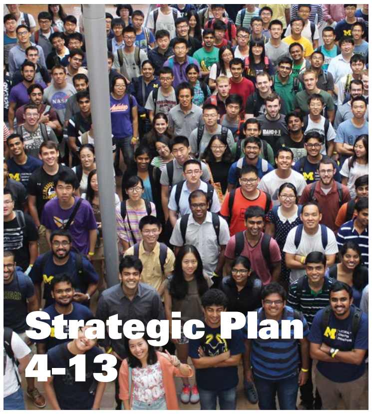

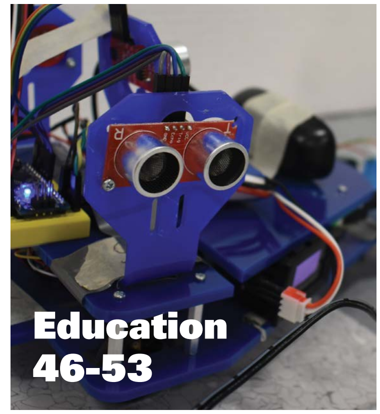
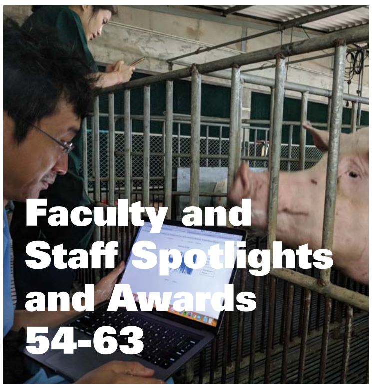
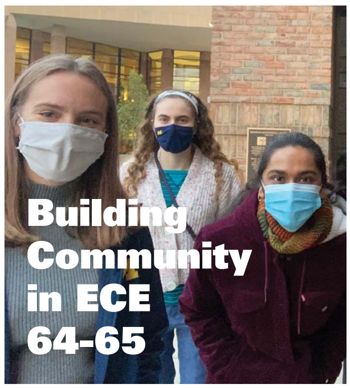

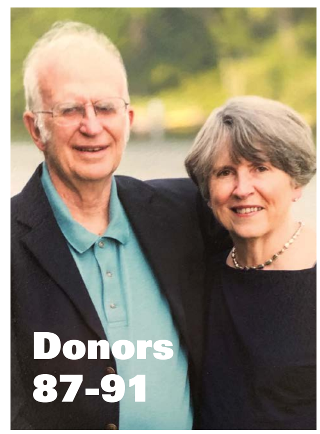


ELECTRICAL AND COMPUTER ENGINEERING

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A Look at ECE TODAY

People

Tenure/Tenure-Track Faculty	70
Research Scientists	16
Lecturers	4
Postdoctoral Researchers	44
Visiting Researchers	19
Staff	65
Alumni	19K+

Undergraduate Students (Fall 21)

Bachelor's: EE	295
Bachelor's: CE	309

Graduate Students

Master's: ECE	582
PhD: ECE	273

Faculty Honors

Professorship Titles	23
Fellow Titles	65
Young Faculty Awards	61
Education Awards	61
NAE Members	5 active/5 living emeritus
National Academy of Inventors	3
Nobel Prize	1

Tech Transfer (FY21)

U.S. Patents	43
Invention Disclosures	69
License Agreements	30
Startups Since 2010	31

Degrees Awarded (AY 20)

Bachelor's: EE	99
Bachelor's: CE	97
Master's: ECE	245
PhD: ECE	50

Research Expenditures (FY21)

$49.9M

Top 10 Programs at U-M

>100

Rankings: U.S. News & World Report

Undergraduate Programs

– Electrical Engineering	5
– Computer Engineering	7

Graduate Programs

– Electrical Engineering	7
– Computer Engineering	5

STRATEGIC PLAN

Electrical and Computer Engineering (ECE) is the technological foundation of modern society. It is the unseen force behind today's intelligent systems, and with its impact on clean energy, precision health, cybersecurity, autonomy, communications, the quantum revolution and more, ECE holds the key to solving many of society's most pressing problems.

Michigan ECE is proud to be part of a worldwide community of passionate researchers and educators that are continuing to push the boundaries of what is possible. We have brilliant, motivated students, world-class faculty with wide-ranging expertise, and highly committed staff. Our 18K+ game-changing alumni established the Information Age (Claude Shannon) and forever changed our access to information (Google co-founder Larry Page). Others are running some of the world's biggest companies (Steve Mollenkopf, former CEO, Qualcomm, and Rick Wallace, CEO, KLA), starting new companies, developing transformative technology, and teaching at the best schools all over the world.

Throughout its history, Michigan ECE has maintained close ties with industry. We are leaders in the generation of intellectual property leading to technology transition impacting our economy, health care, security, and environment.

To focus our efforts in the coming years for maximum continued impact, Michigan ECE has undergone a thorough strategic planning process.

We have identified three major areas of primary importance to the future of Michigan ECE:

- Research excellence and impact for a better society
- Education and enrichment for future leaders
- People-first culture for innovation, excellence, community

This strategic plan provides a general overview of recent achievements in each of these areas, as well as specific priorities for the future. Task forces composed of faculty, staff, and students will be working over the next several years to develop and implement specific initiatives to accelerate progress in each area.

Mingyan Liu
Peter and Evelyn Fuss Chair of
Electrical and Computer Engineering

PEOPLE POWERING INNOVATION

VISION

To exemplify the highest levels of creative innovation in education and research, working collaboratively to protect and enhance the public good.

MISSION

The mission of Electrical and Computer Engineering (ECE) at Michigan is to pursue the discovery, communication, education, and application of fundamental and applied principles of electrical and computer engineering, and to integrate these principles with other engineering, scientific, and medical domains to provide the greatest possible benefit to society.

VALUES

In pursuing its vision and mission, ECE at Michigan will:

- Pursue innovation in education and research to meet the changing needs of our students and society
- Emphasize creativity in education, research, and problem solving
- Promote and foster equity, diversity, and inclusion for all people in our teaching, research, and service to the community
- Strive for excellence in all that we do, practice the highest standards of professional ethics in advancing knowledge and technology, and do so with an awareness of environmental and social impact
- Bring a spirit of collaboration and partnership to every level of interaction
- Serve the university, the state, the nation, and the world by sharing our unique talents
- Prioritize professional growth of faculty, students, and staff to inspire lifelong learning

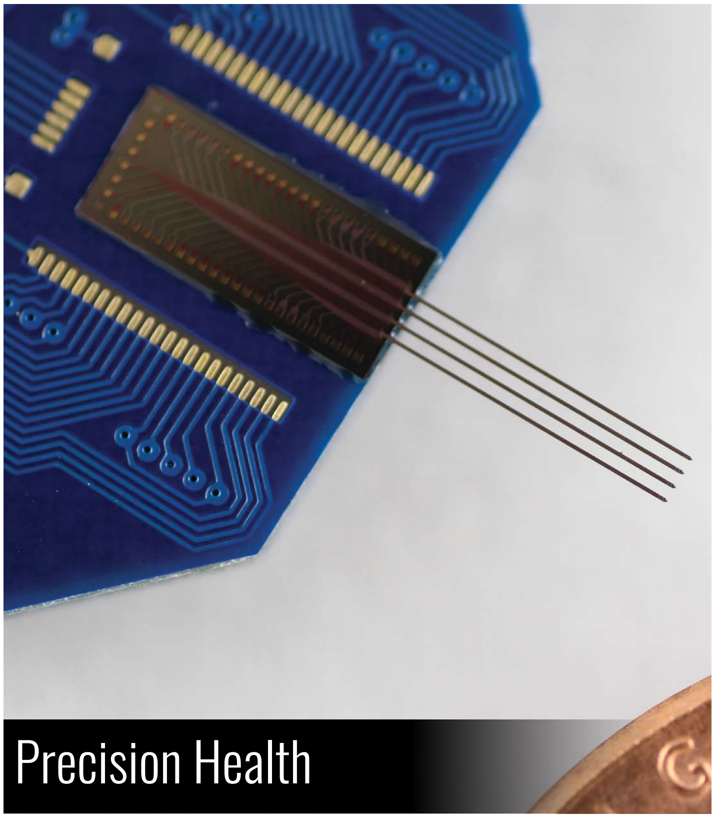
Michigan ECE leads a new program to produce clean chemicals and fuels using sunlight.

RESEARCH EXCELLENCE AND IMPACT FOR A BETTER SOCIETY

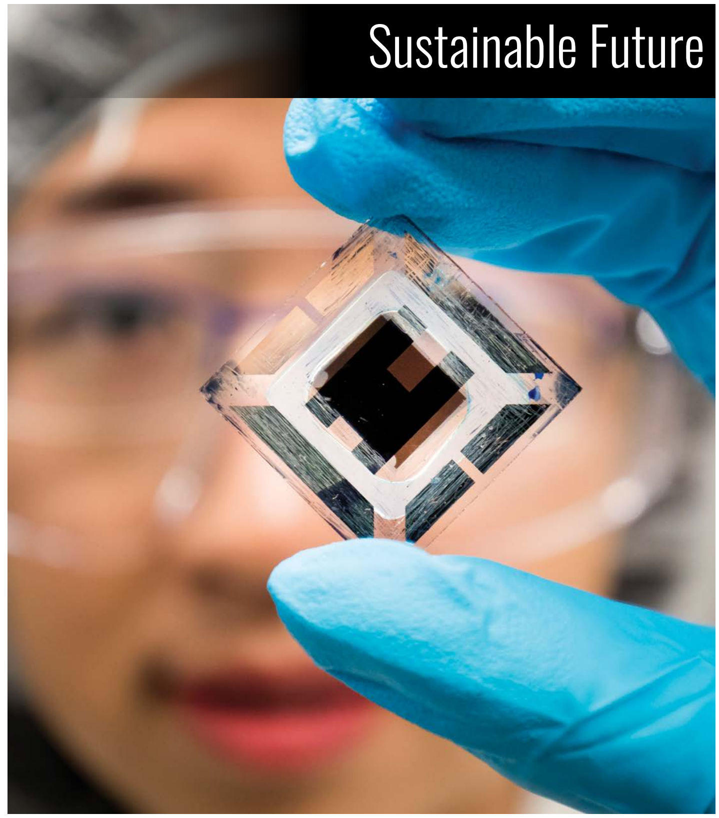
Electrical and Computer Engineering drives the technology of today and tomorrow. ECE is critical to future developments in areas such as precision health, autonomous systems, sensing systems, Internet of Everything, 5G and beyond, quantum computing, sustainable energy, post CMOS computing, and data science. Michigan ECE is looking to maximize our impact in these areas, as well as emerging areas in the future.

We have an excellent track record for impact. Our technology is evident in the marketplace, and Michigan ECE is one of the top producers of intellectual property within the University. We plan to expand our already strong relationships between faculty and industry to create tighter connections between research, academics, and societal impact.

Collaborative teamwork between groups with complementary expertise is critical to solving the grand challenges facing humankind. It's how the major breakthroughs by Michigan researchers have occurred. Continuing this legacy is important to achieving lasting and positive impact on our communities.



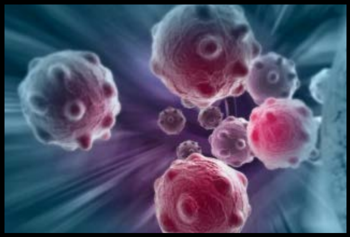
Neural probes equipped with LEDs tiny enough to target a single neuron are making it possible to demystify the brain.



This organic photovoltaic cell reached record-high efficiencies, paving the way for commercialization. These flexible and transparent solar cells can be built into windows of the future.

ECE researchers developed an augmented reality system to facilitate a life-sized version of air hockey where people of all physical abilities can play together.

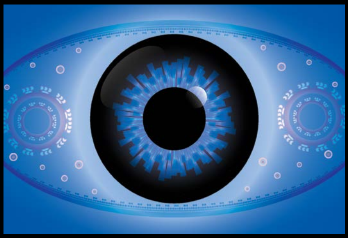
Mcity is the 32-acre playground for testing autonomous systems, one area of focus at Michigan ECE.



Monitoring cancer treatment

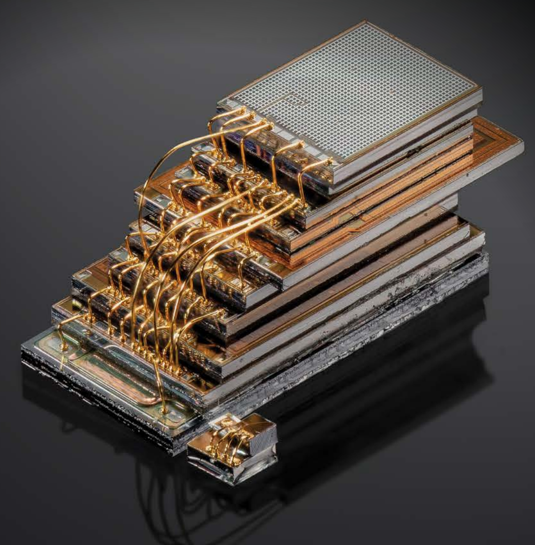
Island and forest ecosystems

Butterfly migrations and survival



Detecting glaucoma

The Michigan Micro Mote (the world's smallest computer) is a technological marvel on its own, but it was created to solve problems, like monitoring cancer treatment and conducting small animal studies. It is key to realizing the full potential of the Internet of Things.

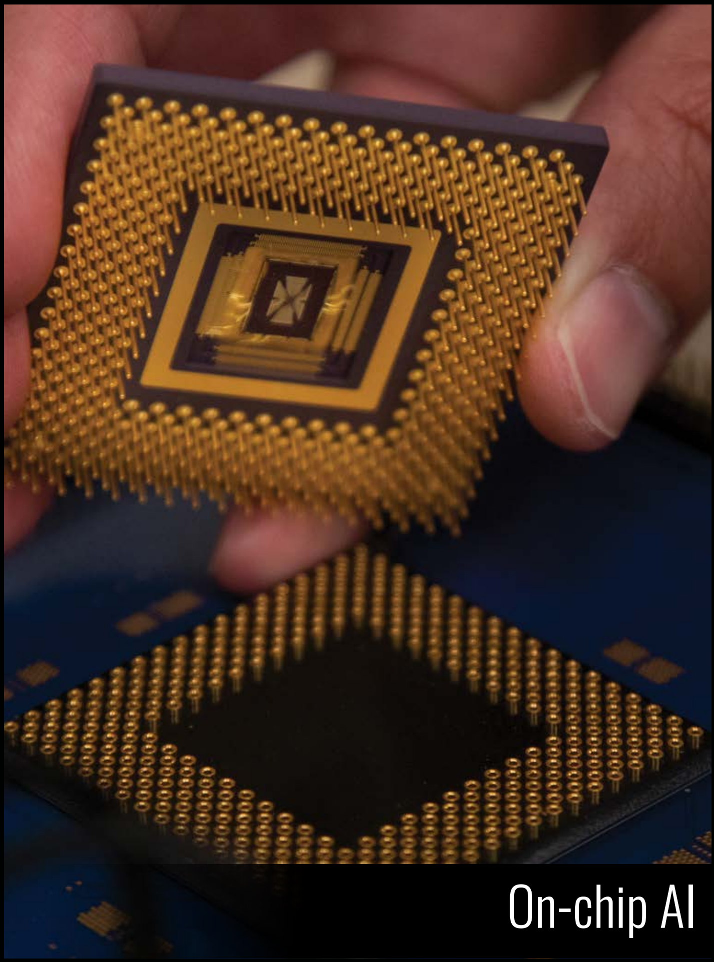


ECE is at the center of computing

From building the world's smallest computer, to designing next-generation quantum computers, and facilitating data processing on chip, at the edge, and in the cloud - Michigan ECE stands at the center of the computing revolution, and places this as a priority for the future.

Computing is at the center of ECE

Active 5G research includes bringing 5G to rural communities, designing advanced chips for Beyond 5G, improving secure and reliable computing, and more.



This memristor array chip runs three types of machine learning algorithms, which could lead to AI processing directly on smartphones or sensors.

ACCOMPLISHMENTS + INITIATIVES

- Contributions to twelve recent Multidisciplinary University Research Initiatives and Engineering Research Centers reflect our commitment to collaborative, interdisciplinary teamwork
- Inventors of the Michigan Micro Mote (the world's smallest sensing computer)
- World-class research in the Center for Wireless Integrated MicroSensing & Systems (WIMS2), revolutionizing research in neural probes, environmental monitoring, and smart stents
- Nobel Prize winning research at the Gérard Mourou Center for Ultrafast Optical Science, leading to bladeless Lasik surgery, record-breaking high-intensity lasers, and a new 3 PW laser ZEUS, to be the highest power laser in the U.S. and operated as an NSF user facility
- Wide-ranging and fundamental research in health, including cancer treatment, genomic sequencing, and medical imaging
- Groundbreaking research in sustainable energy sources through photovoltaics and artificial photosynthesis
- Best-in-class low-power lighting and displays
- Groundbreaking research in quantum devices and computing
- World-class research in wide bandgap semiconductor electronics, optoelectronics, and nanotechnology
- Innovative research in communications and networks: 5G, 6G+, edge computing, IoT
- World-class contributions to radar remote sensing of environment
- Forward-looking research in smart energy distribution
- Record-breaking and fundamental research in robotics, autonomous systems, and cyber-physical systems
- Leadership in ECE education research
- World-class facilities and research labs, including the Lurie Nanofabrication Facility

STRATEGIC PLAN PRIORITIES

- Continue to excel in areas of research with positive societal impact
- Focus new faculty hiring in computing
- Expand relationships with industry
- Support and encourage interdisciplinary and multidisciplinary research
- Plan a new research building dedicated to ECE physical layer work to centralize work in nanotechnology, optics, electromagnetics, and more

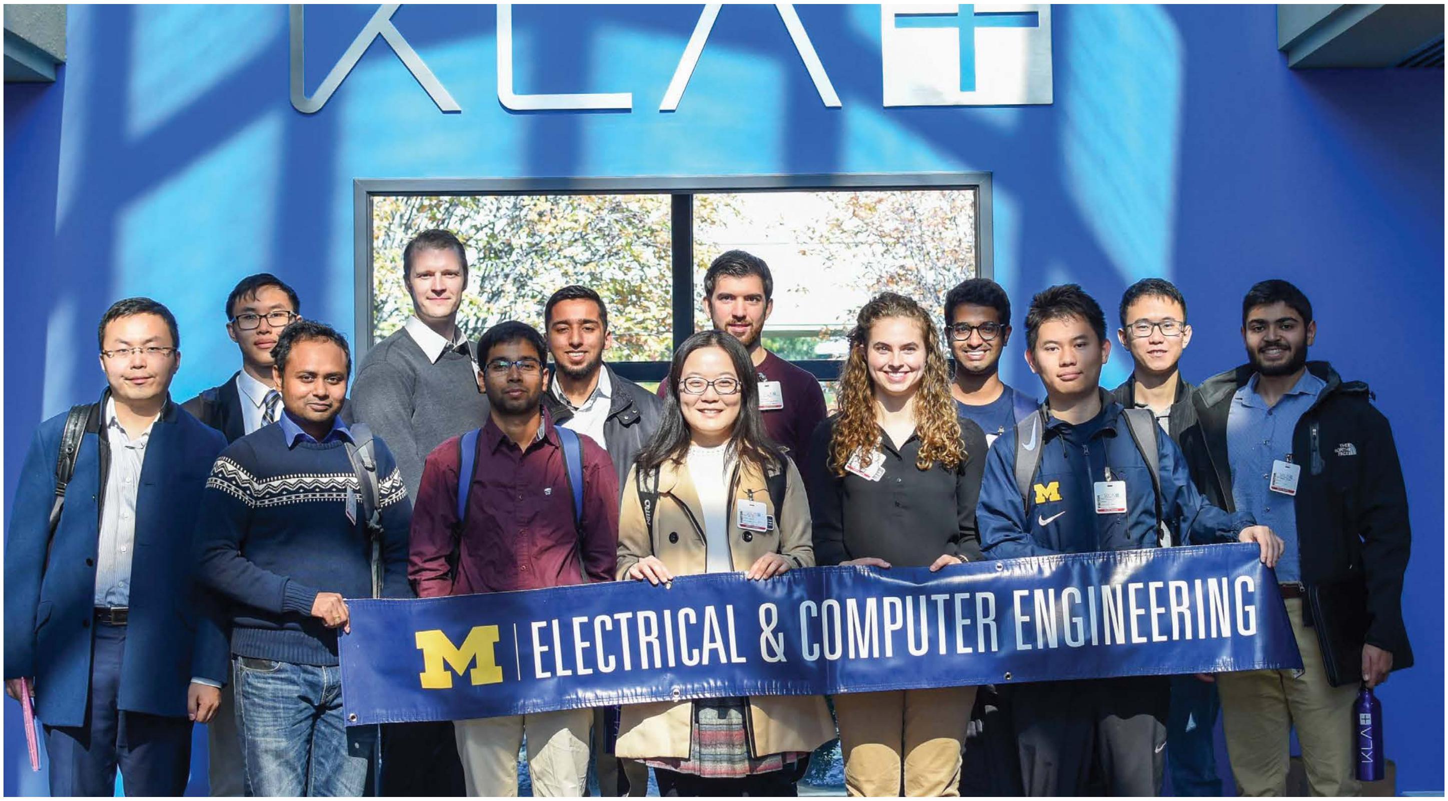
These ECE students are participating in the student group GRID Alternatives Students for Sustainable Energy, which sends students to underprivileged communities around the world to install solar panels to provide clean, affordable energy to homes and communities.

EDUCATION AND ENRICHMENT FOR FUTURE LEADERS

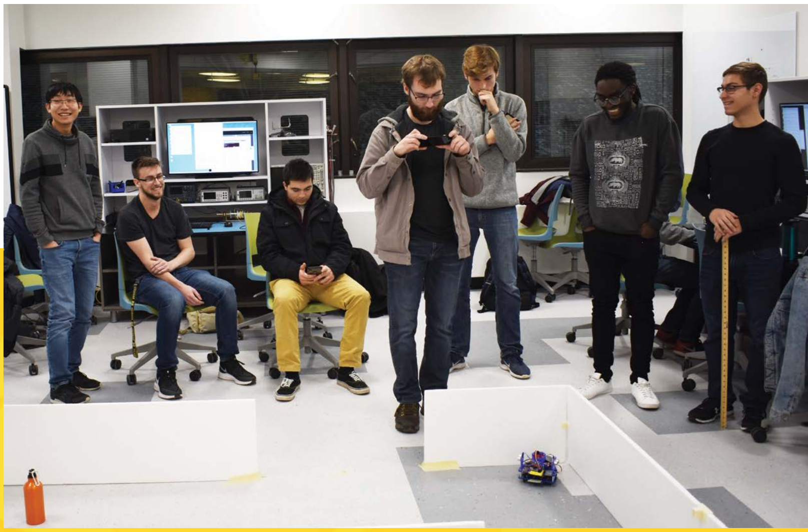
Today's students are more dedicated than ever to work on problems with positive societal impact, and they want hands-on experiences both in and out of the classroom. ECE offers a rich combination of learning experiences that begin in the classroom and extend far beyond, producing students who are global citizens and leaders.

ECE students contribute their unique training and skills to a wide variety of interdisciplinary student teams. They work with others in multidisciplinary design projects, often sponsored by industry. They work with faculty on research projects, and acquire the knowledge to help bring world-changing technology to society. ECE is also developing online learning programs suitable for pre- college to seasoned professionals to democratize education on a global scale.

A key initiative for the future is expanding the focus on computational skills throughout our educational programs.



ECE students get exposure to different companies and learn about the day-to-day life of an electrical and computer engineer through the ECE Expeditions program.



Electrical Engineering System Design I is the first of two new required undergraduate courses in electrical engineering focusing on engineering design, using an autonomous platform with a societally-relevant challenge.

ACCOMPLISHMENTS + INITIATIVES

- New Master's of Engineering degree for industry-focused students
- New continuing online learning program, called Continuum
- Newly updated undergraduate curriculum focusing on engineering design and social impact
- Successful implementation of a free textbook initiative for undergraduate students
- New opportunities for multidisciplinary design projects
- Initiated the ECE summer camp, Electrify, for pre-College students
- Focused efforts on entrepreneurial thinking and opportunities
- New programs to support student professional development
- New courses in computational data science, machine learning, artificial intelligence, quantum computing, software defined radio, big data, cybersecurity, and energy
- New Exploring ECE Graduate School Workshop to encourage undergraduate students to consider graduate school
- New focus on identifying teaching practices to support a more diverse student body
- Expanded relationships with Historically Black Colleges and Universities

STRATEGIC PLAN PRIORITIES

- Increase computational tools and thinking throughout the curriculum, both within existing courses and in new courses
- Expand opportunities for student research and student internships
- Support and incentivize at-home learning and non-classroom education
- Develop graduate course in professional ethics
- Enhance what we do to train students to communicate and lead teams
- Increase student fellowships

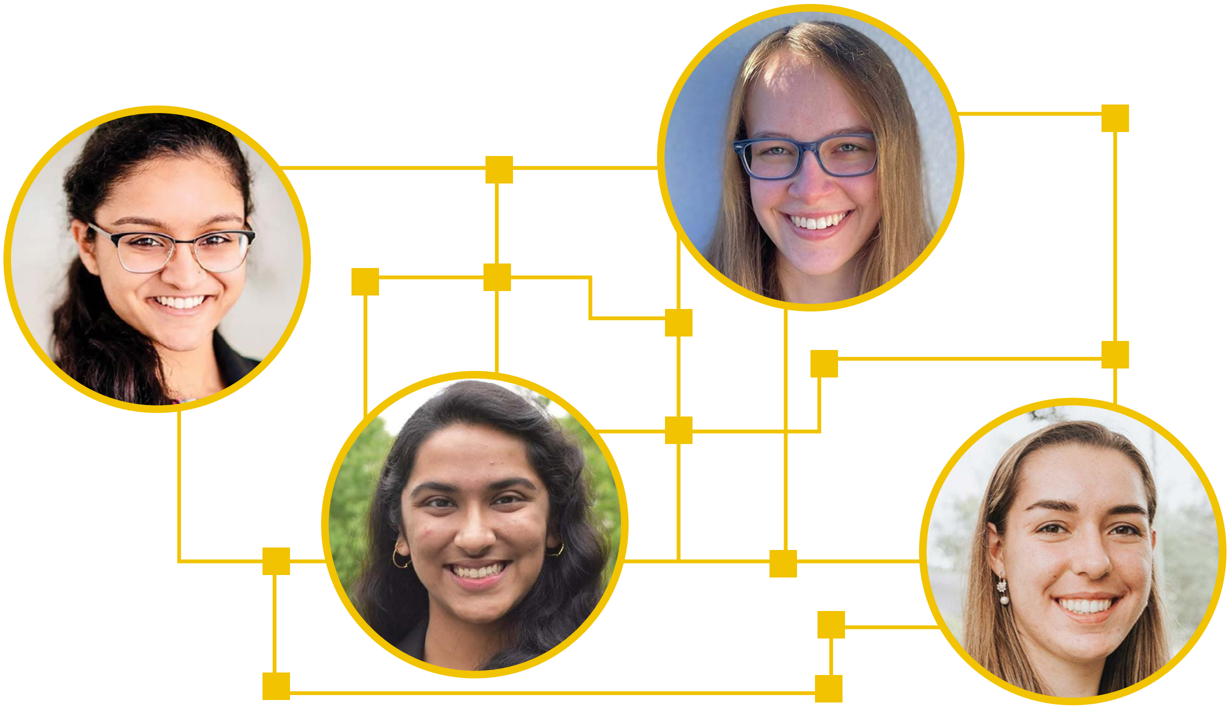
PEOPLE-FIRST CULTURE FOR INNOVATION, EXCELLENCE, COMMUNITY

People power innovation, and ECE is laser-focused on providing an environment that empowers all its people to be their best and most creative selves. This can only be achieved in a diverse and inclusive environment.

Michigan ECE has implemented a wide variety of programs and initiatives focused on improving connections between and among faculty, students, staff, and alumni.

While continuing those efforts, our faculty will be working together to make changes that allow them greater freedom to pursue individual passions in a transparent and supportive environment.

For all our people, we encourage a culture of entrepreneurship and innovation, where failure is expected and success celebrated.



WECE

Women in ECE (WECE) is a new student-run, diversity-focused organization dedicated to the personal and professional growth of those committed to innovation and excellence in ECE fields.

More than 250 students had a hand in launching a cubesat into space in 2021, testing the feasibility of a new propulsion method that could enable very small satellites to move around space without carrying fuel.

ACCOMPLISHMENTS + INITIATIVES

- Special programs promoting entrepreneurship and innovation
- Improved mentoring of new and young faculty members
- Enhanced onboarding programs for new graduate students
- New faculty and staff training in issues of diversity, equity, and inclusion
- Student-focused events celebrating individual cultures (including Diwali, Lunar New Year, Nowruz, Iftar, LGBTQ+ Spirit Day, and International Women's Day)
- Work-life balance improvements for faculty and staff
- ECE Expeditions: connecting students with ECE companies
- Recognition of alumni, staff, and students through newly-created awards and honors
- New committees to support diversity, positive community, and non-curricular student education
- New staff hires to support alumni engagement and student recruiting

STRATEGIC PLAN PRIORITIES

- Enhance freedom for faculty to explore new areas and focus on individual priorities
- Continue efforts to improve diversity, equity and inclusion for faculty, students and staff
- Empower ECE people (faculty, students, staff) to explore their passions and be their best both individually and through collaborative partnerships
- Attract and retain the best students from diverse backgrounds to Michigan ECE by providing a welcoming and supportive environment where students of all backgrounds can thrive

Working Together to Make Big Things Happen

We bring a collaborative spirit to the interdisciplinary teamwork needed to find innovative solutions to tough problems.

One example of this is our participation in twelve Multidisciplinary University Research Initiatives (MURIs) and Engineering Research Centers over the past eight years - working with 30 other institutions and total funding for all institutions of more than $85M. These projects involve groundbreaking research in information networks, dynamic systems, AI, electromagnetic transmission, light energy, high power lasers, artificial photosynthesis, new materials from plasma, photonics, adaptive systems, and cellular metamaterials.

2021 Lead PI: Zetian Mi, Michigan
Michigan ECE: Ted Norris

MURI: Tunable III-Nitride Nanostructures for N≡N and C-H Bond Activation

The goal of this MURI is to provide a new, inexpensive method, using a process that involves solar photocatalysis, to produce clean chemicals and fuels such as green hydrogen and methanol utilizing solar energy.

2021
Lead PI: Mario Sznaier, Northeastern
Michigan ECE: Necmiye Ozay

MURI: Control and Learning Enabled Verifiable Robust AI (CLEVR-AI)

The goal of this MURI is a new neurally inspired framework for learning and control, where insights from dynamical systems are used to design verifiable and safe machine learning algorithms, and insights from machine learning and neuroscience are used to design the next generation of learning-enabled control systems.

2020 Lead PI: Peter Bruggeman, Minnesota
Michigan: Mark Kushner (ECE),
Sujo Linac (ChemE)

MURI: Plasma Driven Solution Electrochemistry

Combining plasmas with conventional solution electrolysis opens the possibility of new non-equilibrium reactions to synthesize new classes of materials – super-hard alloys and complex polymers. This MURI is focused on investigating these unique plasma-driven processes.

2018
Lead PI: Mingyan Liu, Michigan
Michigan: Michael Wellman (CSE)

MURI: Multiscale Network Games of Collusion and Competition

The goal of this MURI is to develop tools to understand and shape online and on-the-ground networks that drive human decision making, focusing on areas such as international diplomacy, street crime, cyber-terrorism, military strategy, financial markets and industrial supply chains.

2019 Lead PI: Andrea Alù, CUNY
Michigan ECE: Anthony Grbic

MURI: Magnet-Free Non-Reciprocal Metamaterials Based on Spatio-Temporal Modulation

The goal of the MURI is to introduce and develop novel ideas and revolutionary concepts to model, design, analyze, fabricate and characterize magnet-free non-reciprocal metamaterials for the next generation of integrated electromagnetic and photonic systems.

2018
Lead PI: Uwe Kortshagen, Minnesota
Michigan: Mark Kushner (ECE),
Angela Violi (ME)

MURI: New Materials from Dusty Plasmas

This MURI is investigating methods to make new materials using plasma-synthesized nanoparticles, for applications ranging from energy, sensors, environment, health to defense.

2017 Center Director, David Bishop, Boston U.
Michigan ECE: Stephen Forrest, Thrust Leader

NSF Engineering Research Center in Cellular Metamaterials (CELL-MET)

The goal of this NSF ERC is to advance nano-bio-manufacturing methods that could lead to large-scale fabrication of functional heart tissue which could replace diseased or damaged muscle after a heart attack.

2017 Lead PI: Hui Deng (Physics), Michigan
Michigan ECE: Stephen Forrest, Zetian Mi

MURI: Room Temperature 2D Polaritronics with Van Der Waals Heterostructures

This MURI combines state-of-the-art fabrication capabilities with strong experimental and theoretical expertise on four core aspects of the project: polariton physics, 2D materials, photonic devices, and many-body physics in photonic and electronic systems.

2017 Lead PI: Igor Mezic, UCSB
Michigan ECE: Shai Revzen

MURI: From Data-Driven Operator Theoretic Schemes to Prediction, Inference and Control of Systems

This MURI team is developing a comprehensive theory that pertains not only to analysis of high dimensional systems, but also to inference from data, prediction and control for such systems. The Michigan team will focus on developing tools for linearization of hybrid systems both offline and on-the-fly, and application of these tools to the control of robots.

2016 Lead PI: James Eden, UIUC
Michigan ECE: Stephen Rand

MURI: Internal Cooling of Fiber and Disk Lasers by Radiation Balancing and Other Phonon Processes

Leaders in the fields of fiber lasers, laser cooling, rare earth-doped optical materials, and fiber fabrication have been assembled to pursue a new capability for cooling laser gain media at high power loadings to improve beam quality.

2015 Lead PI: Yorem Bresler, UIUC
Michigan ECE: Alfred Hero, Raj Nadakuditi

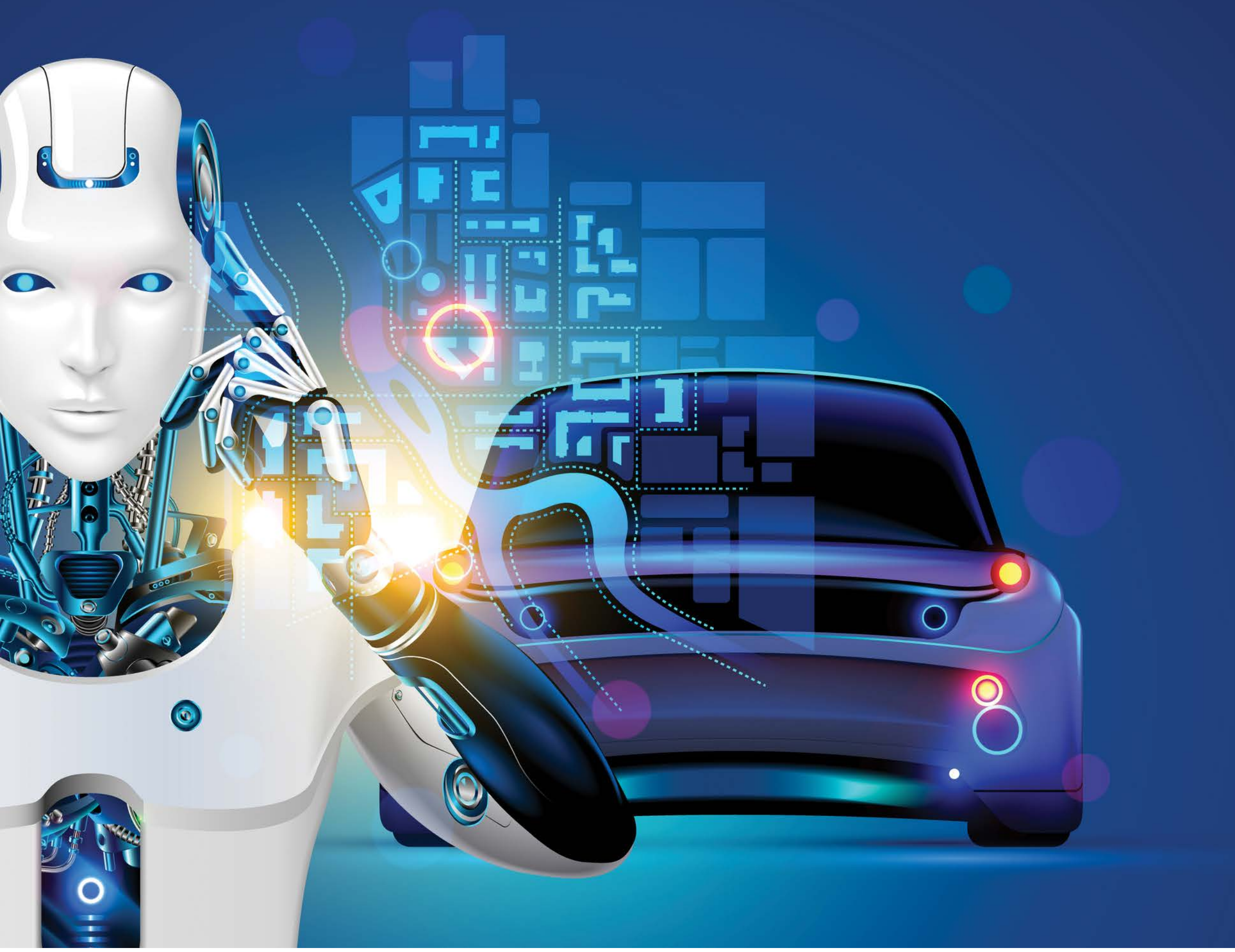
MURI: Adaptive Exploitation of Non-Commutative Multimodal Information Structure

The goal of this MURI is to develop a new information theory for data collection, analysis, and decision-making. Applications range from social network analysis to interactive machine learning with humans in the loop, such as brain computer/robot interfaces (BCI/BRI) or crowdsourcing.

2014
Lead PI: Stephen Rand, Michigan

MURI: Center for Dynamic Magneto-Optics (DYNAMO)

The objective of this MURI is to exploit dynamic magneto-optical processes and materials for new technological capabilities. Magneto-electric conversion should enable direct conversion of any kind of intense light into electricity, whether the input is in the form of sunlight, laser beams, or other forms of directed energy.



"This is an exciting project with important implications for the future of AI."
- Necmiye Ozay

New $7.5M MURI for CLEVR-AI

Autonomous vehicles are on the roads and improving all the time. Drones are expected to be used in healthcare, agriculture, weather forecasting, emergency response, monitoring systems and wildlife, and much more.

Researchers are in a race to make these autonomous dynamic systems safe and reliable – yet often use different techniques to achieve the desired results. The two leading approaches pull from the complementary areas of control theory and machine learning, with each approach informed by the latest advances in optimization and neuroscience.

With lives on the line, which is going to provide the best artificial intelligence (AI) solution?

Prof. Necmiye Ozay is the Michigan lead in a new $7.5M, five-year, four-institution MURI project that aims to take the best from both control theory and machine learning to create dynamic, intelligent systems that are safe, robust, and capable of performing complex tasks. The MURI title is "Control and Learning Enabled Verifiable Robust AI (CLEVR-AI)."

"We want a better understanding of where the middle ground is between control and machine learning," says Ozay. "When we take advantage of the powerful parts of both of these different areas, what can you expect to achieve?"

Ozay will attempt to reverse-engineer neural networks, assess when machine learning or control approaches are most appropriate, and develop a new AI theory combining both control theory and machine learning.

These studies will feed into a new and improved theory for artificial intelligence in dynamic systems, created by combining the most successful methods.

"We want to use control to make learning and AI more clever," Ozay said, "but we also want to use data to make control and formal methods better."

Test cases will be carried out at state-of-the-art testing facilities, including the University of Michigan's 10,000 sq. ft., four-story outdoor M-Air drone lab and the 32-acre Mcity facility, built for safe testing of the broad range of complexities automated and connected vehicles encounter in urban and suburban environments.

"We've been a very coherent group from the very beginning," said Ozay, "and we find new connections in each meeting. This is an exciting project with important implications for the future of AI.

The MURI Team

Northeastern University

Lead PI: Mario Sznaier, Dennis Picard Trustee Professor of ECE; Octavia Camps; Milad Siami; Eduardo Sontag, University Distinguished Professor

Johns Hopkins University

René Vidal, Biomedical Engineering; Noah J. Cowan, Mechanical Engineering

University of California, Berkeley

Peter Bartlett, Computer Science and Statistics

University of Michigan

Necmiye Ozay, Electrical and Computer Engineering

SUNNERGY: New $6.25M MURI for Breakthroughs In Renewable Energy

Prof. Zetian Mi is leading a new MURI, called SUNNERGY, consisting of a team from four institutions who are attempting to synthesize fuel and chemicals using the power of the sun. The entire process is known as artificial photosynthesis, and provides a pathway for sustainable energy independence. The MURI title is "Tunable III-Nitride Nanostructures for N=N and C-H Bond Activation."

"The fundamental process is considered the Holy Grail of renewable energy and sustainability," said Mi.

The process, which involves solar photocatalysis, is expected to provide a new, inexpensive method to produce clean chemicals and fuels such as green hydrogen and methanol utilizing solar energy. Solar photocatalysis uses the energy of the sun to accelerate a chemical reaction in materials into which a catalyst has been added. The process could also generate one of the most common fertilizer ingredients – even in remote locations.

Traditional artificial photosynthesis works by splitting ordinary fresh or salt water into hydrogen and oxygen, and then reducing carbon dioxide to hydrocarbons – all through the power of the sun. The new semiconductor based photocatalysts can offer much more, including novel photoelectrochemical reactions to turn natural gas to liquid chemicals and fuels.

Research in this area has been going on for some time, explains Mi. But to make it really work, there are three major challenges that still need to be overcome: efficiency, selectivity, and stability.

"To our knowledge," said Mi, "with our III-nitride nanostructures, we have demonstrated to date the most efficient artificial photosynthesis system capable of direct pure water splitting; the first photo-electrochemical water splitting device with over 3,000 hours of operation without any degradation; the first light-driven conversion of methane into aromatic compounds with selectivity >90%; and photo-reduction of nitrogen to ammonia under visible light at ambient temperature."

Building on these accomplishments, Mi's team aims to provide a single process that is efficient, selective, and stable enough to be a viable solution for society's needs.

"If we can build a semiconductor device to directly convert solar energy to a chemical fuel … we could address some of the most critical energy and environmental challenges of the 21st century."
- Zetian Mi

The team also plans to tweak the chemistry in a different direction, using nitrogen and water to make ammonia, a key ingredient in fertilizer.

Mi has been building an interdisciplinary team to realize the promise of his technology for a few years. Seed funding for early-stage research came from the University of Michigan College of Engineering, through the Blue Sky Initiatives program. Mi, as director of one of these grants, led a team of 11 faculty from several departments.

"If we can build a semiconductor device to directly convert solar energy to a chemical fuel, like what nature does with photosynthesis but with significantly higher efficiency, better stability, and very low cost, we could address some of the most critical energy and environmental challenges of the 21st century," said Mi.

The MURI Team

University of Michigan

Lead PI: Zetian Mi; Emmanouil Kioupakis, Materials Science & Engineering; Ted Norris, Gérard A. Mourou Professor of EECS

University of California at Santa Barbara

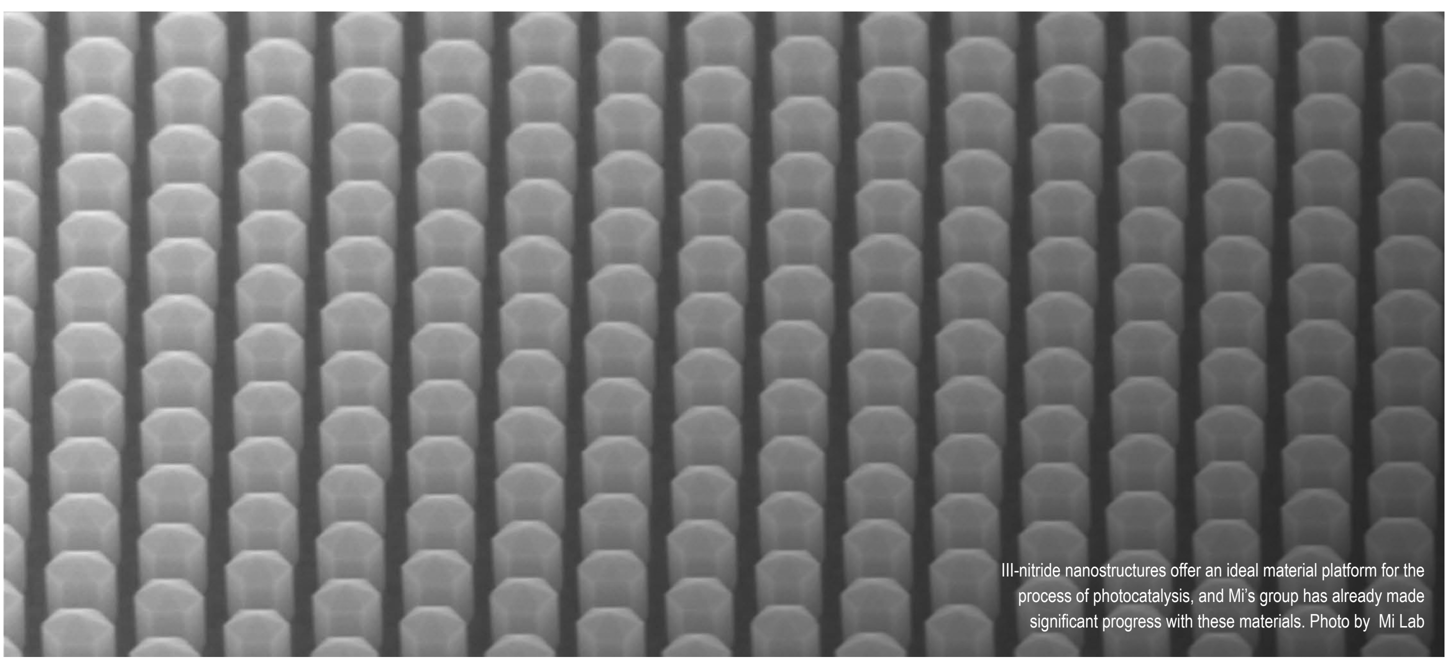
Phillip Christopher, Chemical Engineering

University of Illinois at Urbana-Champaign

Xiuling Li, Donald Biggar Willett Professor of ECE

Yale University

Victor Batista, John Randolph Huffman Professor of Chemistry



III-nitride nanostructures offer an ideal material platform for the process of photocatalysis, and Mi's group has already made significant progress with these materials. Photo by Mi Lab

$20M NSF AI-EDGE INSTITUTE AIMS TO TRANSFORM 5G AND BEYOND NETWORKS

Next-generation networks, including 6G and beyond, are changing how and where AI applications are trained and implemented. By providing much higher bandwidth, faster speed, lower latency, and broader coverage, next-generation networks invite a new way of configuring networks.

This is especially true at the edges of where most of the growth of network intelligence and distributed AI is expected. These edge networks will encompass mobile and stationary end devices, wireless and wired access points, and computing and sensing devices.

Professors Mingyan Liu and Lei Ying are core members of a newly-established $20M NSF AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE), led by The Ohio State University (OSU). AI-EDGE is expected to make AI more efficient, interactive, and secure for applications in sectors such as intelligent transportation, remote health care, distributed robotics and smart aerospace.

"The Michigan team will be developing theories and algorithms for AI-aware networks that deliver the right information at the right time and place to support distributed AI in dynamic, heterogeneous, and non-stationary wireless edge networks," said Liu. "We will also co-direct a substantial effort in education and workforce development aimed at the joint education in AI and networks."

"Our interest is to design new network architecture and algorithms that can support future AI applications and distributed intelligence," said Prof. Lei Ying, who will lead the research team focusing on Network Operation for Distributed AI-Applications.

Next-generation networks, including 6G and beyond, are changing how and where AI applications are trained and implemented.

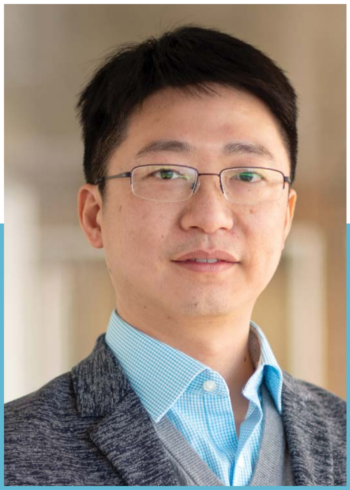
By providing much higher bandwidth, faster speed, lower latency, and broader coverage, next-generation networks invite a new way of configuring networks. This is especially true at the edges of where most of the growth of network intelligence and distributed AI is expected. These edge networks will encompass mobile and stationary end devices, wireless and wired access points, and computing and sensing devices.

"In the future, we envision we can move the intelligence from a centralized cloud center to distributed network edges," said Ying. The primary benefits of doing this are to satisfy the requirements of real-time applications, such as autonomous driving, and to enhance data security and privacy.

Another major challenge is to design a flexible network able to adapt to uncertain and changing conditions. While it may sound like this network would require massive resources, in fact they must also be able to service devices which are severely energy constrained, such as battery-powered IoT devices.

Ying's group has been doing related research looking at distributed computing in networks and how to do dynamic resource allocation in communication networks, but the scale has been smaller and the tasks relatively simple.

AI-EDGE is expected to create a research, education, knowledge transfer and workforce development environment that will help establish U.S. leadership in next-generation edge networks and distributed AI for many decades to come.



Mingyan Liu and Lei Ying are core members of the new $20M NSF AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE)

Ying believes that by being part of this Institute, with multiple groups working together in the same or complementary research topics, he and others can enable exciting applications to occur more quickly, while making the implementation easier.

As a member of several research specialties in AI-EDGE, Liu is looking to examine the implications of distributed AI on data security and privacy in these types of networks, and how to design more resilient distributed algorithms, a subject her group has been studying.

Educating the individuals who will power AI-EDGE advances is key to the Institute's ultimate success. As co-directors of Education & Workplace Development, Liu and OSU Professor Eylem Ekici plan to tackle this goal through a multi-pronged approach that focuses on curriculum development, engagement with industry, and outreach to middle and high school age students.

For a successful example of education at scale, Liu points to Michigan's graduate-level course Computational Data Science and Machine Learning. This course offers individualized attention while leveraging technology and teamwork to enable students from a wide variety of majors and backgrounds to succeed. In addition, Michigan ECE's online learning program known as Continuum is designed to reach thousands of learners from high school to seasoned managers looking to expand into new areas of technology.

Equity-centered engineering is central to Michigan Engineering's approach to education, and will be the guiding principle behind the development of AI-assisted teaching strategies that learn and adapt to individual student progress and engagement in AI-EDGE.

Hands-on learning in and out of the classroom combined with industrial collaborations is a focus of the ECE approach to student professional development, and will be central to a newly-developed curriculum focused on AI and edge networks.

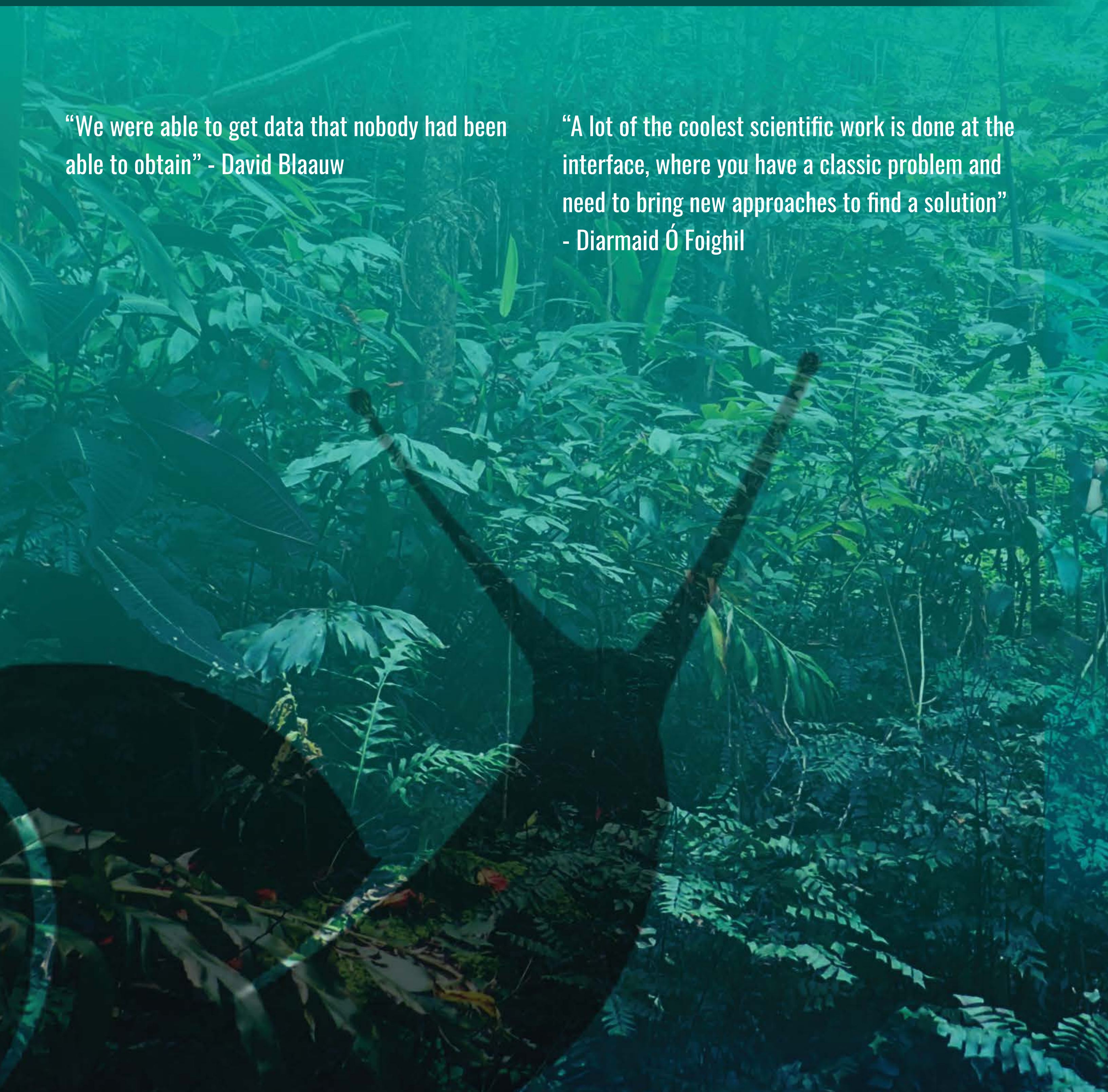
Finally, Michigan's team will work with other members of the Institute to help build excitement for engineering among middle and high school students through special online and in-person programming, such as the Electrify Tech Camp.

AI-EDGE is directed by The Ohio State University professor Ness Shroff, Ohio Eminent Scholar in Networking and Communications. In addition to Michigan and OSU, the Institute brings together researchers from Carnegie Mellon University, Northeastern University, Purdue University, University of Wisconsin-Madison, University of Texas-Austin, University of Washington, University of Massachusetts-Amherst, University of Illinois-Urbana-Champaign, and University of Illinois-Chicago, as well as three Department of Defense research labs and four global companies.

SNAILS CARRYING THE WORLD'S SMALLEST COMPUTER HELP SOLVE MASS EXTINCTION SURVIVOR MYSTERY

"We were able to get data that nobody had been able to obtain" - David Blaauw

"A lot of the coolest scientific work is done at the interface, where you have a classic problem and need to bring new approaches to find a solution" - Diarmaid Ó Foighil



A Rosy Wolf Snail *(Euglandina rosea)* marked and equipped with an M^3 in the Fautaua-Iti Valley site in Tahiti. Photo: Prof. Inhee Lee

More than 50 species of tree snail in the South Pacific Society Islands were wiped out following the introduction of an alien predatory snail in the 1970s, but the white-shelled *Partula hyalina* survived.

Now, thanks to a collaboration between biologists and engineers, scientists understand why: *P. hyalina* can tolerate more sunlight than its predator, so it was able to persist in sunlit forest edge habitats.

“We were able to get data that nobody had been able to obtain,” said David Blaauw, the Kensall D. Wise Collegiate Professor of EECS and co-developer of the Michigan Micro Mote (M^3). “And that’s because we had a tiny computing system that was small enough to stick on a snail.”

Most ecology and conservation studies involving data from sensors are done on vertebrate animals, which can carry larger and heavier devices than invertebrates. The current study not only offers insights into the conservation measures needed to ensure the survival of a species of snails, it points the way for future studies of very small animals through similar partnerships.

“A lot of the coolest scientific work is done at the interface, where you have a classic problem and need to bring new approaches to find a solution,” said Diarmaid Ó Foighil, professor of Ecology and Evolutionary Biology (EEB) and Curator of the U-M Museum of Zoology.

How Society Island Snails Were Wiped Out

The giant African land snail was introduced to the Society Islands, including Tahiti, to cultivate as a food source, but it became a major pest. To control its population, agricultural scientists introduced the rosy wolf snail in 1974. But unfortunately, most of the 61 known species of native Society Islands tree snails were easy prey for the rosy wolf snail. *P. hyalina* is one of only five survivors in the wild. Called the “Darwin finches of the snail world” for their island-bound diversity, the loss of so many *Partula* species is a blow to biologists studying evolution.

Ó Foighil and Bick hypothesized that *P. hyalina’s* distinctive white shell might give it an important advantage in forest edge habitats, by reflecting rather than absorbing light radiation levels that would be deadly to its darker-shelled predator. To test their idea, they needed to be able to track the light exposure levels *P. hyalina* and rosy wolf snails experienced in a typical day.

Bick and Ó Foighil wanted to attach light sensors to the snails, but a system made using commercially available chips would have been too large for their purposes.

Matching the Technology to the Application

“In 2015, I was looking around to see who had the technology capable of tracking snails, and discovered that the people who can do this are also at Michigan. It was serendipitous,” said Cindy Bick, who received a Ph.D. in EEB from U-M.

The system Bick found online was the M^3, created to go where other sensing devices could not. Measuring just 2x5x2mm, including packaging, it could be used to track animals the size of the rosy wolf snail (with an adult shell 3-7cm) in their natural habitat.

But could it be altered to sense light? It was time to move the M^3 from the laboratory to the real world and adapt it for the special needs of their collaborators.

“It was important to understand what the biologists were thinking and what they needed,” said Inhee Lee (PHD ECE 2014), assistant professor of Electrical and Computer Engineering at the University of Pittsburgh.

Lee adapted the M^3 for the study.

“The sensing computers are helping us understand how to protect endemic species on islands.” - Cindy Bick

A *Partula hyalina* snail resting on a wild red ginger leaf next to an M^3 in a forest edge habitat in Tahiti. Photo: Prof. Inhee Lee

“It was important to understand what the biologists were thinking and what they needed.” - Inhee Lee

Tahitian Experiments

After local testing enabled by local Michigan snails, 50 M^3s made it to Tahiti. They were attached to the rosy wolf snails, and placed next to the *P. hyalina* snails, because of their status as a protected species.

The data revealed a dramatic difference in how much sun reached the habitats of the surviving *P. hyalina* as opposed to the rosy wolf snail. During the noon hour, the *P. hyalina* habitat received on average 10 times more sunlight than the rosy wolf snails. Specifically, the average light intensity reached 7,674 to 9,072 lux for the *P. hyalina* habitat, but only 540 to 762 lux for the rosy wolf snail.

The researchers suspect that the rosy wolf doesn’t venture far enough into the forest edge to catch *P. hyalina*, even under cover of darkness, because they wouldn’t be able to escape to shade before the sun became too hot.

Model for Future Collaborations Between Biologists and Engineers

The success of this project broke new ground from the perspective of the engineers as well as the biologists.

“It’s underappreciated how large a step it is to go from the lab into the field and get meaningful data,” said Blaauw. “It’s essential to achieve success in order to propel the technology forward, but it takes a great deal of trust among the collaborators.”

“The M^3 really opens up the window of what we can do with invertebrate behavioral ecology,” said Ó Foighil, “and we’re just at the foothills of those possibilities.”

Cindy Bick and Inhee Lee working in the field in Tahiti.

Empowering the Wireless Systems of the Future

Prof. Elaheh Ahmadi was awarded a $1 million contract from the Defense Advanced Research Projects Agency (DARPA) to design a new kind of semiconductor that can empower the sensor and communication systems of the future.

“We are living in an era where communications are becoming more and more wireless, so we need devices that can provide high power at high frequency to enhance the communications infrastructure,” Ahmadi says. “We’re hoping to create the building blocks for these devices.”

Conventional semiconductors are limited in their ability to provide high power at high frequencies, which makes it difficult to advance beyond 5G. In the era of the Internet of Things (IoT), artificial intelligence and autonomous vehicles, there is an urgent need for high-power and high frequency transistors that can facilitate ultra-fast, highly reliable, and low latency wireless networks.

To serve the RF applications of the future, new transistors are needed which can provide a combination of high power density and high efficiency at high frequencies. Ahmadi is looking to create a hybrid semiconductor that literally combines the best of a variety of materials to achieve performance beyond the roadmap of any one semiconductor. She plans to mix Gallium Oxide with dissimilar materials to overcome the limitations of traditional Gallium Nitride transistors.

“It’s a very high-risk project, but it could produce breakthrough performance for beyond-5G applications,” Ahmadi says. “I’m excited to see what happens.”

Advancing Low-Power Speech Recognition

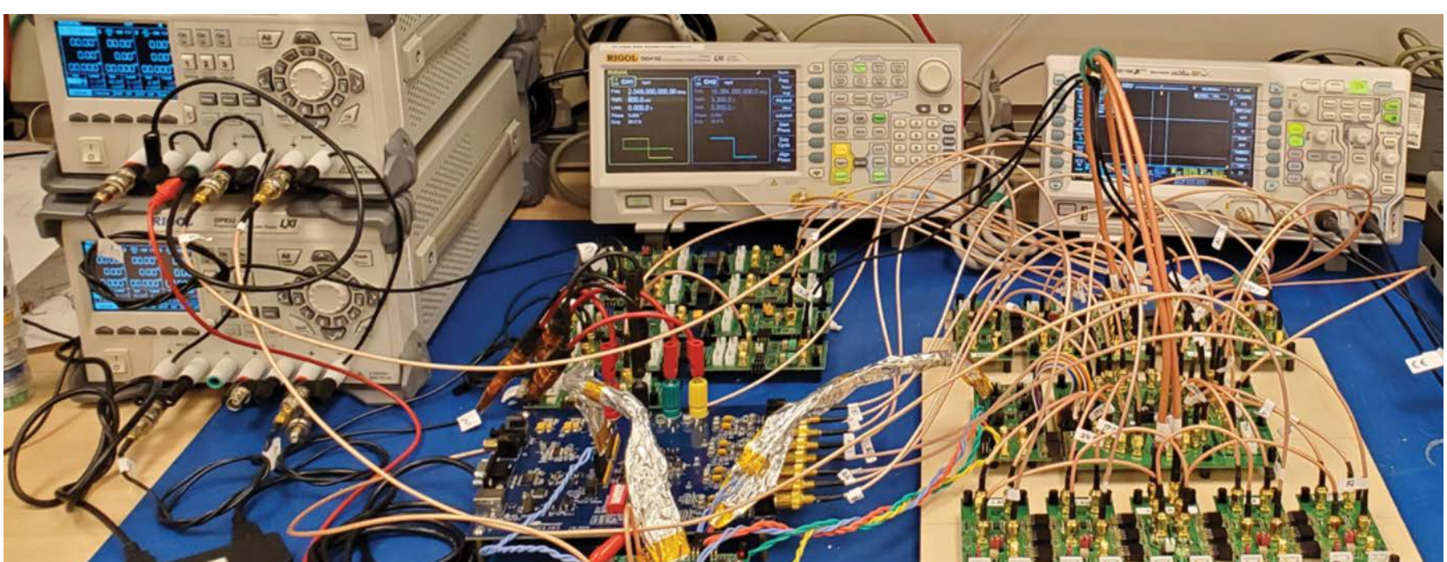
Prof. Michael Flynn is applying his breakthrough technology in beamforming to reduce the energy cost and die area for speech recognition by an order of magnitude. He has already developed a single chip with 8 high-fidelity ADCs, beamformer, and feature extraction that runs on less than 3mW, and plans to add a neural network to the chip.

Speech recognition technology allows individuals to control smart devices or receive information from the Internet with applications such as Microsoft’s Alexa. Alexa works by using a device called an Echo to listen for the appropriate command, ie, “Alexa,” before acting on that command.

The Echo is a device measuring approximately four inches that includes four microphones. Once it perceives a command, it sends the data to the cloud to be processed. This takes significant power because the device is actually listening all the time. Those concerned with privacy may avoid the technology altogether.

So Flynn decided to tackle the problem of processing the data on-chip, rather than in the cloud. Such on-chip processing would require a sharp reduction in the power needed to accomplish several actions: zero in on the command, digitize it, and then do the speech processing required to interpret the command.

For this groundbreaking research, Flynn was one of 18 researchers recognized with the Intel 2020 Outstanding Researcher Award.



ENGINEERING EQUITY AND FAIRNESS

New technologies often greatly improve our world. They provide better medical care, increased accessibility, and more ways to stay connected to our loved ones. But, as science fiction fans know, technology can have a dark side. When engineers fail to address the harmful impacts of new technologies, or when they create technologies that only benefit the privileged, they can worsen socio-economic inequalities and end up causing more harm than good.

Our researchers are empowering engineers to prevent this harm by rooting out bias in AI and machine learning systems. We're applying technologies to mitigate social inequalities -- not worsen them. We're centering ethics in engineering education, and we're advancing inclusive teaching practices to better support neurodiverse and marginalized students.

Fairer AI For Long-Term Equity

Prof. Mingyan Liu

"There is an increasing awareness in the AI research community of the issue of bias," says Mingyan Liu, the Peter and Evelyn Fuss Chair of ECE. "There's a lot we need to learn if we want solutions that achieve equity in the long-term." Liu is one of the principal investigators on a new project, funded by NSF in partnership with Amazon, to help achieve this equity.

Called Fairness in AI, this project aims to identify and mitigate bias in AI and Machine Learning systems to achieve long-lasting equitable outcomes. It focuses specifically on automated or algorithmic decision-making that involves some level of human participation. This includes learning algorithms that are trained using data collected from humans, or algorithms that are used to make decisions that impact humans.

"We often have a lot of data for certain groups and less data for other groups, which creates bias," said Liu. "This bias means the product won't work as well for the underrepresented groups, and this can be very dangerous."

For example, facial recognition software is better at recognizing white faces than Black faces, which puts Black people more at risk for wrongful arrest. Job search platforms have been shown to rank less qualified male applicants higher than more qualified female applicants. Auto-captioning systems, which are important for accessibility, vary widely in accuracy depending on the accent of the speaker. Without mitigation, such bias in AI and ML systems can perpetuate or even worsen societal inequalities.

The project is a collaboration with lead institution UC Santa Cruz (UCSC), as well as Ohio State University and Purdue University.

Addressing Energy Insecurity in Detroit

Some Detroiters spend up to 30% of their monthly income on home energy bills, a sky-high rate that places the city among the Top 10 nationally in a category that researchers call household energy burden.

The COVID-19 pandemic has only worsened the situation, adding financial challenges that make it increasingly difficult for many low- and moderate-income residents to pay their utility bills.

A new University of Michigan project, in partnership with four Detroit community-based organizations, is looking to improve home energy efficiency and lower monthly utility bills for residents of low- and moderate-income (LMI) households. Energy insecurity often co-occurs with food insecurity — a phenomenon sometimes called the "heat or eat" syndrome — which can severely impact personal health.

The project is focused on three Detroit neighborhoods, Jefferson Chalmers, Southwest Detroit and The Villages at Parkside, and is funded by a $2.1 million grant from the U.S. National Science Foundation's Smart and Connected Communities program.

Prof. Johanna Mathieu

Prof. Tony Reames

"One goal of the NSF Smart and Connected Communities program is to engage directly with real communities, and I think this project is structured to accomplish just that, since the research goals and approaches are structured around real challenges faced by LMI households in Detroit," said Johanna Mathieu, an associate professor of EECS who is one of four principal investigators on the project.

U-M researchers will explore the possibility of reforming the utility rate structure to provide the basic electricity needs of LMI households for free while ensuring that the utility provider's costs are covered.

"Our premise is that energy is a basic human right," said project leader Tony Reames, an assistant professor of Energy Justice at the U-M School for Environment and Sustainability. "With a better understanding of energy consumption, we can determine if there is a free block of 'essential' energy that everyone should get—and if not everyone, then those least likely to be able to afford it."

The project is planned to take place over the next four years, and involves home visits and neighborhood focus groups. 30% of the funding goes to U-M's community partners in Detroit: Jefferson East Inc., Friends of Parkside, Southwest Detroit Environmental Vision, and Ecoworks. DTE Energy is also a partner.

Ethical Engineering in the Curriculum

Where does the power and responsibility lie when a company is developing technology that may be harmful to the public? A new National Science Foundation project aims to teach engineers that the responsibility lies with them—and empower them to take action.

Erin Cech, associate professor of Sociology, and Cindy Finelli, professor of ECE, are designing a new master's-level course to address what they view as a hole in the education of engineering students in the area of professional responsibility.

"It can be challenging to uphold your ethics," said Finelli, who also directs the graduate program in Engineering Education Research. "But we hope our course will not only help future professionals recognize situations that may negatively impact society, but will also help them identify and act on effective strategies to address those situations."

Prof. Cindy Finelli

Prof. Erin Cech

"It's such an important issue right now because we're seeing reports of inequalities built into the algorithms of surveillance technology, web searches and facial recognition—where engineers are at the forefront of processes that potentially reinforce and reproduce existing socio-demographic inequalities," said Cech.

Because today's technology is far more complicated than most non-engineers can understand, creating ethical engineers may be the public's first line of defense against products that are not fair to everyone.

"This effort will help promote better ethical responsibilities and will be useful for engineers across disciplines," said Finelli.

Embracing Neurodiversity in Engineering

A new study funded by the National Science Foundation aims to improve teaching practices in science, technology, engineering, and mathematics (STEM) education for college students with attention deficit hyperactivity disorder (ADHD). The researchers expect that it will ultimately improve education for many neurodiverse students—not just those with ADHD— and make the entire STEM field more inclusive.

"The study of students who have ADHD or other neurodiversity such as autism, dyslexia, and obsessive-compulsive disorder is missing from the field of higher education, so this is a really understudied population," said project leader Prof. Cindy Finelli.

Companies such as Dell Technologies, IBM, Hewlett Packard, Ford, and Microsoft have been expanding their hiring of individuals with neurodiversities such as ADHD. The result is a competitive advantage through "productivity gains, quality improvement, boosts in innovative capabilities, and broad increases in employee engagement."

"We believe that this study will potentially enhance STEM education, attract more students with ADHD to STEM, and increase the diversity of the future STEM workforce," said Finelli. "More specifically, we plan to come up with concrete faculty development activities that could be used to help instructors better support students with neurodiversity."

Prof. Laura Balzano

Prof. Hessam Mahdavifar

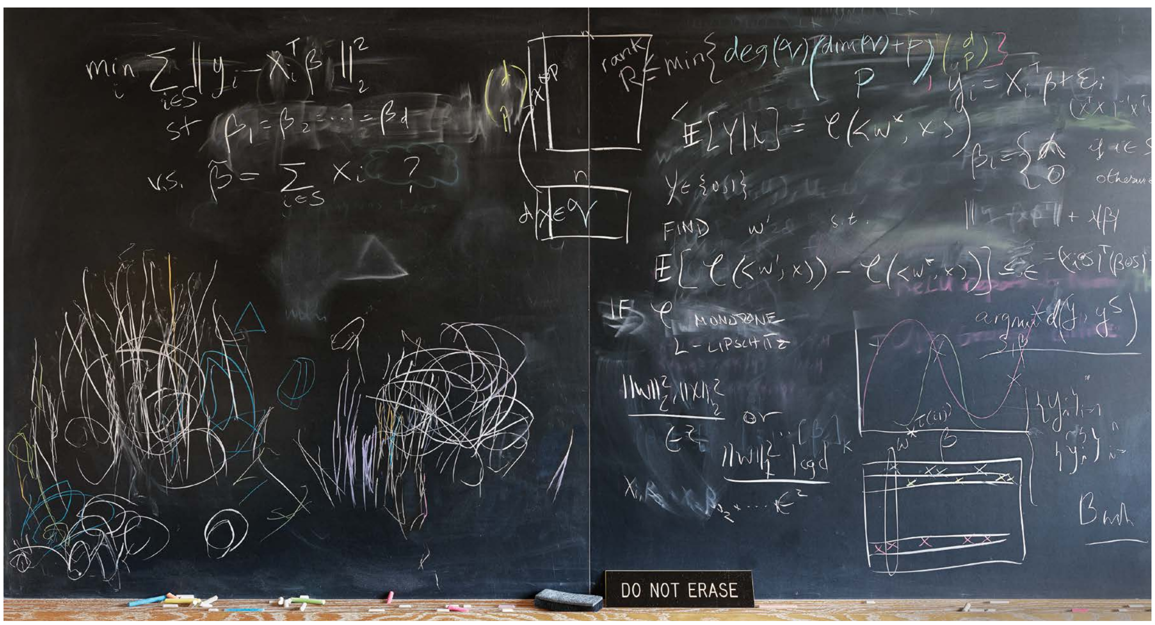
High-Performance Algorithms for Non-Real Data

A new research project led by Professors Laura Balzano and Hessam Mahdavifar will help revolutionize the data processing pipeline with state-of-the-art algorithms to optimize the collection and processing of any kind of data.

Algorithms available now are built for real data, meaning real numbers, however, most of the data we see on the internet is non-real, like discrete data, or categorical. The researchers will study randomized sketching and compression for high-dimensional non-real-valued data with low-dimensional structures.

“Randomized sketching and subsampling algorithms are revolutionizing the data processing pipeline by allowing significant compression of redundant information,” said Balzano. “Sketches work well because scientific data are generally highly redundant in nature, often following a perturbed low-dimensional structure. Hence, low-rank models and sketching that preserves those model structures are ubiquitous in many machine learning and signal processing applications.” The project is funded by the Department of Energy.

The Artistry of Mathematical Models



Balzano’s blackboard featured in Jessica Wynne’s “Do Not Erase” photography book.

To an engineer, a chalkboard is a tool for sharing ideas and brainstorming solutions to new and complex problems. Prof. Laura Balzano, for example, takes to the chalkboard to work through complex problems and brainstorm solutions with colleagues. But to Jessica Wynne, a professor of photography at the Fashion Institute of Technology, that same chalkboard is an artistic expression of human thought and ingenuity.

“When I’m looking at a chalkboard filled with math, I have the same sort of experience as when I’m looking at a great abstract painting,” Wynne said. “You feel the intensity of what’s shown on the board, but you can’t access the meaning. I really like that tension of being pulled in and pushed away at the same time.”

Wynne encountered one of Balzano’s chalkboards during their mutual stay at the Institute for Advanced Study, a place dedicated to liberating scholarly creativity.

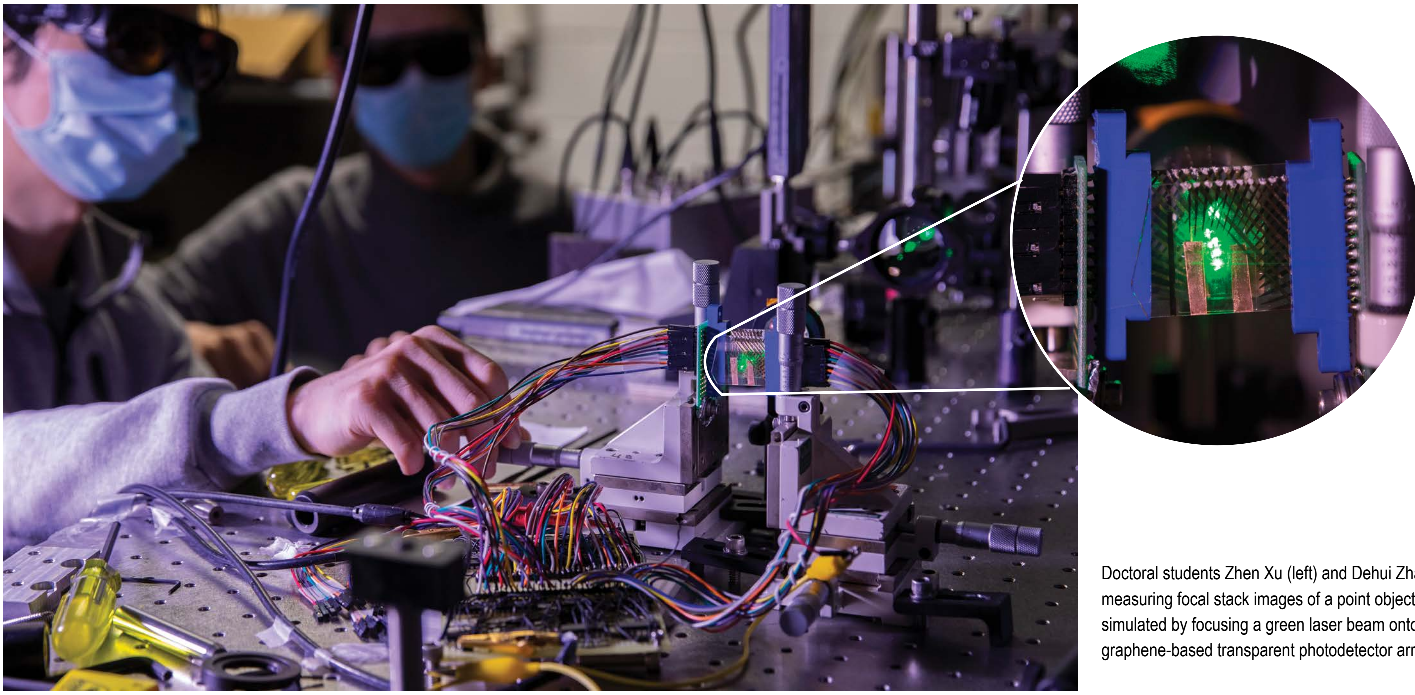
Balzano was exploring new approaches to modeling big data, specifically highly incomplete or corrupted data, uncalibrated data, and heterogeneous data. Her research focuses on the applications of such big, messy data in networks, environmental monitoring, and computer vision, which means much of her board is covered in complex mathematical equations that grapple with abstract theory and experimentation. This made her a perfect match for Wynne’s project.

“In general, ideas are hard to articulate, but that’s the amazing part of math – it’s a universal language,” Balzano said. “We’re able to come to a common understanding, and think about what we don’t yet understand, and where we could go with it together.”

When Wynne came to document Balzano’s board, it already featured sketches from three different collaborative projects in machine learning. The last section of the board, the lower left, was drawn by Balzano’s young daughter, aged two and half at the time. Despite its origins, it was just as compelling and meaningful to Wynne as the rest.

“I’m very interested in children’s art, for there’s so much freedom and exploration,” Wynne said. “To me, seeing it beside Laura’s equations really showed the experience of being a working mom. You know, bringing your child to work at the office, having them experience that with you. I thought it was really beautiful.”

Balzano’s blackboard became one of the featured pieces in Wynne’s photography book, *Do Not Erase*.



Doctoral students Zhen Xu (left) and Dehui Zhang measuring focal stack images of a point object simulated by focusing a green laser beam onto a graphene-based transparent photodetector array.

3D Motion Tracking System Could Streamline Vision for Autonomous Tech

A new real-time, 3D motion tracking system combines transparent light detectors with advanced neural network methods to create a system that could one day replace LiDAR and cameras in autonomous technologies. Future applications include automated manufacturing, biomedical imaging, and autonomous driving.

The imaging system exploits the advantages of transparent, nanoscale, highly sensitive graphene photodetectors developed by team co-leader Prof. Zhaohui Zhong and his group. They're believed to be the first of their kind.

"The in-depth combination of graphene nanodevices and machine learning algorithms can lead to fascinating opportunities in both science and technology," said ECE PhD student Dehui Zhang. "Our system combines computational power efficiency, fast tracking speed, compact hardware and a lower cost compared with several other solutions."

The graphene photodetectors in this work have been tweaked to absorb only about 10% of the light they're exposed to, making them nearly transparent. Because graphene is so sensitive to light, this is sufficient to generate images that can be reconstructed through computational imaging. The photodetectors are stacked behind each other, resulting in a compact system, and each layer focuses on a different focal plane, which enables 3D imaging.

But 3D imaging is just the beginning. The team also tackled real-time motion tracking, which is critical to a wide array of autonomous robotic applications. Hardware alone was not enough to produce the desired results.

They also needed deep learning algorithms. Helping to bridge those two worlds was ECE PhD student Zhen Xu. He built the optical setup and worked with the team to enable a neural network to decipher the positional information.

The neural network is trained to search for specific objects in the entire scene, and then focus only on the object of interest—for example, a pedestrian in traffic, or an object moving into your lane on a highway. The technology works particularly well for stable systems, such as automated manufacturing, or projecting human body structures in 3D for the medical community.

"It takes time to train your neural network," said project leader Ted Norris, the Gérard A. Mourou Professor of EECS. "But once it's done, it's done. So when a camera sees a certain scene, it can give an answer in milliseconds."

ECE PhD student Zhengyu Huang led the algorithm design for the neural network. The type of algorithms the team developed are unlike traditional signal processing algorithms used for long-standing imaging technologies such as X-ray and MRI. And that's exciting to team co-leader Jeffrey Fessler, the William L. Root Collegiate Professor of EECS who specializes in medical imaging.

"In my 30 years at Michigan, this is the first project I've been involved in where the technology is in its infancy," Fessler. "We're a long way from something you're going to buy at Best Buy, but that's OK. That's part of what makes this exciting."

The team demonstrated success tracking a beam of light, as well as an actual ladybug with a stack of two 4×4 (16 pixel) graphene photodetector arrays. They also proved that their technique is scalable. They believe it would take as few as 4,000 pixels for some practical applications, and 400×600 pixel arrays for many more.

While the technology could be used with other materials, additional advantages to graphene are that it doesn't require artificial illumination and it's environmentally friendly. It will be a challenge to build the manufacturing infrastructure necessary for mass production, but it may be worth it, the researchers say.

"Graphene is now what silicon was in 1960," Norris said. "As we continue to develop this technology, it could motivate the kind of investment that would be needed for commercialization."

The research is funded by the W.M. Keck Foundation and the National Science Foundation. Devices were fabricated in the U-M Lurie Nanofabrication Facility.

ECE Startup Memryx, Inc. Promises Faster, Cheaper AI Processing

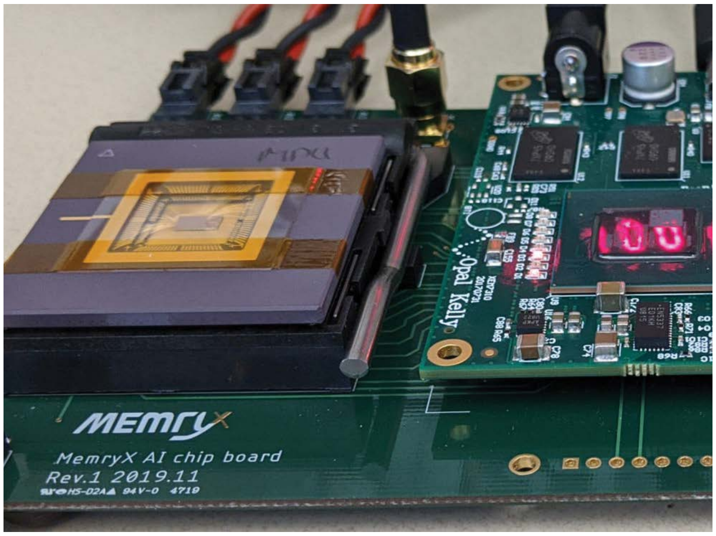
U-M ECE startup, MemryX, Inc., is developing a programmable AI accelerator chip that promises unmatched performance at relatively low power for high-performance applications, including autonomous driving, smart cameras for robots, smart manufacturing, and smart retail.

The company is currently focusing on edge computing applications where speed, power, cost, and security are paramount, though their technology is also scalable for use in large data centers. And their technology could save a company thousands of dollars per chip.

"Our devices are cheap and powerful, but not power hungry," said Prof. Wei Lu, company co-founder and current CEO.

The company's devices are specifically targeted at running neural networks, which drive AI.

"Neural networks are a disruptive technology used everywhere," said Mohammed Zidan, senior director of architecture at MemryX and Lu's former postdoctoral researcher. "However, classical architectures are not designed for this type of application."



Memory Processing Unit, 1st generation presented at CES 2020.

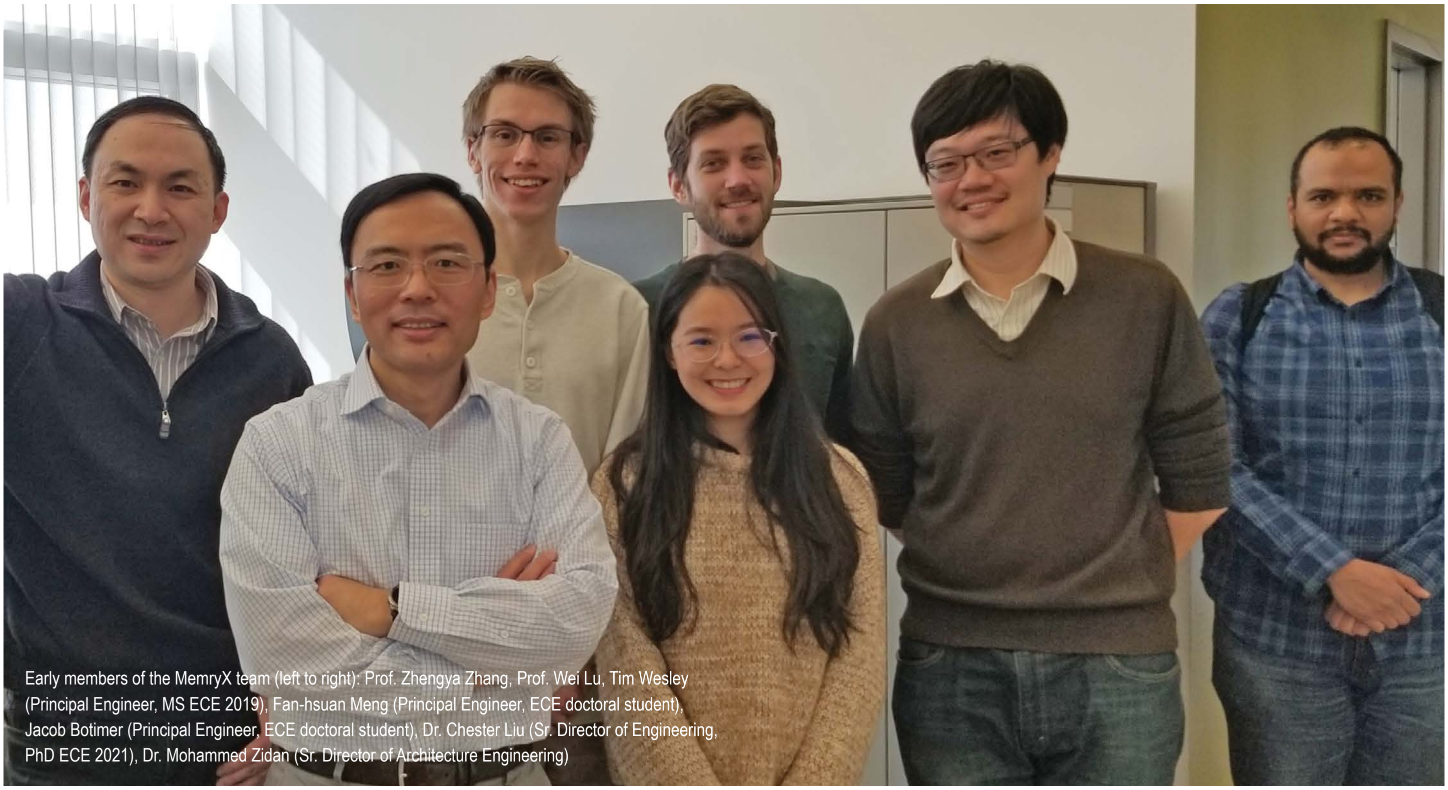
MemryX offers a new solution with their patent-protected memory processing unit (MPU). This technology offers high-performance with low latency and low power, making it ideally suitable for edge computing. It is also capable of supporting many different machine learning models, or neural networks, making it a programmable chip. Basically, it's technology is ideally suited for anything that includes an intelligent robot, including those used in industrial and hospital settings.

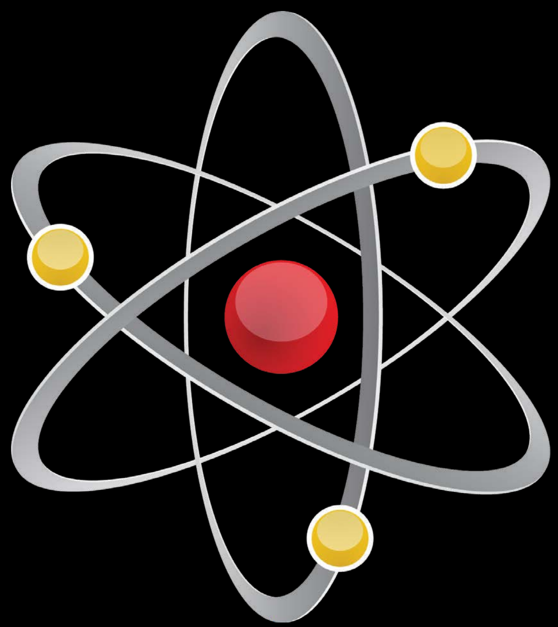
MemryX was co-founded by Lu and Prof. Zhengya Zhang in 2019. Leading the architecture and circuit design teams at MemryX are Lu's former postdoctoral researcher, Zidan, and Zhang's former doctoral student, Chester Liu, respectively.

"Each and every member of our team in the company is amazing," said Zidan. "At this point, all the members of my team were products of the University of Michigan."

Officially launched in 2019, the MemryX team presented their first chip at CES in January 2020, and are currently working on the third generation. Several companies are testing out the chip right now.

MemryX is based in Ann Arbor, with a second office in Taiwan to facilitate collaboration with Taiwan Semiconductor Manufacturing Co. (TSMC). They recently announced the closing of Series A funding, as well as the addition of Rick Wallace (President and CEO, KLA) to the Board of Directors, and Dr. Peter Hsieh (VP of Innovation & Investment, ARM) to the Technical Advisory Board.


Early members of the MemryX team (left to right): Prof. Zhengya Zhang, Prof. Wei Lu, Tim Wesley (Principal Engineer, MS ECE 2019), Fan-hsuan Meng (Principal Engineer, ECE doctoral student), Jacob Botimer (Principal Engineer, ECE doctoral student), Dr. Chester Liu (Sr. Director of Engineering, PhD ECE 2021), Dr. Mohammed Zidan (Sr. Director of Architecture Engineering)



When you push the size of a system to atomic scale, new quantum phenomena come alive. We know what they are, but we haven't quite figured out how to control them.

Control is the next step to the ultimate goal of full integration of quantum devices with traditional semiconductor devices.

CONTROLLING THE QUANTUM FUTURE

Developing New Nano-Quantum Materials

ECE faculty and collaborators are developing a new family of III-nitride nano-quantum materials (nQMs) which are expected to contribute to future advances in quantum devices for quantum information, communication, air purification, object sterilization, and sensing.

At the center of these nQMs are extreme quantum-dot arrays – called extreme because they contain just a few atoms compared to the thousands found in "normal" dots. For the project to be a success, the researchers will innovate and control these quantum-dots arrays at nanoscale to produce the desired macroscopic, collective actions.

"By demonstrating the controlled synthesis of such atom clusters utilizing industry-standard processing tools, we hope to establish the material platform for scalable, next-generation quantum technology," said project director Zetian Mi.

Control is the key, and it's very tricky business.

"When you make these quantum nanostructures, new operational principles come alive," said co-investigator Mackillo Kira.

These quantum principles cause unusual things to happen when a small number of nanosized particles are confined. Called quantum effects, they don't conform to the expectations of classical physics, but they can be predicted by quantum theory. In addition, different quantum effects sometimes come into play depending on the number of nano-quantum particles that begin to work together.

Kira will be in charge of developing a systematic quantum theory that will predict the behavior of the nQMs. The newly-developed theory will enable scientists to precisely predict and determine the electronic, optical, excitonic, and entanglement properties of quantum nanostructures, and perhaps most importantly for this research - how to control quantum light.

"We're talking about controlling the energy of light, and then what type of light is emitted," said Kira, "which is also critical for quantum information applications, such as moving information long distances, quantum processing, information security, or highly sensitive sensing and detection."

Building on the theory, Mi's group will grow quantum nanostructures based on III-nitride semiconductors.

"This is also a wide bandgap material ideally suited for UV optoelectronics, including UV LEDs for disinfectant applications," said Mi. "Broadly speaking, 200 to 280 nanometers is very important for disinfection purification applications. But there is no viable way to do that using conventional semiconductor technology."

Air purification and room sterilization, critical in hospital settings, are some of the key applications for Mi's research. Current technology uses mercury lamps, a highly toxic material. In addition, Mi says that by using quantum nanostructures, as opposed to traditional semiconductors, the process can be made highly efficient.

In addition to Mi and Kira, key members of the team include Professors Ted Norris and Parag Deotare, who will test and evaluate the materials, Prof. Manos Kiopakis (Materials Science and Engineering Department), who will help with the design and modeling of monolayer GaN structures, and industrial partners Sandia National Lab and the Air Force Research Lab, who bring extensive experience in materials characterization.

"If we can make a few entanglement-based demonstrations, based on the new materials, that's a big step forward," said Kira. "That would be a founding moment of making semiconductors quantum ready."

Mapping Quantum Structures With Light

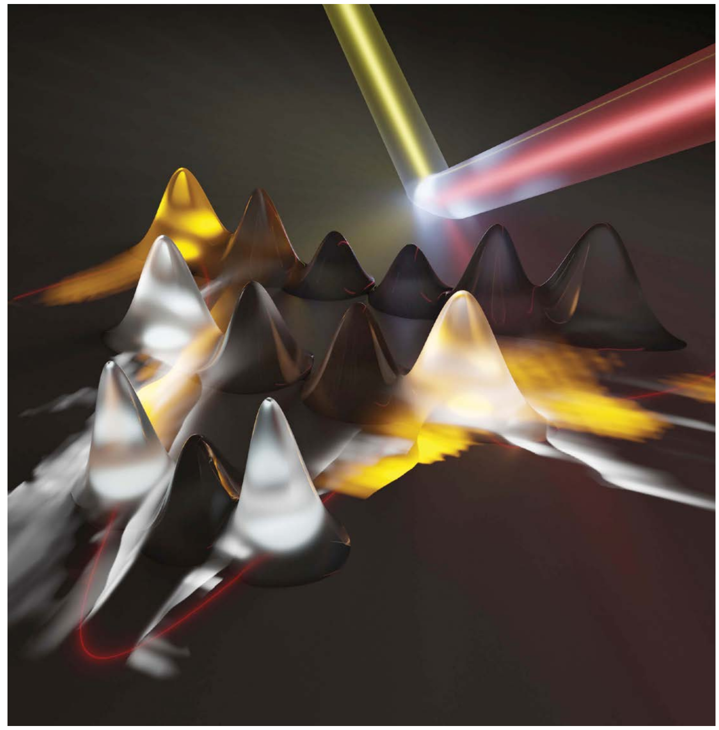
A new tool that uses light to map out the electronic structures of crystals could reveal the capabilities of emerging quantum materials and pave the way for advanced energy technologies and quantum computers.

"Quantum materials could have an impact way beyond quantum computing," said Prof. Mackillo Kira, who led the theory side of the new study. "If you optimize quantum properties right, you can get 100% efficiency for light absorption."

Silicon-based solar cells are already becoming the cheapest form of electricity, although their sunlight-to-electricity conversion efficiency is rather low, about 30%. Emerging "2D" semiconductors, which consist of a single layer of crystal, could do that much better—potentially using up to 100% of the sunlight. They could also elevate quantum computing to room temperature from the near-absolute-zero machines demonstrated so far.

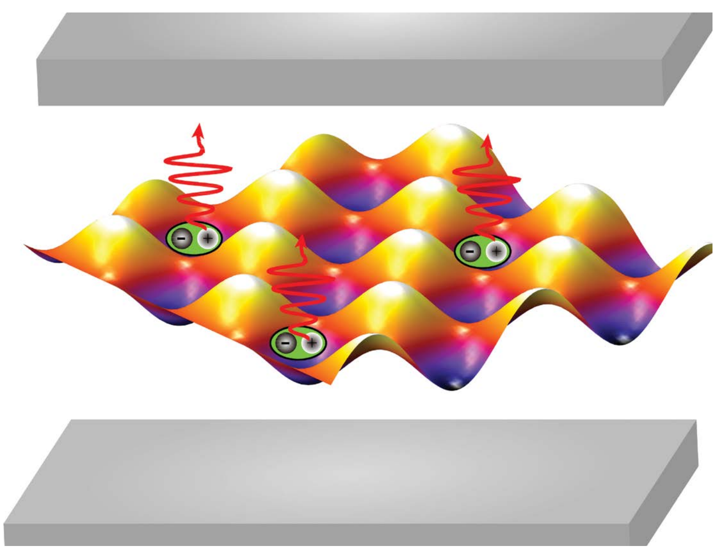
"New quantum materials are now being discovered at a faster pace than ever," said Rupert Huber, professor of physics at the University of Regensburg in Germany, who led the experimental work. "By simply stacking such layers one on top of the other under variable twist angles, and with a wide selection of materials, scientists can now create artificial solids with truly unprecedented properties."

The research team succeeded in measuring 2D quantum materials using a laser-based method at room temperature and pressure. The measurable operations include processes that are key to solar cells, lasers and optically driven quantum computing. Additional applications for this avenue of research, which was published in Science, include LED lights, solar cells and artificial photosynthesis.



The electrons absorb laser light and set up "momentum combs" (the hills) spanning the energy valleys within the material (the red line). When the electrons have an energy allowed by the quantum mechanical structure of the material—and also touch the edge of the valley—they emit light. This is why some teeth of the combs are bright and some are dark. By measuring the emitted light and precisely locating its source, the researchers mapped out the energy valleys in a 2D crystal of tungsten diselenide. Credit: Markus Borsch, Quantum Science Theory Lab, University of Michigan.

Information Processing Using Quantum Dot Arrays



An illustration of the electronic structure.
Credit: Long Zhang, Deng Lab, University of Michigan

By putting a twist on new "2D" semiconductors, an international team of researchers have demonstrated their potential for using single photons to transmit information. Their experiment demonstrated the possibility of using an effect known as nonlinearity to modify and detect extremely weak light signals, taking advantage of distinct changes to a quantum system to advance next generation computing.

"We are coming to the end of Moore's Law," said Stephen Forrest, Peter A. Franken Distinguished University Professor of Electrical Engineering, Paul G. Goebel Professor of Engineering, and key investigator on the project. "Two dimensional materials have many exciting electronic and optical properties that may, in fact, lead us to that land beyond silicon."

In order for an array of quantum dots inside a 2D semiconductor to be controlled as a group with light, the team built a resonator by making one mirror at the bottom, laying the semiconductor on top of it, and then depositing a second mirror on top of the semiconductor.

"Researchers have wondered whether detectable nonlinear effects can be sustained at extremely low power levels—down to individual photons. This would bring us to the fundamental lower limit of power consumption in information processing," said Hui Deng, a professor of physics who directed the research. "We demonstrated a new type of hybrid state to bring us to that regime, linking light and matter through an array of quantum dots."

Xinjing Huang, ECE Graduate Student Research Assistant, displays a transparent solar cell in Stephen Forrest's lab. Photo: Robert Coelius, Michigan Engineering

Windows That Power Communities With Sustainable Energy

Imagine windows that can harness the power of solar energy to power entire buildings. A new transparency-friendly solar cell design could do just that, providing highly efficient energy for 30-years or more.

"Solar energy is about the cheapest form of energy that mankind has ever produced since the industrial revolution," said Stephen Forrest, the Peter A. Franken Distinguished University Professor of Electrical Engineering and Paul G. Goebel Professor of Engineering, who led the research. "With these devices used on windows, your building becomes a power plant."

While silicon remains king for solar panel efficiency, it isn't transparent. For window-friendly solar panels, Forest's team—which included researchers at North Carolina State University and Tianjin University and Zhejiang University in China—explored new methods using organic, or carbon-based, materials.

The challenge for Forrest's team was how to prevent very efficient organic light-converting materials from degrading quickly during use.

The strength and the weakness of these materials lie in the molecules that transfer the photogenerated electrons to the electrodes, the entrance points to the circuit that either uses or stores the solar power. These materials are known generally as "non-fullerene acceptors" to set them apart from the more robust but less efficient "fullerene acceptors" made of nanoscale carbon mesh. Solar cells made with non-fullerene acceptors that incorporate sulfur can achieve silicon-rivaling efficiencies of 18%, but they do not last as long.

"Non-fullerene acceptors cause very high efficiency, but contain weak bonds that easily dissociate under high energy photons, especially the UV [ultraviolet] photons common in sunlight," said Yongxi Li, U-M assistant research scientist in ECE and first author of the paper in *Nature Communications*.

By studying the nature of the degradation in those unprotected solar cells, the team recognized that they only needed shoring up in a few places.

First, they added a layer of zinc oxide, a common sunscreen ingredient, on the sun-facing side of the glass. They also added two buffer layers—a carbon-based material called IC-SAM and a fullerene shaped like a soccer ball—to protect the fragile light absorber. In testing these methods, the team extrapolated that the solar cells would still be running at 80% efficiency after 30 years.

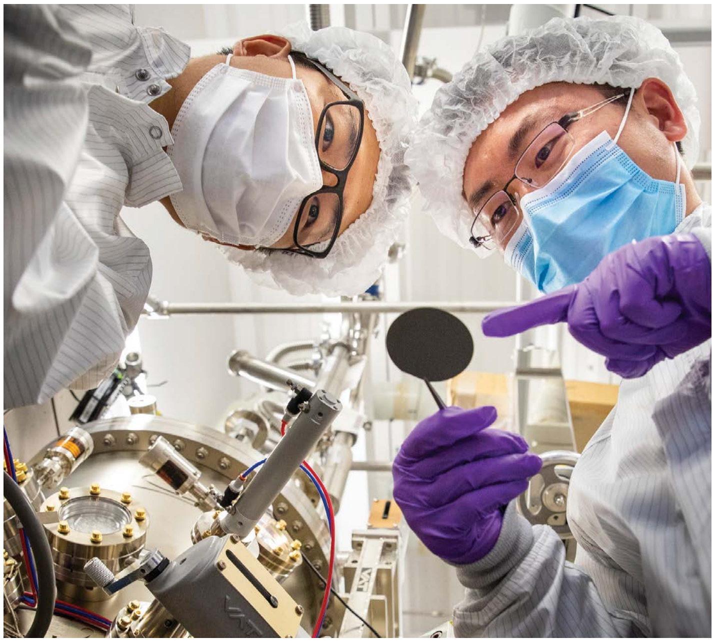
Forrest sees a future of these devices "coming to a window near you." His team has already increased the transparency of the module to 40%. They believe they can approach 60% transparency.

They're also working on bumping up the efficiency from the 10% achieved in the reported semitransparent modules, closer to the 15% believed to be possible at high transparency.

The manufacturing costs are expected to be relatively low because the materials can be prepared as liquids.

Part of the research, funded by the Office of Naval Research and the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, was conducted in the U-M Lurie Nanofabrication Facility. Universal Display Corp. holds a license to the work. U-M has a financial interest and Forrest has an ownership interest in Universal Display Corp.

Dawn of Nitride Ferroelectronic Semiconductors for Next-Generation Electronics



Postdoctoral researchers Ding Wang (left) and Ping Wang (right) check the surface of a single-crystalline ferroelectric ScAlN wafer grown utilizing molecular beam epitaxy.

For the first time, a team of researchers, led by Prof. Zetian Mi, achieved single-crystalline high quality ferroelectric III-V semiconductors that can be integrated into existing platforms for a broad range of ferroelectric, electronic, optoelectronic, and photonic device applications.

Their achievement paves the way to a new generation of semiconductors that offer post-Moore's Law performance with a wide variety of applications.

"From a scientific point of view, we were very excited to work on this," said Mi. "We wanted to see if we could create a ferroelectric III-V semiconductor by MBE [molecular beam epitaxy], which was seen as a big challenge in the community."

A semiconductor that is ferroelectric allows for the switching of electrical polarization. This quality is particularly promising in microelectronic memory devices for neuromorphic computing and artificial intelligence, where it can result in longer retention times, lower energy costs, higher integration density, and increased robustness in harsh environments.

With its endless possibilities for improving devices with transistors, LEDs, lasers, photovoltaics, and power electronics, ferroelectric semiconductors also have the ability to enhance 5G technology for mobile communications, and is also being explored for use in biological research.

But to be commercially successful, the ferroelectric semiconductor has to be reliable, reproducible, and precisely tuned to the needs of the application.

Through their unique process, Mi's team was able to precisely control both the current leakage in the materials and their electrical polarization. They anticipate being able to scale their devices into the nanometer regime.

The devices were grown in the Lurie Nanofabrication Facility, and funding was provided by the Naval Research Office.

Bringing More Light to Your Displays

An ECE team led by Prof. L. Jay Guo created a new electrode that could free up 20% more light from organic light-emitting diodes (OLEDs). Their innovation could help extend the battery life of smartphones and laptops, or make next-gen televisions and displays much more energy efficient.

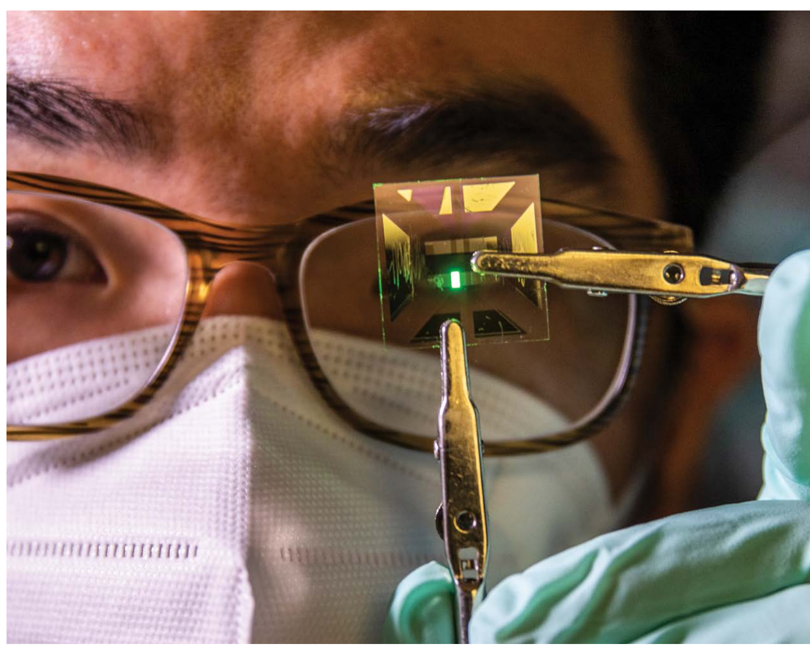
The team was able to prevent light from being trapped in the light-emitting part of an OLED, enabling OLEDs to maintain brightness while using less power. And, the electrode is easy to fit into existing processes for making OLED displays and light fixtures.

"With our approach, you can do it all in the same vacuum chamber," said Prof. L. Jay Guo, who led the research.

About 80% of the light produced by an OLED gets trapped inside the device. It does this due to an effect known as waveguiding.

By swapping out the ITO for a layer of silver just five nanometers thick, deposited on a seed layer of copper, Guo's team maintained the electrode function while eliminating the waveguiding problem in the OLED layers altogether.

"Industry may be able to liberate more than 40% of the light, in part by trading the conventional indium tin oxide electrodes for our nanoscale layer of transparent silver," said Changyeong Jeong, PhD candidate in ECE.



Changyeong Jeong, PhD candidate in ECE, handles an ultrathin Ag film based OLED inside Professor Jay Guo's lab. Photo: Robert Coelius, Michigan Engineering

This research was funded by Zenithnano Technology, a company that Guo co-founded to commercialize his lab's inventions of transparent, flexible metal electrodes for displays and touchscreens. U-M has filed for patent protection, and the device was built in the Lurie Nanofabrication Facility.

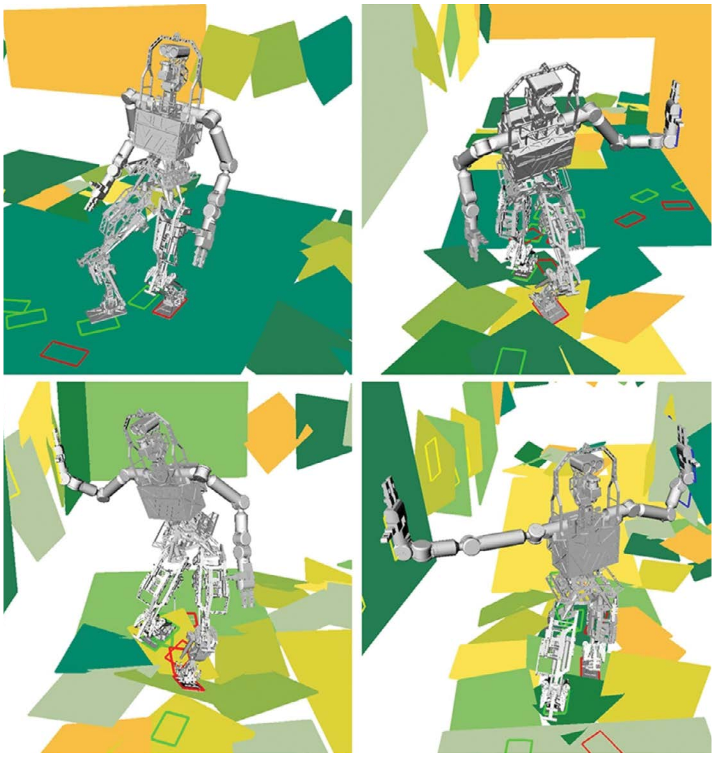
An aerial view of the U-M Ford Robotics Building.
Photo: Levi Hutmacher, Michigan Engineering

THE ROBOTS ARE COMING!

The next time you're on North Campus, be sure to check out the sparkling, brand new U-M Ford Motor Company Robotics Building, which is officially open. The four-story, $75 million, 134,000-square-foot complex serves as the hub of the U-M Robotics Institute. Its first three floors hold custom U-M research labs for robots that fly, walk, roll, and augment the human body—as well as classrooms, offices and makerspaces. Through a unique agreement, the fourth floor houses Ford's first robotics and mobility research lab on a university campus, as well as 100 Ford researchers and engineers.

In celebration of this new complex, we're featuring some of the current projects headed by ECE faculty that aim to accelerate the future of advanced and more equitable robotics and mobility.

Faster Path Planning for Rubble-Roving Robots



A virtual robot shows different modes of motion, with only feet, with one hand, or with both, as it traverses rough terrain. Credit Yu-Chi Lin (Robotics PhD)

A new algorithm speeds up path planning for robots that use arm-like appendages to maintain balance on treacherous terrain such as disaster areas or construction sites.

"In a collapsed building or on very rough terrain, a robot won't always be able to balance itself and move forward with just its feet," said Prof. Dmitry Berenson, who led the research. "You need new algorithms to figure out where to put both feet and hands. You need to coordinate all these limbs together to maintain stability, and what that boils down to is a very difficult problem."

The improved path planning algorithm enables robots to determine how difficult the terrain is before calculating a successful path forward, which might include bracing on the wall with one or two hands while taking the next step forward. The approach found successful paths three times as often as standard algorithms, while needing much less processing time.

The team also showcased their method's ability to work on a real world, mobile manipulator—a wheeled robot with a torso and two arms. With the base of the robot placed on a steep ramp, it had to use its "hands" to brace itself on an uneven surface as it moved. The robot utilized the team's method to plan a path in just over a tenth of a second, compared to over 3.5 seconds with the basic path planner.

In future work, the team hopes to incorporate dynamically-stable motion, similar to the natural movement of humans and animals, which would free the robot from having to be constantly in balance, and could improve its speed of movement.

$1M for Open-Source First-Responder Robots

A Mini-Cheetah robot. Photo: Robert Coelius/Michigan Engineering

A new project funded by a $1 million grant from the National Science Foundation aims to take bipedal (or two-legged) walking robots to a new level, equipping them to adapt on the fly to treacherous ground, dodge obstacles, or decide whether a given area is safe for walking. The technology could help protect firefighters and other first-responders by enabling robots to proceed first into areas that are too dangerous for humans, including collapsed buildings and other disaster areas. It could also lead to prosthetics that are more intuitive for their users.

“I envision a robot that can walk autonomously through the forest here on North Campus and find an object we’ve hidden. That’s what’s needed for robots to be useful in search and rescue, and no robot right now can do it,” said Jessy Grizzle, Elmer G. Gilbert Distinguished University Professor, who is leading the project.

Grizzle, an expert in walking robots, is partnering on the project with Maani Ghaffari Jadidi, an assistant professor of Naval Architecture and Marine Engineering and expert in robotic perception. Grizzle says the pair’s complementary areas of expertise will enable them to work on broader swathes of technology than has been possible in the past.

To make it happen, the team will embrace an approach called “full-stack robotics,” integrating a series of new and existing pieces of technology into a single, open-source perception and movement system that can be adapted to robots beyond those used in the project itself. The technology will be tested on Digit and Mini Cheetah robots.

In addition to developing new technology, the project will also collaborate with the U-M School of Education on outreach to a Detroit high school, working to share the project’s material with them and develop interest in robotics.

Robots, Teach Thyself

The models that robots use to do tasks work well in the structured environment of the laboratory. Outside the lab, however, even the most sophisticated models may prove inadequate in new situations or in difficult to model tasks, such as working with soft materials like rope and cloth.

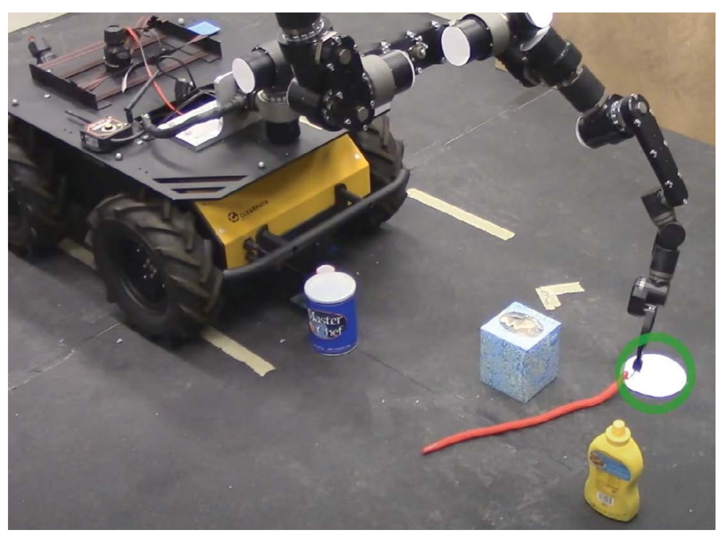
To overcome this problem, Prof. Dmitry Berenson led a team that created a way for robots to predict when they can’t trust their models and to recover when they find that their model is unreliable.

“In our approach, ... we have a simple model of a rope, and we develop ways to make sure that we are using it in appropriate situations where the model is reliable,” said Berenson. “This method can allow robots to generalize their knowledge to new situations that they have never encountered before.”

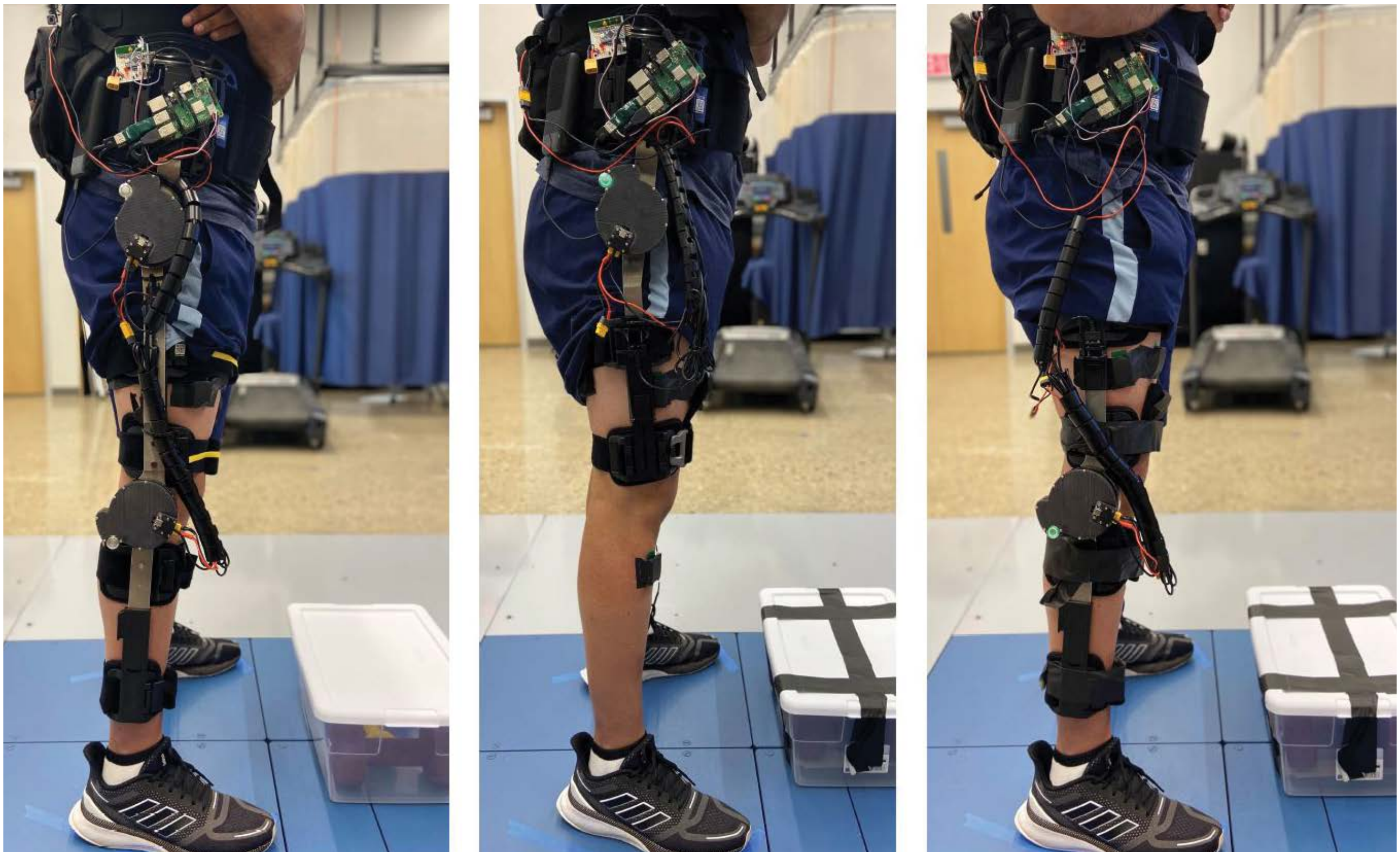
The team also demonstrated the success of their model in two real-world settings: grabbing a phone charging cable and manipulating hoses and straps under the hood of a car.

The next step in this research is exploring where else a given model might be useful.

The research was done in collaboration with the Toyota Research Institute, and published in *Science Robotics*.



The robot was tasked with navigating multiple objects before placing the rope inside the marked circle.



Preliminary knee and hip designs for a new powered exoskeleton system. It attaches motors to off-the-shelf orthotic braces to provide better mobility to the wearer. Photo: Locomotor Control Systems Laboratory, University of Michigan

Everyday Exoskeletons

One in eight Americans faces a mobility disability, with serious difficulty walking or climbing stairs, but a robotic solution could be far less bulky than sci-fi's full-body suits.

In an effort to bring robotic assistance to workers, the elderly, and more, a team led by Prof. Robert Gregg is developing a new type of powered exoskeleton for lower limbs.

The U-M team plans to develop a modular, powered exoskeleton system that could be used on one or multiple joints of the legs. The three-year project, funded by $1.7 million from the National Institutes of Health, will first study workers who lift and lower objects and the elderly who have lost mobility with age. In future work, the team would like to include people with other disabilities.

“Imagine adding a small motor to a bicycle—the rider still pedals, but there's that extra power to get up hills without breaking too much of a sweat,” said Gregg. “Similarly, we can take the conventional ankle, hip or knee braces used today, add a self-contained specialized motor and gear system, and provide power at a specific joint to increase mobility.”

Conventional braces, or orthotics, cannot actively assist human joints during challenging activities. State-of-the-art exoskeletons, on the other hand, are built in a way that makes it difficult for users to move against the motor, also known as backdriving the motor. This is in part because these exoskeletons are usually designed to replace the complete function of an entire limb. Partially assisting specific joints is a different challenge.

However, one of the greatest hurdles for exoskeletons is that they must accurately recognize the user's intent, and match that intent with a correct action. Otherwise, the exoskeleton adds to the effort required from the user.

“There is a continuum of human movement possibilities, from jumping jacks to walking up a slightly different incline,” Gregg said. “If the exoskeleton recognizes the wrong activity, then it's getting in the way of the human.”

There are two keys to the system Gregg and his team envision will make up for these shortcomings: a newer style of motor and transmission and a different kind of control algorithm.

Working with Chandramouli Krishnan, an associate professor of Physical Medicine and Rehabilitation, and Alicia Foster, a certified prosthetist orthotist at U-M's Orthotics and Prosthetics Center, the team will determine the best configurations of the modular system for different populations. The team will also study whether the additional weight of the motor is helpful overall.

Gregg hopes that the project will result in a low-cost system that any clinician would be able to replicate by simply adding it to current off-the-shelf ankle, hip, and knee orthoses. And beyond the workers and elderly populations of this project, Gregg hopes the system could be helpful to the broad populations that require just a bit, but not complete, assistance with getting around.

Most Powerful Laser in the U.S. to Begin Operations At U-M Soon

U-M was awarded $18.5 million by the National Science Foundation to establish its three petawatt ZEUS laser facility as a federally-funded international user facility, enabling experimental teams from around the world to travel to U-M to run experiments.

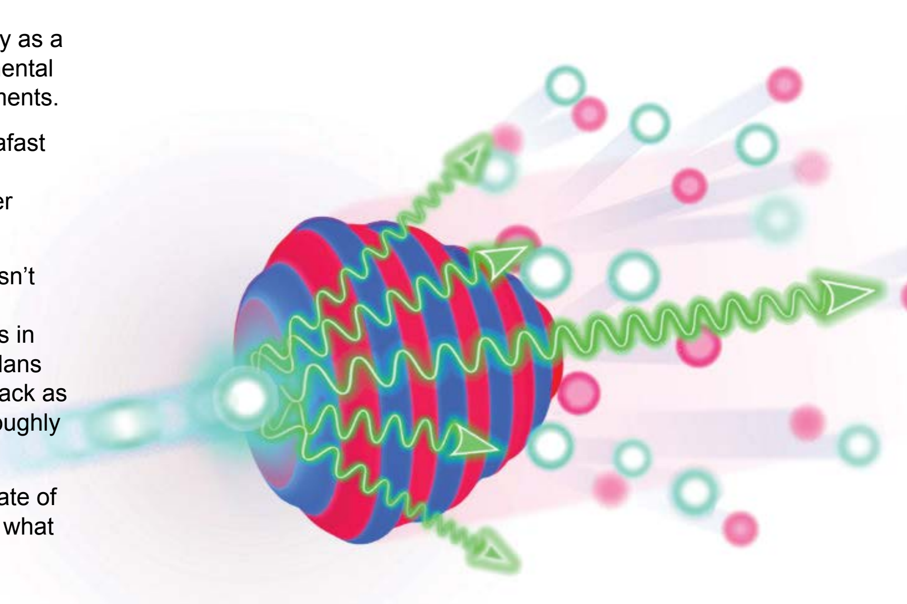
Faculty affiliated with ECE's Gérard Mourou Center for Ultrafast Optical Science (CUOS) have been leading the design and creation of ZEUS (Zetawatt Equivalent Ultrashort pulse laser System).

The U.S. built the world's first petawatt laser in 1996 but hasn't kept pace with more ambitious systems under construction elsewhere in the world. This includes two 10-petawatt lasers in Europe and a 5.3-petawatt laser in China, which also has plans to build a 100-petawatt laser. While the new laser doesn't pack as much raw power, its approach will simulate a laser that is roughly a million times more powerful than its three petawatts.

ZEUS will be used primarily to study extreme plasmas, a state of matter in which electrons break free of their atoms, forming what amounts to charged gases.

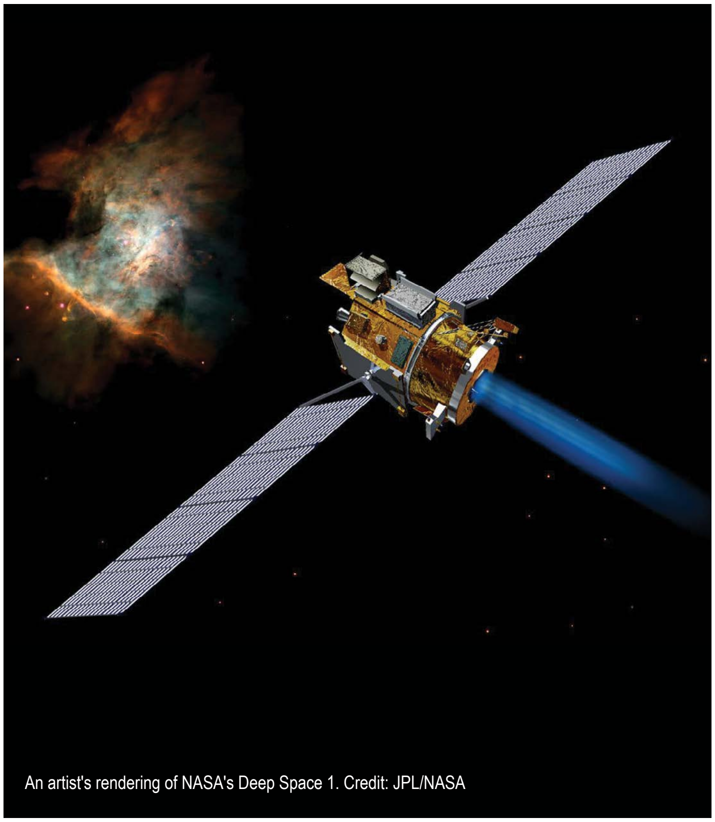
Experiments at the facility are expected to contribute to the understanding of how the universe operates at the subatomic level, how astrophysical phenomena such as jets can be produced by black holes, how materials change on extremely fast timescales, and the development of smaller and more efficient particle accelerators for medical imaging and treatment.

ZEUS is scheduled to begin its first experiments in early 2022 and is expected to put the U.S. back on the map of high power laser facilities.



Graphic depiction of ZEUS's signature experiment where a laser pulse collides with a laser-driven electron beam, to create high-energy photons and pairs of electrons and their antiparticles, positrons, from the vacuum. This experiment will probe extreme aspects of quantum electrodynamics, the leading theory explaining the interaction of light and matter. Credit: Steve Alvey, Michigan Engineering

First Observation of the "Charge Separation Effect"



An artist's rendering of NASA's Deep Space 1. Credit: JPL/NASA

Prof. Stephen Rand and his multi-institution team successfully demonstrated the "charge separation effect." This effect, predicted over a decade ago, has important potential for direct conversion of light to electricity without the thermodynamic losses typical of photovoltaic (solar cell) technology. The results are expected to be important to future developments in ultrafast switching, nanophotonics, and nonlinear optics as well.

"For over 150 years since Maxwell's equations were first formulated, no one has thought that effects enabled by the magnetic force of light were possible at low intensities," said Rand.

According to Rand, the new research does not contradict Maxwell's equations, but it does rely on a different set of assumptions than the traditional arguments regarding magnetic effects that are based on mobile charges.

The magnetic effects in insulators generated by low-intensity light are one million times stronger than previously expected.

This suggests that magneto-electric interactions could support the direct conversion of sunlight to electrical energy, leading to a new kind of solar power source without semiconductors and without absorption to produce charge separation. This could help revolutionize the development of clean energy because theoretically the process could be over 95% efficient. It's also particularly relevant for the space industry, for example, by re-energizing deep space missions or stations on Mars that are running out of power.

This research was facilitated with the Center for Dynamic Magneto-optics (DYNAMO) MURI and a $1.5M equipment grant. It was funded by the Air Force Office of Scientific Research, the Defense University Research Instrumentation Program, and NSF.

Faculty, staff and students of the RadLab in 2018

THE RADLAB: PEOPLE IN SERVICE TO SOCIETY

The Radiation Laboratory (RadLab) is a tight-knit group that celebrates student defenses, special lectures, alumni events, birthdays, weddings, and more with homemade food, cake, and lots of good cheer. Their collegiality is as strong as their success. This team of researchers, both faculty and students, are consistently ranked as one of the best, if not the best, electromagnetics groups in the world. Students are highly placed in industry and academia, a high percentage of faculty have become members of the National Academy of Engineering, and they are called into leadership roles when only the best will do.

"When I think about the RadLab, I think about the positive impact the lab has had on the country," said Kamal Sarabandi, Rufus S. Teesdale Professor of Engineering, who served as Director of the RadLab between 2000-2021.

Faculty and students in the Radiation Laboratory study electromagnetics, which is the interaction of electric and magnetic fields. Electromagnetics is fundamental to the field of electrical and computer engineering, and spans all technologies within the electromagnetic spectrum. Practical applications range from early radar to seeing through walls, DC to wireless power and energy systems, remote sensing of the environment, medical imaging, communications, and even modern computer design.

"The beauty of the RadLab is its focus on developing new technologies, and the science that underlies that technology," said former director Fawwaz Ulaby, Emmett Leith Distinguished University Professor Emeritus and Sarabandi's doctoral advisor.

This brief introduction to the RadLab is meant to provide a small window into the longstanding and far reaching contributions the faculty and students have had on fundamental science and technology, as well as their impact on society through their collaborations with industry and government.

Professors Leung Tsang and Kamal Sarabandi at the College of Engineering NAE reception

Current and former RADLAB faculty members of the National Academy of Engineering

Current Faculty:

Fawwaz Ulaby

Kamal Sarabandi

Mark Kushner

Leung Tsang

Former Faculty*:

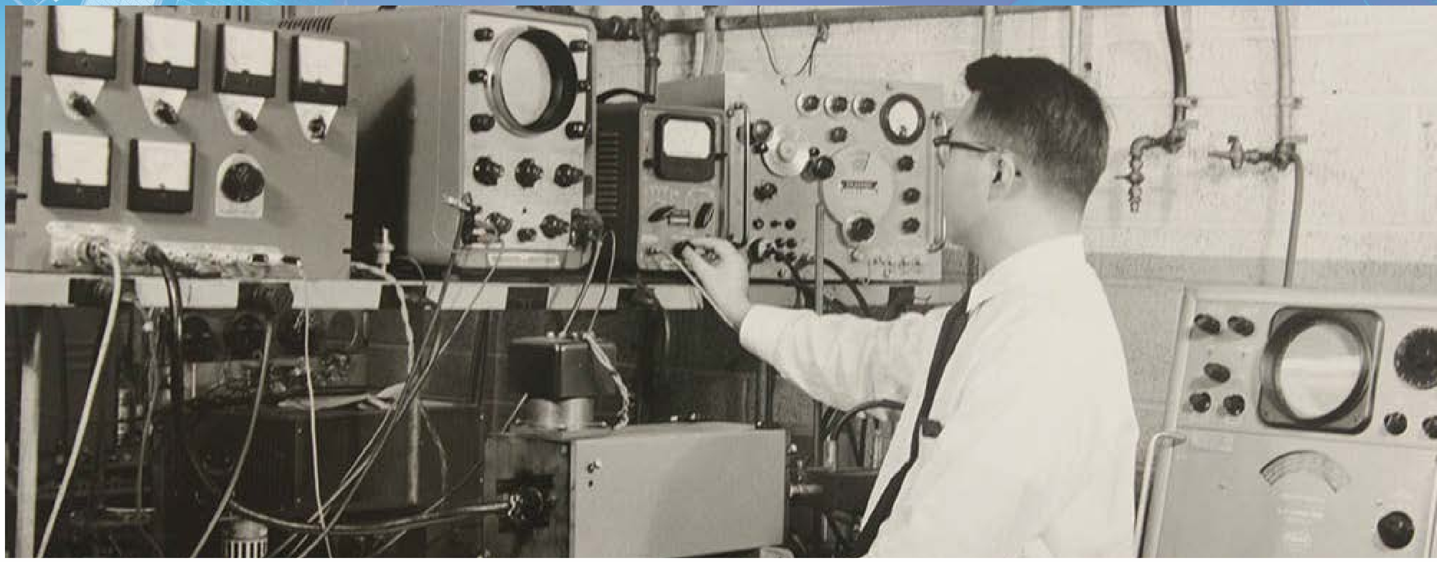
Chen-To Tai

Mahta Moghaddam

Linda Katehi

Gabriel Rebeiz

*Katehi, Moghaddam, and Rebeiz became members after leaving Michigan



A researcher sending signals inside the original 100 ft. anechoic chamber. He is positioned just outside the chamber. Photo credit: Bentley Historical Library (1958)

Early History

The early history of the Radiation Laboratory reaches back to the activities at Willow Run. Built for the production of aircraft during WWII, in particular the B-24 Liberator bomber, a portion of Willow Run was sold to Michigan on July 1, 1946 for $1.00.

In 1948, an Upper Atmospheric Physics Group was formed within Willow Run, later renamed the Theory and Analysis Department. This group later held an URSI-sponsored Symposium on Electromagnetic Wave Theory in 1955 that was attended by most of the scientists involved in electromagnetic scattering around the world. The papers were published the following year in a special issue of the *IRE Transactions on Antennas and Propagation*; these papers became standard references in the field.

In 1957, the Theory and Analysis Department became part of the Electrical Engineering Department and assumed its current name, Radiation Laboratory.

One of the key facilities needed to conduct electromagnetics experiments is an anechoic chamber. An anechoic chamber is a very large room coated with a material to reduce any reflection of signals off the wall. At the time, the material was not very good, so you needed a large room to help reduce the reflected signals.

There were only two anechoic chambers in existence in 1957, so the RadLab built its own to facilitate its research.

During the 1960's, RadLab researchers were the first to measure surface fields with the purpose of designing better stealth aircraft. Former faculty member and RadLab director Thomas Senior and former research scientist Valdis Liepa used small scale models to measure and confirm their theoretical calculations. They came up with the first designs for stealth aircraft – designs similar to the later Northrop-Grumman B-2 Spirit (first built in 1987).

When gas prices soared in the 1970's, wind became a viable option for energy. CBS Technology Laboratories funded research to understand how the turbines might be impacting television reception. Former research scientist Dipak Sengupta and Senior proved that the wind turbines installed on Block Island were, in fact, negatively impacting television reception for residents of Rhode Island, leading to the U.S. government providing cable to every resident in the state. Back then, the turbines were made of metal which dramatically increased the interference. Senior and his team developed procedures that are now part of all environmental assessments of wind turbines.

Students working inside today's anechoic chamber.

"Our long-term success has been built on our people and their collaborations with others."
- Kamal Sarabandi

Impact of Remote Sensing On The Environment

Remote sensing is a key tool for monitoring environmental conditions. In remote sensing, satellites or high-flying aircraft measure the reflected and emitted radiation from a target geographical area to learn about the physical properties of that area.

By the 1980's, the main areas of RadLab research included microwave and millimeter wave remote sensing of terrain and vegetation, as well as electromagnetic scattering from both manmade and natural targets, and the computer-aided design (CAD) of microwave and millimeter wave circuits.

Trees and overall forest structure is an important indication of the Earth's carbon cycle, which impacts global climate, biodiversity, land use and development, and more. Trees absorb atmospheric CO_2 through photosynthesis and then release it through decomposition. With 30% of the Earth's landmass comprised of forests, scientists need a detailed understanding of their size and makeup to evaluate their overall impact.

In 1988, Prof. Fawwaz Ulaby, referred to by many as the Father of Microwave Remote Sensing, developed the Michigan Microwave Canopy Scattering model (MIMICS). This technique for the remote sensing of biomass (in particular, tree canopies) has been widely used and cited by the research community.

Sarabandi worked on MIMICS as a graduate student under Ulaby. His dissertation on electromagnetic scattering from vegetation canopies demonstrated pioneering work in the use of imaging radar systems for monitoring vegetation at the global scale. Many of his algorithms and theoretical models are considered classics and are heavily used by remote sensing practitioners even today.

In 1994, Ulaby, Sarabandi, and other members of their group were instrumental in the design and calibration of the Shuttle Imaging Radar that flew on NASA's Shuttle Imaging Radar-C (SIR-C) mission in 1994. This was, and may still be, the most advanced radar system to ever fly in space. It mapped large portions of the Earth's land surface, and resulted in the launch of later satellite missions by Canada, Japan, and the European Space Agency.

Sarabandi was later involved in the Shuttle Radar Topography Mission (SRTM), which provided data to generate the first nearly global, high-accuracy topographical map of the Earth. The shuttle was launched aboard the Space Shuttle Endeavor on Feb. 11, 2000. High-resolution topographic data generated from this mission continues to be used worldwide.

In recognition of his positive leadership and impact on the field, Sarabandi served as a member of NASA Advisory Council for two successive terms (2006-2011), and later served as President of the IEEE Geoscience and Remote Sensing Society (2015-2016). He currently serves as Chair of Commission F, U.S. National Committee for The International Union of Radio Science (USNC/URSI) and as an Administrative Committee member of the IEEE Antenna and Propagation Society.

Soil Moisture And Climate

Snow and ice levels have serious ecological consequences.

As early as the 1970's, former professor Anthony England, who was part of the U.S Geological Survey, was among the first scientists who realized that you couldn't understand global climate and the human effect on climate without considering the interrelationship of the atmosphere, the ocean, and the water cycle. England noticed that hydrologists did not look at the water cycle in a global perspective. Realizing it was because they lacked the tools to do so, he set about providing those tools.

England's team built instruments to calibrate and validate information received from Space not only for Michigan, but other institutions. His group was one of the first to generate land-surface models that were linked to satellite observations. His team was also the first to incorporate microwave brightness to determine levels of moisture in the soil.

More recently, Sarabandi and his team constructed the most powerful radar calibration device in the world to interface with NASA's newest orbiting satellite, called Soil Moisture Active Passive (SMAP), which launched Jan. 31, 2015. SMAP is a 5-year mission to measure the amount of water present in the top 2 inches of soil around the entire Earth (excluding the Poles). The data collected by SMAP is expected to improve our ability to

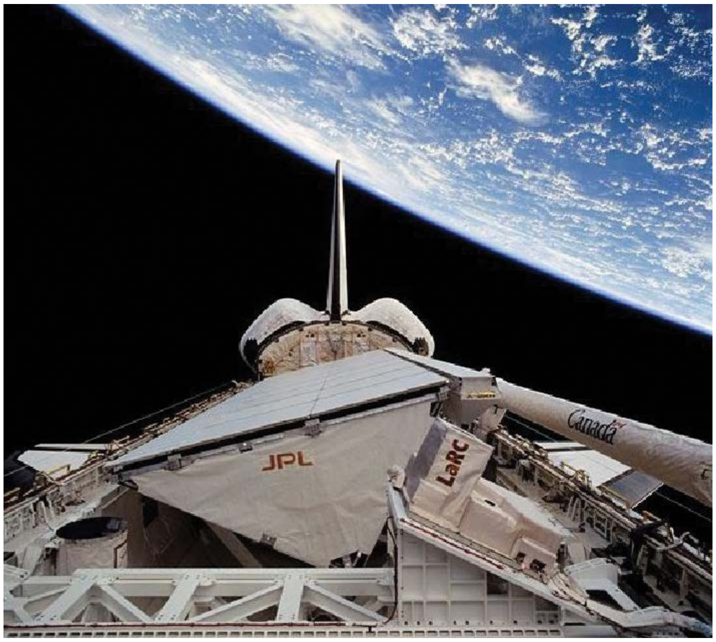


Photo of the SIR-C/X-SAR payload in the Shuttle bay. Image courtesy NASA

Doctoral student Haunting Huang (shown above) and her advisor Prof. Leung Tsang, used computational electromagnetics to improve the accuracy of remote sensing of soil moisture through dense tree canopies.

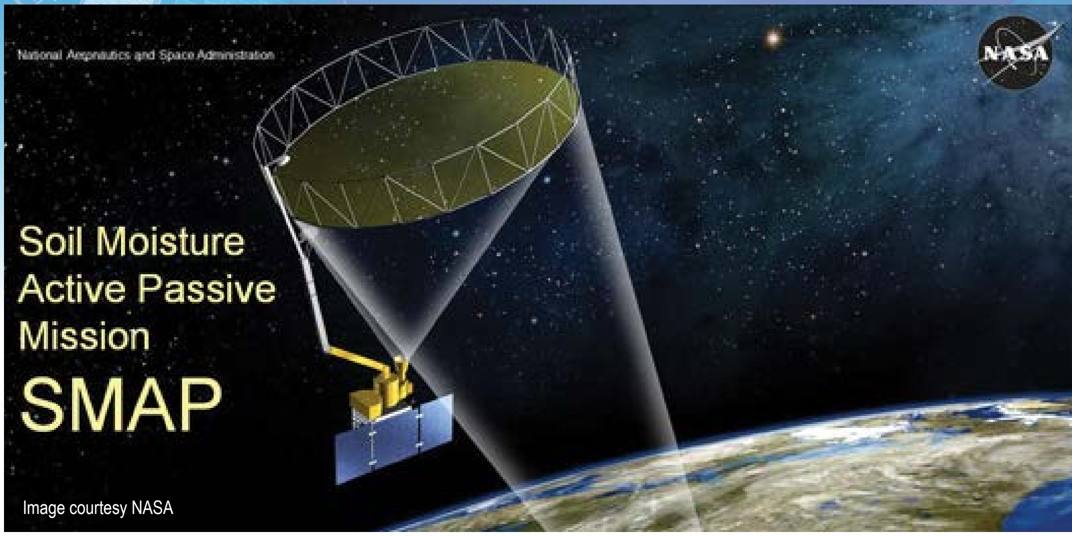


Image courtesy NASA

"The beauty of the RadLab is its focus on developing new technologies, and the science that underlies that technology."
- Fawwaz Ulaby

Researchers are setting up the instrument that was interacting with a device in Space. In the photo are research scientists Leland Pierce (front), Adib Nashashibi (back left) with Kamal Sarabandi and graduate student Mani Kashanianfard (back right).

forecast the weather, monitor droughts, predict floods, enhance crop productivity, and understand the Earth's water, energy, and carbon cycles. SMAP is the first satellite ever built to specifically target soil moisture. Sarabandi is a member of the Science Team for NASA SMAP Mission.

The SMAP radar built by JPL worked briefly but unfortunately failed only months into the mission. Fortunately, by tweaking the algorithms that interpret the data, the radiometer is providing better information than originally anticipated, thanks to Prof. Leung Tsang and his group.

In an attempt to get the best data from remote sensing measurements, Tsang developed physical microwave scattering models that combine the radar from the European Space Agency Sentinel with the L band radiometric signals of SMAP.

"Recent physical modelling based on full wave simulations is showing much larger microwave penetration through vegetation and forests than predicted by previous models," said Tsang. "These new models encourage re-examination of data already collected, particularly over dense vegetation and forests."

In addition to soil moisture, Sarabandi, Tsang, and their students are finding better ways to determine global levels of snow and ice.

More NASA Connections

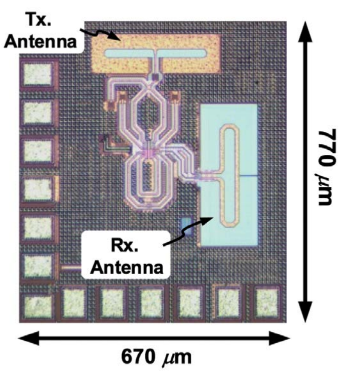
With much of their research taking place in outer space, the RadLab faculty have extensive ties to NASA and its missions. England himself was an actual NASA astronaut who flew during the Space Shuttle program before joining Michigan in 1988. Several faculty have received significant awards for their service to NASA, as well as their contributions to remote sensing and space missions. Sarabandi has served as member of the NASA Advisory Council, the highest advisory council in NASA.

Prof. Brian Gilchrist is focused on Space Electrodynamics and Tether Systems. He was director of the Shuttle Electrodynamic Tether System (SETS) experiment that flew on the STS-75 shuttle mission in 1996. Recently, he directed the project, Miniature Tether Electrodynamics Experiment-1 (MiTEE-1), involving more than 150 undergraduate students over the course of six years that put a cubesat into space. MiTEE-1 is part of a mission to explore the feasibility of a new propulsion method, electromagnetic tethering, that could enable very small satellites to move around Earth's orbit without carrying fuel. Read more about MiTEE on pp. 70-71.

Artist's design of the flying integrated COMBAT system

High Frequency and Terahertz Technology

The NASA Center for Space Terahertz Technology, established in 1988, was the first of its kind in the country. Directed by Fawwaz Ulaby, this 10-year, $13M Center pioneered the development of Terahertz antenna arrays, sources, and circuit components.



A fully integrated 220GHz FMCW radar with 62GHz of bandwidth.

The Center helped create international forums for research in THz technology. These included the publication of special issues of scientific journals dedicated to this subject, and the establishment of the Symposium on Space Terahertz (SSTT), which was first convened in Ann Arbor in 1990 and has since gone international.

Prof. Ehsan Afshari is currently pushing the existing boundaries in high frequency communication by combining novel circuit topologies and efficient systems in his millimeter-wave (electromagnetic waves ranging ~30-300 GHz) and terahertz (electromagnetic waves ranging ~300 GHz-3 THz) devices.

His integrated systems are able to add significant functionality, such as signal processing, right on the chip, and his chips can be combined into an array. These arrays can do beamforming, which means an image can be captured in 3D from a single vantage point, saving the need to move either the device or the object.

Afshari and his group have achieved numerous records in their devices, which have applications including the detection of concealed weapons, cancer diagnosis, food quality control, and breath analyses for disease diagnosis.

COMBAT Center

The 10-year multi-institution Center for Objective Microelectronics and Biomimetic Advanced Technology (COMBAT) was established at Michigan in 2008, and directed by Sarabandi. With total funding of about $20M, COMBAT focused on remote sensing, autonomy, communications, and operation in an ensemble of collaborating miniature flying robots.

The goal of COMBAT was to enable autonomous flying robots to navigate in poor conditions (ie, smoke, fog, darkness) and inside buildings, take photos and acquire and transmit other types of information, and do so on a small device that needed continuous power from a lightweight source.

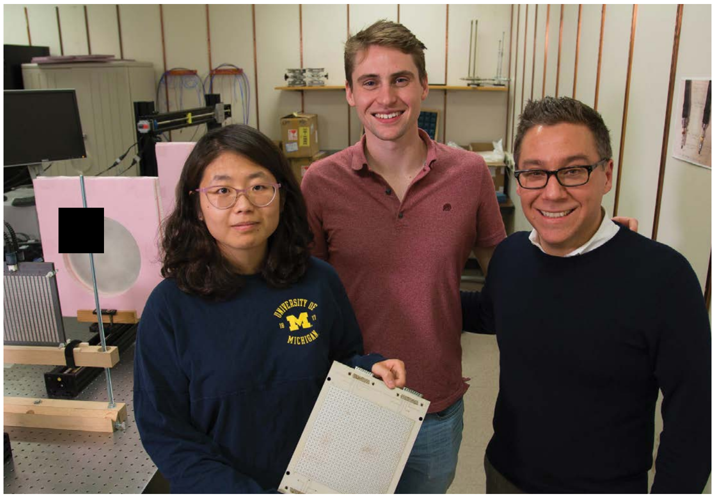
COMBAT led to several groundbreaking projects, including: development of the world's smallest and most advanced radar; new designs and techniques for ultra low-power operation of digital and analog circuits for processing information; development of the world's best image sensor chip; development of the world's most sensitive air velocity wind sensors; and development of flexible skin-like biomimetic solar cells for power harvesting.

This entire activity has enabled broad collaborative efforts among industry, academia, and the Army Research Laboratory. Technology developed over the course of the project was transferred successfully to both industry and the Army Research Labs.

The Better Antenna

Radios were among the core early technologies that kept electrical engineers busy in the early decades of the 20th century. Even today, all radios need antennas to convert electric power into radio waves to transmit and receive information.

Radio waves are electromagnetic waves, and the antenna couples the electrical connection of transmitters and receivers to the electromagnetic field. The first antenna was built by Heinrich Hertz in 1888, just a year before the first course in electrical engineering was taught at Michigan.



Prof. Grbic (right) with PhD students Zhanni Wu (left) and Cody Scarborough (center). Wu holds a metamaterial they created in the lab as part of a MURI project.

With the rise of electronics and computers in the middle of the 20th century, followed by the extreme shrinking of electronics and the move to wireless in the 21th century, research into building "the better antenna" has continued unabated.

Former professor and NAE member Chen-To Tai, who joined the department in 1964, was an acknowledged leader in this area. Tai established the foundation of multielement array antennas, which are used extensively in a variety of radio systems.

Terahertz antenna arrays, sources, and circuit components were pioneered in the late 1980's and throughout the 1990's within the Center for Space Terahertz Technology. And in 2000, an electromagnetic metamaterials program, the first of its kind, was established under the direction of Sarabandi under a MURI DARPA program.

More recently, fundamental studies on metamaterials and their applications to electromagnetic devices and radiating systems have been carried out by Prof. Anthony Grbic and his team. Grbic is a pioneer in the metamaterials area, well known for his foundational work on metasurfaces and first demonstration of a metamaterials superlens.

Grbic currently is one of the PI's on a $7.5M MURI with the goal of developing metamaterials that vary both in space and time. These new metamaterials, which break time invariance, promise unprecedented functionality, and compact and cost-effective ways to transmit and even simultaneously receive electromagnetic waves. The project could lead to breakthroughs in areas such as next-generation wireless communication, commercial and military radar systems, imaging, and antenna systems.

Wireless Power Transfer

First demonstrated by Nikola Tesla in the 1880s, wireless power transfer has only recently been developed to the point where it is being used in consumer electronics. The prevalence of wireless devices such as smartphones and laptops fueled interest in this area of research. Potential applications also include wireless powering of implanted medical devices and ubiquitous charging of electric vehicles.

RadLab faculty and students are actively pursuing wireless power transfer from both fundamental and practical perspectives. A major initiative is focused on powering devices from the size of a cell phone to an electric vehicle with greater ease and/or efficiency than possible today.

Prof. Amir Mortazawi, who was named the new Director of the Radlab in September, is creating devices that allow for ever-greater distances between the device and the power. This technology could be used to charge electric vehicles while at a stoplight, or driving down the road. It is expected to have a dramatic impact on all mobile robotics and electronic devices, including those for biomedical applications.

Computational Electromagnetics

Computational electromagnetics (CEM) involves modeling how the electromagnetic field interacts with physical objects and the environment. It is important to the design and modeling of antenna, radar, satellite and other communication systems, optical, nanophotonic and electronic devices, medical imaging, and other applications and devices. The field has grown in response to the computational power available to engineers.

Eric Michielssen, Louise Ganiard Johnson Professor of Engineering and Associate Vice President for Advanced Research Computing, is an acknowledged leader in the field. In 2017, he developed a new algorithm, called Butterfly, that is orders of magnitude faster than prior algorithms, while using fewer computer resources. Through his fundamental contributions, researchers have been able to tackle very large and multi-scale computational problems not feasible previously.

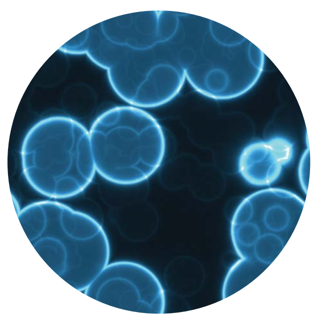
Luis Gomez (EE PhD 2015), former student of Eric Michielssen, is working on a device capable of sending signals deeper into the brain to treat depression more effectively, thanks to computational electromagnetics.

Proposed MMW Imaging radar placed on top of vehicle, based on successful miniaturization of a 230 GHz radar system

Plasma Science and Engineering

A vast array of modern technologies, including renewable energy sources, lighting, microelectronics, and medicine, would not exist in the absence of low-temperature plasmas, a specialty of Mark Kushner, George I. Haddad Professor of EECS. Kushner directs the Michigan Institute for Plasma Science and Engineering (MIPSE), which is a community of faculty, staff and students at U-M and Michigan State University whose research and education programs are devoted to the advancement of the science and technology of plasmas.

Kushner also directs the DOE Plasma Science Center. The fundamental research that is being conducted at the 10-institution Center could lead to more efficient solar cells, finer-featured microchips and new medical tools that cut and heal tissues with plasma-activated chemistry.



An acknowledged leader in the field, Kushner co-chaired the Decadal Study of Plasma Science, conducted by the National Academies of Science, Engineering and Medicine, and recently joined the Standing Council of the $8M NSF Engineering Research Visioning Alliance (ERVA), the first engineering research visioning organization of its kind. ERVA seeks to envision high-impact solutions to society's grand challenges and to spark new research directions for a more secure and sustainable world.

His current research, as director of the Computational Plasma Science and Engineering Group (CPSEG), is development of 2- and 3-dimensional computer models for plasma materials processing, and plasma remediation of toxic gases. The CPSEG is well known in the microelectronics fabrication industry for its innovative simulations and visualizations of plasma processing reactors, and for its close working relationships with industry and national laboratories. Many of the computer models and CAD tools developed by the CPSEG are available for licensing and transfer to industry.

Kushner has also been applying his research in low-temperature plasmas to medical applications, in particular, developing computer models to determine how these plasmas interact with human tissue. Applications include unique approaches to wound healing and sterilization, and cancer treatment.

Detecting Communication among Biological Cells

In the past five years, members of Sarabandi's group have been examining how cells in the human body communicate.

"Recently we acquired evidence that bacterial cells are communicating and radiating electromagnetic waves," said Sarabandi. "We don't know what they're saying, but we've built devices that are so sensitive that we could track these measurements and listen to them. It's very exciting."

Michigan Institute for Plasma Science and Engineering (MIPSE) poster session (2019)

This research, funded under DARPA's RadioBio program, could allow doctors to disrupt the communication of infectious bacteria or the growth of cancerous tumors. It could even lead to greater understanding about the formation of Alzheimer's disease.

Center on Microwave Sensor Technology

In 2015, the RadLab formed an international partnership with King Abdulaziz City for Science and Technology, which is providing significant funding for the UM-KACST Joint Center of Excellence on Microwave Sensor Technology. The Center has been led by Sarabandi and is focused on designing the next generation of automotive radar.

Current radar systems can sense the presence of people and vehicles, but cannot convey much more information. These radar systems operate at 77GHz, a frequency specifically allocated for automotive radar by the Federal Communication Commission (FCC).

The FCC is considering allocating a frequency band in the 230GHz range, intended for future generations of automotive radar. By moving from 77GHz to 230GHz, the resolution of the same size antenna improves dramatically, which will provide a much greater variety of information about the surrounding scene. RadLab faculty are well on their way to reducing the size of desktop systems into mm-scale chips capable of providing this technology.

Additional research happening in the Center includes:

- subsurface imaging of buried objects
- compact and low-power THz integrated circuits for hidden object detection in airports as well as detection of cracks in industrial settings
- wireless power transfer

A goal for all these projects is the ultimate transfer of the technology to industry.

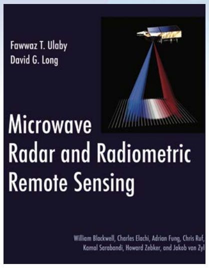
Education and Students

The RadLab is home to about 70-80 graduate students of diverse backgrounds. Its graduates hold top academic and industry positions, and are successful entrepreneurs.

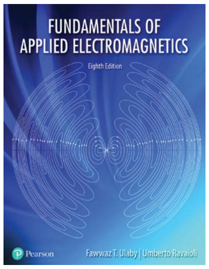
Former students have gone on to lead major companies, such as Steve Mollenkopf, CEO of Qualcomm Inc., or to teach the next generation of students, such as Rhonda Franklin, professor at the University of Minnesota and Nader Bedhad, professor at the University of Wisconsin. In recognition of their outstanding contributions, each of these alumni have received individual ECE alumni awards and recognition.

In addition to graduating 100's of PhD students, RadLab faculty have educated countless undergraduate and master's students, and along the way have written more than 20 textbooks, including classics in their field.

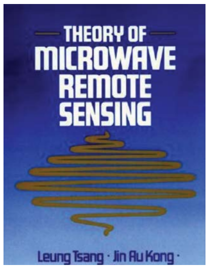
Collaborating with other academics across the country, Ulaby initiated a unique textbook initiative to ease the financial burden of students by offering newly-published books for free online, and "at cost" in hardcover.



Microwave Radar and Radiometric Remote Sensing, by Fawwaz T. Ulaby and David G. Long with contributions by William Blackwell, Charles Elachi, Adrian Fung, Chris Ruf, Kamal Sarabandi, Howard Zebker, and Jakob van Zyl, published 2014, provides a comprehensive review of the field. In addition to resources for instructors, the textbook includes an online interactive supplement that includes computer codes, a list of satellite and airborne microwave sensors, and high-resolution radar and radiometric images available for download. It is in use at educational institutions throughout the world.



Fawwaz Ulaby's *Fundamentals of Applied Electromagnetics*, first published in 1996 and adopted by hundreds of engineering departments around the world, is now in its 8th edition.



Theory of Microwave Remote Sensing, by Leung Tsang, Jin Au Kong, and Robert Shin, published in 1985, was a foundational book in the field.

Leading Future Technology

For many decades, the group known as the RadLab has been collectively recognized as the best in their field. RadLab faculty are regularly called upon to take on leadership roles on both institutional and international levels, and they maintain close ties with government agencies and industry.

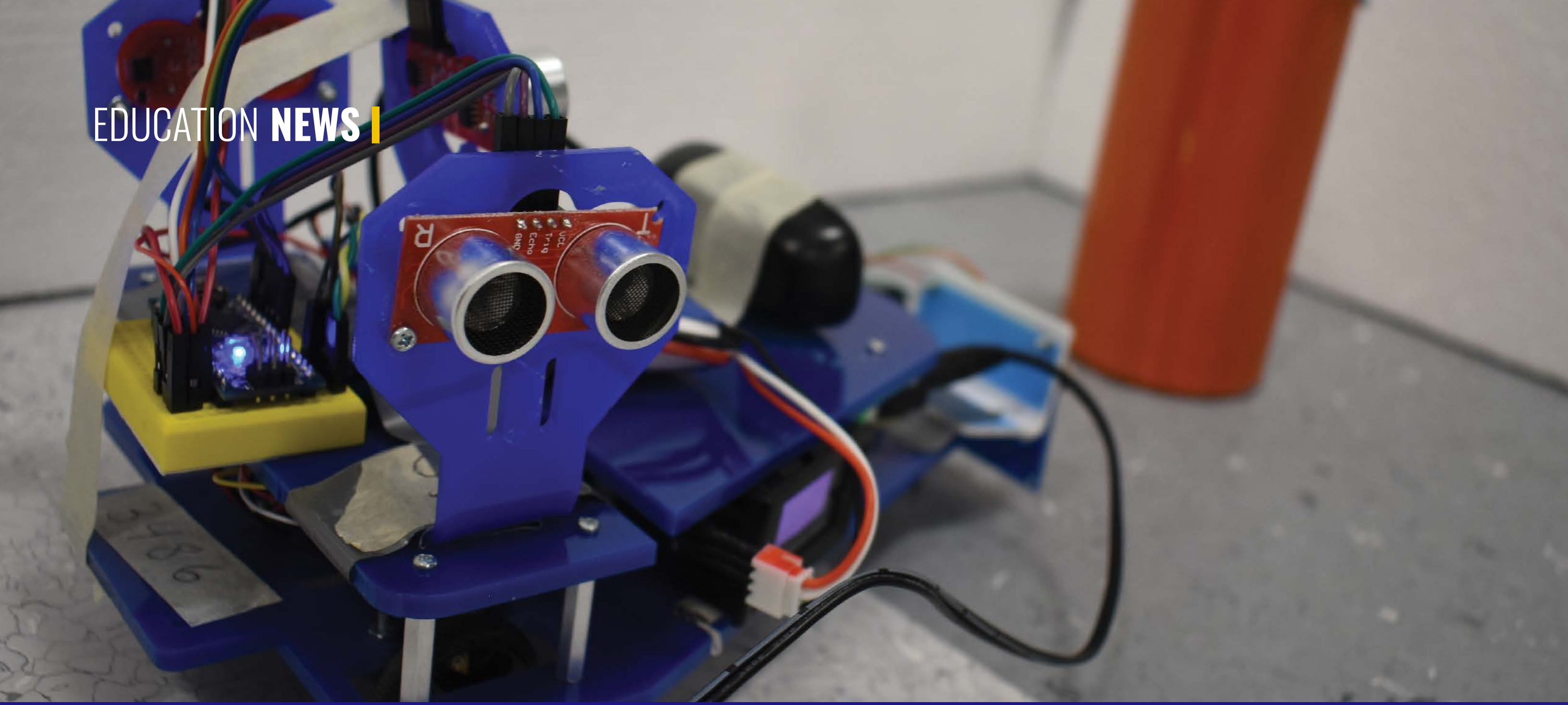
As the world has become more connected, so has the RadLab. Especially through its research centers and institutes, RadLab faculty have interacted with countless researchers throughout the College of Engineering, the University of Michigan, and at other institutions here and abroad.

Much of the RadLab's current research is expected to impact the autonomous vehicle industry as well as 5G applications, thanks to ongoing collaborations with General Motors, Ford Motor Company, and the government.

While continuing the critical research the RadLab is known for, future research will expand further into individual health. Can electromagnetic waves replace antibiotics? What is the impact of radiation on brain cells?

Wherever the faculty of the RadLab apply their expertise, success follows.

"Our long-term success has been built on our people and their collaborations with others," said Sarabandi. "We encourage our people to get into interdisciplinary areas to apply electromagnetics to a wide range of problems, from outer space to individual biological cells."



REDESIGNING OUR UNDERGRADUATE EE CURRICULUM WITH A FOCUS ON SYSTEMS PRINCIPLES AND ENGINEERING DESIGN

> "You have to really engage students and turn them from what I call makers into engaged young engineers and, ultimately, engineers that can lead other young engineers." - Steve Battel

With new courses at the freshman, sophomore, and junior levels, the undergraduate program in Electrical Engineering has been redesigned over the past few years to place a stronger emphasis on systems principles and engineering design, with projects having a positive impact on society. The onslaught of COVID-19 led to imaginative solutions that could further enrich these lab-based courses even post-pandemic.

"These new courses will give students experience early in their student careers synthesizing what they learned in different courses and then applying it to a complete system having an application that is in service to society," said Mingyan Liu, Peter & Evelyn Fuss Chair of Electrical and Computer Engineering (ECE). "This goes to the heart of what it means to be an engineer."

In the past three years, three new courses have been added to the curriculum:

ENG 100: Self-Driving Cars, Drones, and Beyond: An Intro to Autonomous Electronic Systems (1st year undergraduate course open to all engineering disciplines)

EECS 200: Electrical Engineering Systems Design I (2nd year undergraduate course in electrical and computer engineering)

EECS 300: Electrical Engineering Systems Design II (3rd year undergraduate course in electrical and computer engineering)

Each of these courses provide training in systems and open-ended engineering design, while introducing a broad range of EE topics and how they can be applied to areas of positive societal impact, such as health care, energy & sustainability, automation, and communication.

"If you're smart about design it doesn't just affect the product, it affects the process," says Prof. Shai Revzen, co-designer of EECS 300. "And if you're smart about the process, then you end up working less to get a better result. And that's true no matter what your discipline is."

> "If you're smart about design, ... you end up working less to get a better result." - Shai Revzen

Students checking out their drone before setting it loose in the maze.

ENG 100: Self-Driving Cars, Drones, and Beyond

Autonomous systems such as quad copters and self-driving cars are being used today in a wide range of applications; from helping first responders, to smart farming, to driving you to work, to delivering goods to your home.

The newest ENG 100 course, open to all engineering freshmen and taught by ECE faculty, features core ECE topics such as embedded systems, sensors, circuits, signal processing algorithms, and control algorithms. Students learn, develop, and implement key functionalities in an autonomous drone to manage sensing, data acquisition and processing, and motion control. Their final project is to set their drone loose to navigate a maze. This team-based course has become quite popular among freshmen.

EECS 200: Electrical Engineering Systems Design I

Electrical Engineering System Design I is the first of two new required courses in Electrical Engineering focusing on engineering design – using a 2-wheeled robot platform with a societally-relevant challenge.

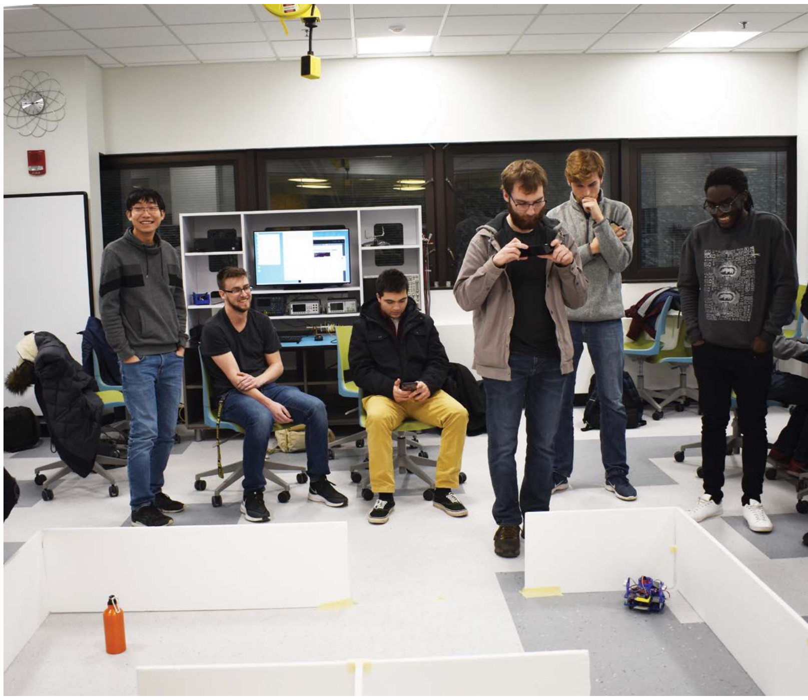
Students spend time exploring the subsystems that allow the robot to sense, think, and act; and then work together in teams to help the robot achieve a specific goal, such as navigating a maze to find an object, mimicking a search and rescue activity. Starting from a stripped-down robot the first week, the final robot has heat sensors, a video camera, and distance sensors for navigation.

“One week in the lab you’re working on some kind of hardware. The next week you’re working on some software that makes that hardware do something,” said Leland Pierce, the research scientist and lecturer who developed the labs and is now teaching the entire course.

The engineering design element is a bit more advanced than in an ENG100 course, but students are still guided through the process until the final project. At that point, students create their own design, and explain why their choices make sense.

The course was introduced Fall term 2019, and one of the first students to take the course was Michael Shkolnik.

“It was a lot of fun,” said Shkolnik, who is now taking EECS 300. “We went over all these broad concepts that relate to so many different fields of engineering – and by the end we made this really cool robot. I was still exploring what I wanted to do as an engineer, but seeing this entire systems perspective drove me towards embedded systems.”



EECS 200, pre COVID-19.

EECS 300: Electrical Engineering Systems Design I

By the time students reach EECS 300, they will have taken several additional courses in Electrical Engineering and are ready for more challenging adventures in engineering design. In designing this course, Prof. Brian Gilchrist brought his experience in multidisciplinary design, and Prof. Shai Revzen his love for open-ended design, reflected in his senior-level Hands-on Robotics course.

To design the labs, Revzen recruited master's student Duncan Abbot, co-founder of a VR company who worked with Revzen as an undergraduate student. Abbot wanted to teach the course so badly, he enrolled for his master's degree just to be a graduate student instructor for the course.

A recent addition to the team is Professor of Engineering Practice, NAE member, and ECE alumnus Steve Battel, who brings his lifelong passion for mentoring young minds and building high tech electronic devices for space. His machines fly all over the solar system.

"You have to really engage students and turn them from what I call makers into engaged young engineers and, ultimately, engineers that can lead other young engineers," said Battel.

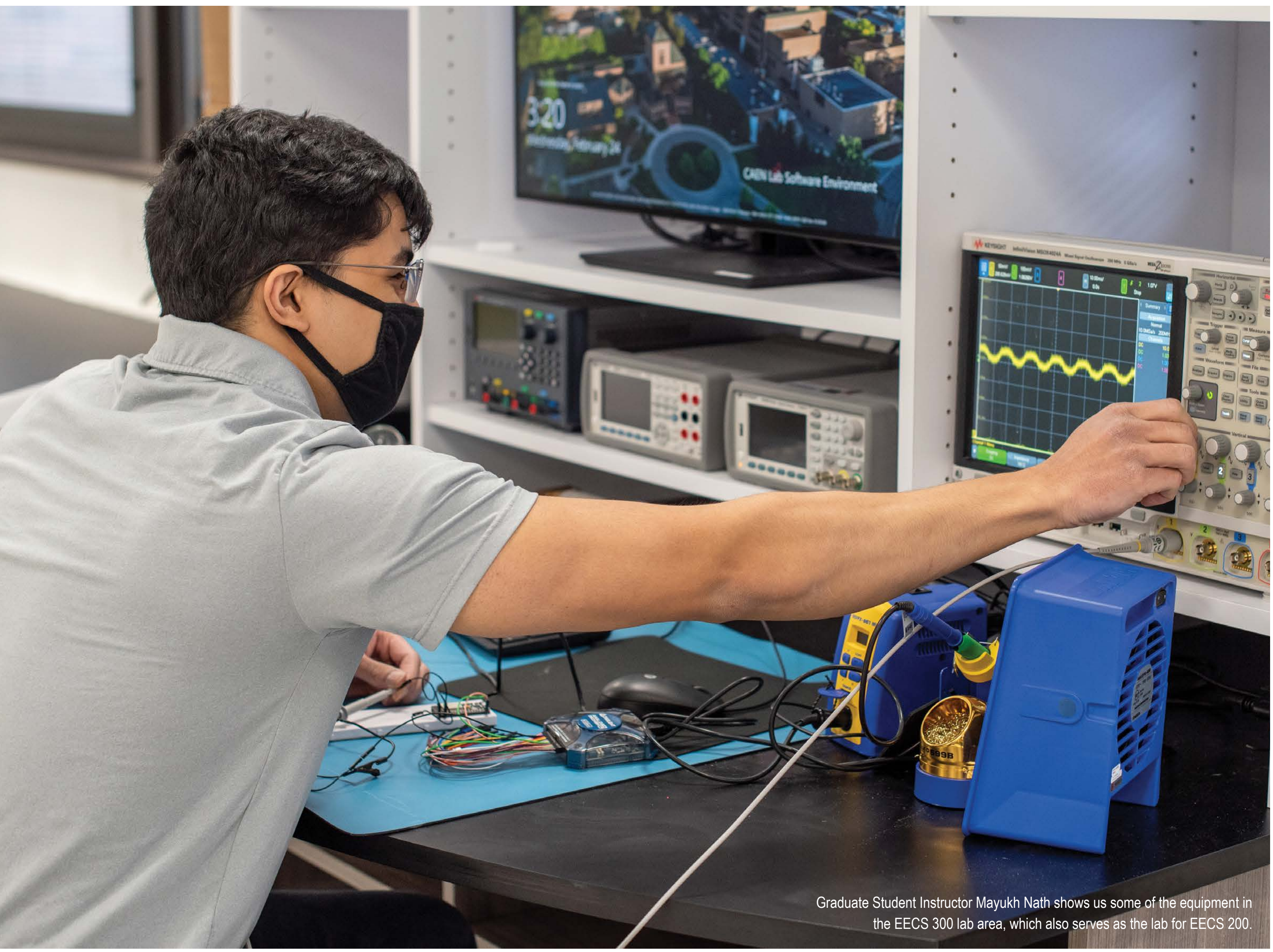
The project for the Winter 2021 semester pitted the Internet of Things vs. COVID-19.

"Students are applying IoT technology to enhance campus safety in COVID-19 times by tracking the number of people entering and exiting a building, the classroom, or an open study area," said Gilchrist.

The project touched upon the knowledge gained in four pre- or corequisite courses, integrated into a single application. The project forced the students to be systems thinkers and think holistically.

"For the new project, we decided that it had to be something that could be tested even at home," said Abbot.

Students leave EECS 300 with a clearer understanding of which future courses match their own passions. And they will more fully understand the expertise of future professional team members after they enter the workforce.



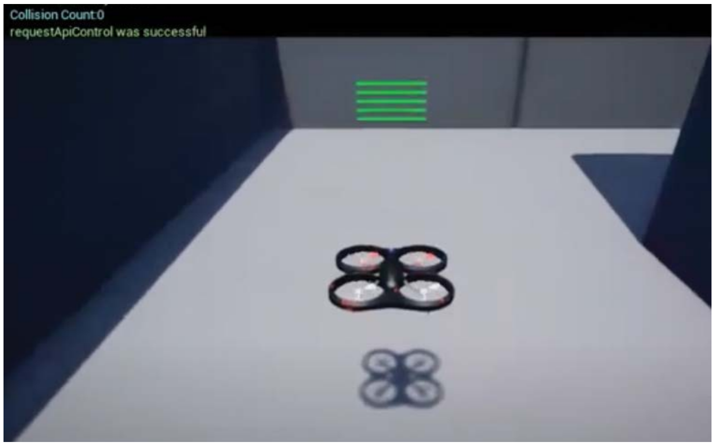
Graduate Student Instructor Mayukh Nath shows us some of the equipment in the EECS 300 lab area, which also serves as the lab for EECS 200.

ADVERSITY BREEDS CURRICULAR INNOVATION

COVID-inspired engineering innovation is all around us, but perhaps most hidden is the work being done by teachers across the country moving to digital platforms in an effort to educate our students.

The COVID-19 crisis meant that the EE curriculum, known for its hands-on labs, was going to require some significant re-thinking in many of its courses. Here are some ways our faculty adapted the curriculum to provide a pseudo lab experience at home.

Some of these solutions will be continued post-pandemic. They may also serve as a model for how other institutions, perhaps lacking major lab equipment and/or space, could offer similar courses.



Screenshot of the drone simulation using AirSim.

ENG 100: Self-Driving Cars, Drones, and Beyond

Graduate student Juhyeon Kim, a gaming aficionado with expertise in quantum optics, brought the drones into cyberspace. He adapted Microsoft's open source platform, AirSim, a simulator for autonomous systems, so that the students would need to do much of the work themselves.

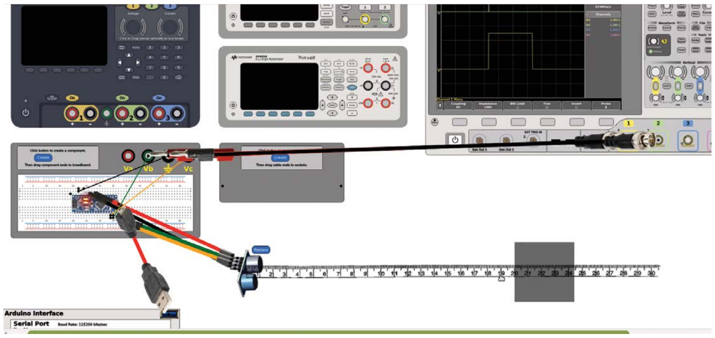
"I adapted the system so that in addition to sensing distance in a virtual environment, we can set the direction and power of the wind, and we can even add rain or snow, which we can't do in the physical lab," Kim said. "I think that's one exciting thing that we can do with the simulation environments."

Individual lab station for EECS 200 accommodates a team of four, or just one person during COVID-19 restrictions.

EECS 200: EE Systems Design I

Research scientist and lecturer Dr. Leland Pierce spent the summer of 2020 developing software that closely mimics the lab setup. Everything students did in the lab, such as grabbing wires to connect the breadboard socket to the breadboard banana socket, and cables to connect the breadboard to the power supply, or grabbing a motor, they were able to do virtually. The virtual lab also mimics sensors, arduinos, cameras – and includes a ruler to measure distance.

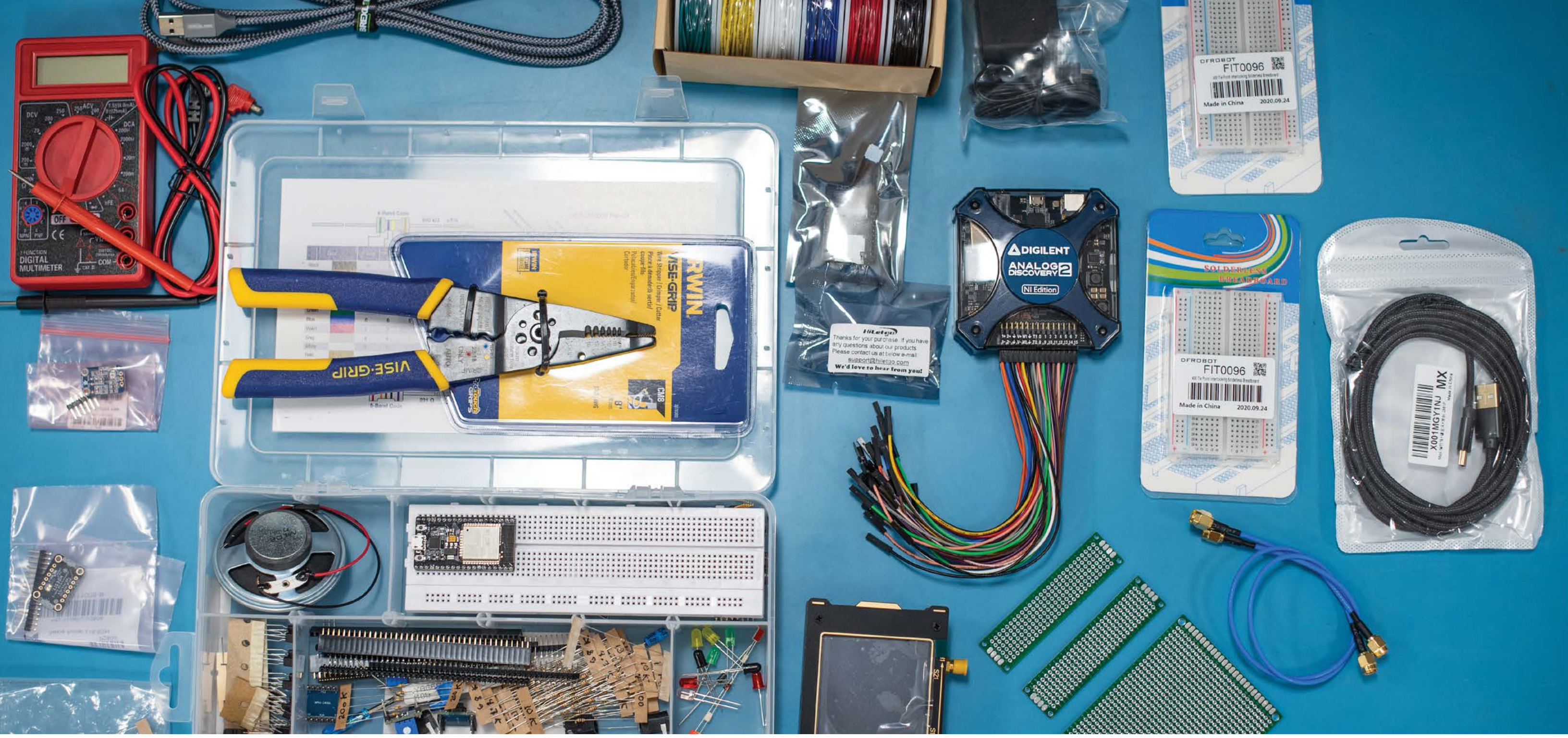
"I'm hoping that I can turn this into something that schools that don't have access to this kind of technology could use," said Pierce. "This is about as close as you can get to the actual instruments."



Simulated lab equipment for EECS 200.

"It [EECS 200] was a lot of fun. We went over all these broad concepts that relate to so many different fields of engineering – and by the end we made this really cool robot. I was still exploring what I wanted to do as an engineer, but seeing this entire systems perspective drove me towards embedded systems."

- Michael Shkolnik



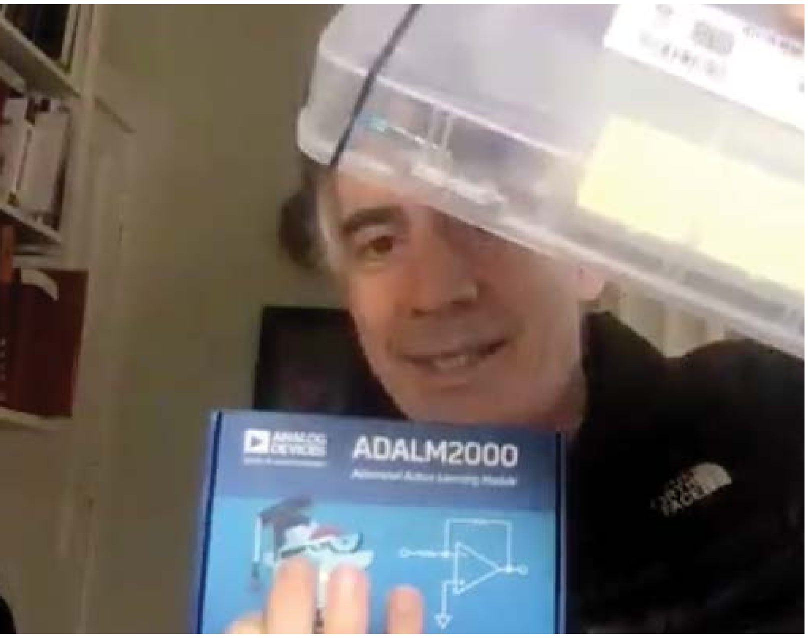
Lab kits identical to this were sent to EECS 300 students so they could complete the labs at home.

EECS 300: EE Systems Design II

As was instituted in several other ECE undergraduate courses in response to COVID-19, lab kits were sent to each and every student in the class so they could all work from home if needed.

A positive aspect of each student having their own kit is they each get experience implementing the lab.

“Before, it could be the case that one or two team members would take over, so that some didn’t get the complete experience,” said Abbot. “I’m finding more people are struggling with this than when I taught the course in person, and that’s probably because everyone is doing it this time instead of only the people who are good at it.”



Prof. Michael Flynn showing the lab kits during a zoom call.

EECS 311: Analog Circuits

Analog Circuits is a junior-level undergraduate course that covers single-transistor amplifier design and analysis of circuits commonly used in wireless radios, audio amplifiers, and several other interface applications. Prof. Michael Flynn was slated to teach it for the third time in the Fall of 2020, but with a new academic year ahead consisting of on-line only courses, he knew that things had to change.

Flynn began talking to colleagues at Michigan and other institutions, and decided on a flipped approach, where students prepare in advance of a lecture, and at least some of the class time is reserved for working on problems and applying what they learned.

He then reached out to his contacts at Analog Devices for lab kits that mimicked the state-of-the-art tools they would normally find on campus.

“I was fedexing boxes out all over the world,” said Flynn.

The course content was stripped down to essential material only, and the labs were completely rewritten with the help of three graduate students.

His efforts paid off. The students said the labs were “hard, but really good.” And Flynn received his best teaching evaluations ever: 4.9 out of 5.0.

Would Flynn consider continuing any of his new teaching techniques post-COVID?

“Yeah, totally. The lab kits are the way to go,” said Flynn. “The students appreciate the chance to do stuff themselves rather than being scheduled in the traditional lab. And the quality of the equipment is very good.”

Four More UG Courses Turn To Lab Kits

Faculty in charge of four different undergraduate courses, including three large introductory courses in ECE (with individual enrollments of 100-230 students), went the same route as EECS 311.

Each of these courses is normally taught in labs outfitted with industry-standard equipment with teams of students sitting at each station. These faculty determined that the Analog Discovery 2 (AD2) kit by Digilent would serve well as a core component for a take-home lab kit, supplemented by additional course-specific equipment.

During the 2020-21 academic year, more than 1,000 of these kits, along with additional devices and parts, were distributed to students still on campus, or mailed to those remaining at home. Home included states across the United States, as well as foreign countries, including China, Armenia, Korea, Israel, Thailand, United Arab Emirates, Bosnia and Herzegovina, and India. The $130K price tag was not passed on to any of the students.

How did the students like the kits?

It was a hit according to end of semester surveys. One student wrote, "The AD2 is an incredible device. I have quite a bit of lab experience from internships, and everything that was crammed inside that thing was very impressive."

"The use of portable instruments in every student's hands may revolutionize teaching," said Dr. Sasha Ganago, who completely redesigned EECS 314 (Electrical Circuits, Systems, and Applications) for remote teaching. Having their own kits allowed students to more closely associate theory with practice, rather than waiting for tightly scheduled lab times. Students could also do preliminary experiments with their kits prior to more advanced measurements with the industry-standard equipment available in the labs.

New Approaches to Engaging Students Online

Prof. Jeff Fessler teaching class on Zoom.

While a few lab-intensive classes offered students the possibility of some in-person instruction, most transitioned to a fully-online experience for Fall term 2020.

For faculty like Jeff Fessler, William L. Root Collegiate Professor of EECS, this meant significantly redesigning the course structure while choosing a really cool matrix background for his Zoom lectures.

Fessler taught EECS 551: Matrix Methods for Signal Processing, Data Analysis, & Machine Learning, and the biggest change he made was to the exam structure – typically a sit down affair.

"It's a lot harder to write an exam that's open notes where students can access the internet," Fessler says. "I'm using available software tools to make it harder to cheat, but we're mostly relying on the Honor Code."

Other adjustments included a more generous grading and homework policy, a longer time to access the online lectures, more flexible office hours times, and online quizzes to make sure the students are keeping up with the material.

"I just think there's a lot going on with life right now," Fessler says. "With the stress of what we're all going through, there are a lot of reasons someone might have a bad day. The most important thing is to be fair and consistent."

Lessons Learned

There was no one size fits all approach to redesigning the ECE curriculum for online learning. Some courses introduced take-home lab kits, or offered hybrid learning solutions. Still others resorted to novel solutions that relied on software to mimic electronic devices and equipment.

Those without a major lab component went completely online, and focused their energy on student engagement and new ways of presentation and evaluation of the subject material.

Many faculty plan to incorporate their creative solutions to student learning into future courses.

However, one point seems particularly glaring, and that is how important the actual physical setting, the bricks and mortar, are to higher education in engineering.

Colleges and universities don't simply provide the lab space through their facilities, they provide faculty and the student teaching assistants which are essential to providing quality education. They provide a space to work together to find solutions. And they provide the opportunity to build relationships that often last a lifetime.

Educating A Quantum Workforce While Opening Doors to a Broad and Diverse Range Of Students

Michigan is one of five institutions collaborating in a 2-year $5M NSF initiative called QuSTEAM: Convergence Undergraduate Education in Quantum Science, Technology, Engineering, Arts and Mathematics. This multidisciplinary program aims to revolutionize quantum science education and develop a diverse, effective and contemporary quantum-ready workforce.

“The spirit of the project is to build a scalable model and expand quickly to other institutions in the U.S.,” said Prof. P.C. Ku, coordinator of the effort at Michigan.

QuSTEAM is a massive collaborative effort involving 66 faculty across the United States with expertise in quantum information science and engineering, creative arts and social sciences, and education research. Ohio State University leads the project, and in addition to U-M, the University of Chicago, Michigan State University, and the University of Illinois complete the team. Each university is also collaborating with local community colleges and regional partners with established transfer pipelines to engage underrepresented student populations.

In addition, the group is collaborating with Chicago State University, which is a Minority Serving Institution (MSI), and the IBM-HBCU Quantum Center to recruit faculty from its network of over 20 partner colleges and universities, as well as Argonne National Laboratory.

“By collaborating with faculty from MSIs during course development,” said Ku, “we can address diversity, equity, and inclusion from day one.”

Industry is quickly expanding into emerging areas that include quantum computing, quantum sensors, and quantum communications. In the auto industry, for example, Ford is exploring quantum AI to address the technological needs of self-driving cars. Additional applications include secure computing and communications, big data analysis, highly-accurate healthcare imaging and environmental sensing, weather forecasting, and scientific discoveries.

What’s needed, but lacking, is a workforce comprised not only of highly-trained doctoral recipients, but also entry-level engineers holding bachelor’s degrees, or even associate certificates, with some exposure to the area of quantum science and technology.

The courses will be designed in a modular way so that they can be easily adapted for use by any institution – with little need for additional input from faculty teaching the course.

This will allow each school to create the course that works best for their institution based on its unique resources and its own culture. Michigan ECE may focus on materials, devices and technology, for example, while another department may want to focus on quantum algorithms.

The first course in the QuSTEAM minor will only require a high school level mastery of basic algebra, trigonometry, and pre-calculus. The four courses will focus on quantum information, quantum logic and devices, quantum systems and applications, and include a quantum laboratory.

In addition to Ku, faculty contributing to the core course modules at Michigan are Parag Deotare, Mack Kira, and Duncan Steel from Electrical and Computer Engineering, and Robert Hovden and Max Shtein from Materials Science and Engineering. These six faculty will work alongside their collaborators from the larger group of 66 faculty.

Ku expects Michigan to pilot its first set of QuSTEAM courses as early as Fall 2022.

“The spirit of the project is to build a scalable model and expand quickly to other institutions in the U.S.” - P.C. Ku

New Online Education Program Brings High-Demand Topics in Technology to the World

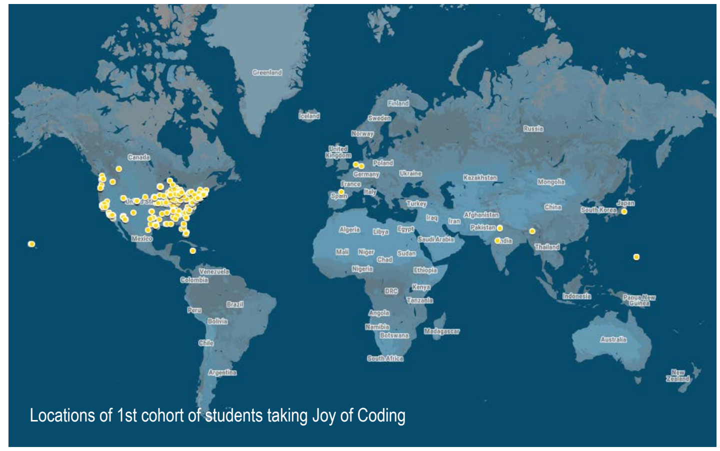
The Continuum program, launched in Fall 2020, offers continuing online education courses in machine learning, linear algebra, and coding. The courses are taught by U-M faculty in Electrical and Computer Engineering and range from introductory classes designed for high school students to specialized classes for those already established in their careers.

“This program is about making education more accessible for everyone,” said Mingyan Liu, the Peter and Evelyn Fuss Chair of ECE. “Our goal is to advance inclusive teaching by reaching more students without sacrificing quality.”

Continuum courses are rigorously designed to give participants knowledge that will serve to jumpstart their learning and serve as a bridge to more advanced courses. Students apply to the program, and must demonstrate they have the appropriate background to succeed in each course.

The Joy of Coding, an introductory course that teaches teens how to use Python to empower apps such as Snapchat, TikTok, Instagram, and Siri, was launched this past summer. Over 1,400 students from 5 countries and 36 states have taken the course.

“We created The Joy of Coding, because we realized that many high school students wanted to, and were ready to, learn to code, but many didn’t know where to start,” said Prof. Raj Nadakuditi, who created Continuum. “We welcome anyone and everyone who has a desire to learn, including first-generation coders and students from rural communities and homeschoolers.”

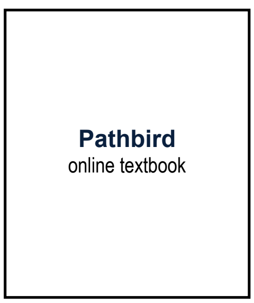

Locations of 1st cohort of students taking Joy of Coding

Continuum uses Pathbird, a cloud-based interactive textbook platform Nadakuditi developed with CSE alum Travis DePrato. Pathbird enables instructors to build their materials into video game-like journeys that unfold as the learner progresses, creating a more interactive experience for the students.

“We welcome anyone and everyone who has a desire to learn, including first-generation coders and students from rural communities and homeschoolers.”

- Raj Nadakuditi

New Courses + Books



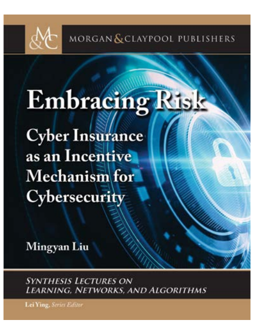
Pathbird

Raj Rao Nadakuditi and Travis DePrato

Pathbird is a cloud-based interactive textbook platform that enables instructors in the computational sciences to build their materials into video game-like journeys that unfold as the learner progresses.

“Our vision is an interactive computational textbook platform designed to stimulate deeper conversations between students and the material they are attempting to master,” said Nadakuditi, who sees this as the future of writing computational textbooks.

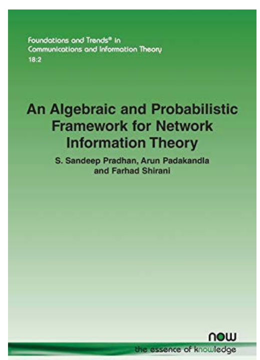
The technology is being licensed through Nadakuditi’s and DePrato’s new company, Pathbird, Inc. It is used for ECE’s online learning program, Continuum.



Embracing Risk: Cyber Insurance As An Incentive Mechanism For Cybersecurity

Mingyan Liu

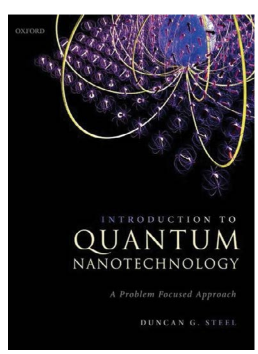
Liu has drawn from her expertise as a researcher and entrepreneur to write a book, published by Morgan & Claypool Publishers, providing novel insights into how cybersecurity can be enhanced through cyber insurance.



An Algebraic and Probabilistic Framework for Network Information Theory

S. Sandeep Pradhan, Arun Padakandla, Farhad Shirani

This monograph addresses the overarching challenge of designing efficient information processing strategies from a fundamental network information theory viewpoint. It is aimed at students, researchers and practitioners in information theory and communications. Padakandla and Shirani are ECE alumni and former students of Pradhan.



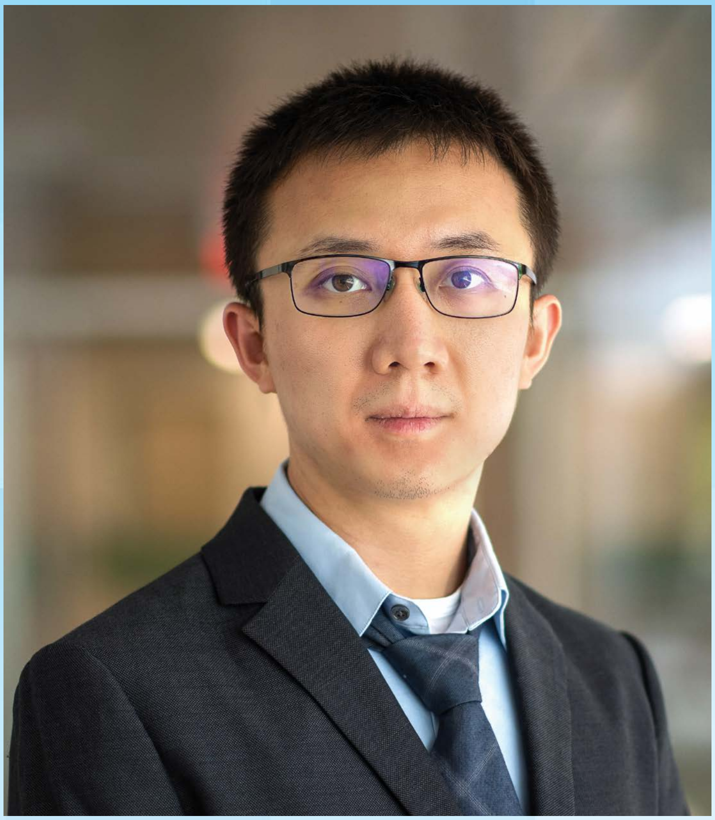
Introduction to Quantum Nanotechnology: A Problem Focused Approach

Duncan Steel

Steel’s textbook, published by Oxford University Press, helps students prepare to be part of the quantum revolution by providing the technical background to work in a field that has emerged as a game-changer in technology. The textbook introduces undergraduate students to material often not seen until graduate school, yet only presumes an introductory level of physics.

Prof. Qing Qu Uses Data and Machine Learning to Optimize the World

Prof. Qing Qu specializes in signal & image processing and machine learning. His research has applications in imaging sciences, scientific discovery, healthcare, and more.



Tell us about your research:

Broadly speaking, my research interest lies in the intersection of signal processing, data science, machine learning, and numerical optimization. I am particularly interested in developing guaranteed computational methods for learning low-complexity models from high-dimensional data, leveraging tools from machine learning, numerical optimization, and high dimensional geometry, with applications in imaging sciences, scientific discovery, and healthcare, etc.

In particular, my past work developed a new framework for studying nonconvex optimization problems in signal processing and machine learning, such as phase retrieval and dictionary learning. We showed that these challenging nonconvex problems often have benign global landscapes due to symmetry and low-dimensional structures, leading to the development of efficient global optimization methods. Very recently, I got very interested in understanding deep networks through the lens of landscape analysis and low-dimensional modeling, building upon the work we have done in the past.

What got you interested in ECE?

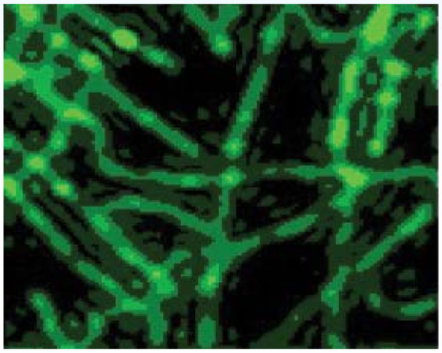
The interest is rooted in my family; my father is a geophysical engineer who claims himself "doing CT imaging for the Earth." During high school, I loved math and physics, so during my undergraduate career in Tsinghua I decided to join the academic talent program with a focus on math and physics. During my senior year, I felt more excited to use math and physics to change the world, so I changed my major to electrical engineering with a focus on signal processing. During my graduate study, I found that machine learning is rapidly transforming every discipline of engineering and science, and I was very convinced that this is the area that I can make the biggest impact.

"Machine learning is rapidly transforming every discipline of engineering and science, and I was very convinced that this is the area that I can make the biggest impact."

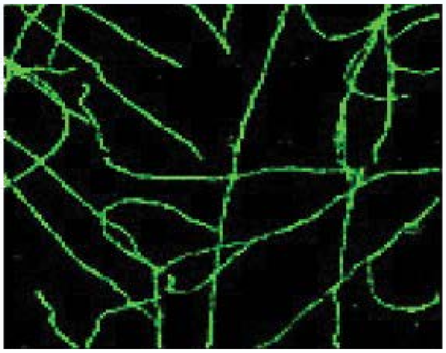
Why did you choose Michigan?

There are some obvious facts that made me excited to join U-M. The engineering school is consistently ranking top five, and the ECE program is also among the top five in the nation. But more importantly, I think what made up my mind is more due to the people and collegial environment here. During the interview, I could feel that the faculty here really appreciated my work and were very supportive of me. I have a feeling that my research fits well into the current research in the area of signal processing and machine learning at U-M, and that I can find many collaborations within my area and across the engineering school.

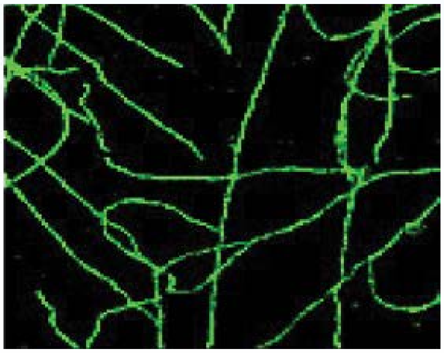
Moreover, because of the top quality of the faculty and the university, it is easy to attract top students into my research group, building a high-quality research program into the future. All these factors made me really excited to join U-M and go BLUE!



Observation



High resolution image: Truth



High resolution image: Recovered

Prof. Pei Zhang Solemnly Swears That He's Up to Some Good

Prof. Pei Zhang specializes in cyber-physical systems learning by integrating data, physical knowledge, and hardware systems for real-world applications. His work can benefit many fields including medicine, eldercare, farming, and smart buildings.

"We're literally building magic here."

Tell us about your research:

My students and I refer to one of my projects as "Structures as Sensors." We nicknamed it "The Marauder's Map," [the magical map of Hogwarts from Harry Potter] because we're literally building magic here.

Instead of using a small diaphragm in a microphone, we can use a humongous building or a fleet of cars as our physical element for the sensor. We install grophons to detect the vibrations of the physical building structure, but the sensors are so sensitive – their range is about 20 meters – we don't need very many. The pattern of vibration we get can then tell us what's happening. For example, when I was kid, I could tell whether it was my dad or my mom coming up the stairs based on their footsteps, so I knew whether I should be pretending to do my homework or not.

We can actually track and predict when an elderly person is about to fall, which is important for eldercare. We can track people's heartbeats and breathing patterns, which are important metrics for medical professionals, especially when you have to monitor someone's recovery after a major health condition, like an aneurysm or something.

We've also been working with the USDA folks to track and monitor pigs. So, mother pigs crush and kill a lot of their babies when they're not in a good mood, but with our method, we can identify which ones are bad mothers, and we save a lot more of the litter that way. I remember having to crawl under a lot of defecating pigs to plant our sensors, so my students take great pleasure in calling it, "the sh***y project."

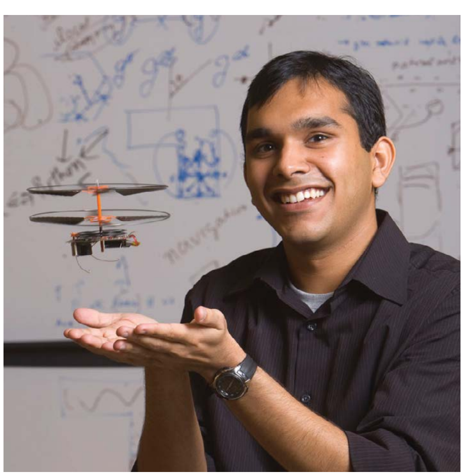
Also, using mobile carriers as sensors, we utilize the movement of sensors to increase the efficiency of measuring phenomena that cover a wide area (e.g. cities). As part of this work, we 1) actuate the sensors to optimize sensor placement, movement, and data gathering; and 2) fuse with physical models to generate missing data (e.g. physical model of air flow to model pollution).

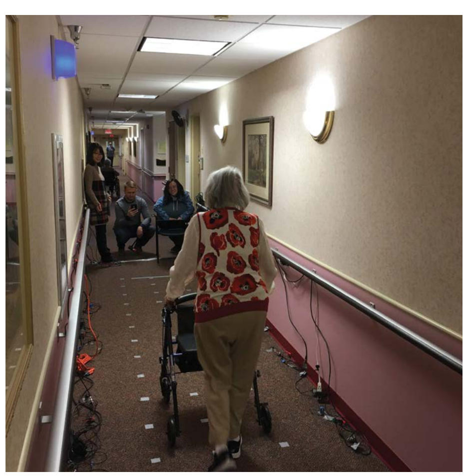
What got you interested in ECE?

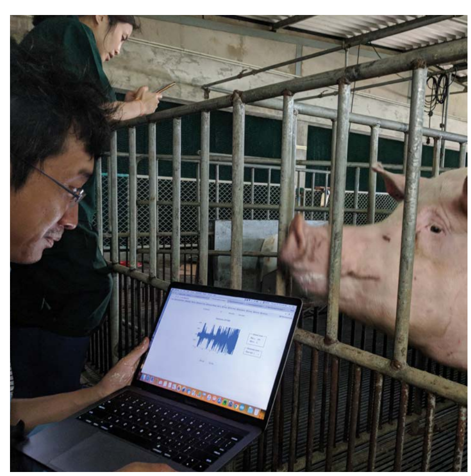
I took an EE class as an undergrad, and thought, hey, this is pretty interesting. I get to put things together and occasionally things might catch on fire and that's actually kind of fun.

Why did you choose Michigan?

Michigan has a strong reputation in research, so it certainly is a top choice for any faculty or student. But I also have a personal connection. My grandmother was one of the few first Chinese students that came to the U.S. to study. She got her PhD here in physics or something, and then I think she stayed to do a bit of research. So it feels a bit like coming home to me.







Kamal Sarabandi is Newest Member of the National Academy of Engineering

Prof. Kamal Sarabandi, Rufus S. Teesdale Professor of Engineering, was elected to the 2021 class of the National Academy of Engineering “for contributions to the science and technology of radar remote sensing.”

A fellow of the National Academy of Inventors, IEEE, the American Association for the Advancement of Science and former president of the IEEE Geoscience and Remote Sensing Society, Sarabandi has built a career on seeing through obstacles and monitoring the earth from space.

The advanced mathematical models of radar scattering that he developed have enabled satellites to measure soil moisture, snowpack volume and how much carbon a forest holds, for example. Such measurements shed light on the global water cycle and how it changes, as well as how trees and plants respond to increasing levels of carbon dioxide in the atmosphere. He also developed miniaturized radar devices for small autonomous systems for reconnaissance and surveillance missions.

He is currently part of a large effort at Michigan to design the next generation of automotive radar in order to provide a much greater amount of scene information to autonomous vehicles.

Said his former doctoral advisor and fellow NAE member Fawwaz Ulaby, “Kamal works to advance radar science and technology not incrementally, but by giant leaps forward - always ahead of the competition.”

Sarabandi and his team have published more than 1,000 journal and conference articles. His research group is large, but always treated like family.

“It is of critical importance to us, as faculty here at Michigan, to create a nurturing environment for our graduate students,” said Sarabandi at a special ceremony honoring his accomplishments.

Sarabandi holds 28 U.S. patents and is co-founder of four startup companies. His awards include the IEEE Judith A. Resnik Field Award, IEEE Geoscience and Remote Sensing Society Distinguished Achievement Award, NASA Group Achievement Award, Humboldt Research Award for senior scientists from The Alexander von Humboldt Foundation, and IEEE Geoscience and Remote Sensing Society Education Award. He has served as a member of the NASA Advisory Council, the highest advisory council in NASA, and currently serves as Chair of USNC-URSI Commission F - Wave Propagation and Remote Sensing.

“It has been a long and joyful scientific journey for me so far and getting such recognition along the way is truly wonderful,” said Sarabandi. “I am earnestly grateful, and attribute much of this to the support I have received from my students and colleagues as well as my department, the College, and the University of Michigan.”

“It is of critical importance to us, as faculty here at Michigan, to create a nurturing environment for our graduate students.” - Kamal Sarabandi

“Kamal works to advance radar science and technology not incrementally, but by giant leaps forward - always ahead of the competition.”
- Fawwaz Ulaby

Elaheh Ahmadi Receives NSF Career Award

Title: A novel Gallium Oxide based transistor for low-waste power conversion applications

Prof. Elaheh Ahmadi received an NSF CAREER Award to develop a novel transistor for high-power electronic applications. Specifically, she is developing an ultra-high voltage switch which will enable efficient high-power switches in the 2 kV-20 kV voltage range. This research could improve efficiency in systems such as electric vehicles, grid systems, mass transit, and industrial automation.

The project has an educational plan that includes tutorials prepared for high school students that will be publicly available on Ahmadi's website and on YouTube.

Herbert Winful receives University Diversity and Social Transformation Professorship

For his tireless work building inclusive communities and supporting individuals in science, technology, engineering and mathematics, Herbert Winful has received a University Diversity and Social Transformation Professorship. Winful is also the Joseph E. and Anne P. Rowe Professor of Electrical Engineering, and Arthur F. Thurnau Professor.

As director of education and outreach for U-M's National Science Foundation Center for Ultrafast Optical Science, he provided STEM enrichment activities for pre-college minority students. In electrical and computer engineering, he established the Committee for an Inclusive Department and the annual Willie Hobbs Moore Distinguished Alumni Lecture named in honor of the first African American woman to earn electrical engineering degrees from U-M.

He leads the MI-Louis Stokes Alliance for Minority Participation, a higher education partnership that seeks to increase the number of minority graduates in STEM fields. He has fostered scientific exchanges with Africa, helped establish a doctoral program in optics at Ghana's University of Cape Coast and contributed to rebuilding engineering education in Liberia after its civil war.

Winful has received numerous accolades, including U-M's Harold R. Johnson Diversity Service Award, the College of Engineering Raymond J. and Monica E. Schultz Outreach and Diversity Award, a 2021 MLK Spirit Award from the College of Engineering, and a State of Michigan Teaching Award.

As a researcher, Winful has made fundamental contributions in many areas, including nonlinear fiber optics, nonlinear optics in periodic structures, the nonlinear dynamics of laser arrays, the propagation of single-cycle pulses, and the physics of quantum tunneling. He received the IEEE Photonics Society Quantum Electronics Award, and is a Fellow of the Optical Society of America, the American Physical Society, and Life Fellow of IEEE.

Additional Faculty Awards

CINDY FINELLI

Professor

IEEE Fellow "for leadership and scholarship in engineering education"

2021 EECS Outstanding Achievement Award

2021 CoE MLK Spirit Award

Co-leading a COE team working to limit the pandemic's long-term impact on undergraduate students

YOGESH GIANCHANDANI

Professor

Co-Chair, 2021 Air Quality Workshop: Emerging Sensor Technologies and Data Analytics for Air Quality Monitoring

BRIAN GILCHRIST

Professor

Named new Director of the Leinweber Space Innovation Laboratory

STEPHEN FORREST

Peter A. Franken Distinguished University Professor of EECS;
Paul G. Goebel Professor of Engineering

"Waiting for Act 2: What is the future of organic electronics after OLED displays?", S. R. Forrest, plenary, Asian Conference on Organic Electronics – 2020, Busan, Korea (virtual) (Nov. 9, 2020).

MARK KUSHNER

George I. Haddad Professor of Electrical Engineering and Computer Science

Standing Council member, NSF Engineering Research Visioning Alliance

Plasma Materials Science Hall of Fame Prize, Japan Society for the Promotion of Science (11/20)

CARL LANDWEHR

Lecturer

Co-organizer of theThe First IEIP Workshop on Intelligent Vehicle Dependability and Security (IVDS)

ZETIAN MI

Professor

General Chair, 2020 IEEE Photonic Conference

2021 CoE David E. Liddle Research Excellence Award

Best Paper Award for "Toward Ultrahigh Efficiency GaN Nano and Micro Full-Color LEDs," 27th International Display Workshops

2020 Editor-in-Chief Choice Awards from Photonics Research for "High-efficiency AlGaN/GaN/AlGaN tunnel junction ultraviolet light-emitting diodes."

RAJ RAO NADAKUDITI

Associate Professor

2021 Ernest and Bettine Kuh Distinguished Faculty Award

KHALIL NAJAFI

Schlumberger Professor of Engineering

2021 CoE Stephen S. Attwood Award, the highest honor awarded to a faculty member

MINGYAN LIU

Peter and Evelyn Fuss Chair of Electrical and Computer Engineering

Elected to the executive board of the ECE Department Head's Association (ECEDHA)

ANATOLY MAKSIMCHUK

Research Scientist

2021 U-M Research Faculty Achievement Award

NECMIYE OZAY

Associate Professor

Invited to 2021 NAE Frontiers of Engineering Symposium

LELAND PIERCE

Associate Research Scientist

2021 EECS Outstanding Achievement Award

SANDEEP PRADHAN

Professor

IEEE Fellow "for contributions to coding for distributed compression and structured coding"

2021 HKN Professor of the Year

Welcome Hannah Rose to our expanding ECE family!

Photo courtesy Hannah's parents, Prof. Hessam Mahdavifar and Dr. Najme Ebrahimi

STAFF **AWARDS**

Lisa Armstrong - CoE Judith A. Pitney Staff Service Career Award

Lisa Armstrong, ECE Unit Administrator, was awarded the Judith A. Pitney Staff Service Career Award in recognition of her three decades of excellence and service. This award is the highest honor given to staff in the College of Engineering.

Armstrong has been a driving force for many of the department's biggest advancements, and she's known for fostering a thriving, inclusive, collaborative, and fun environment. She has the distinction of being the longest tenured Unit Administrator in the College, beginning in the Department of Biomedical Engineering, which she helped transition from a graduate program to a department. She joined the department of Electrical Engineering and Computer Science in 2006, where she oversaw several major programmatic changes and has led or been involved in many unit, college, and university initiatives.

Armstrong has long been one of the strongest advocates for advancing Diversity, Equity, and Inclusion goals for both the college and the department. In addition to establishing the staff diversity committee, she won the University of Michigan Distinguished Diversity Leader's Award and Team Award. Her initiatives to improve the department's culture and climate has helped make ECE a role model for many other departments.

"I am deeply grateful for Lisa's dedication to her service to the college and the university," said Mingyan Liu, the Peter and Evelyn Fuss Chair of Electrical and Computer Engineering. "Her deep institutional knowledge has been invaluable."

Dr. Pilar Herrera-Fierro - CoE Staff Excellence Award

Dr. Pilar Herrera-Fierro was honored with a Staff Excellence Award for her extraordinary efforts as Senior Director of User Services for the Lurie Nanofabrication Facility (LNF). She regularly goes out of her way to support student, faculty, and external users of the Lurie Nanofabrication Facility, and is considered a key component of its success.

As Director of User Services, Herrera-Fierro is responsible for facilitating the work of all researchers who use the LNF. The facility averages about 450 users per year from more than 100 research groups representing over 20 departments within the University, as well as more than 15 universities and 35 different companies.

Students requested Herrera-Fierro take on the role of staff sponsor of the LNF User Committee when the previous member retired because they appreciate her strong sense of community.

Herrera-Fierro is "one of the outstanding professional staff in the Lurie NanoFabrication Facility" said Stephen Forrest, Peter, A. Franken Distinguished University Professor of Engineering and one of the primary users of the LNF. "In many respects, I regard Pilar as one of my group members, since she has been unfailingly helpful with training and assisting my many students over the years in their projects in the LNF. She shows a very personal interest to all students and invests in their success."

Kristen Thornton - CoE Staff Excellence Award

Kristen Thornton, the PhD Program Coordinator for ECE, has been honored with a Staff Excellence Award in recognition of her exemplary service to students over the years.

Thornton handles all administrative duties that support ECE PhD students from their initial registration, through candidacy, to their final defense or graduation. She manages the admissions paperwork, plans of study, preparing and filing nominations for fellowships and other awards, and she keeps track of academic requirements and deadlines.

In addition to her administrative excellence, Thornton is known for going above and beyond to celebrate student success while fostering a supportive, inclusive, and family atmosphere in ECE.

"Kristen has supported me through every step of my PhD program," says PhD student Haley Northrup, who serves on the ECE Graduate Student Council. "She brings joy to the department through her positivity, holiday sweaters, open door policy, unending patience and kindness."

Don Winsor - EECS Outstanding Achievement Award

Dr. Don Winsor received this award in recognition of his steadfast and distinguished service to the Department as leader of the Departmental Computing Organization and for contributions as a model citizen of EECS.

Winsor is an alumnus, full-time staff member, and occasional adjunct faculty member of the department. He is known to be a thoughtful and caring manager, with a creative approach to problem solving, whether that be creating a new program or system, or dealing with the many problems that arise in a department that specializes in computing.

He worked diligently throughout the pandemic to make sure students and faculty had the equipment they needed to work remotely, including setting up a remote kiosk system so that staff could work remotely, yet still serve those wanting assistance in the building. This is just one of the innumerable systems Winsor created to help faculty and staff get their work done more easily and efficiently.

ECE Lab Kit Team - CoE Team Staff Excellence Award

When the pandemic shut down in-person instruction, the team of Silvia Dykstra, Rob Giles, Bobbi Scheffer, Jennifer Honeycutt, Nicole Doher, and Jeffrey Horosko created and delivered individual lab kits to 1,200 students around the world so hands-on lab experience could continue. For their efforts, they were honored with the Team Staff Excellence Award.

Lab courses where students gain direct hands-on experience in learning electronics are considered a critical component of engineering education. When in-person instruction was discontinued, this team of ECE staff was tasked with finding a new way to deliver a meaningful lab experience in seven different EECS courses.

By August 2020, the team had designed and assembled over 600 lab kits, which were handed out to students on campus and shipped to students around the world. At the end of the semester, the team recollected the lab kits, sanitized them, reassembled them, and redistributed them to the next cohort of students for Winter 2021. Over 1,200 students have now been served through this new system.

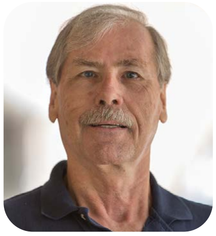
“We simply could not have fulfilled our teaching mission without them,” says Prof. Mingyan Liu, the Peter and Evelyn Fuss Chair of ECE. “They are an indispensable part of our community, and they exemplify truly the best of us at a time of national crisis. I am deeply grateful for their dedication, professionalism, and excellence in their service.”

Nicole Doher

Jennifer Honeycutt

Bobbi Scheffer

Jeffrey Horosko



Rob Giles

Silvia Dykstra

Professor Stephen Rand: Officially Retired, But Still Breaking New Ground

Prof. Steve Rand recently retired from the University of Michigan after a 33-year career in the area of nonlinear optics, though it may be more appropriate to say he simply stepped down from teaching. Rand has two active grants based on his groundbreaking research in magneto-electric effects of light that will go for two more years, and he plans to see his final three doctoral students through to their graduation.

Rand joined Michigan in 1987 after leaving Hughes Research Labs, where he invented the H3 diamond laser - which was the first room-temperature color-center laser.

The first person he visited upon arriving at campus was the renowned Prof. Emmett Leith, inventor of practical holography. “One of the things I always treasured,” said Rand of his interactions with Leith, “was learning how to do effective demonstrations that got the students excited.

After twenty years of distinguished teaching and research, Rand and his group discovered a dramatic and surprising magnetic effect of light that overturned a century-old tenet of physics. What Rand and his colleagues found is that at the right intensity, when light is traveling through a material that does not conduct electricity, the light field can generate magnetic effects that are 100 million times stronger than previously expected. Under these circumstances, the magnetic effects develop strength equivalent to a strong electric effect.

Based on this research, Rand received a $7.5M Multi University Research Initiative in 2014 called the Center for Dynamic Magneto-Optics (DYNAMO) to investigate the prospects for direct conversion of light to electricity without the thermodynamic losses typical of photovoltaic (solar cell) technology. And earlier this year, he and his team successfully demonstrated the charge separation effect, a key step in unleashing the potential for direct conversion of light to electricity without any thermodynamic loss.

“People have had a great deal of difficulty understanding and accepting our findings because they are contrary to what the entire present generation was taught,” said Rand. “However, time will tell.”

Throughout his career, Rand has taught 14 different courses, evenly split between graduate and undergraduate. He was the go-to guy when the department needed someone to teach a course. His broad experience teaching led to his book, *Nonlinear and Quantum Optics using the Density Matrix*.

Former department chair Khalil Najafi remarked at a virtual retirement party, “We could always depend on you. That’s why you served in so many different roles. Thank you for always being so positive, and so open to helping the department.”

Rand is a Fellow of the American Physical Society and the Optical Society of America. He has 15 published U.S. patents, and additional patents pending. He graduated 19 doctoral students, with several going into academia as well as industry.

Alex Fisher (PhD Applied Physics 2016), who worked on Rand’s MURI project, said, “Steve cultivated a research environment which required close collaboration with students and faculty from a broad range of disciplines, not just at U-M, but at several top research institutions across the country...I appreciate his guidance and the time he devoted to both his students and his research.”

What’s next - along with continuing research? Rand looks forward to travelling, visiting his children, music-making, artisan cheese-making, and even constructing a wind turbine.

Induced magnetic dipole scattering can equal electric dipole scattering through a two-photon magneto-electric interaction, making enhanced optical magnetism possible. Image by PhD student Laura Andre, with “doughnuts” signifying the radiation patterns of electric and magnetic dipoles added by Steve Rand.

Fawwaz Ulaby Retires After Nearly Four Decades Championing Students and Excelling at Research and Leadership

Fawwaz Ulaby, the Emmett Leith Distinguished University Professor of EECS, Chen-To Tai Professor of Engineering, and Arthur F. Thurnau Professor, is saying farewell after thirty-seven years of teaching at the University of Michigan.

Ulaby is an internationally renowned researcher in the fields of terahertz technology and microwave remote sensing. His scholarship has resulted in more than 700 scientific papers and 16 books. He's served as thesis advisor to 115 graduate students, many of whom are leaders in academia and industry.

He was elected to the National Academy of Engineering "for contributions to the science and technology of radar remote sensing and its applications." He also received the IEEE Edison Medal "for pioneering research in microwave and radar remote sensing technology and their environmental and industrial applications."

Ulaby has directed large, interdisciplinary NASA projects aimed at the development of high-resolution satellite radar sensors for mapping earth's terrestrial environment. These remote sensing systems now fly aboard satellites operated by NASA as well as the European, Canadian, and Japanese space agencies.

He also designed the first radar to fly in space. The home of his radar system was aboard Skylab, America's first space station.

Ulaby served as the founding Director of a NASA-funded Center for Space Terahertz Technology at Michigan, and he received the NASA/Department of the Interior William Pecora Award in 2002.

As a leader in the professional community, Ulaby's influence has been far-reaching. He served as founding President of the IEEE Geoscience and Remote Sensing Society, as Editor-In-Chief of the *Proceedings of the IEEE*, and as Vice President for Research at the University of Michigan.

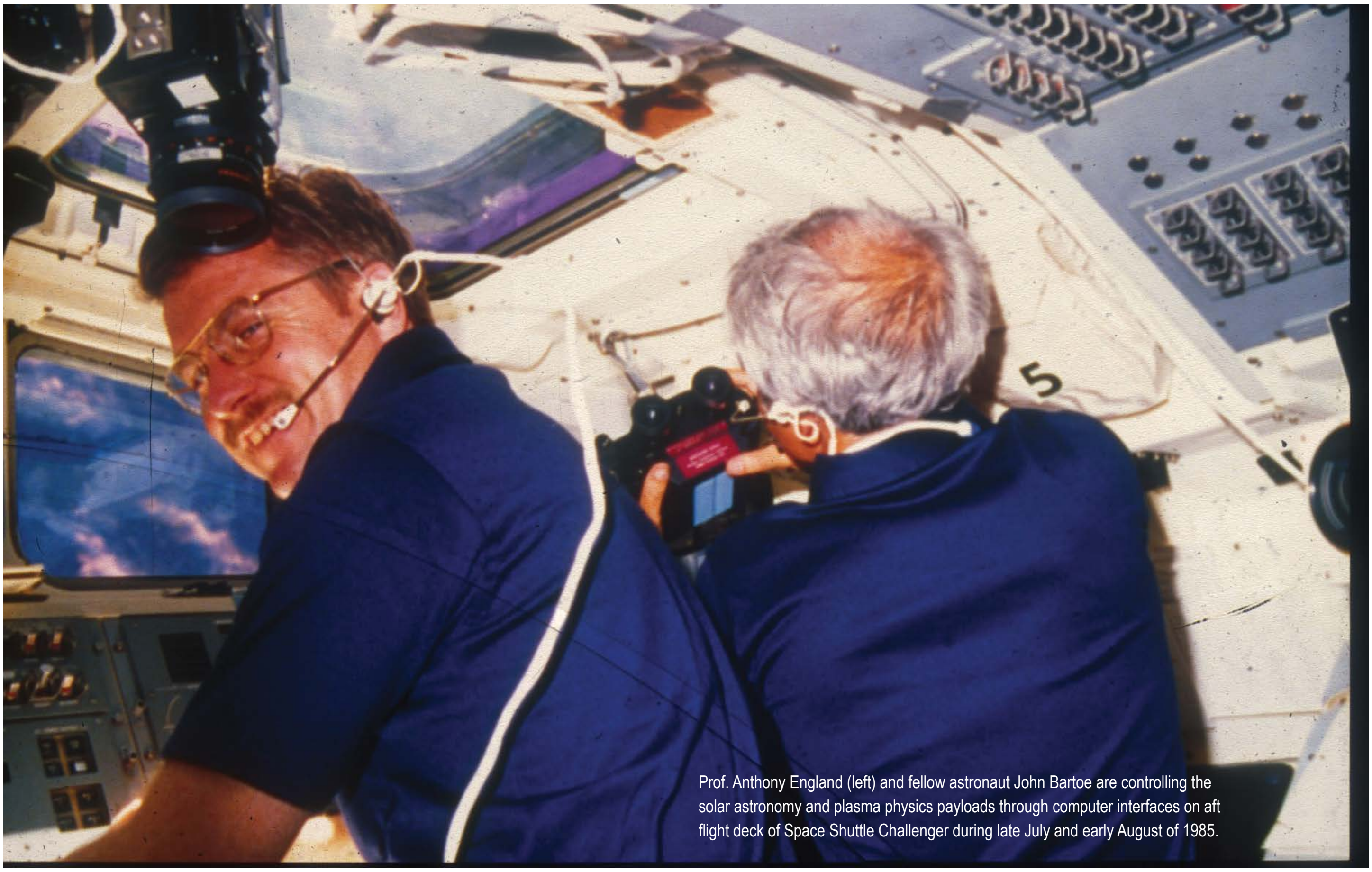
In the classroom, Ulaby is known for his personalized and compassionate approach to teaching.

"He cares more about how students feel, what they learn, and their future goals," said PhD student Menglou Rao, who took one of his graduate courses. "He was so warm and encouraging and helped me believe in myself."

In 2012, Ulaby received the IEEE James H. Mulligan Education Medal, "For contributions to undergraduate and graduate engineering education through innovative textbooks, dedicated mentoring of students, and inspirational teaching." Students voted him Professor of the Year three times.

"It's really his mentorship and the way he deals with students," said Dr. Émilie van Deventer (BSE MSE PhD EE 1985, 1986, 1992), who worked with Ulaby on some of his early research at U-M and is currently the Head of the Radiation and Health Unit at the World Health Organization. "He's always been a bit of a father figure to me. I just adore him."

"Michigan is very conducive to creativity and to success," Ulaby said. "I got recruited to a number of schools over the years, but I always turned them down, because nothing can compare to Michigan."



Prof. Anthony England (left) and fellow astronaut John Bartoe are controlling the solar astronomy and plasma physics payloads through computer interfaces on aft flight deck of Space Shuttle Challenger during late July and early August of 1985.

Anthony England, Former NASA Astronaut, Professor, and Dean, Retires

Professor Anthony England retired from the University of Michigan after 32 years of distinguished research and leadership. England joined U-M as a professor of Electrical Engineering and Computer Science in 1988 and served as Associate Dean for the Rackham School of Graduate Studies from 1995-1998. He left Ann Arbor to serve as Dean of the College of Engineering and Computer Science at the University of Michigan-Dearborn, a position he served with distinction from 2014 to 2020.

England's research has included ground probing radar, and radar studies of temperate and polar glaciers in Alaska and during two field seasons participating in and leading traverses in the Pensacola Mountains of Antarctica, and microwave studies of snow, ice, freezing soils, and planetary regoliths (layers of dust usually caused by meteor impact). He focused on modeling processes that occur in the soil, vegetation, or snow to inform weather and climate models, which helps predict patterns in climate change.

"Back in the 1970s we began to understand that the earth sciences were linked together," said England. "You couldn't understand global climate-and the human effect on climate-without considering the atmosphere, the ocean, and the water cycle because they were all interrelated."

He earned bachelor's and master's degrees in geophysics and geology, respectively, from the Massachusetts Institute of Technology (MIT), as well as a PhD in geophysics in 1970.

Prior to joining U-M, England was a scientist and former astronaut with NASA, where he served as mission scientist for Apollo 13 and 16 and space station program scientist in 1986-87. While England's opportunity to fly to the Moon was lost when Apollos 18 through 20 were cancelled, he did fly as a mission specialist crewman on Space Shuttle Challenger in the summer of 1985. His mission focused upon solar astronomy and plasma physics.

"We were in a high inclination orbit, and you could see the aurora over Antarctica standing up as a green curtain with waves on the front of it," England remembered. "This was in early August during the Perseid showers, so while you're watching the aurora, you're seeing shooting stars below you. It's pretty spectacular to see the Earth that way."

England loved to share his love for science, his experiences at NASA, and his concern for teaching, with area K-12 children. He has given hundreds of speeches to school children about careers in science and education.

"My message is that science and engineering can be exciting, and that research universities even offer opportunities for students to work on instruments that could fly into space," England said. "They begin to see the university as a place to do things and experience things and not just as a place to go to read books. All science and engineering is a physical experience. It's an adventure."

In addition to receiving the Presidential Medal of Freedom, England is an IEEE Fellow, and recipient of the U.S. Antarctic Medal, NASA Outstanding Scientific Achievement Medal, NASA Space Flight Medal, NASA Exceptional Service Medal, Radio Society of Great Britain's Calcutta Key, American Astronomical Society Flight Achievement Award, and the IEEE Judith A. Resnik Award. He has also received numerous awards for his efforts in diversity.

Women in ECE Provides Professional Development and Community

A new student organization, Women in Electrical and Computer Engineering (WECE), puts ECE topics front and center while helping to build a stronger community for women and gender minorities in engineering.

"There's a lot of camaraderie in ECE courses, and we wanted to continue those relationships beyond the classroom," says WECE President and co-founder Isha Bhatt, a Computer Engineering undergraduate student.

Bhatt and Enakshi Deb, an Electrical Engineering undergrad and current Internal Vice President of WECE, decided to form WECE to make it easier for ECE students to find study groups and share advice about classes. They assembled a team of ECE women who officially launched the club last winter. While there are other EECS-related student groups on campus, WECE is the only one that focuses specifically on ECE topics and fields.

"One of my favorite events was the graduate school panel," said Deb. "We had a few students who'd just recently graduated and Prof. Willingale. It was very helpful for me, because I'm considering grad school, and it was nice hearing fresh perspectives and honesty about the pros and cons. And it was great getting to ask questions."

In addition to class-related support, WECE hosts a variety of events related to career and advanced degree topics. Members of WECE include over 100 undergraduate students, graduate students, and faculty, who host discussions about their personal journeys and advice for pursuing different routes. WECE has also hosted a virtual career fair with representatives from a variety of industries.

One of WECE's central missions is to foster a supportive, inclusive environment in engineering for women and other underrepresented minorities. Membership is open to people of all identities who support that mission. As a result, WECE hosts many events, activities, and trainings about striving for an intersectional approach to allyship. This enables community dialogue on topics such as identity, current events, and systemic oppression.

"We wanted a way to channel our voices and have an open discussion, especially about all the events that were happening over the summer," Deb says. "These conversations are so important and support our overall mission, because our goal is for everyone to be considered equally and have all the opportunities that other students have."

Laurel Saxe, a Computer Engineering undergraduate and first-generation college student, is the Outreach Officer for WECE. Her favorite activities have been the internship panel and the technical interview workshop. She is currently developing programming targeted to high school students.

"When I was in high school, I was interested in Computer Engineering, but nobody talks about it at all," Saxe says. "I really wanted to help expose high school students to ECE, and it's a great opportunity for WECE members to develop speaking skills and things like that."

When in-person events become possible again, Saxe hopes to arrange more in-person demonstrations and experiences, including bringing high school students onto campus for exposure to our labs and facilities.

WECE has never been able to meet in person due to the pandemic, but that hasn't slowed them down. They've hosted over 50 events in the past year and have a very active slack space.

"One of my favorite events was the graduate school panel. It was nice hearing fresh perspectives and honesty about the pros and cons." - Enakshi Deb

ECE's Culture Club Brings the (Virtual) Community Together

When the pandemic shut down ECE's annual cultural celebrations, PhD Coordinator Kristen Thornton suggested a new event series to keep our community connected. With much of the community scattered around the globe, it was the perfect opportunity to learn about one another's home regions and cultures, and so the ECE Culture Club was born.

"I love that our students are so open to sharing a piece of who they are," Thornton says. "My favorite part of the Culture Club is getting to know about students in a new way."

Once a month, an ECE student, faculty, or staff member gave a virtual presentation that showcased the different traditions, languages, food, crafts, history, etc., of their home country or region. Attendees asked the presenter questions on different topics, including recommendations for places and times to visit and foods to try.

India
Ady Hambarde,
ECE PhD student

Egypt
Omar Abdelatty,
ECE PhD student

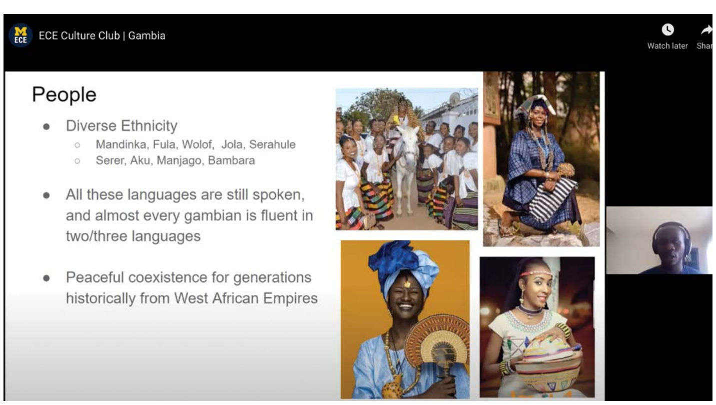
Venezuela
Fanny Pinto,
ECE PhD student

China
Chenlan Wang,
ECE PhD student

Hawaii
Christopher Okumura,
EE UG student

Japan
Silvia Dykstra,
ECE Events Assistant

Gambia and West Africa
Demba Komma, ECE PhD student



"I am thankful for the friends and memories that I have made here! I owe my growth and accomplishments during my college experience to them!" - Joseph Rottner

Photo provided by Alan Gerdov

Photo provided by Jiaxiang Ma

“Thank you to all of the EECS professors and IAs for their dedication to teaching students how to become excellent, knowledgeable, and curious engineers.” - Samina Abdullah

“To new beginnings!” - Samudhbhav Prabhu Srinivas

“Onwards and upwards from here on. Proud Wolverine. Go Blue!” - Saptadeep Debnatha

“I am so thankful to UofM for giving me an incredible two years of learning and growing. I have never felt more excited or prepared to tackle the next phase of my life head-on!” - Nidhi Sridhar

“When I leave, a piece of me will never leave.” - Kai Cheng


Photo provided by Amogh Rane

“Grad school was full of hectic schedules, late nights, and early mornings; but U of M made everything worth it!” - Rucha Apte


Photo provided by Malvika Dayanand Shetty

Photo provided by Jaehyun Lee

“Thank you to everyone who helped me get to where I’m at today and helped me become a better me! Part of the journey is the end.“ - Burhan Husain


Photo provided by Elisabeth Jahnke


Photo provided by Matt Lamb

Photo provided by Gillian Minnehan

“Michigan is not just a place where I learned knowledge, researched on interesting topics, and graduated, it is also where I met the one, got married and had my baby girl. Overwhelming happiness comes to my mind when thinking of my time in Michigan.” - Xiuzhang Cai


Photo provided by Brian Lin

"My favorite memory is coming back to campus after a long freshman year summer and feeling like I had truly found a home in Ann Arbor."
- Marcelo Almeida

"These two years would be the most special and memorable time in my life! Thank you to everyone I met at Umich!" - Rui Sun


Photo provided by Nidhi Sridhar

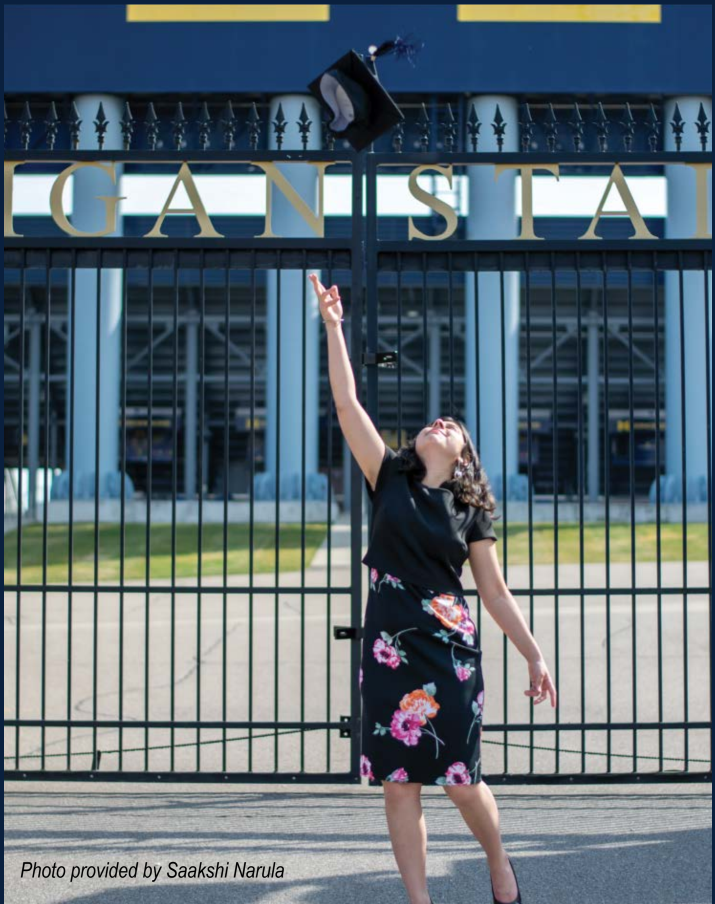
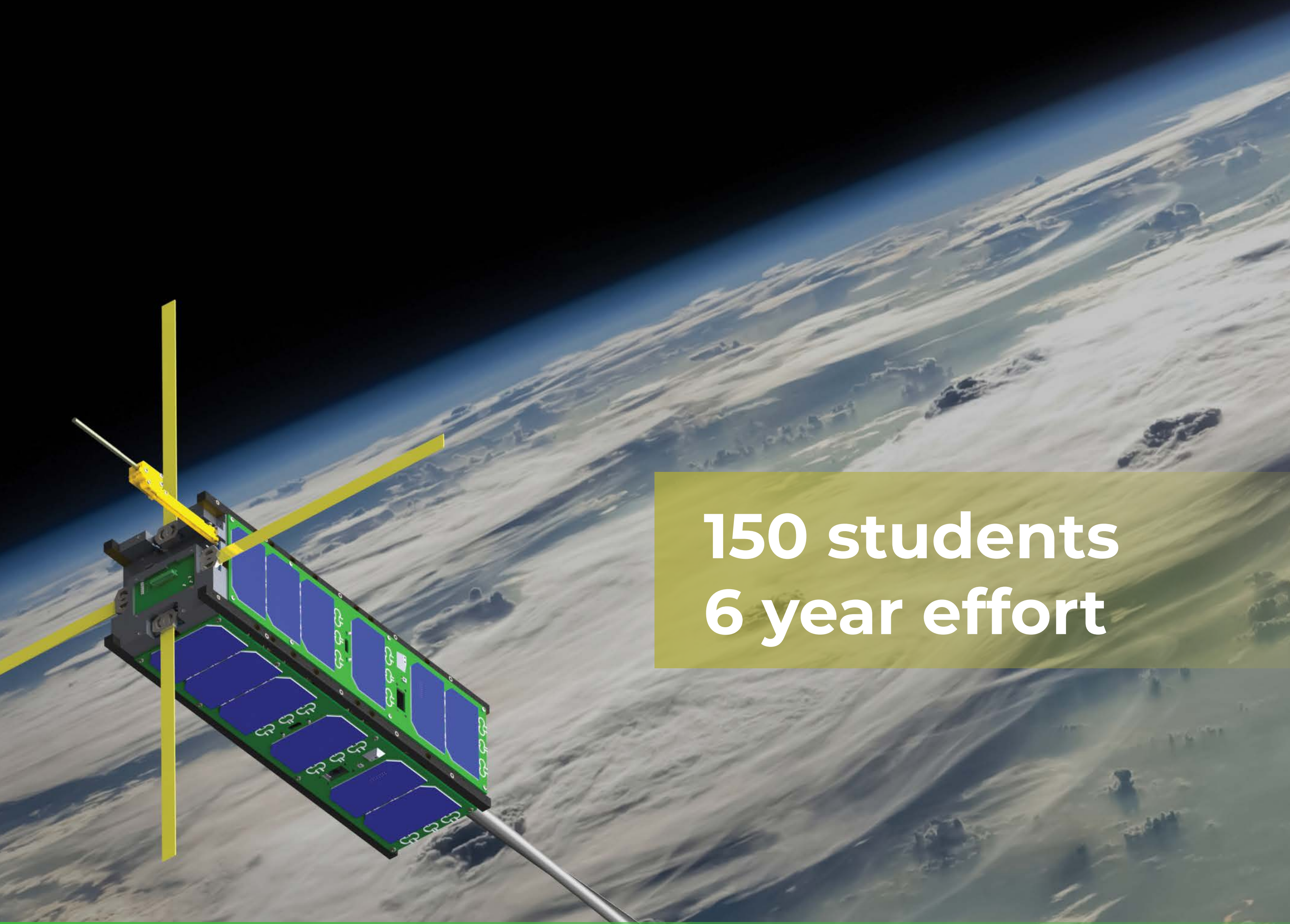


Photo provided by Saakshi Narula

Photo provided by Sung Yul Chu

"You can never find a better bed than the chairs in EECS 2420." - Guanru Wang


Photo provided by Michelle Gehner



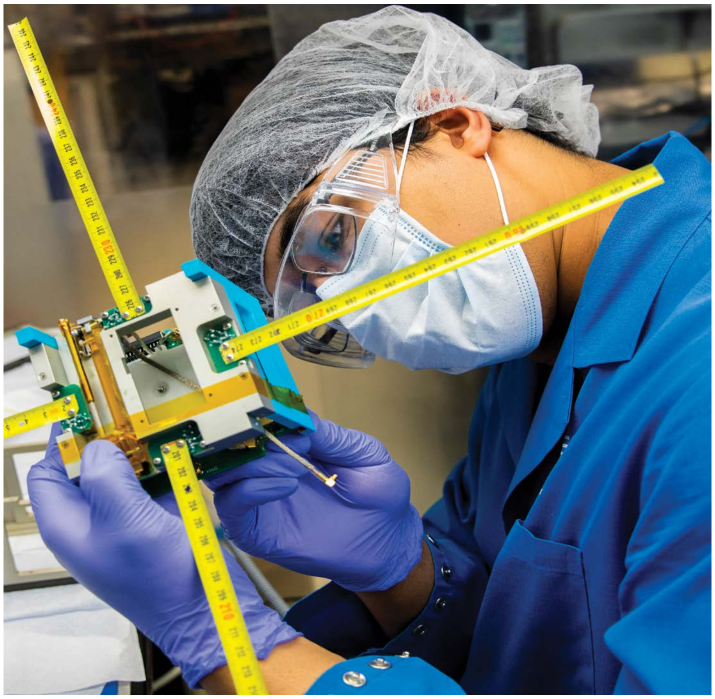
THE MITEE STUDENTS SHAPING THE FUTURE OF SPACE SATELLITES

After years of preparation and a global pandemic that delayed the launch for months, the Miniature Tether Electrodynamics Experiment-1 (MiTEE-1) officially blasted into space in late January 2021, hitching a ride on Virgin Orbit's Launch Demo 2 from the Mojave Air and Space Port. The tiny satellite, or "CubeSat," is about the size of a loaf of bread and was largely built by more than 150 undergraduate students over the course of six years.

"We had a watch party for the launch on zoom," said subteam leader Maya Pandya. "Everyone was on the edge of their seats as the plane went up and then the rocket launched from the plane. There was a point where the rocket shook, and we were like, 'Oh no!' but it was okay. They showed the first picture, and in that picture, we could see our satellite, and it was this incredible feeling of, wow, there it is. We actually made something that's in space."

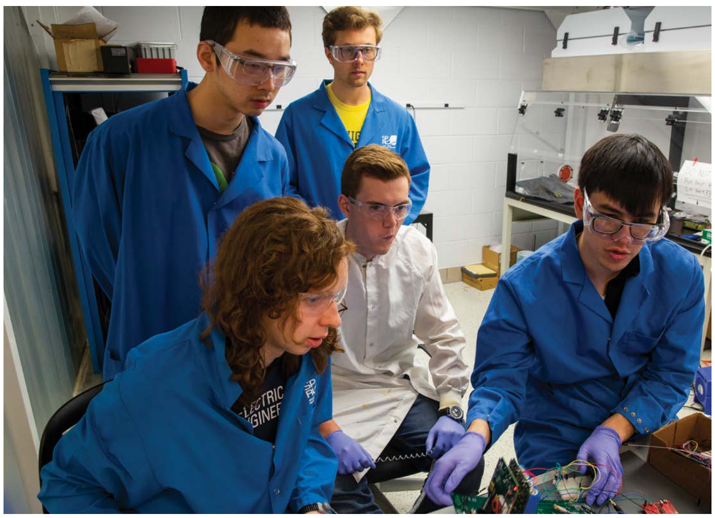
Pandya, a senior majoring in Electrical Engineering, joined the team her freshman year and has served as the Orbits, Attitude Determination and Control Systems Lead for the past two years. Her team was tasked with using photodiodes and magnetometers to determine the attitude of the spacecraft and applying that information to control the spacecraft.

MiTEE-1 is part of a mission to explore the feasibility of a new propulsion method, electromagnetic tethering, that could enable very small satellites to move around Earth's orbit without carrying fuel. With this method, two satellites are connected with a wire 10 to 30 meters long that is able to drive current in either direction using power from solar panels and closing the electrical circuit through the Earth's ionosphere. When a wire conducts a current in a magnetic field, that magnetic field exerts a force on the wire.



Mayukh Nath, Computer Engineering Undergraduate Student inspects the upper unit on the Mi-TEE (Miniature Tether Electrodynamics Experiment) cubesat.

Maya Pandya (center) and fellow students working on the IMU for the cubesat.



Students testing the MiTEE cubesat.

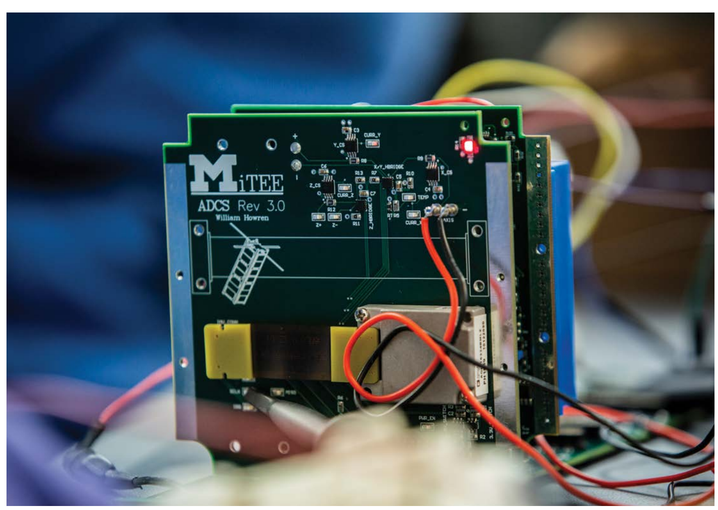
Cade Wright (L) and Virgin Orbit engineer loading the MiTEE-1 spacecraft into the dispenser that will deploy it from the rocket once in space.

CubeSats can then use the force from the Earth's magnetic field to climb higher in orbit, which compensates for the drag of the atmosphere.

Electromagnetic tethering could enable coordinated fleets of tens to hundreds of miniature satellites, transforming the way we monitor natural disasters, space weather, and the broader space environment. These fleets could also serve as a blueprint for future interplanetary communication arrays that would allow faster, more reliable signals to be transmitted from Earth to colonies on the moon, Mars, and more.

The project was organized through U-M's Multidisciplinary Design Program, and advised by Prof. Brian Gilchrist.

> "Everyone was on the edge of their seats as the plane went up and then the rocket launched from the plane." - Maya Pandya



MiTEE circuit board.

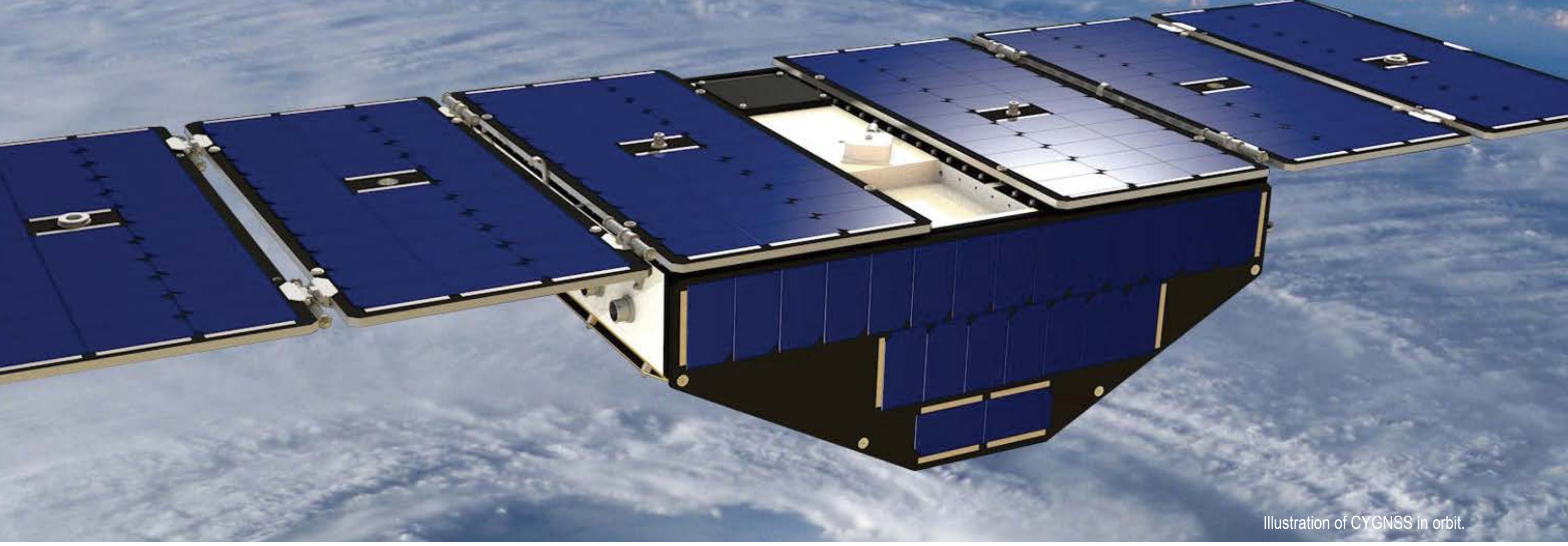


Illustration of CYGNSS in orbit.

Tracking Microplastics in the Ocean

Madeline Evans (BSE EE 2020) spent the majority of her undergraduate career in Electrical Engineering working on how to spot miniscule particles of plastic from space. As a research assistant with Christopher Ruf, a Professor of Climate and Space Sciences and Engineering and Electrical and Computer Engineering, Evans used NASA's Cyclone Global Navigation Satellite System (CYGNSS) to monitor the movement and location of microplastic pollution.

"The goal is to get a better handle on where microplastics are entering the ocean and where they go from there," Evans says. "The oceans are just giant, and our technique could help target clean-up efforts by showing where the biggest entry locations and accumulation sites are."

Microplastics are plastic particles that measure less than 5 millimeters in diameter and pollute entire ecosystems of marine life. They're difficult to see and even more difficult to remove, making them a particularly difficult problem to solve. With humans producing over 359 million metric tons of plastic in 2018, the scale of the problem continues to grow.

Ruf and Evans were able to track ocean microplastics in real time, and found that their concentrations tend to fluctuate seasonally. They are currently serving on a global task force dedicated to remote sensing of marine litter and debris.

"I've always wanted to do something good for the world. The scale of this problem is going to require a lot of different solutions."
- Madeline Evans

Award-Winning Metamaterials Research

PhD student Cody Scarborough is developing methods to rapidly model and simulate traveling-wave modulation in metamaterials, which could facilitate breakthroughs in areas such as next-generation wireless communication, commercial and military radar systems, imaging, antenna systems, and more.

He was awarded the Best Student Paper Award at the 2021 European Conference on Antennas and Propagation (EuCAP) for the paper, "The Interpath Relation for Spatially-Discrete Traveling-Wave Modulated Structures," co-authored with his advisor, Prof. Anthony Grbic, and he was also a finalist for the Best Electromagnetics Paper Award at the conference.

Metamaterials consist of subwavelength patterned cells designed to attain electromagnetic properties which do not arise in nature. Their properties can be varied as a function of space and – more recently – time, to manipulate waves propagating through the structure.

Scarborough applied a new computational method to traveling-wave modulation along two dimensions, which enables a higher degree of control on the emitted radiation.

"This results in dramatic computational savings," Scarborough says. "We demonstrated that the memory requirement to solve a particular case of two-dimensional traveling-wave modulation was reduced from 2 TB down to just 187 MB. This can mean the difference between simulating on a high-performance cluster and a personal laptop."

The research was funded in part by the MURI, "Time-varying metamaterials for next generation communication, sensing, and defense systems."

Michigan Electric Racing Takes First Place at Formula SAE Michigan

MER race crew post endurance event at 2021 Formula SAE Michigan.

In their first competition since the pandemic shut everything down, Michigan Electric Racing (MER) was crowned champion of the Electric Vehicle Class at Formula SAE Michigan. The team completed a near perfect sweep of the events, finishing first place in Skidpad, Acceleration, Autocross, and Efficiency, and second place for Endurance.

Shortly before the team was due to begin competition in 2020, the pandemic shut down all events and forced the university to shift to a completely remote schedule. For the entire summer, the team was locked out of the Wilson Center, where they typically construct their car.

The team gained limited access to the center in the fall under strict social distancing guidelines, with only a few members allowed into the space at a time. The team continued to adapt to the unusual working conditions and made progress.

For much of the year, it was uncertain that competition would even take place this summer. When Formula SAE confirmed their competition would occur, there were additional restrictions limiting the number of team members normally allowed at the events. Madeleine Bahorski, an Electrical Engineering senior who served as the low voltage lead on the team, was the only MER member who'd attended the previous MER competitions.

Competing in the Endurance event at the 2021 Formula SAE Michigan.

> "I don't think we showed up prepared to sweep, but I think we had trained ourselves so well that when difficult things happened, even an hour before a race, we were like, all right, we got this."
>
> - Madeleine Bahorski

"I don't think we showed up prepared to sweep," Bahorski said, "but I think we had trained ourselves so well that when difficult things happened, even an hour before a race, we were like, all right, we got this."

Despite a few setbacks that required some on-the-fly repairs, the team remained focused on their strategy and was rewarded with first place after first place finish. Fellow U-M racing team, MRacing, won their class of events as well, so the medal ceremony was a mountain of maize and blue. MER is planning to merge with MRacing next year, where they will continue to compete in the electric vehicle class. Prof. Heath Hofmann will continue to advise the team, along with co-advisor Prof. Harvey Bell from the MRacing team.

"I want to thank the team, because the past two years were pretty crazy, and even with everything we had to go through, we somehow managed to win," said Kanisius Kusumadjaja, a Computer Engineering senior who served as the powertrain lead. "The team has some of the smartest and hardest working people I've ever met, and I'm very lucky to be in such a community."

Bringing MLK's Vision To Life

ECE students Himaja Motheram and Kwesi Rutledge are 2021 recipients of the MLK Spirit Award. The MLK Spirit Awards are given annually to recognize members of U-M's community "who exemplify the leadership and vision of Dr. King through their commitment to social justice, diversity, equity, and inclusion." Recipients include students, student organizations, staff, and faculty members.

Himaja Motheram

Himaja is an undergrad studying Computer Engineering with a specialization in autonomous robotics. She is also pursuing a Sweetland Minor in Writing, for she enjoys bringing code and words to life as a way to connect with others.

She serves as the Advocacy Officer of both Women in Electrical and Computer Engineering (WECE) and the Society of Women Engineers (SWE). She's also a Team Captain for Do Random Acts of Kindness, and a student developer for CLAWS (Collaborative Lab for Advancing Work in Space). After graduation she wants to work with robotics and embedded systems to solve problems in cybersecurity.

"I imagine that a space where DEI work is unnecessary is a space where there is empathy and mutual understanding between everyone in theis community, and that anyone of any identity has assurance that if they speak, their voice will be heard."
- Himaja Motheram

Kwesi Rutledge

Kwesi is a doctoral student specializing in Control Systems. He has long been an active member of the ECE community, participating in many recruitment events, panels, and activities, and he helped design and organize the 2020 EECS Juneteenth celebration. He is a member of the Graduate Society of Black Engineers and Scientists (GSBES) and the ECE Graduate Student Council (ECE GSC).

Rutledge's research is focused on formal guarantees of safety, including tools for testing the safety of self-driving vehicle software systems that use cameras to make decisions, and methods for automating how computers can test and evaluate their hypothesis for how the world works. He plans to continue his research as a postdoctoral researcher in a lab focused on real-world robotic systems. He is advised by Prof. Necmiye Ozay.

"To me, the MLK Spirit award means that someone has noticed my dedication to and improvement in the design of diversity and inclusion efforts. It was difficult work that challenged me to learn to be a better listener, planner, and much more."
- Kwesi Rutledge

Rackham Predoctoral Fellowship Awards

The U-M Rackham Predoctoral Fellowship supports outstanding doctoral candidates working on dissertations that are unusually creative, ambitious, and impactful. It is considered one of the most prestigious awards granted by the Rackham Graduate School. This past year, the Barbour Scholars were selected from the students who applied for the Predoctoral fellowship.

Markus Borsch Awarded Rackham Predoctoral Fellowship

Markus Borsch's research in light-driven quantum electronics is expected to guide next-generation quantum devices. His thesis will present theory alongside computations to precisely guide experiments to realize light-driven quantum electronics with novel quantum materials.

"Quantum information science and technology revolution has already gained enormous momentum, as demonstrated by the recent breakthroughs in quantum computing, communication, and sensing," says Borsch.

Borsch is pursuing a completely new strategy, called rational quantum engineering, to further quantum technology innovations, for quantum systems are inherently too complex and too counterintuitive to be discovered by trial-and-error. He is advised by Prof. Mackillo Kira.

Caroline Crockett Awarded Rackham Predoctoral Fellowship

Caroline Crockett is the first ECE student working to integrate Image Processing & Machine Learning with Engineering Education Research. She researches a medical image reconstruction method that could ultimately decrease radiation exposure for patients while providing doctors with high-quality images to properly diagnose and treat many diseases.

She is also researching how signals and systems concepts are taught to undergraduate students, including which concepts are understandable to students, what factors predict understanding, and how those factors influence understanding. She is advised by Jeffrey Fessler, William L. Root Collegiate Professor of Electrical Engineering and Computer Science, and Prof. Cindy Finelli.

Sijia Geng Awarded Barbour Scholarship

Sijia Geng is working to ensure the safety, stability and cost effectiveness of future power systems that are dominated by renewable resources, through fundamental studies of system operation.

"As the world confronts the limits and problems associated with the use of fossil fuels, the integration of distributed energy resources, using renewable sources such as wind and solar, will become increasingly important," Geng says. "It is my desire to uplift the common welfare of the population at large, and I believe that my research supporting ubiquitous integration of renewable DERs for power systems will help achieve this goal." She is advised by Prof. Ian Hiskens, the Vennema Professor of Engineering.

Menglou Rao Awarded Rackham Predoctoral Fellowship

Menglou Rao researches highly efficient miniaturized antennas for compact systems, as well as detection of electromagnetic radiation from biological samples. She designed an extremely low-profile monopole antenna for very high frequency (VHF) applications. She also helped design a system to detect very weak radiation from biofilms in the 3 GHz band.

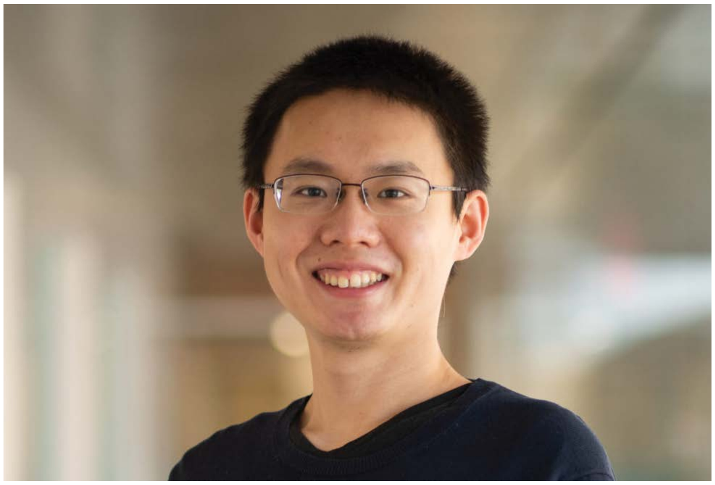
"If we can truly understand the communication mechanisms in biofilms, we may be able to disrupt the communication of infectious bacteria and improve cancer and disease treatments," she says. She is advised by Kamal Sarabandi, Rufus S. Teesdale Professor of Engineering.

Xin Zan Awarded Rackham Predoctoral Fellowship

Xin Zan is researching high frequency power converters for wireless power transfer. He's developing a new scalable architecture for HF and VHF WPT, with applications ranging from watts, for biomedical and consumer electronics, to hundreds of watts, for robots and drones.

"In my mind, the future of wireless power transfer is to provide energy anytime and everywhere and support peer-to-peer charging of not only consumer electronics, but also for industrial, scientific and medical applications," Zan says. He is advised by Prof. Al Avestruz.

Xiaofan Cui Awarded Towner Prize for Distinguished Academic Achievement in ECE



Xiaofan Cui, a doctoral student in ECE, has been awarded the Richard F. and Eleanor A. Towner Prize for Distinguished Academic Achievement by the College of Engineering for his outstanding achievements in research, as well as contributions in teaching and service to the department.

Cui's current research is building a repurposed energy storage architecture (RESA) that will reuse second-life batteries from electric vehicles (EV) for supporting the renewable energy grid, resulting in significant environmental and economic benefits. His goal is to build a bridge between fundamental control theory and high-performance power converters.

"Advanced power converters are rapidly reshaping the architecture of classic power systems in data centers, the microgrid, and electric utilities," says Cui. "Lots of interdisciplinary knowledge like control, optimization, and artificial intelligence are magically interacting in this exciting area."

As a graduate student, he already has nine publications, with several more in the works, including two patents. He has another published patent that he worked on as an undergraduate student at Tsinghua University in China.

In addition to a PhD in Electrical and Computer Engineering, Cui is working on a master's degree in Mathematics, and a Certificate in Data Science. He is advised by Prof. Al Avestruz.

Excellence in ECE Honor Roll

The Excellence in ECE Honor Roll, established in 2021, recognizes students who have gone above and beyond in service to the ECE department through their contributions to department-specific events and programming designed to foster an inclusive, supportive community for all.

Omar Abdelatty
Doctoral Student

Isha Bhatt
Undergraduate CE Student

Enakshi Deb
Undergraduate EE Student

Osvaldo Gutierrez, Jr.
Undergraduate EE Student

Aaditya Hambarde
Doctoral Student

Demba Komma
Doctoral Student

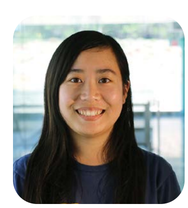
Nathan Louis
Doctoral Student

Christopher Okumura
Undergraduate EE Student

Nicholas Peabody
Undergraduate EE Student

Fanny Pinto Delgado
Doctoral Student

Kwesi Rutledge
Doctoral Student



Chenlan Wang
Doctoral Student

CHRISTOPHER ALLEMANG
Doctoral Student

IEEE Electron Devices Society PhD Fellowship

BESTE AYDIN
Undergraduate CE Student

Distinguished Achievement Undergraduate Award

MOHAMMED AZZOUZ
Undergraduate EE Student

EECS William Harvey Seeley Prize

SARA AZZOUZ
Undergraduate EE Student

EECS William Harvey Seeley Prize

ISHA BHATT
Undergraduate CE Student

Outstanding Service Award

NATHAN BLOCK
Master's Student

Outstanding Graduate Student Instructor 2019/2020

KEVIN BUCA
Undergraduate EE Student

Big Ten Distinguished Scholar

2020-21 Big Ten Men's Soccer All-Tournament Team

William L. Everitt Award of Excellence

University of Michigan Bates/Deskins Award

SUNNY CHEN
Doctoral Student

National Science Foundation Graduate Research Fellowship Honorable Mention

SUNG YUL CHU
Doctoral Student

IEEE Power Electronics Society PhD Thesis Talk Award

VERONICA CONTRERAS
Doctoral Student

GEM PHD Fellowship

CAROLINE CROCKETT
Doctoral Student

Outstanding Graduate Student Instructor Fall 2020

XIAOFAN CUI
Doctoral Student

Richard F. and Eleanor A. Towner Prize for Distinguished Academic Achievement in ECE

MICHELLE GEHNER
Undergraduate EE Student

Outstanding Service Award

Outstanding Institutional Aide Winter 2021

SIJIA GENG
Doctoral Student

2021 MIT Rising Stars in EECS

ALAN GERDOV
Master's Student

2021 B1G Individual Sportsmanship Award

Team award in B1G Varsity Gymnastics

JAMES GRUBER
Doctoral Student

National Defense Science and Engineering Graduate Fellowship

IOANNIS MARIOS GRANITSAS
Doctoral Student

Gerondelis Foundation Graduate Study Scholarship

BAHAREH HADIDIAN
Doctoral Student

2021 MIT Rising Stars in EECS

ADY HAMBARDE
Doctoral Student

Outstanding Graduate Student Instructor Winter 2021

MAIA HERRINGTON
Undergraduate CE & AE Student

Charles F. Barth, Jr. Prize

NASIMEH HEYDARIBENI
Doctoral Student

2021 MIT Rising Stars in EECS

MITCHEL HUANG
Undergraduate CE & ME Student

Outstanding Achievement Award

MOHAMMAD VAHID JAMALI
Doctoral Student

Qualcomm Innovation Fellowship

CAMERON KABACINSKI
Undergraduate CE Student

Tom S. Rice Tau Beta Pi Award

HANNAH KEMPEL
Undergraduate EE Student

Roger M. Jones Fellowship

JONAS KERSULIS
Doctoral Student

Outstanding Graduate Student Instructor Fall 2019

DEMBA KOMMA
Doctoral Student

National Science Foundation Graduate Research Fellowship

Microsoft Research Ada Lovelace Fellowship

REVA KULKARNI
Undergraduate EE Student

Outstanding Research Award

MATTHEW LAMB
Undergraduate EE Student

Outstanding Achievement Award

JEREMY LATHAM
Undergraduate EE Student

Distinguished Achievement Undergraduate Award

BOWEI LI
ECE Master's Student and CEE Doctoral Student

2021 Probabilistic Methods Committee Best Student Paper Award for "A Deep Learning Metamodeling Framework for High-dimensional Nonlinear and Dynamic Structural Systems Subject to Stochastic Excitation."

MATTHEW LICHTINGER
Undergraduate CE Student

Commercialization/Entrepreneurship Award

JIAXIANG MA
Undergraduate CE Student

William L. Everitt Student Award of Excellence

JEREMY MAURICE
Undergraduate EE Student

Outstanding Institutional Aide Winter 2020

HANNAH ESTHER MORING
Doctoral Student

National Science Foundation Graduate Research Fellowship Honorable Mention

HIMAJA MOTHERAM
Undergraduate CE Student

MLK Spirit Award, University of Michigan

CHRISTOPHER OKUMURA
Undergraduate EE Student

Commercialization/Entrepreneurship Award

KALEO ROBERTS
Doctoral Student

American Indian Science and Engineering Society Scholarship

JOSEPH ROTTNER
Undergraduate EE Student

Richard K. Brown Memorial Scholarship

KWESI RUTLEDGE
Doctoral Student

MLK Spirit Award, University of Michigan

AKSHAY SARIN
Doctoral Student

Outstanding Graduate Student Instructor Winter 2020

CODY SCARBOROUGH
Doctoral Student

Best Student Paper Award at the European Conference on Antennas and Propagation

Exceptional Student Contributions Award by the 14th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2020

YIXIN XIAO
Doctoral Student

National Science Foundation Graduate Research Fellowship

XINLONG YIN
Undergraduate CE Student

Outstanding Research Award

PAUL YOUNG
Doctoral Student

Outstanding Graduate Student Instructor 2020/2021

TONY ZHANG
Doctoral Student

2021 Social Impact Award, COE Engineering Research Symposium

ECE COUNCIL

The ECE Council (ECEC) is a prestigious group of alumni and friends of the department who are committed to ECE's goal of being a national and global nexus of positive, transformational change across all industries. The ECEC provides guidance and help with key priorities, including alumni engagement, industry engagement, development, diversity, entrepreneurship, education innovation, and future initiatives.

SYED ALI
MSE EE '81

Board of Directors, Marvell.
Founder, Cavium Inc.

TODD COLEMAN
BSE EE and CE '00; also MS and PhD EE from MIT

Professor, Bioengineering, Stanford University

RHONDA FRANKLIN
MSE PhD EE '90 '95

Professor, Electrical and Computer Engineering, University of Minnesota

K. CYRUS HADAVI
PhD EE '83

Founder & CEO, Adexa, Inc.

KATHERINE HERRICK
BSE MSE PhD EE '93' 95 '00

Senior Fellow, Raytheon Missile Systems

ZACHARY LEMNIOS
BSE EE '76; also MS EE Washington University

Consultant

PRASHANTH MAHENDRA-RAJAH
BS ChemE 1992; also MS in Engineering,Johns Hopkins University; MBA, Purdue University

Senior Vice President, Finance and Chief Financial Officer, Analog Devices, Inc.

ISAAC PORCHE
PhD EE:S '98

Deputy Director, Applied Research Lab, Penn State University

JORDI RIBAS
PhD EE:S '96; also MSE EE, UC Irvine

Corporate Vice President, AI Products, Microsoft

MITCHELL ROHDE
BSE MSE EE '94 '96; MSE PhD BME '97, '00

CEO & Co-founder, Quantum Signal AI, LLC

NAVIN SHENOY
BSE EE '95; also completed Stanford Executive Program

Former Executive Vice President and General Manager, Data Platforms Group, Intel Corp.

AMIT SINGHI
MSE EE:S 1989

COO and CFO, Piston Group

VIK VERMA
MSE EE '89

Member, Board of Directors, Cambium

DAWSON YEE
MSE EE '87

System Engineer – Azure Hardware, Quantum Computing, Microsoft

Rucha Apte Begins Her Journey

> "We used to stay all night at the Duderstadt doing homework and coming up with solutions and collaborating, and that was really fun." - Rucha Apte

Rucha Apte graduated this past spring with a Master's degree in ECE with a focus on signal & image processing and machine learning. Currently, she's working at Velodyne Lidar as a Machine Learning Engineer where she plans to delve deeper into the domains of computer vision and deep learning.

Apte earned her Bachelor's in Engineering in Electronics and Telecommunications from the University of Pune. Her brother, a U-M engineering alum who specialized in Automotive Systems Engineering, encouraged her to pursue her master's at Michigan.

During her career at Michigan, Apte had several experiences that cemented her future career path. One of her opportunities was with the company Optra Health.

"My task was to automate the histopathology process for immunotherapy," said Apte. "That experience made me want to delve deeper into machine learning and digital image processing."

Apte also secured a data science internship at Altair Engineering, where she specialized in computer vision and deep learning, and she was a software engineering intern at DeepMap, where she specialized in HD Mapping and Localization.

She also had an internship on campus at Mcity, which got her interested in the application of computer vision to autonomous vehicles, her current focus at Velodyne Lidar.

"Michigan was one of the universities that offered a lot of flexibility in courses and offered a specialization in what I wanted to learn," Apte says.

Douglas Densmore Programs Biology Like You Program a Computer

> "I thought Michigan did a really good job of creating a community for folks and mentoring them. I love Michigan."- Douglas Densmore

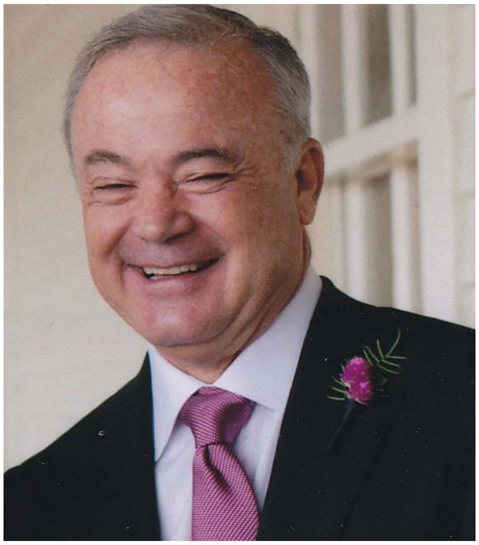
Douglas Densmore (BSE CE 2001), an Associate Professor of Electrical and Computer Engineering and Biomedical Engineering at Boston University, is working at a research intersection called "synthetic biology." The discipline explores ways to manipulate biological organisms and tissues as though they were programmable computers.

"I want to make cells compute in that way, to make decisions," Densmore says. "I do it with software that reflects the same way we designed computers. You start with high level languages, but instead of compiling to ones and zeros it compiles to DNA."

In his Cross-disciplinary Integration of Design Automation Research (CIDAR) group, Densmore and his team apply electronic design automation to improve how we do things like compiling code to DNA. He's compiled the popular hardware description language Verilog directly to strands of DNA, and has designed new programming languages that let you manipulate biology with commands such as if, then, else statements. Among other groundbreaking developments, this research promises smart therapeutics that can be delivered directly where they're needed in our body by pre-programmed organisms.

Densmore took the processes involved in this work from design all the way to fabrication as the founder of BU's Design, Automation, Manufacturing, and Prototyping (DAMP) Lab, where DNA strands with various sets of instructions can be rapidly synthesized or assembled. His work has brought him to a leadership position on NSF's "Living Computing" project. He's also the co-founder of three companies and two nonprofit organizations, all specializing in synthetic biology research and technology.

Fred Gibbons Teaches Engineers to Make Products That People Need



"I remember being helped by lots of people [at Michigan], and having the freedom to kind of find my path." - Fred Gibbons

Fred Gibbons, a first-generation college student from the small, sleepy, seaside village of Woods Hole in Cape Cod, originally came to U-M to study naval architecture. A drafting class featuring a computer and a plotter sparked his interest in computer engineering instead.

He graduated from U-M with a Bachelor of Science in Science Engineering and a Master's of Science in Computer Information and Control Engineering in 1967. After Michigan, Gibbons went to Harvard for an MBA, and then joined Hewlett Packard (HP) as a Product Manager. He served as Marketing Manager of HP's 3000 mini-computer product line.

While working at HP, Gibbons became lifelong friends with Steve Jobs. Jobs even helped Gibbons found his own startup, the Software Publishing Corporation, which produced Harvard Graphics, the PFS Series, IBM Assistant Series, and Power-Up Catalog.

"He gave me a computer, he gave me a printer, he gave me everything I needed to develop my first applications for the personal computer," Gibbons said. "I don't know why that happened. I used to tell him his ideas were wrong."

After Gibbons took his startup public and sold it, he received an offer from Stanford to start their entrepreneurship program in their Graduate School of Electrical Engineering. He was then hired as an adjunct professor and allowed to develop his own course in product management and product design.

"I've worked with too many great engineers who can build anything, but they end up building things that people don't want," Gibbons said. "So my course teaches Master's and PhD students that when you're going to build a product, you must first understand the job somebody is trying to do."

Scott Hanson Awarded the 2020 ECE Alumni Rising Star Award

Scott Hanson (BSE MSE PhD EE '04 '06 '09) has been awarded a 2020 ECE Alumni Rising Star Award. This award recognizes younger ECE alums who have achieved early success within their careers.

Hanson is the co-founder and Chief Technology Officer of Ambiq Micro, a startup semiconductor company that works to advance ultra-low power electronics for next generation Internet of Things.

The company was founded based on technology Hanson developed with his doctoral advisors and co-founders, Professors Dennis Sylvester and David Blaauw.

Ambiq Micro has received numerous accolades and awards for its technology, including a 2021 BIG Innovation Award from the Business Intelligence Group, and it was named 2021 IoT Semiconductor Company of the Year by the IoT Breakthrough Awards.

Recently, Ambiq Micro has been working to advance AI-empowered devices, such as smartwatches that may be able to do much more than tell time or relay text messages.

"Think about it like a doctor that you wear on your wrist," Hanson said. "It uses blood oxygen sensors and other sensors to detect health concerns before you actually get diagnosed."

Hanson lives in Austin, TX, where Ambiq Micro is now based, but he has a strong affection for the decade he spent in Ann Arbor. In addition to enjoying football games at the Big House, Hanson met his wife while they were both undergrads living in West Quad.

"Sometimes you just need to go and do the thing, and that's the best thing about entrepreneurship." - Scott Hanson

Linda Guillory Breaks Two World Records for Vintage Game Collections

Linda Guillory, an Electrical Engineering alumna, will be officially recognized in the 2022 Guinness Book of World Records as the holder of two record titles: “Largest Collection of LCD Gaming Systems (1,599)” and “Largest collection of playable gaming systems (2,430).”

Guillory’s favorite games as a kid included the Coleco Tabletop Pacman, Digital Derby, Conic basketball, and any handheld football game. Her favorite games continue to be anything Zelda related.

Guillory always wanted to be a wolverine, and two of her siblings are also U-M alums – her brother studied law and her sister studied social work.

“Professors Linda Katehi and Leo McAfee had a huge impact on me, and I enjoyed my time at U of M,” Guillory says.

Guillory went on to earn a Master’s degree from Michigan State University in Electrical Engineering, and then joined Texas Instruments as a Product Engineer fabricating semiconductors. She now works as an Assembly Strategy Manager, ensuring the best sourcing for TI’s products.

In the future, she wants to use vintage gaming systems as a method to teach children about electronics. She hopes to design electronic gaming kits for kids one day, so they can build a gaming system from scratch in an electronics workshop or at home.

> “The University of Michigan prepares you to work in teams and problem solve together while at the same time allowing you to be more independent and gain skills needed for your chosen career path.” - Linda Guillory

Katherine Herrick is the 2020 ECE Alumni Merit Award Winner

> “For engineering to work, you need all different perspectives and different types of people with different backgrounds.” - Katherine Herrick

Katherine Herrick (BSE MSE PhD EE ‘93 ‘95 ‘00) is the 2020 recipient of the ECE Alumni Merit Award, which recognizes mid-career alumni who are leaders in their field. She is a Senior Fellow and Director of Advanced Enabling Technology at Raytheon Company, which specializes in defense, civil government, and cybersecurity solutions.

“I really enjoy working with state-of-the-art technologies and innovating,” Herrick said. “And getting to shape what kinds of contracts we go after definitely appealed to me.”

Herrick was encouraged to pursue engineering by her father, Don Herrick, who earned an MSE in Electrical Engineering and Math from U-M in 1975. As a graduate student at U-M, Herrick joined Prof. Linda Katehi’s research group and worked on microwave and millimeter-wave micromachined circuits for communications applications. She joined Raytheon right after completing her doctoral degree in 2000.

In addition to her technical achievements, Herrick is passionate about supporting women and underrepresented minorities so they may thrive in engineering.

Herrick’s honors include the 2008 Outstanding Young Engineer Award of the IEEE MTT-S, the 2008 National Academy of Engineering Frontiers of Engineering, and the 2007 Raytheon Integrated Defense Systems President’s Award. She is a Senior Member of IEEE, has published over 50 technical papers, and holds several patents in the areas of antennas, RF MEMS packaging, and microwave circuits. She serves on the ECE Advisory Council.

Tara Javidi is Awarded ECE’s Distinguished Educator Award

Tara Javidi, Professor of ECE and founder and Co-Director of the Center for Machine-Integrated Computing and Security at the University of California, San Diego (UCSD), is a 2020 recipient of the University of Michigan ECE Distinguished Educator Award. This award is the highest recognition granted by ECE to its alumni in academia and recognizes those who have made a significant and lasting impact in education.

The main objective of the UCSD Center for Machine-Integrated Computing and Security is to integrate hardware/platform constraints and security requirements within the design of data analytic algorithms.

“With the increasing success of AI-enabled mobile and IoT applications, there is a critical need to educate a new generation of engineers who can bring analytics and system design considerations together efficiently,” Javidi said.

Javidi has also been a strong advocate for inclusion and diversity in engineering and academia. In 2015, she was awarded a UCSD Equal Opportunity/Affirmative Action and Diversity Award in recognition of her mentorship of the underrepresented minority students and postdoc scholars.

Javidi earned her BS in Electrical Engineering at Sharif University of Technology, Tehran, Iran. She earned an MS degree in Electrical Engineering: Systems, an MS degree in Applied Mathematics, and a PhD in Electrical Engineering and Computer Science all from the University of Michigan, Ann Arbor. She was advised by Demosthenis Teneketzis, Prof. Emeritus of EECS.

> “I really felt a sense of belonging at Michigan. I loved how close-knit the community was.”
>
> - Tara Javidi

Jian-Ming Jin is Awarded ECE's Distinguished Educator Award

Jian-Ming Jin, the Y. T. Lo Endowed Chair Professor of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign, is a 2020 recipient of the University of Michigan ECE Distinguished Educator Award. This award is the highest recognition granted by ECE to its alumni in academia and recognizes those who have made a significant and lasting impact in education.

> "Those seven and a half years at Michigan were the best time in my life."
>
> - Jian-Ming Jin

Jin earned a B.S. in Physics and an M.S. in Applied Physics from Nanjing University in Nanjing, China. He earned his Ph.D. degree in Electrical Engineering from the University of Michigan, Ann Arbor, in 1989, where he remained as a postdoctoral researcher and assistant research scientist for three years, working closely with Prof. John Volakis, who is now Dean at Florida International University.

Jian-Jin joined the University of Illinois at Urbana-Champaign in 1993. He was appointed as the first Henry Magnuski Outstanding Young Scholar in the Department of Electrical and Computer Engineering in 1998 and later as a Sony Scholar in 2005. His name appeared 26 times in the University of Illinois at Urbana-Champaign's List of Excellent Instructors, which is chosen by the students. He wrote six books on a variety of topics from numerical methods, special functions, fast algorithms, antennas, to MRI.

Jin is a Fellow of IEEE (elected 2001), the Electromagnetics Academy, Applied Computational Electromagnetics Society (ACES), and the Optical Society of America. He received the 2014 ACES Technical Achievement Award, the 2015 Chen-To Tai Distinguished Educator Award from the IEEE Antenna and Propagation Society. the 2016 ACES Computational Electromagnetics Award, the 2017 IEEE Harrington-Mittra Computational Electromagnetics Award, and served as an IEEE Distinguished Lecturer to promote research and education in the field of computational electromagnetics.

Shirin Mangold Found Her Passion And Her Voice Through Michigan Engineering's Co-Op Program

Between Michigan football games, seeing shows at the Mendelssohn theatre, and enjoying a "Cult" Archaeology class about Bigfoot and other urban legends, Shirin Mangold was trying to decide if she really wanted to be an engineer. She'd declared a major in Computer Engineering, but the traditional engineering curriculum was challenging, and she struggled to find her voice in classes.

Then she heard about the Engineering Cooperative (Co-op) Education Program, where students can spend a semester or more working for an engineering company. Through this program, she spent the second semester of her junior year and subsequent summer working for a company called Northern Telecom, which was a leader in telecommunications at the time.

Mangold's Co-op experience in the corporate world inspired her to pursue a career in software engineering and helped her recognize that the problem-solving techniques she learned in her engineering classes were relevant to creating software products for technology manufacturers. What's more, she found herself working for and with other women, which was far rarer in the academic environment.

> "[The Co-op program] helped me imagine what my life might be like if I got this engineering degree and chose to work in software engineering as a profession." - Shirin Mangold

"Getting to work in that corporate environment with other women helped prove that I can do this, I can be an engineer," she said. "It made me feel smart again."

Today, Mangold is a Senior Director at Deltek, a leading computer software development company. Her youngest son is a freshman at U-M this year, and she's encouraging him to take advantage of as many opportunities as he can.

"At Michigan, you meet people from every walk of life, you meet people from other countries, you're exposed to international students who don't have anywhere to go for Thanksgiving so you invite them to your house, you get to explore so many things," Mangold said. "I absolutely loved it."

Robert Scott’s Journey From Michigan Engineer to Corporate Leader to DEI Champion

Robert Scott graduated from Michigan with a BSE in computer engineering in 1975. After graduation, he embarked upon a 32-year career at Procter & Gamble, during which he served in numerous leadership roles in strategic planning and analysis, IT management, product distribution, and global learning systems. Scott also served as P&G’s corporate leader for an organizational development program providing facilitated training to build high performing global teams.

“I was told early on when I got to P&G that I was one of the best technically prepared new hires that they had ever had,” Scott said. “So that’s a testimony to Michigan and the power of its educational process.”

Between 1997-2001, Scott led the P&G IT organization for Europe, Middle East, and Africa when they went through the millennium bug issue.

“I thought the millennium bug was the biggest thing ever,” said Scott. “Then, Europe decided to move to the Euro, and the conversion to the Euro was actually bigger than the millennium bug issue from a technology standpoint.”

Scott returned to the University of Michigan and founded the Center for Engineering Diversity & Outreach (CEDO) at the College of Engineering, which supports students from a variety of marginalized backgrounds.

“CEDO is about bringing all of these activities together and strengthening them under a single umbrella,” Scott said.

> “As I continue to move through life, my ultimate responsibility is to do what was done for me, which is to create opportunities and platforms for other people to be successful.” - Robert Scott

Navin Shenoy Awarded ECE’s Highest Alumni Award Honor

> “Choosing Michigan ended up being one of the best decisions I’ve ever made.” - Navin Shenoy

Navin Shenoy (BSE EE ’95), the Executive Vice President and General Manager of Data Platforms Group at Intel Corporation, is the recipient of the 2020 ECE Alumni Impact Award. This award is the highest recognition granted by ECE to its alumni.

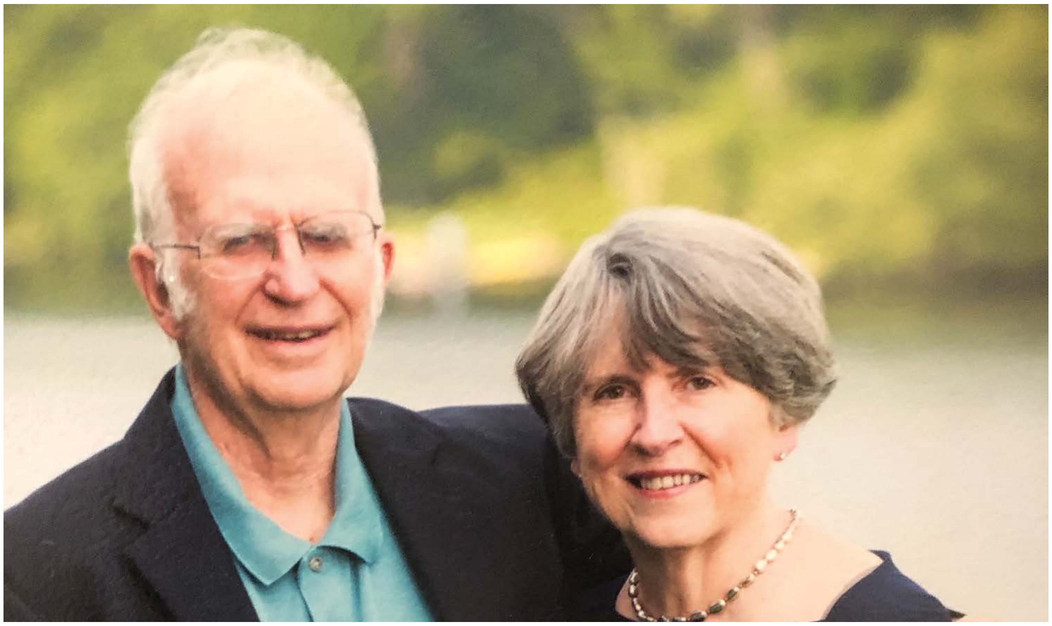
At Intel, Shenoy leads the worldwide organization that develops the company’s data center platforms, which is a business that spans servers, networks, and storage across all customer segments. He is responsible for the group’s product lines and business strategies, which encompass traditional business models as well as innovative solutions that help drive the industry transformation toward cloud computing, virtualization of network infrastructure, and the adoption of artificial intelligence.

“Our goal is to create world changing technology that enriches the lives of every person on Earth,” Shenoy said. “It’s such a privilege to work for a place that has that kind of purpose and to be at the cutting edge of technology.”

Before assuming his current role in 2017, Shenoy served as general manager of Intel’s Client Computing Group. He also served as general manager for Intel Asia Pacific, and has held leadership roles in Intel’s PC and tablet business units and in the CEO’s office.

Shenoy credits Michigan with encouraging him to pursue opportunities outside of his comfort zone and embrace a collaborative, interdisciplinary environment, which shaped attitudes that helped him excel throughout his entire career.

John And Sarah Lawser's Family Scholarship Empowers the Next Generation Of Engineers



"U-M set us up to have successful, enjoyable careers, and giving back to enable others the same opportunity has been a top priority for us."
- Sarah Lawser

Fifty years after John Lawser graduated from the University of Michigan, he and his wife, Sarah, found themselves back on a rattling blue bus, weaving through the streets of Ann Arbor toward North Campus for an alumni reunion. Seated next to Sarah was a current student, and they struck up a friendly conversation. The student talked about her experience being the first in her family to go to college, which moved Sarah so much that she and John decided it was time to do something more.

John and Sarah Lawser had already been longtime donors to the university. After that conversation on the bus, they decided to formalize their giving into an official fund. The John and Sarah Lawser Scholarship has supported U-M EECS undergraduates ever since.

John and Sarah had known each other while attending high school in Dearborn, MI, but they reconnected during their undergraduate years at Michigan, and were married for fifty-five years.

John Lawser earned his BS, MS, and PhD degrees in Electrical Engineering, and his wife, Sarah, earned her bachelor's and master's degrees in sociology and educational research, all from the University of Michigan.

"Both of us felt that having a Michigan experience and those Michigan degrees meant a tremendous amount in so many different ways," Sarah said.

Many students have written to the Lawsers over the years expressing their appreciation for the support they received as recipients of the John and Sarah Lawser Scholarship. Sarah said it was particularly touching to read messages from students who had been supported by the scholarship for several years and who wrote about how this helped empower their dreams.

"John and I have been grateful that we could help support current and future U-M students to follow their passions and achieve their goals, for education enables opportunities for a purposeful life," Sarah said. "U-M set us up to have successful, enjoyable careers, and giving back to enable others the same opportunity has been a top priority for us as we transitioned to our retirement years."

John passed away last summer, and Sarah contributed a significant additional gift to their scholarship fund in his honor.

"I knew John always wanted to give more to our scholarship, and last summer I welcomed the opportunity to honor him this way," Sarah said.

Entrepreneur and Philanthropist, Dr. B. Jin Chang, Gives Back to the U-M ECE Community


The Chang family.

Entrepreneur and founder of SurgiTel, Dr. B. Jin Chang, earned a PhD from ECE in 1974, where he was advised by Prof. Emmett Leith, the inventor of practical holography.

"Professor Emmett Leith picked me up every morning from my Northwood campus apartment for his early classes for several semesters," Chang says. "I worked with Emmett making holographic optical elements which eventually were applied to the head-up display (HUD) system of F18 aircrafts and special notch filter needed for advanced holographic Roman Spectrometer which I invented with KOSI [Kaiser Optical System, Inc.] later and is the main product of KOSI today."

After founding KOSI as a subsidiary of Kaiser Aerospace & Electronics, Chang purchased GSC and founded SurgiTel, which provides dental professionals and surgeons with ergonomic vision-aide products, as one of its divisions. The purpose of SurgiTel was to develop ergonomic vision-aid products for dental professionals and surgeons.

Today, SurgiTel is known worldwide as a top developer of loupes, LED headlights, and digital cameras. It has over twenty-five sales reps in North America and over twenty international distributors with plans to further expand its business areas.

"The biggest challenge as an entrepreneur," said Chang, "is to grow the company while continuing to maintain majority ownership. My experience with KOSI helped me manage initial financial issues wisely without losing the majority ownership."

He believes that young people should be encouraged to think about starting their own companies. "Most people may think that starting new businesses is risky," said Chang, "but I think that "not taking risk" may be the real risk."

Chang came to Michigan over Stanford because of the superior financial aid package, and because he liked the campus.

Among his favorite memories are Michigan sports and the discovery of new technical ideas. "But my fondest memory is with Professor Emmett Leith, who was my PhD program advisor," said Chang.

Chang is now the father of a Michigan legacy family. He and his wife, Sharon, are the proud parents of their daughter Jane (BA Economics 1992), son-in-law Charlie (BA Liberal Arts 1993), and their son Michael (BSE Industrial Operations 1999; MBA 2012). All have been longtime supporters of ECE.

"I give because the financial aid I received from U-M made me what I am today," Chang says. "My family will continue to support U-M and ECE."

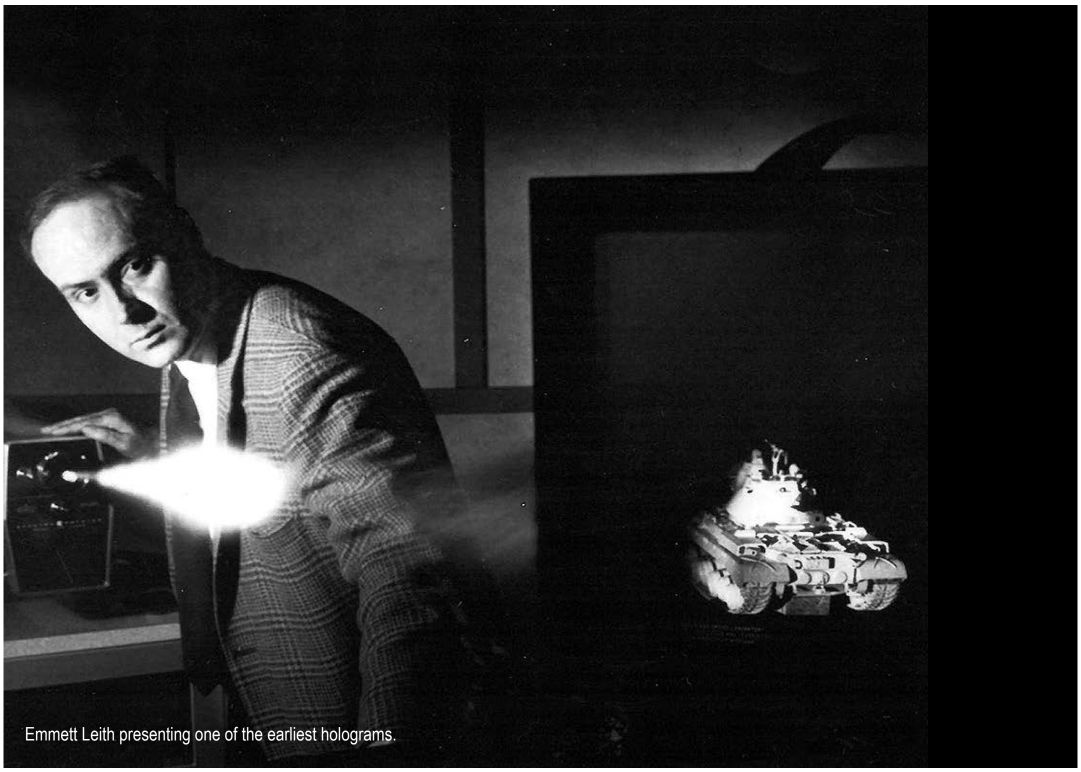
"I give because the financial aid I received from U-M made me what I am today."
- Jin Chang

Dr. Jim and Judith Seydel Gifts to ECE Support Students While Honoring Those Who Empowered His Career

Dr. Jim Seydel (BS MS Physics ’64 & ’67; PhD EE ’73) and his wife, Judith (also a U-M alum), have been longtime supporters of the ECE department. While their priority is to empower the current generation of students, the Seydels also wanted to honor the ECE faculty who supported Seydel at every opportunity.

Before a long, successful career as an engineer for both EG&G and Lockheed-Martin at the Idaho National Laboratory, Jim Seydel was working alongside icons such as Emmett Leith, the inventor of practical holography, Thomas B.A. Senior, a renowned expert in scattering and electromagnetics and former director of the Radiation Laboratory, and inspired by former ECE Chair Hansford W. Farris.

“I am now pleased to donate to ECE so that today’s students can attain their career goals.” - Jim Seydel



Emmett Leith presenting one of the earliest holograms.

Seydel joined the Radar and Optics Laboratory of the Willow Run Laboratory in the summer of 1964, after receiving his bachelor’s degree in physics from University of Michigan.

He worked on the optical processing of radar data, which he says, “was right in the middle of all the exciting work that Emmett Leith and Juris Upatnieks (and many other researchers) were doing on optical holography. After I had finished my radar work for the day, I worked late into the evening on holography.”

Seydel was asked to staff a holography display at the National Electronics Conference in 1965, just one year after Leith and Upatnieks wowed the attendees at the 1964 meeting of the Optical Society of America with their real-life hologram. The display attracted long lines of visitors, including former department chair Hansford Farris.

Hansford W. Farris

“He [Farris] then asked me what my career goals were,” recalled Seydel. “I related my current, rather hazy goals, and he described how those goals could best be met in the ECE Department.”

Farris gave Seydel his card - and invited him to stop by his office and discuss graduate opportunities in ECE. The seed took root, and Seydel became a doctoral student under Prof. Thomas Senior three years later.

“I am especially appreciative of the help I received from Chairman Farris,” Seydel says. “Without him, I would not have attained a PhD and achieved a successful career. I am now pleased to donate to ECE so that today’s students can attain their career goals.”

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