THE UNIVERSITY OF WASHINGTON DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING'S ANNUAL MAGAZINE

THE INTEGRATOR 2021

ELECTRICAL & COMPUTER ENGINEERING

UNIVERSITY of WASHINGTON

FOCUS ON IMPACT

• Sustainable Energy • Neurotechnology • Photonics • Quantum Systems

THE INTEGRATOR 2021 • CONTENTS

THE INTEGRATOR is an annual publication of The University of Washington Department of Electrical & Computer Engineering

EDITORIAL
Wayne Gillam
Public Information Specialist, Writer

GRAPHIC DESIGN AND PHOTOGRAPHY
Ryan Hoover
Public Information Specialist, Designer

additional editorial and photography credits where noted

Featured on cover, left to right:

Baosen Zhang
Keith and Nancy Rattie Endowed Career Development Professor

Azadeh Yazdan
Washington Research Foundation Innovation Assistant Professor

Sajjad Moazeni
Assistant Professor

Mo Li
Professor; Graduate Program Coordinator

photos by Ryan Hoover


14


7


3


9


35

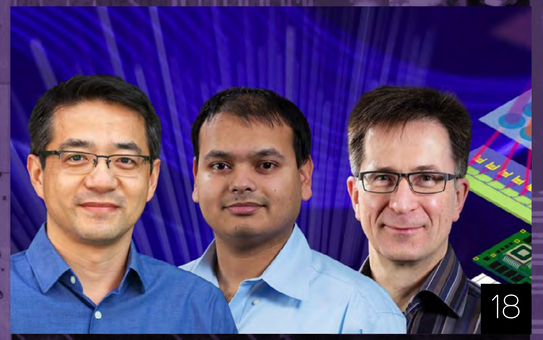

31


28


21


4


16


18


32


12

IN THIS ISSUE

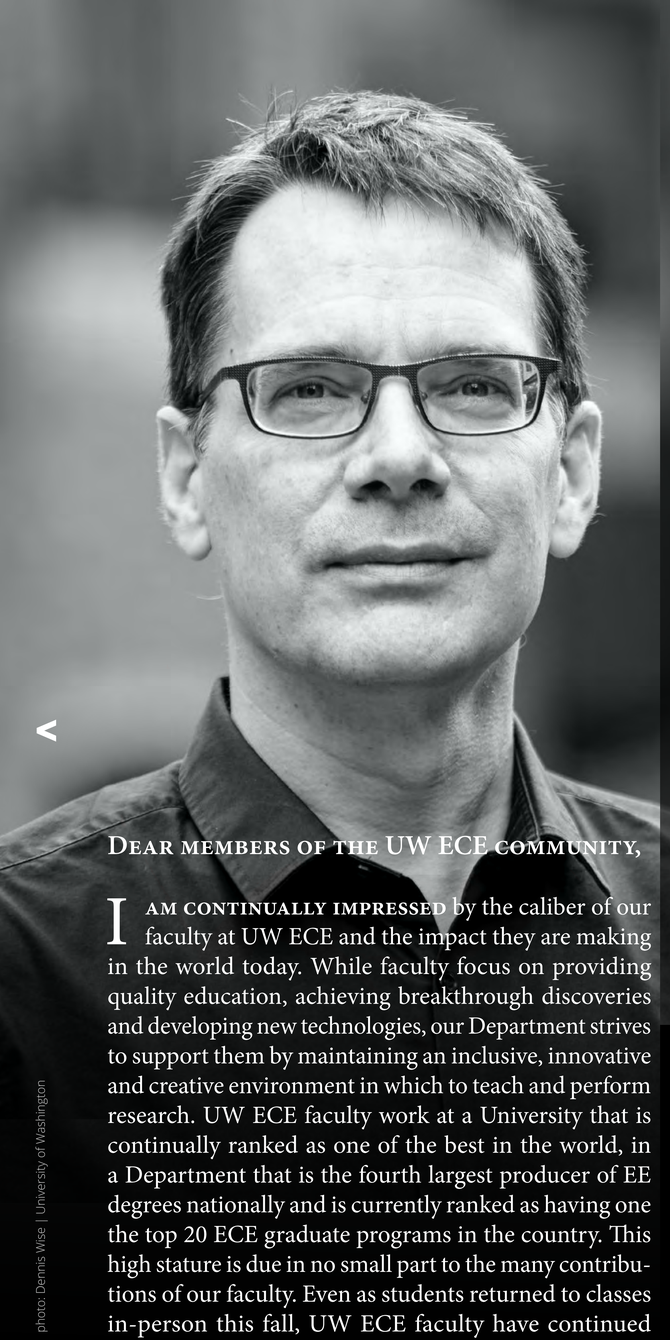


photo: Dennis Wise | University of Washington

MESSAGE FROM **THE CHAIR**

Dear members of the UW ECE community,

I am continually impressed by the caliber of our faculty at UW ECE and the impact they are making in the world today. While faculty focus on providing quality education, achieving breakthrough discoveries and developing new technologies, our Department strives to support them by maintaining an inclusive, innovative and creative environment in which to teach and perform research. UW ECE faculty work at a University that is continually ranked as one of the best in the world, in a Department that is the fourth largest producer of EE degrees nationally and is currently ranked as having one the top 20 ECE graduate programs in the country. This high stature is due in no small part to the many contributions of our faculty. Even as students returned to classes in-person this fall, UW ECE faculty have continued to push their research and teaching methods forward, demonstrating remarkable adaptability while developing and implementing a new, hybrid-learning environment tailored to students' needs.

In this issue of The Integrator, we are highlighting outstanding faculty members who are working at the cutting edge of technology, such as those pictured on the cover. These individuals are making national and international impact in fields such as sustainable energy, neural engineering, quantum computing, data science, optics and photonics. And we are continually adding to their ranks through new hires such as Sara Mouradian and Rahul Trivedi, leaders in their field who specialize in quantum information science and technology. Mouradian and Trivedi will be joining UW ECE as assistant professors in March 2022 and September 2022, respectively, and we welcome them both to the Department.

Our faculty are also leading interdepartmental, cross-campus and multi-institutional collaborations with global impact. For example, Professor and Associate Chair for Research Maryam Fazel is principal investigator at the Institute for Foundations of Data Science, which is developing the theoretical foundations of this fast-growing field. Associate Professor Kai-Mei Fu is leading the Quantum X Initiative at the UW, pioneering the development of quantum-enabled technologies at the University. Associate Professor Chet Moritz and Adjunct Professor Rajesh Rao lead the Center for Neurotechnology, engineering new ways to help the brain and spinal cord heal and recover after injury. And Assistant Professor Brian Johnson is co-leading a national consortium that is remaking the nation's electrical grid to better support renewable energy. You can learn more about all the aforementioned efforts within the pages ahead.

We are highlighting many other UW ECE student, faculty and alumni accomplishments within this issue as well. Learn more about our ongoing programs and standout events such as the ENGineering INnovation and Entrepreneurship (ENGINE) capstone program, the Dean W. Lytle Endowed Lecture Series, and the annual UW ECE Graduation Celebration. Read about our 2021 Graduation Celebration speaker Rico Malvar and learn what has been foundational to supporting his career success and motivating his philanthropic efforts. We congratulate our longstanding faculty member Mari Ostendorf in this issue, who this year was elected to the National Academy of Engineering and was named UW Vice Provost for Research. And we recognize the 2021 recipient of the Yang Research Award, James Rosenthal. I am also excited to announce in these pages the establishment of the new UW ECE Outstanding Mentorship Award in Electrical and Computer Engineering, which will honor students, faculty and staff who have championed, advocated for and guided students in their personal and professional growth.

UW ECE is making a profound, positive impact on our students, communities, nation and world, and that is clearly demonstrated by those featured in The Integrator. I also would like to say on behalf of the Department that we are very grateful for your continued engagement with and support of UW ECE. Your involvement helps to make possible the many advances and accomplishments described in this magazine.

As always, it's my honor to serve as chair of this outstanding Department. I wish you and your loved ones all the best.

Eric Klavins
Professor and Chair
UW Department of Electrical & Computer Engineering

UW ECE ANNOUNCES NEW MENTORSHIP AWARD

Thanks to a generous gift from an anonymous donor, we are pleased to announce a new, annual, departmental award. The **UW ECE Outstanding Mentorship Award in Electrical and Computer Engineering** has recently been established to recognize the critical role mentorship plays in the life of students in the Department. The award acknowledges mentorship is provided by a variety of people to enhance the quality of education through providing a supportive and caring learning environment. Recipients of the award can include faculty, staff, peer students or volunteers who have championed, advocated for and guided students in their personal and professional growth. This is a first-of-its-kind award at the UW College of Engineering with ECE as the lead department to launch this level of recognition. The award is scheduled to be given out this academic year. Details about the nomination and review process for the award will be forthcoming.

Through this award, it is the donor's intent to ensure mentorship is elevated to a level where its impact on our students' lives and its importance in the culture of the Department is recognized. By establishing this award, awareness will be enhanced for the work being done on a personal level to bolster students' fulfillment and sense of belonging in our community in addition to achieving academic success.

UW ECE Professor and Chair Eric Klavins said, "It is my goal to ensure that the recipients of the ECE Outstanding Mentorship Award share their best practices for mentorship with our broader community to teach others how to become mentors or help current mentors be even better at it. That's the exciting part of recognizing excellence in mentorship."

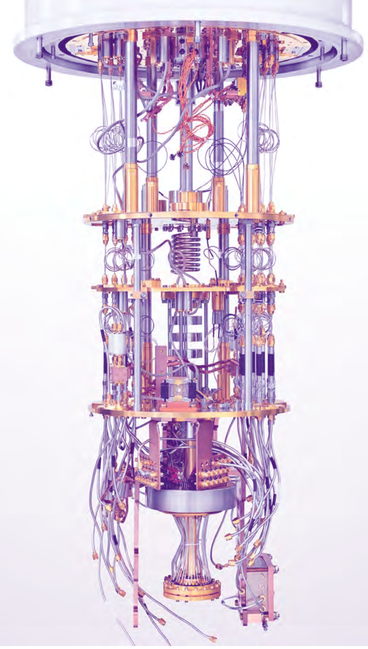


photo: Justin Fantl | UW Magazine

UW ECE welcomes two new faculty members in quantum information science and technology

SARA MOURADIAN AND RAHUL TRIVEDI WILL BE JOINING UW ECE AS ASSISTANT PROFESSORS IN MARCH AND SEPTEMBER 2022, RESPECTIVELY.

By Wayne Gillam

Quantum computing systems hold the potential to spur significant breakthroughs in science, medicine and engineering by approaching complex problems in new ways. These breakthroughs could impact many aspects of our lives, leading to improvements in data and online security, healthcare, energy production and finance. The University of Washington Department of Electrical & Computer Engineering is committed to pioneering the development of quantum-enabled technologies through participation in the UW's interdisciplinary QuantumX Initiative and through several associated research projects led by UW ECE faculty.

Now, the Department is proud to welcome two new faculty members who specialize in quantum information science and technology, or QIST. Sara Mouradian and Rahul Trivedi will join UW ECE as assistant professors in March and September 2022, respectively. Their new positions are supported by a UW College of Engineering cluster hiring initiative in QIST, which also includes new faculty hires in the UW Department of Mechanical Engineering, UW Department of Materials Science & Engineering and the Paul G. Allen School of Computer Science & Engineering.

"Our vision is for the UW to have expertise across the full quantum stack," said UW ECE and UW Department of Physics Associate Professor Kai-Mei Fu, who is co-chair of the Quantum X Initiative. "Our future colleagues in ECE, ME, MSE and CSE will help the UW address the key QIST engineering challenges of performance and scalability. We want to help develop a Quantum Silicon Valley in the Pacific Northwest, and we want the UW to be the number one place in the world for students to come and build their skills in QIST."

Mouradian and Trivedi are both highly accomplished scholars and educators, and according to UW ECE Professor and Chair Eric Klavins, they will significantly enhance the Department and add great value to the University community.

"We are thrilled to have Sara and Rahul join UW ECE," Klavins said. "Sara brings new technology and experimental methods, while Rahul brings theoretical and algorithmic foundations. Both will help connect physics to engineering, enabling QIST to fulfill its potential as a game-changing technology."

Sara Mouradian is an Intelligence Community Postdoctoral Fellow at UC Berkeley, where she is working to demonstrate a multi-register optical control system for trapped-ion quantum sensing. She received her bachelor's and master's degrees and Ph.D. in electrical engineering and computer science from MIT in 2010, 2012, and 2018, respectively. She began her research in quantum computing as an undergraduate while completing a senior research project. Mouradian's research interests include engineering control infrastructure for large trapped-ion quantum systems without degrading the quantum memory storage time. Her academic interests range from nanophotonics to atomic physics.

"I'm excited to join the growing community of quantum researchers at ECE, UW and the Seattle area at large," Mouradian said. "I'm also looking forward to teaching and working with the undergraduate and graduate students and to exploring the mountains of the Pacific Northwest."

Rahul Trivedi is a postdoctoral scholar at the Max Planck-Harvard Research Center for Quantum Optics, working with Professor J. Ignacio Cirac. He obtained his Ph.D. in electrical engineering from Stanford University in 2020 and Bachelor of Technology in electrical engineering from the Indian Institute of Technology Delhi in 2016. Trivedi's current research focuses on understanding the limitations of near-term quantum computers and simulators, as well as using them to aid simulation and design of next-generation quantum devices. He has previously worked on computational electromagnetics, nanophotonics simulation and design, and theoretical quantum optics.

Trivedi said, "I am looking forward to joining UW ECE, being a part of its diverse and multidisciplinary community and working toward solving both scientific and technological problems in quantum information sciences and beyond."

UW ECE Class of 2021

195

BACHELOR'S DEGREES AWARDED

66

MASTER'S DEGREES AWARDED

84

PROFESSIONAL MASTER'S PROGRAM DEGREES AWARDED

28

PH.D. DEGREES AWARDED

photo: Mark Stone | University of Washington

CLASS OF 19

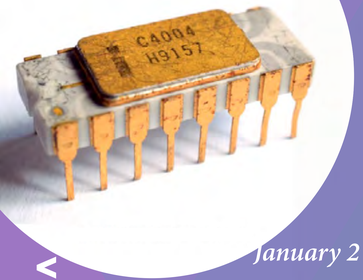
1971

Walt Disney at press conference in Florida. Source: Wikimedia Commons

50 YEARS AGO...

January

A team of logic architects and silicon engineers — Federico Faggin, Marcian (Ted) Hoff, Stanley Mazor, and Masatoshi Shima — invent the world's first commercially produced single-chip microprocessor, the Intel 4004. Containing a 4-bit CPU, the Intel 4004 paves the way for Intel to become the world's largest chip manufacturer, and helped to launch the global digital revolution which continues to shapes our lives today.



Intel C4004 microprocessor. Source: Wikimedia Commons

January 2

The Public Health Cigarette Smoking Act is enacted, banning all advertisements for cigarettes on radio and television in the U.S. from this date onwards.

February 6

Apollo 14, the third crewed mission to land on the moon, begins its return journey back to Earth after landing there the previous day.

March 5

Led Zeppelin's "Stairway to Heaven" is performed live for the first time in Belfast, Ireland at Ulster Hall.

March 8

The "Fight of the Century" takes place, with boxer Joe Frazier defeating Muhammad Ali in a 15-round unanimous decision at Madison Square Garden in New York City - Ali's first ever loss in boxing.

Boxers Muhammad Ali vs. Joe Frazier. Source: Wikimedia Commons

March 15

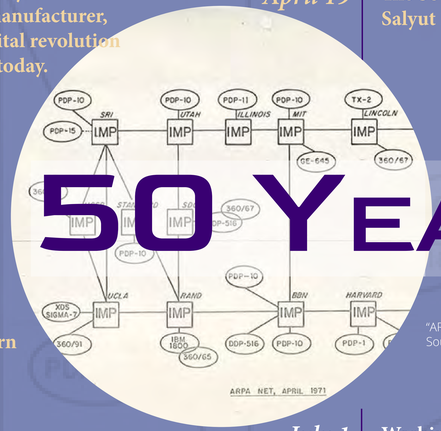
On ARPANET, the precursor to the Internet, "chat rooms" make their debut.

March 31

The major coffee house chain, Starbucks, is founded in Seattle, Washington. The company revolutionizes the coffee experience by turning ordinary coffee into a luxury experience — an approach that has not only been copied by other coffee shops worldwide, but also by many other industries today.

April 19

The Soviet Union launches the first space station, Salyut 1, into low Earth orbit.



"ARPA NET" diagram from April, 1971. Source: Wikimedia Commons

July 1

Washington state becomes the first U.S. state to ban sex discrimination.

July 3

The Doors singer Jim Morrison is found dead of heart failure in his Paris apartment bathtub at the age of 27.

July 5

The 26th Amendment is formally ratified by President Richard Nixon and becomes part of the United States Constitution, lowering the voting age from 21 to 18.

July 31

Following their landing on the moon aboard the Apollo 15 spacecraft, the NASA astronauts enjoy a six and a half hour-long electric car ride around the lunar surface.

September 11

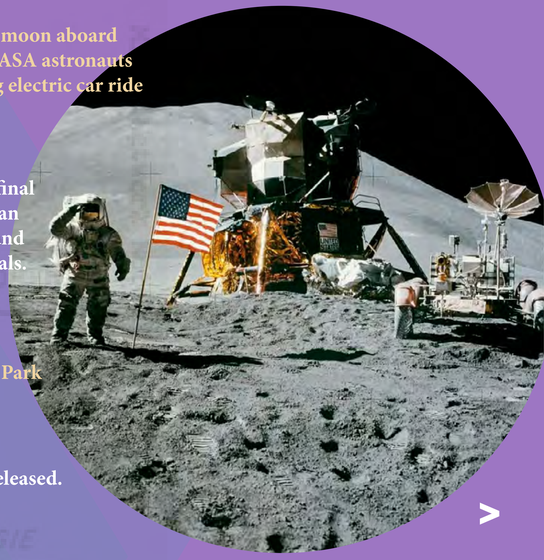
The US Open Women's Tennis final takes place, with an all-American final between Billie Jean King and doubles partner Rosemary Casals. King beats Casals 6-4, 7-6.

October 1

The Walt Disney World Theme Park is opened in Orlando, Florida.

October 8

"Imagine" by John Lennon is released.



Apollo 15 landing module, electric vehicle and crew. Source: Wikimedia Commons

November 3

The first UNIX Programmer's Manual is published. Today, the UNIX-derived systems like Linux, macOS, and operating systems for mobile phones are ubiquitous around the world.

November 13

The Mariner 9 becomes the first space probe to orbit another planet by entering the orbit of Mars. Launched on May 30, 1971, The Mariner 9 was successful in all of its missions, which were: becoming the first artificial satellite to orbit Mars, mapping the surface of the planet, gathering atmospheric data, and taking highly detailed images of the surface. It is expected to remain in orbit until at least 2022, after which time the spacecraft is projected to enter the Martian atmosphere and either burn up or crash into the planet's surface.

American tennis player Billie Jean King. Source: Wikimedia Commons

late 1971

Ray Tomlinson sends the first ARPANET e-mail between two computers.

Associate Teaching Professor Rania Hussein demonstrates one of the portable FPGA lab units she and her collaborators developed for students to remotely access from universities around the world during the COVID-19 pandemic. Photo: Ryan Hoover

RESPONDING TO COVID-19

UW ECE FACULTY, STUDENTS AND ALUMNI continue to lead critically important, collaborative research projects across campus and with other institutions aimed at reducing impacts of the novel coronavirus (COVID-19). Their work ranges from assisting with diagnostics, testing and tracking, to overcoming remote education logistics, to engineering ventilator technology, to developing targeted treatments for the disease. Below are summaries of some of these projects from the past year.

UW ECE Associate Teaching Professor Rania Hussein (pictured left) collaborated with four universities to set up FPGA circuit boards on campus so that students could remotely access and utilize real hardware located at all participating universities via the Labsland hosting platform. Hussein and UW ECE Professor Denise Wilson won a Best Paper Award in the ECE division at the 2021 ASEE Conference for their paper titled "Remote Versus In-Hand Hardware Laboratory in Digital Circuits Courses." The paper evaluated the learning outcome of students in EE 371 using the remote FPGA lab versus using traditional lab kits. Results showed that students were able to take advantage of a full-fledged remote experience without compromising their educational experience versus in-person classrooms or labs. Hussein's research and the Labsland platform was also featured in the June, 2021 issue of IEEE Spectrum magazine.

From 'distressed' to 'unscathed'

To understand how the UW's transition to online-only classes affected college students' mental health in the spring of 2020, a team of UW researchers including Margie Morris, Kevin Kuehn, Jennifer Mankoff, UW ECE Professor Eve Riskin, Paula Nurius and Anind Dey surveyed 147 UW undergraduates over the 2020 spring quarter. The team compared the students' responses to a previous survey of 253 students in spring quarter 2019.

Recent UW ECE PhD graduate Sepehr "Sep" Makhsous was OSAP's recipient of the 2021 Dr. James A Cottone Award for Excellence in Investigative Research for his abstract, Evaluating Aerosol Persistence During Dental Procedures Using a Real-Time Network of Sensors. Makhsous and his team investigate the integration of real-time aerosol sensors in dental settings to help evaluate and improve mitigation strategies to eliminate aerosol transmission. He has been working closely with Dr. Schwedhelm, Dr. Huang, and Dr. Chan from UW School of Dentistry to evaluate a sensor network system, and they are actively looking for collaborators to help them with understanding the current limitations in aerosolized viruses and pathogens during dental procedures. Makhsous, a postdoctoral fellow at UW CoMotion, was advised by ECE Professor Alex Mamishev and is also the CEO and co-founder at AeroSpec, a UW startup that specializes in providing real-time air quality analysis.

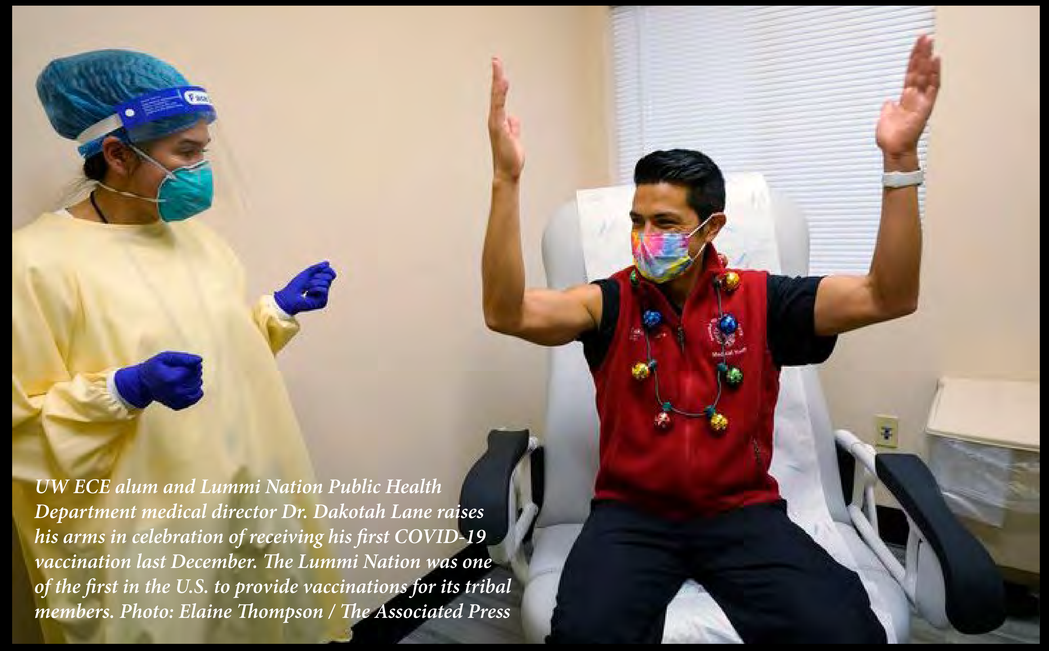
(Continued on next page)

Do international university students experience the engineering classroom differently from that of their domestic peers?

UW ECE Professor Denise Wilson and Ziyan Bai, Ph.D. (UW College of Education), in collaboration with ECE graduate students Shruti Misra and Neha Kardam and Morgan Anderson from the College of Education, recently published a paper that reveals the unique contribution of faculty and TA support to international student success in engineering classrooms before and during COVID, through a cross-sectional study of over 1,200 students. The paper won awards for Best Diversity Paper and 2nd Best Paper in the New Engineering Educator's Division at the recent American Society for Engineering Education (ASEE) 2021 conference. For more information, please visit the team's COVID-19 research website or contact Professor Denise Wilson or Ziyan Bai.

Researchers at Microsoft and the UW, including UW ECE Professor Baosen Zhang, proposed an AI system that uses smartphone location data to forecast electrical load. The pandemic has made a striking impact on the global electrical grid. Stay-at-home orders and social distancing meant to slow the outbreak of COVID-19 resulted in major shifts in load patterns and peak demands, with overall power consumption the U.S. falling to a 16-year low at the start of the pandemic.

The Lummi Nation became one of the nation's first to provide vaccine protection for its tribal members. 300 doses of Pfizer's vaccine were administered in early December, 2020, said UW ECE alumnus and Lummi Nation member Dr. Dakotah Lane (pictured below), who is now the medical director of the Public Health Department for the tribal nation. While Native Americans represent a disproportionate number of COVID-19 cases and deaths nationwide, Dr. Lane and his team have been proactive since the start of the pandemic to mitigate the number of cases in the Lummi Nation.



UW ECE alum and Lummi Nation Public Health Department medical director Dr. Dakotah Lane raises his arms in celebration of receiving his first COVID-19 vaccination last December. The Lummi Nation was one of the first in the U.S. to provide vaccinations for its tribal members. Photo: Elaine Thompson / The Associated Press

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A multidisciplinary team of volunteers, including UW ECE students and faculty members Blake Hannaford and John Raiti, were awarded a Runner Up prize in the Core 77 Design Awards 2021 competition for their WorldVent Ventilator project.

In response to the shortage of accessible and affordable ventilators at the start of the COVID-19 pandemic, a group of Seattle-based volunteer clinicians, designers (including UW School of Art + Art History + Design faculty and students), engineers, and philanthropists came together to form a unique non-profit humanitarian organization called the World Ventilator Foundation. At the heart of this organization was the design and development of a new low-cost emergency response ventilator (right). The WorldVent ventilator is a streamlined, mechanical ICU pandemic ventilator that performs the same life-saving function as highly-technical ICU ventilators at a fraction of the cost. It is lightweight, has a highly-intuitive controls, and can be rapidly and easily produced, facilitating the treatment of COVID-19 patients experiencing respiratory failure. The modular design is meant to operate in a range of medical facilities from hospitals, field hospitals, and even austere environments with limited medical personnel and infrastructure.

UW ECE Professor Les Atlas was interviewed by Zippia about current job market trends during the pandemic and the enduring impact that COVID-19 is likely to have on new graduates, and on Systems Engineers in particular. Atlas covers everything from what type of skills are needed by younger engineers when entering the workforce to which types of experiences really stand out to potential employers on résumés.

A technician demonstrates WorldVent Ventilator prototype units, which were designed by UW ECE students and faculty in collaboration with the UW School of Art + Art History + Design. Images courtesy the WorldVent Volunteer Team.

Empathy helps Rico Malvar engineer a lifetime of success that includes giving back to others

A STRONG SENSE OF SOCIAL RESPONSIBILITY AND EMPATHY FOR OTHER PEOPLE HAS CONTRIBUTED TO RICO MALVAR'S CAREER SUCCESS AND MOTIVATED HIS LONGTIME ENGAGEMENT WITH AND SUPPORT FOR UW ECE.

By Wayne Gillam

Henrique (Rico) Malvar, a distinguished engineer at Microsoft and UW ECE affiliate professor, is widely recognized as a research and industry leader known for his work in signal processing and data compression. He has served as a key connection between UW ECE and its industry affiliates and supported the Department philanthropically for many years. According to those who have worked with Malvar, his many accomplishments stem in part from his unique ability to lead teams, form long-lasting partnerships and leverage collaborations with others to the benefit of all. Malvar has remarked that he sees empathy for others as foundational to his strong interpersonal and collaborative skills. Photo courtesy of Microsoft.

THERE ARE NOT MANY PEOPLE who have had career success comparable to what Henrique (Rico) Malvar has achieved. Malvar, a distinguished engineer at Microsoft, has worked for the company for almost 25 years and has held prominent roles throughout his tenure such as chief scientist for Microsoft Research and managing director for Microsoft Research Redmond. He holds over 120 U.S. patents as inventor or co-inventor and has over 170 technical articles to his name. He is a member of the U.S. National Academy of Engineering, the Washington State Academy of Sciences, the Brazilian National Academy of Engineering and the Brazilian Academy of Sciences. He is also an IEEE Fellow and has received many awards throughout his career, including a Technical Achievement Award from the IEEE Signal Processing Society and the 20th Century Landmark Award from the IEEE Seattle Section.

At UW ECE, Malvar has been an affiliate professor since 1999 and has acted as a pillar of support for the Department, serving as a key connection between UW ECE and its industry affiliates. His mentorship and guidance have proven to be invaluable. In addition to his philanthropic gifts to UW ECE over the years, Malvar served as chair of UW ECE's Advisory Board from 2012 to 2016 and was on the UW College of Engineering's Dean's Visiting Committee from 2016 to 2019. In 2018, he played a leading role in helping UW ECE to update its identity and change its name to better reflect the breadth of the Department. Malvar was also chosen to be guest speaker for the 2021 UW ECE graduation ceremony.

How has Malvar achieved this remarkable level of success and philanthropic involvement and maintained it over such a long period of time? According to many who have worked with him, Malvar's accomplishments stem in part from his unique ability to lead teams, form long-lasting partnerships and leverage collaborations with others to the benefit of all.

"Rico is an exceptional industry leader who has the ability to bring disparate groups of people together to accomplish daunting tasks. UW ECE is very fortunate to be beneficiaries of his involvement with and support of the Department," UW ECE Professor and Chair Eric Klavins said. "He contributes not only through philanthropic giving and as a key connection between the Department and Microsoft, but also as a strong voice for expanding diversity, inclusion and accessibility in engineering."

Malvar has worked throughout his career toward making technologies more accessible, inclusive and aimed toward social good. He currently leads the Enable research group at Microsoft, which seeks to empower people with disabilities and improve their lives

Opposite and above: Malvar leads the Enable research group at Microsoft, which seeks to empower people with disabilities and improve their lives through developing new technologies such as eye-controlled and sound-based user interfaces. Here, Malvar is shown with members of his team in the Enable lab, discussing work on eye-tracking technologies, which ultimately led to the development (in partnership with the Microsoft Windows team) of the Eye Control interface for the Windows operating system. Photos courtesy of Microsoft.

Malvar giving a talk in 2013 to a standing-room only crowd in the auditorium of the electrical engineering department at the Universidade de Brasília. Photo courtesy of Rico Malvar.

Opposite: Malvar with UW ECE Professor Radha Poovendran at a 2018 social event. Malvar worked with Poovendran, who was Department chair from 2015 to 2020, to help UW ECE update its identity and change its name in 2018 to better reflect the breadth of the Department.

through developing new technologies such as eye-controlled and sound-based user interfaces. The work at Enable requires learning how to understand the world through different perspectives, and Malvar is an advocate for bringing diverse points of view to engineering. He has remarked that he sees empathy (the ability to understand and share the feelings of another) as foundational to his strong interpersonal and collaborative skills.

"I try to exercise empathy in all my daily interactions with people. People perceive and appreciate when you sincerely care about what they think and listen to their opinions," Malvar said. "The goal is not simply to be nice to people — although that's a good byproduct — the goal is to learn from them and foster deeper collaborations. That, in turn, leads to better negotiations, better projects and better outcomes."

A path that led to UW ECE

Malvar was born and raised in the suburbs of Rio de Janeiro, Brazil, and when he was in junior high school, the family moved to Brasília, the capital of Brazil. Both of his parents were college professors, and they instilled in him early on the value of education. Malvar was a natural engineer — a self-described 'nerd' who frequently dabbled with electronic kits as a child — and with the support of his parents and many good instructors along the way, he eventually achieved a bachelor's degree in electrical engineering from the Universidade de Brasília and a master's degree in electrical engineering from the Universidade Federal do Rio de Janeiro. After receiving his master's degree, he secured a teaching position at the Universidade de Brasília and soon after took a leave of absence to move himself, his wife and their young daughter to the U.S., where he obtained a doctorate in electrical engineering and computer science from the Research Laboratory of Electronics at MIT. A four-year scholarship made the pursuit of a doctoral degree possible for Malvar, and the experience contributed to his sense of social responsibility.

"I try to exercise empathy in all my daily interactions with people." — Rico Malvar

"There was no way my family would have been able to pay for the tuition at MIT," Malvar said. "A scholarship from the Brazilian National Council for Scientific and Technological Development made a difference in my life, and it led to a successful career. So, I felt a sense of responsibility for giving back."

After receiving his doctoral degree, he returned to Brazil where he continued to teach in the engineering department at the Universidade de Brasília for several years. He enjoyed academic life, and eventually he went on to become the head of the department's graduate program and its digital signal processing research group.

Education had opened many opportunities for Malvar, so after 14 years of teaching in Brazil, he left his professorship and moved his family to the U.S. again. This time they moved to Andover, Massachusetts, so Malvar could take a position as vice president of research and advanced technology at PictureTel (later acquired by Poly). He worked at PictureTel for four years, until the summer of 1997, when he received a unique opportunity to lead the signal processing research group at Microsoft Research in Seattle.

"I am forever grateful to my wife and children for supporting our move to another country, changing schools and moving across the U.S., each time having to rebuild a new network of friends," Malvar said.

In Seattle, Malvar and his family made a successful new start in a welcoming community. And at Microsoft, Malvar found a company that mirrored his research, career and personal interests as well as the value he placed on developing technology for social good.

"I've been working for almost 45 years, and nearly 25 of those years were at Microsoft," Malvar said. "I would have never expected to be in one place for that long, but yeah, it happened. It's always better when you are in an environment where your employer has values that you share. That alignment is a good thing."

It was also shortly after he started at Microsoft that Malvar became involved with UW ECE through Professor Les Atlas, a longtime friend and colleague in signal processing research. Malvar found engagement with the Department rewarding, and he wanted to become more involved, so two years later he became a UW ECE affiliate professor.

"I like the academic environment, I like students, I like talking to professors and I like people who think really freely," Malvar said. "Becoming an affiliate professor gave me the opportunity to have a little bit of the academic involvement that I always enjoyed."

Today, Malvar continues to remain actively involved and engaged with the Department, and he is currently advising UW ECE on reputation-building initiatives. Looking ahead, he said that over the next few years he would like to spend more time with his family, but he also said that he looks forward to continuing his engagement with UW ECE.

"It's very clear that education makes a huge difference in people's lives," Malvar said. "I'm not sure exactly what the future is going to bring, but if at all possible, I would like that future to include my involvement with the UW and with UW ECE in particular."

Bringing light into computers to accelerate AI and machine learning

By Wayne Gillam

UW ECE FACULTY MEMBERS SAJJAD MOAZENI AND MO LI ARE LEADING A MULTI-INSTITUTIONAL RESEARCH TEAM, WHICH HAS RECEIVED A FOUR-YEAR GRANT FROM THE NATIONAL SCIENCE FOUNDATION TO DEVELOP A NEW TYPE OF COMPUTER CHIP THAT USES LASER LIGHT FOR AI AND MACHINE LEARNING COMPUTATION.

Assistant Professor Sajjad Moazeni | photo: Ryan Hoover

It might not be commonly known, but artificial intelligence and machine learning applications are commonplace today, performing a multitude of tasks for us behind the scenes. For example, AI and machine learning helps to interpret voice commands given to our phones and devices such as Alexa, recommends movies and music we might enjoy through services such as Netflix and Spotify, and is even driving autonomous vehicles. In the near future, the reach of AI and machine learning applications is expected to extend even further, to more complex tasks such as supporting space missions and defense operations, and developing new drugs to treat disease.

But the growing sophistication of AI and machine learning applications, as well as their implementation at such a large scale, demands a need for computing power which roughly doubles every three to four months. That's much faster than Moore's law (the observation that the number of transistors in a dense, integrated circuit doubles about every two years). Conventional computing paradigms and hardware platforms are having trouble keeping up. Also, cloud computing data centers used by AI and machine learning applications around the world currently gobble up an estimated 200-terawatt hours per year. That's more than a small country. It's easy to see that this energy consumption will come hand-in-hand with serious environmental consequences.

To help address these challenges, UW ECE faculty members Sajjad Moazeni and Mo Li are leading a multi-institutional research team that recently received a four-year grant from the National Science Foundation to develop a new type of computer chip that uses laser light for AI and machine learning computation. This chip, called a "hybrid co-processing unit," or HCU, stands to greatly accelerate the computing speed and efficiency of AI and machine learning applications, while at the same time reducing energy consumption. The computational power of the HCU will be over ten times greater than today's most advanced silicon-based microprocessors of comparable size.

"There is a need to shift the computing paradigm to something new," said Moazeni, who is lead principal investigator of the project. "One of the most important and distinctive novelties in the work we are doing is that what we are proposing can very tightly get integrated with existing silicon-based microprocessors in today's data centers. That is something very unique."

A new, scalable optical computing paradigm

The HCU combines traditional electronics with photonics, using light generated by lasers instead of electricity for data processing. The device does this by way of an optical computing core that includes phase-change material (a substance similar to what is in CD-ROMs and DVDs) to record information. This computing core can realize an optical neural network on the chip to accelerate computational speed in an ultracompact footprint, storing data on-chip using the phase-change material at essentially zero-power.

"The HCU is a single-chip solution that can be integrated with today's silicon-based microprocessors," Moazeni said. "We call it 'hybrid' because we are co-optimizing the benefits of electronics, photonics and phase-change materials, all within one system."

The project builds on research by Moazeni, who is an expert in large-scale integrated photonics

and microelectronics, as well as Li, who has been developing optical computing systems using phase-change materials at UW ECE. According to Moazeni and Li, this is the first time photonics and electronics have been so tightly integrated together in a single chip for the purpose of accelerating AI and machine learning computations.

"Optical computing is best for data movement and linear computation, while traditional electronics are really good at digital computation and also implementing nonlinear algorithms, which optical computing cannot easily do," Li said. "Our strategy combines the best of the two."

Other members of the research team are Nathan Youngblood, an assistant professor of electrical and computer engineering at the University of Pittsburgh, and Lei Jiang, an assistant professor of intelligent systems engineering at Indiana University Bloomington. Youngblood will work on designing electrically programmable, high density optical memory arrays for ultrafast optical computation, and Jiang will be focusing on optimizing the device for accelerating emerging AI and machine learning applications.

What's next?

The research team is working toward combining the phase-change material with microelectronics circuitry at the Washington Nanofabrication Facility. This will be achieved through integrating the phase-change material with an advanced silicon photonic process fabricated at a commercial foundry. The method allows thousands of photonic elements and millions of transistors to be fabricated together in a cost-effective and scalable manner. The team will also be building computer models to simulate every aspect of the device.

"We'll start by modeling and putting together the full end-to-end model of the HCU, model the phase-change material, model the photonics and construct a new, unique framework on which we can simulate all of them together," Moazeni said.

By the end of the NSF grant in 2025, the research team expects to have a working, physical prototype. Then, the group will be poised to manufacture the device in larger quantities and at a scale capable of moving into the marketplace.

What does that mean for the rest of us? Eventually, the work promises to translate into quicker response times and improved performance for any computer application that involves AI or machine learning (such as our phones, Alexa, Netflix and Spotify). It also will help make possible a significant reduction in energy consumption, making technology driven by AI and machine learning more environmentally friendly.

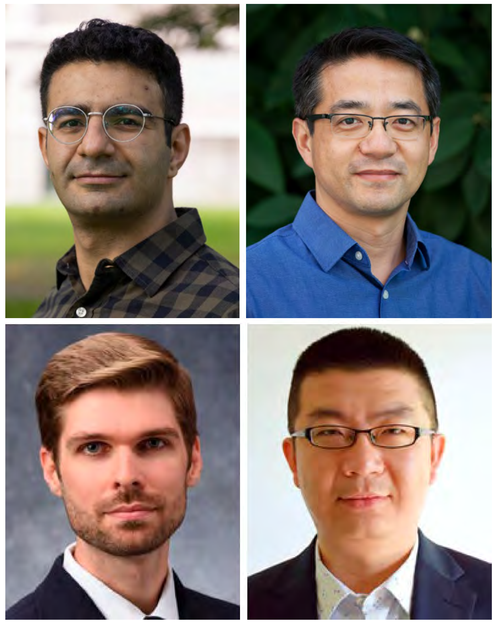
"This is the first time that we'll be bringing a non-traditional computing chip into the real world for practical applications, and I'm really excited about that," Moazeni said. "It's a realization of Moore's law, which stated that eventually new materials would need to be brought into chip development in order to increase computing capacity and speed."

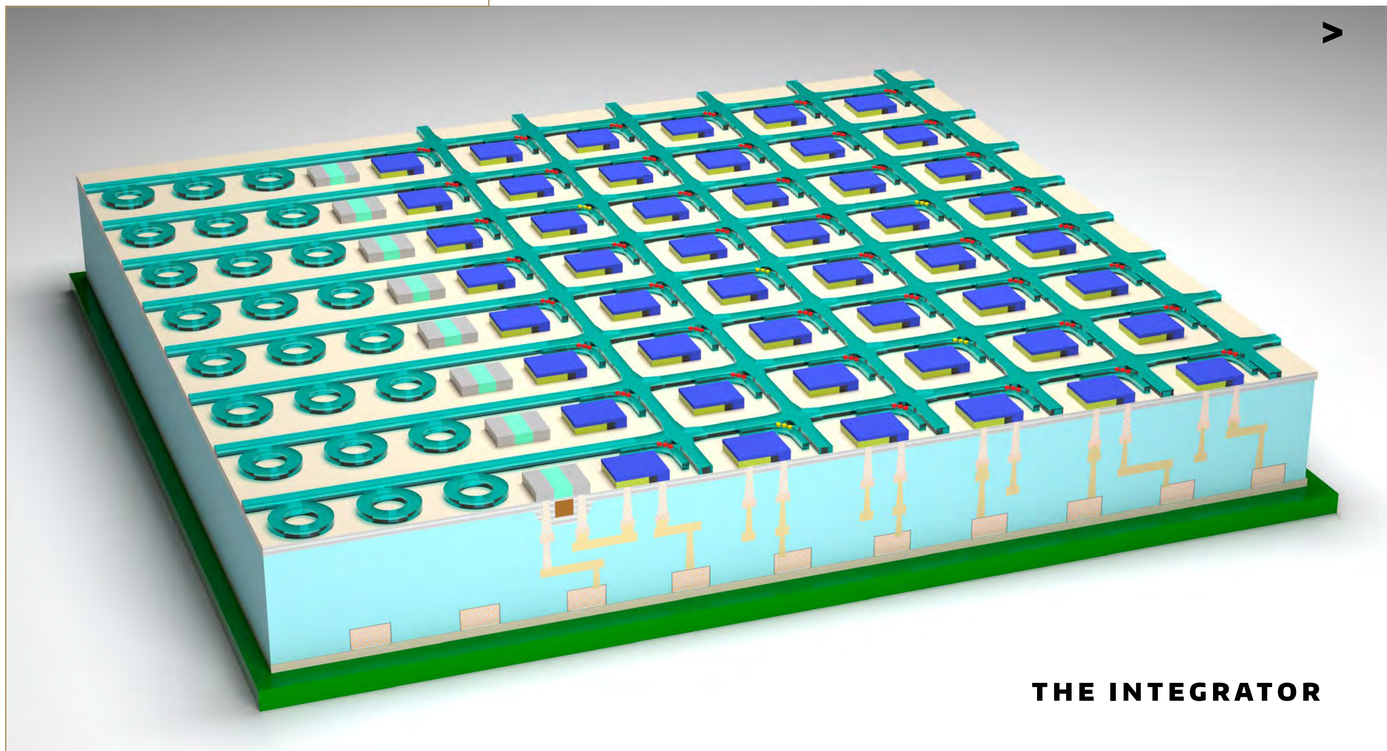
"Our technology will improve speed, performance and power consumption," Li added. "And perhaps most importantly, it will help to put AI computing on a sustainable energy path."

For more information about research described in this article, contact Sajjad Moazeni or Mo Li.

A simplified illustration showing a novel computer chip being developed by a multi-institutional research team led by UW ECE faculty members Sajjad Moazeni and Mo Li. The chip is called a "hybrid co-processing unit," or HCU. The HCU combines traditional electronics with photonics, using light generated by lasers instead of electricity for data processing and phase-change material (a substance similar to what is in CD-ROMs and DVDs) to record information. The computational power of the HCU will be over ten times greater than today's most advanced silicon-based microprocessors of comparable size. The device promises to greatly accelerate the computing speed and efficiency of artificial intelligence and machine learning applications, while at the same time, reduce energy consumption. Illustration by Seokhyeong Lee, UW

The research team developing the HCU, top row, left to right: UW ECE Assistant Professor Sajjad Moazeni, UW ECE Professor Mo Li. Bottom row, left to right: Nathan Youngblood, an assistant professor of electrical and computer engineering at the University of Pittsburgh, Lei Jiang, an assistant professor of intelligent systems engineering at Indiana University Bloomington





Assistant Professor Azadeh Yazdan | photo: Ryan Hoover

Azadeh Yazdan receives $3.2M grant to investigate ways neurotechnology could induce targeted changes in the brain, leading to better treatments for stroke

YAZDAN HAS RECEIVED AN NIH GRANT TO EXPERIMENT WITH USING A CUTTING-EDGE OPTOGENETIC STIMULATION NEUROTECHNOLOGY

By Wayne Gillam

Stroke is a killer, and for those who survive, it can have a devastating impact.

According to the World Stroke Organization, the disease is a leading cause of death and disability globally, causing an estimated 5.5 million deaths and 116 million years of healthy life to be lost each year. It is also a very common experience. One in four adults over the age of 25 will have a stroke in their lifetime. So, why is this disease so deadly and debilitating? The answer to that question has to do in part with how stroke can cause the connections between neurons in the brain to deteriorate, break or disappear entirely, often resulting in death, loss of bodily functions and disability. Unfortunately, there is no cure for this disease. But what if scientists and engineers could use neurotechnology, which has shown promise in treating other neurological conditions such as those caused by spinal cord injury, to intervene? Could key neural connections be targeted and induced to heal and repair themselves after a stroke has occurred?

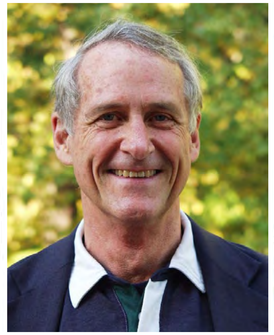
UW ECE Assistant Professor Azadeh Yazdan is investigating possible answers to these questions. Yazdan, who is the Washington Foundation Innovation Assistant Professor of Neuroengineering in UW ECE and the UW Department of Bioengineering and a member of the Center for Neurotechnology, has several years of research experience studying possible ways to treat neurological disorders and diseases such as stroke.

What happens in a lot of these disorders is that there is aberrant neural connectivity in one or more areas," Yazdan said. "For example, if someone has a stroke, they are missing connections between brain areas, whereas if someone has a psychiatric disorder such as post-traumatic stress disorder, they might have connections in the brain that are not supposed to be there."

Yazdan's research focuses on using neurotechnology to induce targeted changes in the brain, reorganizing neural pathways in ways that could address these connectivity issues, helping the brain to heal and recover after injury. She recently received a $3.2M, five-year grant from the National Institutes of Health to further advance her work in this area and to specifically study functional recovery following an ischemic lesion in the brain, a condition that is commonly known as a stroke.

"I'm excited to help people who are dealing with neurological disorders, and I think this research could be especially helpful in finding better treatments for stroke," Yazdan said. "But also, what we learn will have applications beyond stroke. If we can show targeted reorganization in the brain, the knowledge could be used to better treat diseases that are similar to stroke such as traumatic brain injury or cerebral palsy, as well as psychiatric disorders such as depression."

Yazdan is now in the midst of assembling her research team for work supported by the new grant, and she is recruiting for a postdoctoral researcher and lab technician. Co-investigators on the NIH grant include Amy Orsborn, the Clare Boothe Luce Assistant Professor at UW ECE and the UW Department of Bioengineering, who specializes in therapeutic neural interfaces; Eberhard Fetz, a UW professor of physiology and biophysics, who was one of the early pioneers of brain-computer


Co-investigators on the NIH grant include, from left to right, UW professors Amy Orsborn, Eberhard Fetz and Ruikang (Ricky) Wang.

interface development; and Ricky Wang, a UW professor in bioengineering and ophthalmology.

"I am looking forward to working with Dr. Yazdan on this exciting project," Orsborn said. "The work will shed new light on how neurotechnology can be used to rewire brain networks, which will have wide-ranging therapeutic applications."

Optogenetic stimulation of the brain

For her NIH-funded research, Yazdan will primarily be using optogenetics to stimulate neurons in the brain instead of electricity, which is currently the go-to form of brain stimulation for neural engineering. Optogenetics is a technology that uses light to activate and inhibit neurons, and although it has been around for several decades, it is a relative newcomer to neurotechnology. Optogenetics has the advantages of being more precise and controllable than electrical stimulation, and it will allow Yazdan and her team to tease apart complicated neural circuits in ways that will be useful for better understanding neural network connectivity.

"With optogenetics, we have the capability of recording during the stimulation period to see how the neural network is evolving, and what neural changes can lead to functional changes and recovery through simultaneous behavioral measures," Yazdan said. "Following a lesion in the brain, we can measure a behavioral deficit, and we can also measure neural and functional recovery as a result of our stimulation parameters."

Yazdan has been working for several years developing optogenetic tools capable of giving more precise and cell-type specific manipulations of the brain, as well as interfaces that can enable scientists and engineers to manipulate and record from large areas of the brain. Concurrent with her NIH-funded research, she is co-leading a multi-institutional effort to develop a 'smart dura,' a device that has the capability to perform optogenetic stimulation and also allows unprecedented large-scale access to the brain. The smart dura will enable Yazdan and her research team to record and manipulate neural network activity with unmatched, high resolution.

"The brain network structure is actually a big mediator of the changes that we're seeing. There are no two people who have the same stroke and the same damage," Yazdan said. "So, in this grant, we're also including the network structure information into the design of our stimulation protocols. For future stroke therapies, you can imagine that brain stimulation protocols could be customized to a patient's stroke."

What the future holds

By the end of the five-year NIH grant, the research team is aiming to establish a proof of concept that demonstrates the effectiveness of refined brain stimulation patterns for targeted neurorehabilitation and 'rewiring' of the brain. Their work will also help scientists and engineers better understand neural circuits and connectivity in the areas of the brain that are studied.

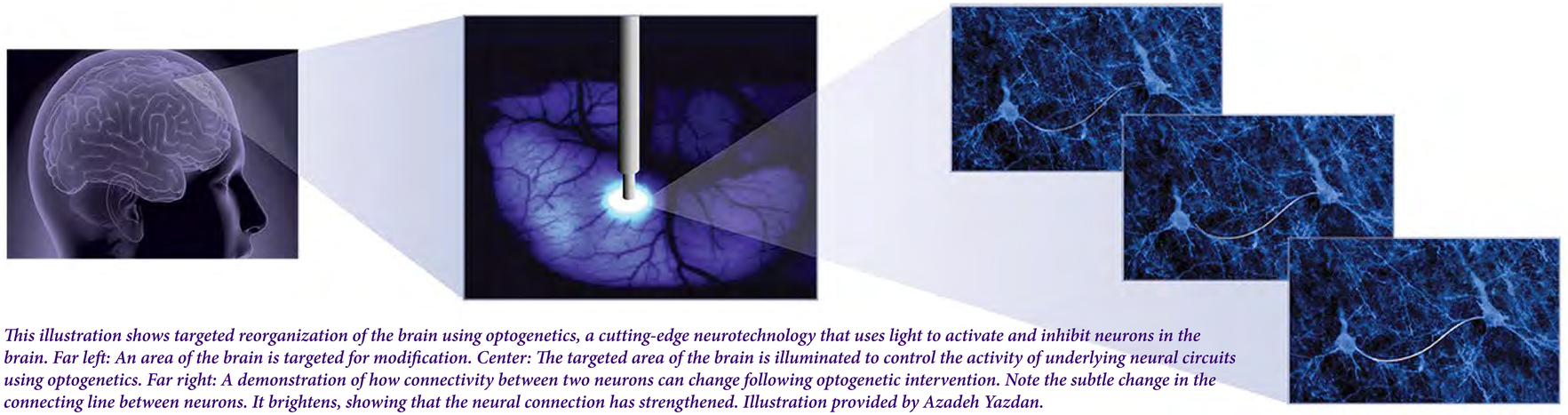
Yazdan said that long-term goals for this line of research depend in part on what the team discovers over the next five years. But because her team is studying functional recovery following stroke, she is hoping that she can pair up with clinicians to apply some of their research findings in a clinical setting. She is also interested in expanding the focus of the research to encompass other neurological and psychological disorders.

"A long-term goal that I have is to see how we can manipulate the brain and induce these targeted changes, which could be used for treating different neurological disorders, beyond stroke," Yazdan said. "This grant will be a really good first step for that."

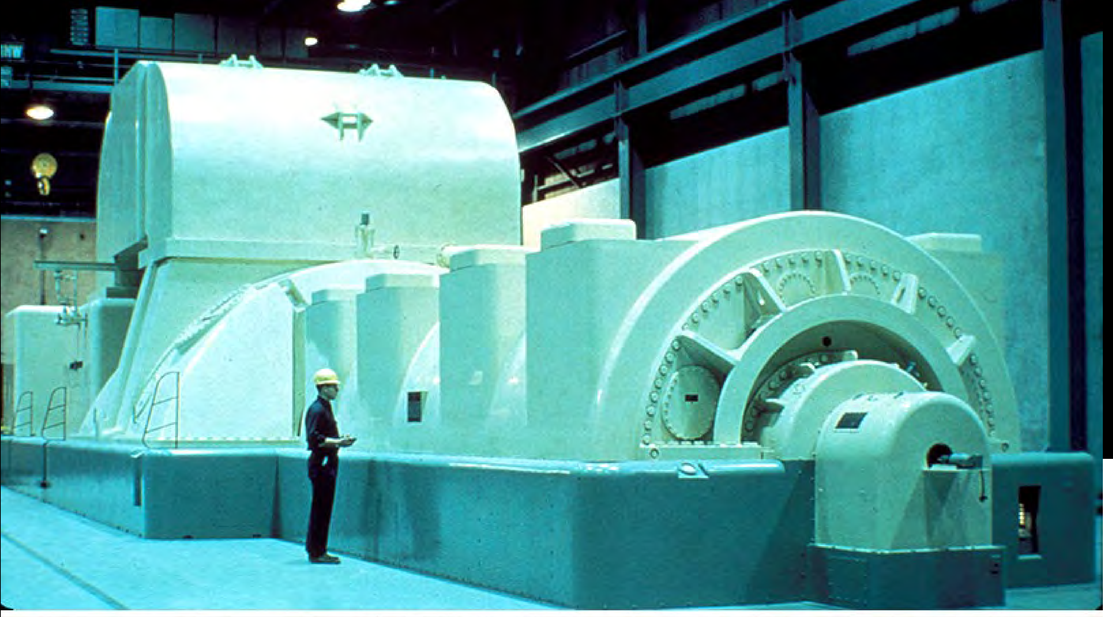
She also noted that because much is still unknown when it comes to neurological disorders and diseases such as stroke, it has historically been difficult for scientists and engineers to develop effective treatments.

"We have about one billion people worldwide that suffer from some kind of neurological disorder. In this research, we will learn much that could help us improve current brain stimulation-based therapies," Yazdan said. "This work could also open up a lot of opportunities for us to understand the brain and its response to stimulation. Basically, it will help us to better understand how to induce these targeted changes to the brain in ways that could potentially cure someone."

For more information about the research described in this article, please contact Azadeh Yazdan.



This illustration shows targeted reorganization of the brain using optogenetics, a cutting-edge neurotechnology that uses light to activate and inhibit neurons in the brain. Far left: An area of the brain is targeted for modification. Center: The targeted area of the brain is illuminated to control the activity of underlying neural circuits using optogenetics. Far right: A demonstration of how connectivity between two neurons can change following optogenetic intervention. Note the subtle change in the connecting line between neurons. It brightens, showing that the neural connection has strengthened. Illustration provided by Azadeh Yazdan.



Currently, the nation's electrical grid relies on large, spinning power turbines such as the one shown at top. Many of these machines are vulnerable to going offline during widespread power outages and are powered by fossil fuels such as coal and natural gas. UNIFI seeks to address these issues by advancing research on 'grid-forming inverters' — an emerging technology that would enable renewable energy devices, such as the rooftop solar power inverter shown above, to remain powered-up during grid disturbances and restart the grid in a coordinated manner if outages occur. Photos by the U.S. NRC (top) and Enphase Energy, a UNIFI partner (bottom)

Transforming the nation's electrical grid to better support renewable energy

By Wayne Gillam

Assistant Professor of Clean Energy Brian Johnson | photo: Ryan Hoover

UW ECE FACULTY MEMBER BRIAN JOHNSON WILL BE CO-LEADING A NEW, NATIONAL CONSORTIUM, FUNDED BY A $25M AWARD FROM THE U.S. DEPARTMENT OF ENERGY. JOHNSON AND HIS COLLEAGUES AIM TO REMAKE THE NATION'S ELECTRICAL GRID, MAKING IT RESILIENT TO POWER OUTAGES AND LESS DEPENDENT ON FOSSIL FUELS.

It's probably not news that electric power systems across the country can be vulnerable to extensive outages, as demonstrated by natural disasters such as Hurricane Ida and the 2021 Texas Ice Storm. But what may not be commonly known is that the electrical system the nation depends on, the North American power transmission grid, is still highly dependent on fossil fuels, not only to generate power, but also to restart the system itself when outages occur.

Recently, the U.S. Department of Energy (DOE) announced the creation of a new public-private consortium, which is aiming to address these issues. It will be co-led by the University of Washington (UW), the National Renewable Energy Laboratory (NREL) and the Electric Power Research Institute (EPRI). The consortium, known as the UNiversal Interoperability for Grid-Forming Inverters Consortium (UNIFI) will bring together leading experts from academia, industry and government organizations to advance research, development and implementation of technology designed to support renewable energy growth across the nation's electrical power system. This effort will strengthen the country's electrical grid, making it more resilient to power failures and blackouts, while also reducing dependence on fossil fuels.

UNIFI is funded by a $25M DOE award and will officially begin after initial negotiations between consortium partners conclude. The consortium will be directed by Ben Kroposki from NREL, and it will be co-led by Aidan Tuohy from EPRI and Brian Johnson, who is the Washington Research Foundation Innovation Assistant Professor of Clean Energy in the UW Department of Electrical & Computer Engineering (UW ECE) and a faculty member of the UW Clean Energy Institute.

"We are pursuing one of the most ambitious ideas in the field of electric power. Our aim is to revolutionize the way the grid works from a fundamental standpoint," Johnson said. "By collecting top researchers and industry leaders under one umbrella organization, we will be best positioned to work as a unified front toward this paradigm shift."

The collaboration is truly expansive in scope. In addition to the UW, NREL and EPRI, the consortium will include three DOE laboratories, 11 North American universities, six inverter manufacturers, five software simulation vendors, two North American power system operators and eight North American power system utilities.

(Continued on next page)

"Brian Johnson's leadership in electric power is inspiring and one of the reasons UW ECE is a leader in developing new approaches to electric power that are driving the technology into the future," UW ECE Professor and Chair Eric Klavins said.

Unifying power sources, technologies and systems for a more resilient and sustainable electrical grid

The nation's electrical grid in its current form relies on large, spinning power turbines fueled chiefly by coal and natural gas. When these power generators go offline, or power transmission lines go down in a storm or natural disaster, such an event can sometimes trigger other energy sources on the electrical grid to turn off, resulting in a cascading blackout.

UNIFI seeks to address these issues by advancing research on 'grid-forming inverters' — an emerging technology that allows renewable energy sources such as solar and wind power, and other inverter-based energy sources such as batteries, to remain powered-up during such grid disturbances, and if cascading outages occur, to help restart the grid in a coordinated manner. The consortium will lead the development, modeling and implementation of this technology, while establishing specifications and standards to ensure interoperability between inverters from different manufacturers.

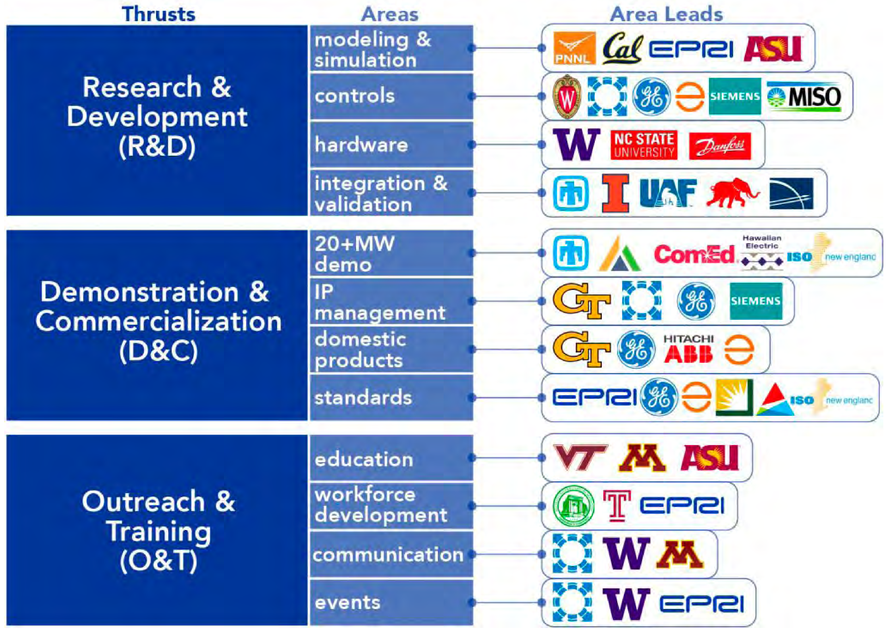
"As we continue to adopt renewables, battery storage and electric vehicles in greater numbers, the grid itself is transforming right under our feet," Johnson said. "What we are aiming to do is to ensure that as the grid evolves over this coming decade, we properly steer it in a direction that not only preserves its reliability and integrity but actually enhances it and makes it better. This use of dispersed, renewable energy allows us to engineer a new type of grid, one that is ultra-resilient and can provide uninterrupted power for consumers and energy users at all scales."

'Evolve' is a keyword. Johnson and his colleagues at UNIFI realize that unlike their predecessors in the early 1900s, who developed and pieced together the electrical grid we use today, current efforts will be building on top of already existing infrastructure. Like its name implies, UNIFI seeks to unify new and old technologies, local and global power control systems, slower conventional machinery and ultra-fast power electronics, big and small power generators, and different types of energy such as solar, wind, battery storage, fossil fuels, and others, all into one, unified electrical grid — a grid that better supports wide-scale adoption of clean energy sources and is more resilient to natural disasters.

Educating tomorrow's engineers and building toward the future

UNIFI includes education and workforce development as a key part of its many planned initiatives over the coming years. The consortium's partners will be working together to develop teaching materials and conduct seminars, tutorial workshops and hands-on training. UNIFI will also broadly disseminate its research results throughout academia and industry.

"The vision that we have for the grid is so transformative that the manner in which students and engineers learn how power grids work will need to be revamped," Johnson said. "Traditional rotating generators have been at the core of power systems curricula up to now. This paradigm shift towards electronically-interfaced energy will be significantly different. Students and engineers will need to be kept up to date on how these changes are happening during these coming years."



UNIFI will bring together leading experts from academia, industry and government organizations to advance research, development and implementation of technology designed to support renewable energy growth across the nation's electrical power system. The organizational structure includes three research thrusts (shown at left), subdivided into areas of focus distributed among participating institutions. Illustration provided by Brian Johnson

In his lab at UW ECE, Johnson will focus on applying fundamental advances in theory toward hardware-based experiments that show how next-generation power-electronics-based grids will work. He'll be bringing on at least two graduate students to assist with this effort. There are also plans in the works to form a graduate student team across universities that are part of UNIFI, so students will be able to directly contribute to the consortium's overarching vision.

Significantly changing a framework as large and expansive as the nation's electrical grid is a massive undertaking, so UNIFI is preparing for a long-term effort. The DOE award has a duration of five years, and after that, the consortium plans to support its work through a combination of income-generating mechanisms such as member fees, intellectual property licenses and contract research. The consortium plans to be fully self-sustaining by the end of the DOE award, so it can follow through on its vision of significantly increasing grid resilience and reducing dependence on fossil fuels by 2035.

"We're trying to reinvent the grid with electronics and new technology, but unlike in the past, it will be done through an evolution, rather than building it from scratch out of nothing," Johnson said. "This will be something that changes slowly over time, but I envision that in 10 to 20 years, we will have a radically different grid."

For more information about the UNIFI Consortium, read recent press releases from the DOE, NREL and EPRI, or contact Brian Johnson.

UW ECE-led team receives $5M award to help bring quantum computing into the real world

A MULTI-INSTITUTIONAL RESEARCH TEAM LED BY UW ECE FACULTY MEMBERS MO LI, ARKA MAJUMDAR AND KARL BÖHRINGER IS DEVELOPING A POWERFUL, MINIATURIZED OPTICAL CONTROL ENGINE, WHICH WILL GREATLY INCREASE CAPACITY AND SPEED OF QUANTUM COMPUTERS.

By Wayne Gillam

QUANTUM COMPUTERS COULD BE A GAME CHANGER. These devices use principles of quantum mechanics to make huge leaps forward in solving complex and challenging problems that are well beyond the scope of the fastest supercomputer in existence. For example, optimizing complex algorithms involved in weather forecasting, controlling traffic flow and managing airline flight schedules is theoretically within reach of a full-scale quantum computer. Simulating complex chemistry and molecules involved in drug development and electronic materials discovery could also be enabled by quantum computing.

A multi-institutional research team led by UW ECE faculty members Mo Li, Arka Majumdar and Karl Böhringer is developing a powerful, miniaturized optical control engine, called PEAQUE, which will greatly increase capacity and speed of quantum computers.

Because of this potential, there is an ongoing, worldwide race to build the first scalable quantum computer. But after several years, the most powerful quantum computer built to date is still well under 300 quantum bits, or 'qubits.' To be applicable to problems like what is described above, a quantum computer needs to have the capacity to operate millions of qubits. With this in mind, building a full-scale quantum computer capable of tackling real-world problems is a daunting challenge.

A multi-institutional research team led by UW ECE faculty members Mo Li, Arka Majumdar and Karl Böhringer has recently taken on this challenge by participating in the National Science Foundation's Convergence Accelerator. The focus of this NSF program is to make timely investments in multidisciplinary research that will deliver tangible solutions improving the lives of millions of people. The NSF Convergence Accelerator is investing $50M to advance 10 out of 29 research teams addressing national-scale societal challenges from phase one to phase two of the program. The UW ECE-led team, part of the program's 2020 cohort, was selected to move on to phase two as one of four teams focusing on quantum technology.

"The NSF Convergence Accelerator is a uniquely inspiring program, providing us with an experience that teaches us how to pitch our ideas, build a team and conduct user interviews," said Li, who is lead principal investigator on the research team. "It helps us to have a fresh view of our original plan, moves us to better manage the project, and most importantly, the program helps us discover new directions, new applications, new stakeholders for our technology."

Along with moving into phase two of the program, the research team will receive a $5M, two-year award from the NSF Convergence Accelerator. The award will help the team build on their efforts and achievements from phase one, which were aimed at scaling up the capacity and speed of quantum computers. In phase two, the team will be developing a 'Photonic Engine Accelerating atomic QUantum Engineering,' or PEAQUE. The PEAQUE project will address quantum computing scalability by developing a powerful, miniaturized optical control engine that interfaces cold atom qubits with quantum software. The team will also participate in the NSF Convergence Accelerator's Idea-to-Market curriculum to assist them in further developing solutions and to create a sustainability plan that ensures their efforts will have a positive impact beyond NSF funding.

"Miniaturization is a main theme of PEAQUE, but on top of that, we will make more powerful technology to optically control many qubits. We're not just shrinking things. We are also using new materials and advanced microwave technology to make this possible," Li said.

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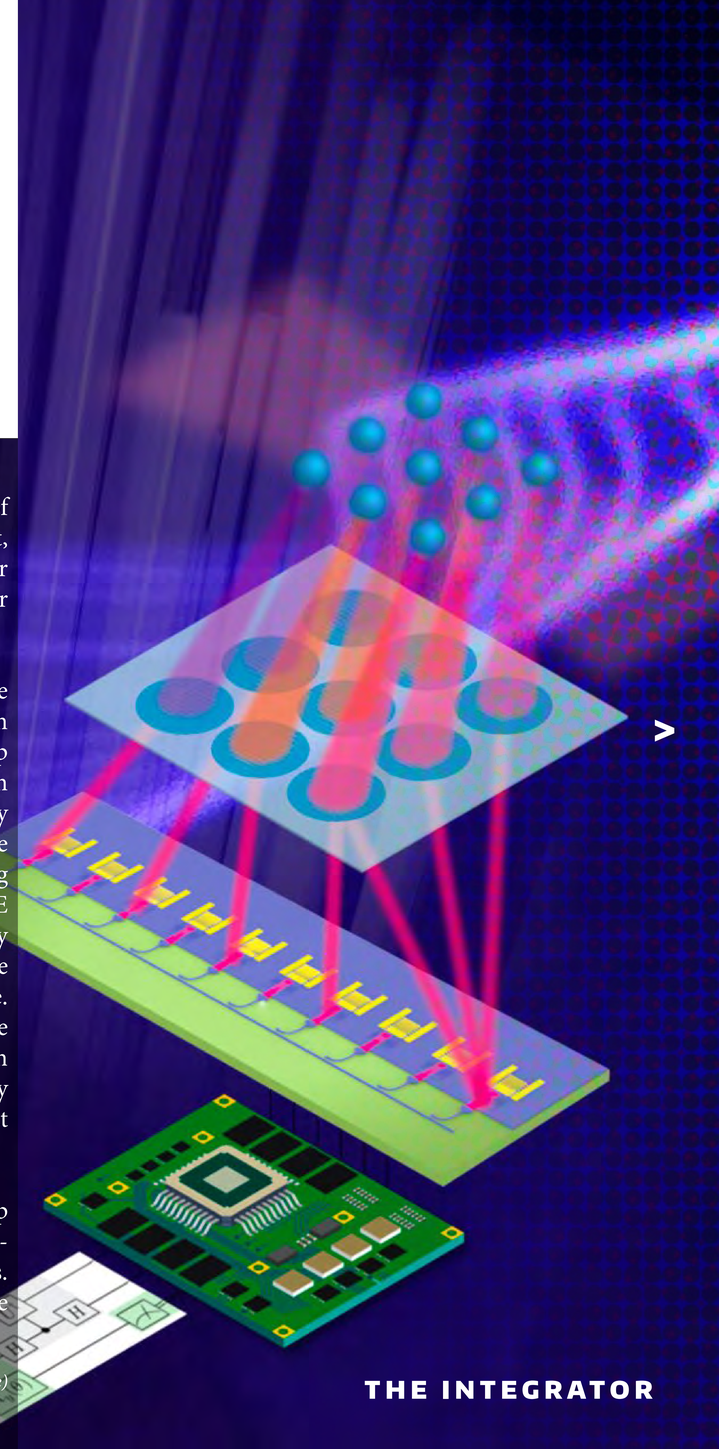
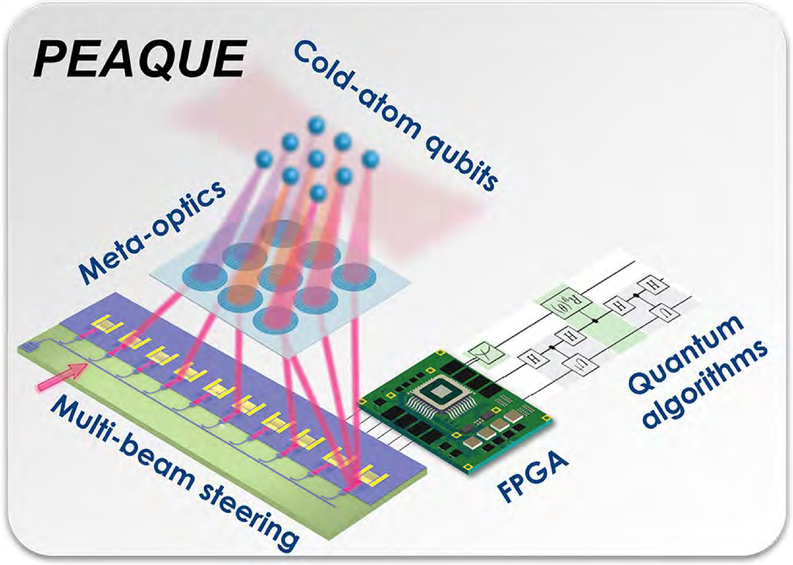


"We are developing a whole system using devices that we prototyped recently using fundamental physical principles," Majumdar added. "Going from fundamental physics to application in a short period of time is very exciting."

The PEAQUE project will be a collaboration between academia, industry and government institutions. The research team includes co-investigators Birgitta Whaley, a professor of chemical physics at UC Berkeley and director of the Berkeley Quantum Information & Computing Center, Adam Kauffman, Jun Ye, and Ana Maria Rey from JILA (a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology), and Ben Bloom and Brian Lester from Atom Computing. Other collaborators include Larry Minjoo Lee from the University of Illinois Urbana-Champaign and Matt Eichenfield from Sandia National Laboratories.



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Developing an 'integrated circuit' for quantum computing

To some extent, quantum computing is now at a stage that is similar to where classical computing was in the 1950s. It takes a room-sized apparatus and quite a bit of human operation to realize a very limited computing capacity. The tipping point for classical computing was in 1959, when the integrated circuit was invented and patented. This ingenious invention allowed computers to be scaled down in size and up in computing speed and power. Li said that he believes quantum computing is at a similar tipping point, and PEAQUE could be to quantum computing what the integrated circuit was to classical computing.

"To build a quantum computer for practical use is an enormous mission to accomplish. It requires solving many challenging technological problems," Li said. "Scalability is one of the key factors to be able to go beyond a million qubits. Therefore, integrated scalable miniaturized technologies, like PEAQUE, are going to play a critical role."

The research team is designing PEAQUE to support a 1,000-qubit quantum computer. This may sound like a far cry from a million qubits, but it is a size that can show proof of concept. And according to Li, this is an important milestone between where we are now and quantum computers capable of impacting the real world.

"Using current technology, it is possible to control 100 qubits. The equipment may be the size of a room, but it is doable," Li said. "But from 100 to 1,000 qubits it is a very big challenge. And even if you manage to do that, how do you go from 1,000 qubits to one million? For that, you'll need a technological breakthrough in terms of scalability. That is what we are trying to address."

In order to achieve this miniaturization, one of the main goals of PEAQUE is to reduce the size of the laser beam steering module that is at the core of the optical control system of a cold-atom quantum computer, while at the same time, greatly increase computing capacity and precision. Current laser beam steering modules for quantum computers are roughly the size of a large shoebox, and each module can generate and control 32 laser beams that interact with cold atoms. But at least 2,000 laser beams are needed to support a 1,000-qubit quantum computer. The research team addressed this issue in phase one of the NSF Convergence Accelerator by proposing a chip-scale multi-beam illumination and steering system, or MBIS, which is slated to go into PEAQUE during phase two.

The MBIS in PEAQUE will be over a hundred times smaller than state-of-the-art beam systems, and it will be much more powerful. Instead of emitting only 32 laser beams, each MBIS module will be able to emit and steer 100 beams. Equally important, the MBIS emits its laser beams perpendicular to the plane of the module, as opposed to emitting beams from the edges of the device like current technology. What this means is that multiple MBIS modules can be placed next to each other like tiles in a compact, planar array to steer thousands of laser beams all at the same time. To help picture this, imagine an extremely complex laser light show, but one that is projected onto an array of single atoms.

"This project is taking a revolutionary new idea all the way to a device for practical applications," Böhringer said, who in addition to being a UW ECE professor and member of the research team is also director of the Institute for Nano-Engineered Systems. "We are building a truly scalable nano-engineered system."

NSF's Convergence Accelerator

This research is supported by the NSF Convergence Accelerator, which is investing $50M to advance 10 out of 29 research teams addressing national-scale societal challenges from phase one to phase two of the program. The UW ECE-led team, part of the program's 2020 cohort, was selected to move on to phase two as one of four teams focusing on quantum technology.

Next steps

In phase one of the NSF Convergence Accelerator, the research team proposed the MBIS and successfully fabricated prototype devices, which are currently under testing. They developed a full production process flow and built the electronics system for PEAQUE to contain a large array of atoms. The progress made in phase one put the team on a fast track to demonstrate the first prototype of PEAQUE early on in phase two.

The team is planning to establish foundry processes at Sandia National Laboratories to fabricate PEAQUE on eight-inch wafers and mass produce the device. By the end of phase two, the team will deliver a full test kit, including devices, electronics and software, all in one package. They plan to disseminate the test kit and their findings broadly to the academic community and the private sector.

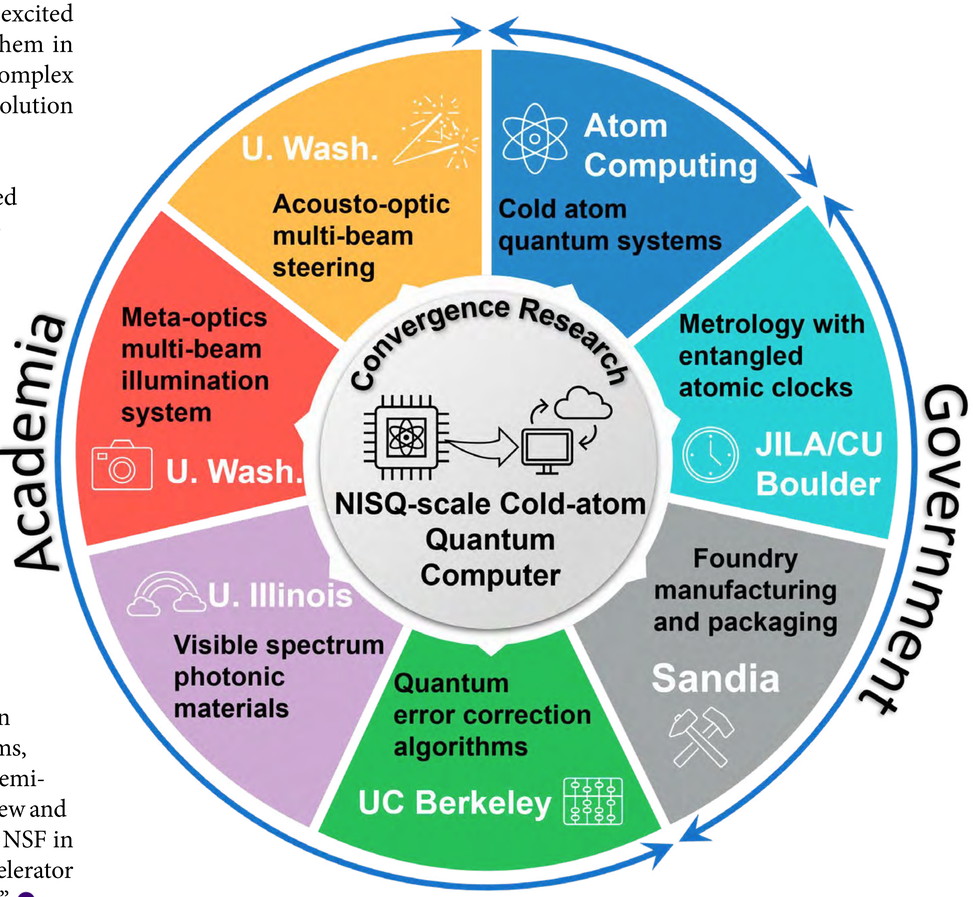
"Quantum research and discovery is a priority for the National Science Foundation. Through the NSF's Convergence Accelerator, teams like PEAQUE are expediting their solutions forward by integrating a convergence research approach to include a wide range of expertise and partnerships from industry, government, non-profits,

academia and other communities of practice," said Douglas Maughan, head of the NSF Convergence Accelerator program. "Today's scientific priorities and national-scale societal challenges cannot be solved by a single discipline. Instead, the merging of new ideas, techniques, and approaches, plus the Convergence Accelerator's innovation curriculum, enables teams to speed their research into application. We are excited to welcome PEAQUE into phase two and to assist them in applying our program's fundamentals to solving this complex scientific challenge. If successful, PEAQUE's scalable solution will provide a positive impact on society at large."

The success of the team's project will make room-sized quantum experiments fit into a much smaller, rack-mounted system. Ultimately, PEAQUE will help to realize a full-scale quantum computer capable of solving important and challenging problems such as predicting weather patterns more accurately, speeding development of life-saving drugs and discovering entirely new materials to be used in future technologies.

According to Li, PEAQUE will likely find many other important research applications outside of quantum computing as well. Much like the race to put people on the moon spawned new, and unexpected inventions, Li anticipates that the race to build a full-scale quantum computer will do the same.

"The research toward building a quantum computer can spawn many innovations in optics, in control mechanisms, in micro-electro-mechanical systems, in packaging, in semiconductor technology," Li said. "Many of our needs are new and have never been seen before, so the investment by the NSF in this project and the new model of the Convergence Accelerator program can generate many new and innovative ideas."



For more information, read the NSF press release, visit the PEAQUE website, or contact Mo Li, Arka Majumdar, or Karl Böhringer.

"This project is taking a revolutionary new idea all the way to a device for practical applications. We are building a truly scalable nano-engineered system."

— Karl Böhringer, UW ECE professor and director of the Institute for Nano-Engineered Systems

The PEAQUE project will be a collaboration between academia, industry and government institutions. In addition to the University of Washington, the organizations involved include UC Berkeley and the Berkeley Quantum Information & Computing Center, Atom Computing, and JILA (a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology). Other collaborators include the University of Illinois Urbana-Champaign and Sandia National Laboratories.

Professor Eve Riskin is returning to UW ECE after 15 years as an associate dean in the UW College of Engineering. And as co-founder and faculty director of STARS, she has plans to share this successful program model with colleges and universities across the country. STARS helps to make higher education more accessible and provides support for students from low-income, first-generation and underserved backgrounds. Photo by Ryan Hoover

Eve Riskin returns to UW ECE with plans to share the STARS program nationwide

PROFESSOR EVE RISKIN IS RETURNING TO UW ECE AFTER 15 YEARS AS AN ASSOCIATE DEAN IN THE UW COLLEGE OF ENGINEERING. AND AS CO-FOUNDER AND FACULTY DIRECTOR OF STARS, SHE HAS PLANS TO SHARE THIS SUCCESSFUL PROGRAM MODEL WITH COLLEGES AND UNIVERSITIES ACROSS THE COUNTRY.

By Wayne Gillam

After 15 years as an associate dean for the UW College of Engineering and one year on sabbatical, professor Eve Riskin has returned to the UW Department of Electrical & Computer Engineering this fall as the Department's newly-appointed undergraduate program coordinator. In this role, Riskin will work closely with the UW ECE associate chair for education and student advising team to manage undergraduate policies, issues and admissions.

"I'm really happy to be back at UW ECE," Riskin said. "I'm so thrilled with the welcome the Department is giving me as I return. I hope to apply some of what I learned as an associate dean to UW ECE."

Riskin started her career at UW ECE in 1990. In addition to receiving several honors and awards over the years as an educator and for her research, she is well-known for her persistent and impactful work in diversity, equity and inclusion at the University. Riskin has received numerous awards related to expanding diversity and access to education, such as an ECEDHA Diversity Award, a Hewlett-Packard Harriett B. Rigas Award and a UW David B. Thorud Leadership Award.

In 2020, her efforts were recognized with one of the nation's highest honors, a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

"When he was chair of UW ECE, Radha Poovendran nominated me for the ECEDHA and PAESMEM awards, and this was so kind of him," Riskin said.

"Eve is very inspiring. She has dedicated her career to increasing access to engineering for underrepresented students," said UW ECE Professor and Chair Eric Klavins. "We are so excited to welcome her back to UW ECE and incredibly lucky to have her in the role of undergraduate program coordinator, where her expertise with diversity, equity and inclusion will have such a positive impact on our students."

Now, fresh from her sabbatical, Riskin shows no signs of slowing down. In addition to her duties as an instructor and her new role at UW ECE as undergraduate program coordinator, Riskin is continuing as faculty director of two successful programs she co-founded at the UW — UW ADVANCE, which is dedicated to the advancement of female faculty in STEM fields, and the Washington State Academic RedShirt program, which is known as STARS. According to Riskin, the STARS program holds a special place in her heart because of its powerful impact on students who come from low-income and underserved backgrounds.

"Eve's leadership has profoundly advanced our College's mission to recruit and retain people from underrepresented or disadvantaged groups," said professor Sam Burden, UW ECE's Associate Chair for Diversity, Equity and Inclusion. "I was thrilled when she recruited me to pitch in on STARS, which is an outstanding program that has enabled unprecedented access to engineering education for women, underrepresented minorities and first-generation college students. We are extremely fortunate to have Eve back full-time in our Department, and I am eager to leverage her expertise to make UW ECE more diverse, equitable and inclusive for all."

What is the STARS program?

The STARS program draws its inspiration from the concept of a "redshirt" year in college athletics, giving students an extra year of preparation to succeed in school. The program

supports engineering and computer science students from low-income, first-generation and underserved backgrounds in navigating the transition to college-level courses, and it is welcoming its ninth cohort this fall. This two-year program includes a specialized curriculum designed to build learning skills and strengthen academic preparation for core math and science prerequisites.

Riskin was the principal investigator for two National Science Foundation grants that helped to launch STARS at the UW and provide substantial support for the program over the last eight years. Now, with the support of colleagues and a third NSF grant, she is laying the groundwork for an upcoming conference to be held in June 2022 on the UW campus, which will share details about how the program works with representatives from colleges and universities across the nation.

"We're going to share the STARS program model and have people look under the hood," Riskin said. "We'll examine curricula, we'll talk about fundraising, and we'll have a panel with STARS students — testimonials, so they can hear about the impact on students. We'll share documents, processes, curriculum, policies, everything we created for STARS, so we can help other institutions across the country get started with their own, similar programs."

Riskin will be working closely with Sonya Cunningham, executive director of the STARS program at the UW, to spread the STARS program model nationwide. The two have formed a strong and effective partnership over the years, and according to Riskin, Cunningham has played a key role in the program's ongoing success.

"STARS wouldn't be half the program without her," Riskin said. "Sonya is one of the very best student services professionals in the country. She just has a knack for knowing what a student needs, figuring out what obstacle is holding that student back and helping them get around it. There are many students out there who have college degrees and are now working engineers that would not have succeeded without her. And they tell her that, so that's really meaningful."

Almost 300 students have participated in the STARS program to date. STARS has also brought on a new director, Lindi Rubadiri-Mujugira, who will be responsible for much of the staff oversight and hands-on work needed to keep the program running smoothly while Riskin and Cunningham are focused on fundraising and disseminating the program model, especially through the June 2022 national conference.

The impact of STARS

Like Riskin, Cunningham is enthusiastic about the impact of the program.

"What is most exciting to me about STARS is that it has immeasurable far-reaching implications individually, locally, nationally and globally," Cunningham said. "There is the obvious possibility to end the intergenerational cycle of poverty for individuals, and beyond this, the program places very diverse students squarely at the decision-making table. This will improve not just the problem-solving process but also the kinds of problems that are chosen to be solved."

Over the first eight cohorts, 79% of STARS students remain enrolled in engineering or computer science, or have graduated. This very high rate of success means better jobs and brighter futures for students. Further evidence of STARS' impact on students can be found within the program participants' own words.

(Continued on next page)

Opposite: *Riskin (right) will be working closely with Sonya Cunningham (left), executive director of the STARS program at the UW, to spread the STARS program model nationwide.*

Right: *STARS' new director, Lindi Rubadiri-Mujugira, will be responsible for much of the staff oversight and hands-on work needed to keep the program running smoothly while Riskin and Cunningham focus on fundraising and sharing the STARS program model. Photo by David Tsay.*

> *"What is most exciting to me about STARS is that it has immeasurable far-reaching implications individually, locally, nationally and globally."*
>
> — Sonya Cunningham, STARS Executive Director

Mathew Garcia, year two at UW ECE

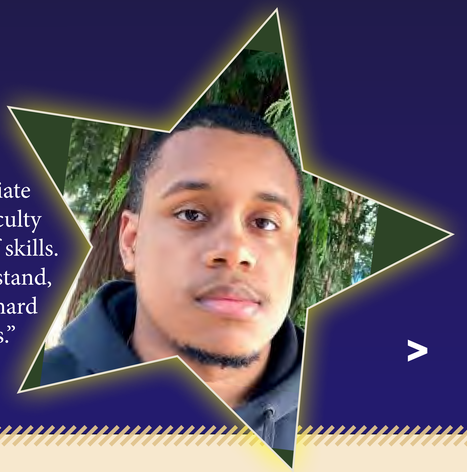
"The STARS program supported me during the difficult transition from high school to university, and it also prepared me for an exciting future in engineering. I not only built lifelong friendships with the other members of my cohort, but I also made important connections with the incredibly caring staff that inspired me to continue studying STEM during tough times. Through these connections and skills gained during my time at STARS, I gained an amazing internship at Boeing that will be instrumental as I continue to grow as an engineer in the years to come."

Diana Verduzco, year four at UW ECE

"Being a part of the STARS program provided many opportunities to become a successful student and accomplish my goals. I had the privilege to be a part of a community and was constantly given support by faculty and staff as well as my lifelong friends I met through STARS. Their encouragement and guidance have genuinely gotten me this far. Through this program, I have also had opportunities to intern for companies, gain hands-on experience, communicate with people in industry and get a head start on what the real world looks like. I'm so grateful for this program because I wouldn't be where I am today without it!"

Grace Kariuki, 2021 UW ECE graduate, Research Software Engineer at IBM Research

"I would have never imagined from that first day of transition week how much the STARS program would completely change my life. The incredible staff supported me throughout the entire five years and helped me find lots of opportunities to build my experience. As a graduate, I will soon begin my journey as an engineer at my dream job in my dream city. Through STARS, I also found lifelong friends whom I consider my family. I will forever be grateful to STARS."



Diallo Wilson, graduating Fall 2021 from UW ECE

"STARS has been my main support network throughout my collegiate career. The tough love early, the cohort model and the excellent faculty taught me that I am someone with my own unique value and set of skills. Rather than being disappointed in what I do not have or understand, STARS taught me to think more about what I do have and that hard work and sacrifice will always be necessary to accomplish my goals."

A bright future for STARS

Alongside her new role as UW ECE undergraduate program coordinator and planning for the June 2022 national STARS conference, Riskin will be fund-raising and working continuously behind the scenes to ensure that STARS remains successful and sustainable over the long term. She remains firmly committed to the vision she has had for the program since its inception, and she is optimistic about the future.

"This is about institutional transformation," Riskin said. "If you want people to succeed, instead of focusing so much on trying to fix the student, you should fix your system. We're fixing our system to better fit students who didn't come from privileged backgrounds. We're finding that STARS students are capable of succeeding and doing many wonderful things in the world. And in fact, many already are." ★

Riskin (far right) and Cunningham (second from right) with the first graduating class from STARS. Over the first eight cohorts, 79% of STARS students remain enrolled in engineering or computer science, or have graduated. This very high rate of success means better jobs and brighter futures for students.

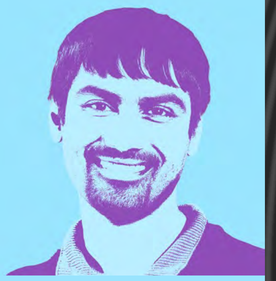
For more information about the STARS program, visit the program website or contact Eve Riskin, Sonya Cunningham or Lindi Rubadiri-Mujugira.

uw ece

SPOTLIGHTS

SPOTLIGHTS

SHWETAK PATEL



Professor Shwetak Patel has earned a place in the Georgia Tech College of Computing's Hall of Fame and a spot on Business Insider's recent list of "30 leaders under 40" who are changing health care for his innovative work combining low-power sensing, signal processing and machine learning for applications ranging from non-invasive disease screening to monitoring appliance-level energy consumption.

→ *(Read full story)*

DENISE WILSON

IEEE Region 6, which represents the western half of the United States, named Professor Denise Wilson as recipient of their 2020 Outstanding Engineering Educator Award. The award recognizes Wilson as an outstanding educator, facilitator and mentor, and it notes her excellence in adaptation and resilience to a broad range of learning environments, including remote learning.

→ *(Read full story)*

CHET MORITZ

Associate Professor Chet Moritz and senior postdoctoral researcher Dr. Fatma Inanici have developed a new way to non-invasively, electrically stimulate spinal cord nerves in people with cervical spinal cord injury, resulting in dramatic functional gains.

→ *(Read full story)*

MARI OSTENDORF

Mari Ostendorf, the Endowed Professor of System Design Methodologies at UW ECE, has been elected to the National Academy of Engineering (NAE), which is recognized as one of the highest professional distinctions in engineering. Ostendorf was elected for "contributions to statistical and prosodic models for speech and natural language processing and for advances in conversational dialogue systems."

Ostendorf was also appointed as Vice Provost for Research at UW. She had been serving as Associate Vice Provost for Research in the Office of Research since 2017.

→ *(Read full story)*

SAM BURDEN

Assistant Professor Sam Burden was named as a recipient of a National Science Foundation (NSF) CAREER award, one of the most prestigious awards in the nation for early-career faculty. The award will fund research by Burden that seeks to build fundamental knowledge related to human-machine interaction as well as education and outreach initiatives aimed at broadening participation of underrepresented students in science, technology, engineering and math (STEM).

→ *(Read full story)*

VISVESH SATHE

Associate Professor Visvesh Sathe was recognized with an Intel 2020 Outstanding Researcher Award for his project focused on developing a more energy-efficient computer architecture. Sathe is one of only 18 leading academic researchers worldwide to receive the award out of over a thousand researchers funded annually by the Intel Corporation.

→ *(Read full story)*

LINDA SHAPIRO

Professor Linda Shapiro received a grant from the UW Medicine Garvey Institute for Brain Health Solutions, which hopes to spur technology-driven solutions that aim to improve brain health. Shapiro is leading a project that aims to leverage deep learning to diagnose Alzheimer's disease and predict its progression.

→ *(Read full story)*

JOSH SMITH

Josh Smith, the Milton and Delia Zeutschel Professor in Entrepreneurial Excellence, was elected into the 2021 class of Fellows of the National Academy of Inventors for his impactful creations in the fields of wireless power, communication, sensing and robotics. Proprio, a spinout co-founded by Smith, received a Health Innovation of the Year award for developing a visualization system for medical use that has been called "the most transformative technology in surgery since the X-ray."

→ *(Read full story)*

SPOTLIGHTS

ELI SHLIZERMAN

A UW ECE team led by Associate Professor Eli Shlizerman has created Audeo, a system that uses artificial intelligence to generate music using only visual cues from video of silent piano performances. When the group tested the music Audeo created with music-recognition apps, such as SoundHound, the apps correctly identified the piece Audeo played about 86% of the time. For comparison, these apps identified the piece in the audio tracks from the source videos 93% of the time.

→ *(Read full story)*

BAOSEN ZHANG

Researchers at Microsoft and the UW, including Baosen Zhang, the Keith and Nancy Rattie Endowed Career Development Professor at UW ECE, proposed an AI system that uses smartphone location data to forecast electrical load. The pandemic has made a striking impact on the global electrical grid. Stay-at-home orders and social distancing meant to slow the outbreak of COVID-19 resulted in major shifts in load patterns and peak demands, with overall power consumption the U.S. falling to a 16-year low at the start of the pandemic.

→ *(Read full story)*

KAI-MEI FU

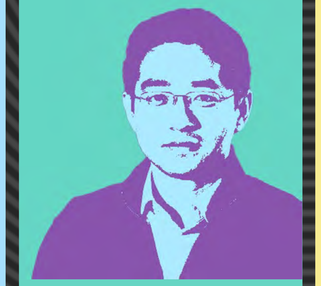
Could defects in diamonds replace traditional silicon computer processing chips? In quantum computing, UW scientists see the building blocks of such a technological revolution, which could reshape physics research, encryption and more. Associate Professor Kai-Mei Fu spoke with UW Magazine about the exciting quantum computing collaborations happening in the Pacific Northwest. Fu will also direct a new NSF Research Traineeship focused on an interdisciplinary quantum future.

→ *(Read full story)*

MO LI

A research team led by Associate Professor Mo Li, in collaboration with researchers at the University of Maryland, developed an optical computing system to help speed up AI and machine learning, while reducing associated energy and environmental costs. The team is among the first in the world to use phase-change material in optical computing to enable image recognition by an artificial neural network, a benchmark test of a neural network's computing speed and precision Li also received the honor of being named an Optica Fellow for his leading contributions to nanophotonics, optomechanics and integrated acousto-optics.

→ *(Read full story)*



RANIA HUSSEIN

Associate Teaching Professor Rania Hussein and her team of collaborators won UW ECE's first ever Global Online Laboratory Consortium (GOLC) award in the category of Remote Controlled Experiments for creating a highly successful distributed remote FPGA lab during the COVID-19 pandemic. Students can remotely access real hardware located at participating universities around the world via the LabsLand hosting platform. Hussein and Professor Denise Wilson also won a Best Paper Award in the ECE division at the 2021 ASEE Conference for their related paper titled, "Remote Versus In-Hand Hardware Laboratory in Digital Circuits Courses."

→ *(Read more)*

ARKA MAJUMDAR

Associate Professor Arka Majumdar was recently selected for a Defense Advanced Research Projects Agency (DARPA) Young Faculty Award. The award will help fund the R&D of optically rewritable photonic integrated circuits based on phase change materials.

→ *(Read more)*

GEORG SEELIG

Professor Georg Seelig's research lab, Seelig Lab, was recently featured in Science Magazine for its new microSPLiT method for detecting gene expression states in bacteria using scRNA-seq. MicroSPLiT is a powerful tool for investigating complex natural and engineered microbial communities.

→ *(Read more)*

RAJESH RAO

UW ECE faculty member Rajesh Rao has received a two-year grant through the Weill Neurohub. The grant will allow Rao and his collaborators to develop a new type of brain-computer interface, called a "brain co-processor," which uses artificial intelligence to restore brain function.

→ *(Read full story)*

SPOTLIGHTS

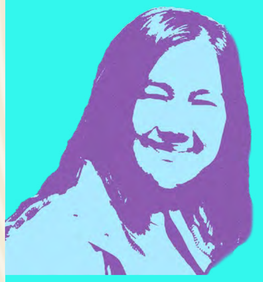
FELIX SCHWOCK

Felix Schwock, a Fulbright Scholar from Germany, was among eight UW graduate students who received this year's Distinguished Dissertation and Thesis Awards. Schwock won in the category of Mathematics, Physical Sciences & Engineering for his work on analyzing and predicting ocean ambient noise, using 3.5 years of acoustical and meteorological data recorded at the northeast Pacific continental margin to characterize the sound of wind and rain in the ocean. The research brings a recent perspective to the field, as most research in this area has used data collected in the 1950s and 1960s.

→ *(Read full story)*

Last winter, recent UW ECE graduate Christin Lin teamed up with her twin, Elizabeth, and their sister Sophia to establish and launch the STEM League Developer Program, a youth online curriculum and mentorship initiative. The sisters invited 300 kids from around the world to join their virtual summer coding program, free of charge, and have since reached hundreds of additional students interested in learning coding during the pandemic.

→ *(Read full story)*



CHRISTIN LIN

VIKRAM IYER

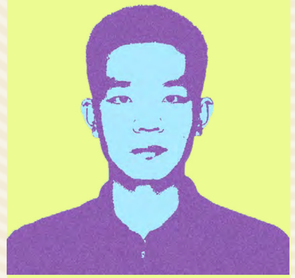
Recent UW ECE Ph.D. graduate Vikram Iyer was featured in the American Association for the Advancement of Science (AAAS) for the murder hornet tracking technologies he developed. Iyer won the Innovation of the Year Award at the 2021 GeekWire Awards for his work, and was also recently hired as an assistant professor in the Paul G. Allen School of Computer Science & Engineering (CSE) at the University of Washington.

→ *(Read more)*

YI-HSIANG HUANG

Xichen Li and Yi-Hsiang Huang, 2nd and 3rd year UW ECE Ph.D. students, were named winners of the 2021 North America Qualcomm Innovation Fellowship (QIF) for their research proposal, "Enhanced Self-Interference Suppression with Phase Noise Cancellation in Full-Duplex Radios" that looks to solve wireless data congestion issues. This research will help in the development of new full-duplex communication methods for devices such as smartphones and laptops that are capable of simultaneously transmitting and receiving data using the same frequency channel.

→ *(Read full story)*



XICHEN LI

C-K. CHOU

UW ECE alum Chung-Kwang "C-K." Chou received an IEEE Standards Association Lifetime Achievement Award for his nearly 50-year-long career devoted to researching and measuring the effects of human and animal exposure to the electromagnetic field (EMF) energy emitted by electronic devices. Through years of rigorous, evidence-based experiments, Dr. Chou helped to determine the safe levels of exposure to these types of electromagnetic-emitting technologies and was instrumental in advocating for the worldwide development and adoption of IEEE safety standards related to their use.

→ *(Read full story)*

UW ECE alum Ben Ferleger won the 2021 CNT Best Student Paper Award for Neurotechnology Advancement. Ferleger's paper, which he wrote as a grad student, explores "Fully Implanted Adaptive Deep Brain Stimulation in Freely Moving Essential Tremor Patients."

→ *(Read more)*

BEN FERLEGER

KEVIN EGEDY

This summer, Advanced Robotics at the University of Washington (ARUW), a team of University of Washington students advised by UW ECE professor Blake Hannaford, took first place in the inaugural North American RoboMaster University League Competition. The team continued a six-year legacy of success, winning the title "North American RoboMaster Champions." This year's winning team included UW ECE undergraduate students Winston Chen and Kevin Egedy.

→ *(Read full story)*

WINSTON CHEN

UW ECE spinout WiBotic, which was co-founded by UW ECE alum Ben Waters and Professor Joshua Smith, won European safety seals of approval for its wireless robot charging systems that can power autonomous drones and robots on land or sea wirelessly, without human intervention. Wibotic is also part of a $5.8M contract to study wireless charging on the moon, and has plans to develop a line of lightweight, ultra-fast wireless chargers that could help both humans and robots live and work on the moon.

→ *(Read full story)*

BEN WATERS

< >

This page and next: Maryam Fazel - IFDS Director, Moorthy Family Inspiration Career Development Professor and Associate Chair for Research at UW ECE

Addressing fundamental challenges in data science: Q&A with Professor Maryam Fazel

By Wayne Gillam | Photos by Ryan Hoover

MOST AUTOMATED TECHNOLOGIES that we use, enjoy and rely on today are built on applications driven by data science and machine learning. Internet search engines such as Google, movie and music recommendations systems embedded in popular entertainment applications such as Netflix and Spotify, and even traffic signals and airline routes are guided by mathematical algorithms working steadily behind the scenes, making decisions and creating outcomes that help to determine the user's overall experience.

But somewhere in the race to develop, market and deploy these fast-changing technologies, the theoretical understanding of how underpinning algorithms function and interact with each other fell behind the ability to implement them, and this has led to unintended consequences. For example, search engines might show us only news that aligns with our current beliefs or expectations, essentially walling us off from information that could challenge or expand our point of view, or recommender systems might only serve up movies or music from a limited number of genres, based on our past choices. In some of the worst cases, these quirks in systems that depend on algorithms can cause serious problems, such as contributing to disinformation and extremism on social media. Algorithmic flaws can also have concerning impacts on transportation systems, robotics, online security, healthcare and other vital areas of the economy that have increasingly come to rely on automation and machine learning.

To help address these issues, UW ECE Professor and Associate Chair for Research Maryam Fazel, who holds the Moorthy Family Inspiration Career Development Professorship, is leading the Institute for Foundations of Data Science, or IFDS, which is a collaboration between the UW and the Universities of Wisconsin-Madison, California-Santa Cruz, and Chicago. The IFDS launched in September 2020 with a broad mandate to build a fundamental understanding of data science, and it is one of only two institutes nationwide funded by the National Science Foundation's Transdisciplinary Research In Principles of Data Science (TRIPODS) Phase II grant. Through studying and developing the theoretical foundations of this fast-changing field, the IFDS aims to tackle complex algorithmic challenges at the root of these problems.

Over the past year, the IFDS has launched several collaborative research projects and educational programs within the UW and between its participating universities and affiliates. Following is a question-and-answer session with Fazel, which explains in more detail the importance of this Institute and its anticipated impact.

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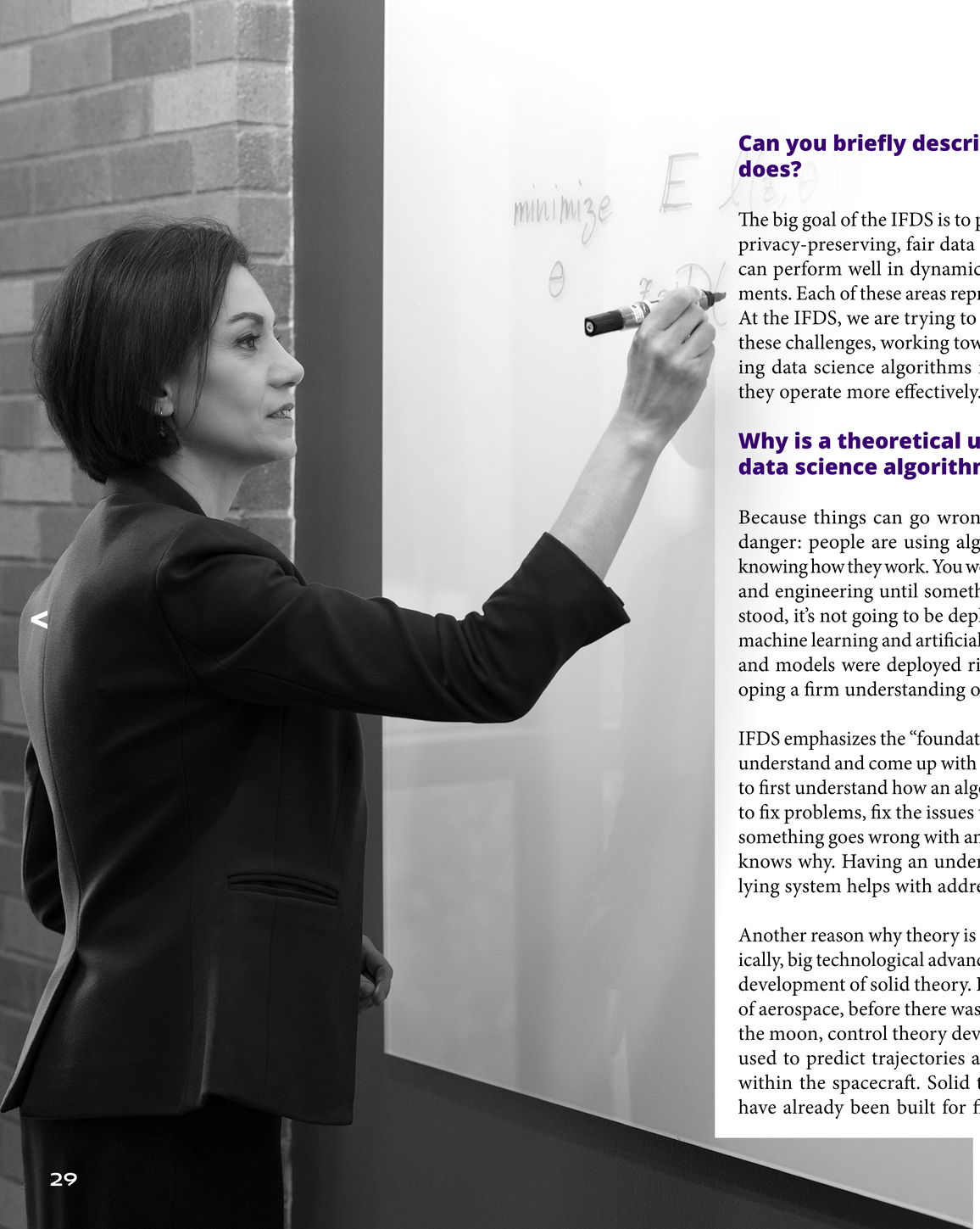


Can you briefly describe what the IFDS does?

The big goal of the IFDS is to produce robust, reliable, privacy-preserving, fair data science algorithms that can perform well in dynamic and complex environments. Each of these areas represents a huge challenge. At the IFDS, we are trying to address a little bit of all these challenges, working toward the goal of improving data science algorithms in substantive ways, so they operate more effectively.

Why is a theoretical understanding of data science algorithms important?

Because things can go wrong. Basically, this is the danger: people are using algorithms without really knowing how they work. You would think that in science and engineering until something is very well understood, it's not going to be deployed. But in the area of machine learning and artificial intelligence, algorithms and models were deployed right away, before developing a firm understanding of how they work.

IFDS emphasizes the "foundations." We need to deeply understand and come up with theoretical explanations to first understand how an algorithm works, and then, to fix problems, fix the issues that arise. Occasionally, something goes wrong with an algorithm, and nobody knows why. Having an understanding of the underlying system helps with addressing such issues.

Another reason why theory is important is that historically, big technological advances have been enabled by development of solid theory. For example, in the field of aerospace, before there was a successful landing on the moon, control theory developed a lot of the tools used to predict trajectories and design mechanisms within the spacecraft. Solid theoretical foundations have already been built for fields such as aerospace and communications. Our hope is that we can provide a similar foundation for data science, machine learning and artificial intelligence.

The IFDS brings together mathematicians, statisticians, computer scientists and engineers. Why did the Institute's leadership choose this interdisciplinary approach?

Data science questions touch upon many different fields, so to find effective solutions to the challenges we're working on, you need to bring teams of experts together who have different expertise, different points of view and get them to work together. Once you put together, for example, the math, statistics, computer science and engineering perspectives, then there is a lot more hope to make progress. That is why we have formed collaborative teams across four departments, both within the UW and between our partner universities and affiliates.

In total, we have four partner universities at the IFDS, 17 total faculty investigators, and six of those are at the UW. We also have a large and growing list of faculty and local affiliates from the UW, Microsoft Research, Facebook Research and Amazon. In addition, over the past year, we have provided partial research funding for 14 graduate students and three postdoctoral scholars that are each co-mentored in at least two different fields.

Can you describe some of the projects you are working on at the IFDS?

Sure. In a project that I'm working on with Professor Mehran Mesbahi in the William E. Boeing Aeronautics and Astronautics Department at the UW, we are aiming to provide a theoretical basis for a common method used in reinforcement learning that, for example, is used in autonomous driving, playing games and computer programs such as AlphaGo. Ultimately, we hope to help explain and improve reinforcement learning algorithms more broadly.

In another interesting IFDS project, I am collaborating with Professor Kevin Jamieson from the Paul G. Allen School of Computer Science & Engineering, Professor Lalit Jain from the Foster School of Business and two IFDS students. The project focuses on closed-loop data collection, aiming to make the same inferences with less data, by collecting it in a smart way. We are designing new selective sampling algorithms that use fewer data labels. This is important because labeling data can be expensive.

I am also excited about a new project with UW ECE Professor Lillian Ratliff and Professor Dmitriy Drusvyatskiy from the UW Department of Mathematics, which involves two IFDS students. This team is studying algorithms that interact with humans and where population data reacts to the actions of competing decision makers, for example, loan decisions made by different banks and admission decisions of different universities. The team is using mathematical tools from game theory and optimization to design algorithms that systematically take into account feedback effects and the fact that people react strategically to algorithmic decisions.

(Continued on next page)

What sort of impact do you anticipate the IFDS will have on everyday life?

The downstream impacts of this work on people's lives will be broad and far-reaching. Algorithms are frequently deployed for data processing, automated reasoning and decision-making in computer applications, online security systems, transportation systems, online financial transactions — pretty much everywhere. So, the progress we make in developing theory and improving our understanding of how algorithms work will have a deep, lasting and positive impact on technologies people depend on worldwide.

Is there anything else you would like people to know about the IFDS?

Education is interwoven into our research efforts. All our projects involve university students in some capacity, and we are offering several summer programs for university and high school students. For example, we have a series of upcoming events at the UW in Summer 2022. AI4All@UW is a two-week summer workshop for high school students with a focus on students with disabilities. It is organized by Anat Caspi, who is the director of the Taskar Center for Accessible Technology. The PIMS-IFDS-NSF Summer School on Optimal Transport is a two-week program for university students, led by Professor Soumik Pal in the UW Department of Mathematics, which the IFDS is helping to organize.We'll also be holding an IFDS Research Workshop on Distributional Robustness in Statistical Learning this summer and an annual meeting and research showcase. Details about these events, workshops and programs will be forthcoming on the IFDS website.

Overall, we're off to a great start. Many of the collaborations we initiated this year are already proving to be quite productive. I am really looking forward to the progress we will be making over the next few years in data science research and education.

> "What the IFDS is trying to do is to develop the foundations of data science, with emphasis on "foundation." We need to deeply understand and come up with theoretical explanations to first understand how an algorithm works, and then, to fix problems, fix the issues that arise."
>
> — Maryam Fazel, UW ECE Professor and IFDS Director

JAMES ROSENTHAL RECEIVES 2021 YANG RESEARCH AWARD

By Wayne Gillam

UW ECE congratulates recent graduate James Rosenthal, who was named as the 2021 Yang Research Award recipient for his work developing neurotechnology. Rosenthal received his master's and doctoral degrees from UW ECE in 2018 and 2021, respectively. He is currently a Marie Curie Postdoctoral Fellow with the Laboratory for Soft Bioelectronic Interfaces at the Ecole Polytechnique Fédérale de Lausanne in Geneva, Switzerland.

Rosenthal completed his doctoral degree at UW ECE as a National Science Graduate Research Fellow, and he was advised by UW ECE Associate Professor Matt Reynolds. Rosenthal's research focuses on the development of wireless brain-computer interfaces. He explores how architectural innovation in embedded systems can reduce the size, weight and power consumption of wireless systems, which in turn can enable new methods for monitoring and treating neurological disorders.

"I am extremely honored to be this year's recipient," Rosenthal stated in his acknowledgement of the award. "There are many uncertainties throughout a doctoral program, and it is often easy to question the impact of one's research. To be selected for this award by leading faculty from our department brings me a lot of confidence as I seek to continue my career in research as a professor."

Rosenthal is passionate about teaching, outreach and mentoring. He was the instructor of record for EE417–Wireless Communications in 2020 and 2021, and he was a teaching assistant for over six academic quarters at UW ECE. He served as UW ECE Graduate Student Association co-chair from 2017 to 2018, and he also served as one of two UW ECE graduate and professional student senators for the University from 2018 to 2020. Rosenthal also co-hosted a scientific communication podcast, "The Paperboys," with fellow UW graduate student Charlie Kelly. Each episode, Rosenthal and Kelly read and discussed the research papers behind headline science news.

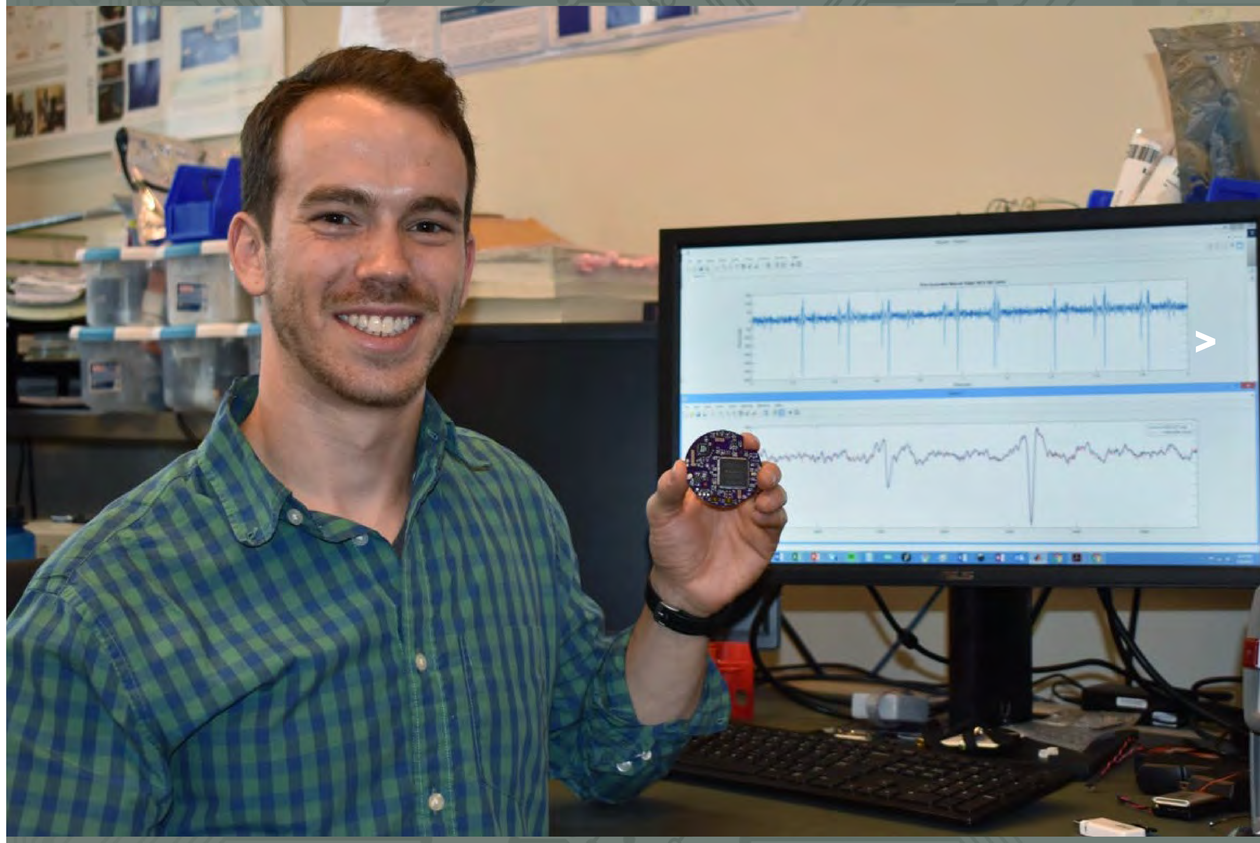
"James is one of the very top Ph.D. students to have graduated from UW ECE in the last several years," Reynolds said. "In addition to his many strengths in research, he was an outstanding mentor to the other students working in my lab, and he is also an excellent teacher."

The Yang Research Award was established by successful entrepreneur and former UW ECE faculty member Andrew T. Yang, who spoke at the UW ECE Graduation Celebration in 2012. Yang has been one of the most influential people in the electronic design automation industry for nearly three decades, and he is known for being a visionary in both research and entrepreneurship. When creating the award, Yang stated that he received a similar award when he was a doctoral student and that the recognition gave him the confidence and motivation he needed to continue his promising career in electrical engineering research.

Rosenthal has been engaged in groundbreaking research at the doctoral and postdoctoral stages of his academic career. In addition to expressing gratitude for the award, he noted the supportive environment he found at the University of Washington.

"The University of Washington offered a unique, interdisciplinary environment to explore my research that would have been difficult to find anywhere else," Rosenthal stated. "The emphasis on collaborative research, particularly through the Center for Neurotechnology, offered me the opportunity to work alongside leaders in wireless electronics, neuroscience and translational medicine."

The purpose of the Yang Research Award is to recognize and encourage outstanding doctoral student research contributions to the field of electrical engineering. The award goes to one qualifying student per year and is open to all doctoral degree candidates in UW ECE. Receiving the award is considered a high honor and helps to create career opportunities for the recipient.



2021 Yang Research Award recipient James Rosenthal holds a NeuroDisc prototype, which he developed at UW ECE in the lab of Professor Matt Reynolds. The NeuroDisc is a low-power wireless brain-computer interface intended for use in electrophysiology experiments. Photo courtesy of Matt Reynolds

Mari Ostendorf

Elected to the National Academy of Engineering / Named UW Vice Provost for Research

Adapted from articles by
Jackson Holtz and Ryan Hoover

Mari Ostendorf, the Endowed Professor of System Design Methodologies in the University of Washington Department of Electrical & Computer Engineering, has been elected to the National Academy of Engineering, which is recognized as one of the highest professional distinctions in engineering. Ostendorf is among 106 members and 23 international members newly elected to the academy this year.

Membership to the academy recognizes individuals for their outstanding contributions to engineering — from research to practice to education, and for pioneering new and developing fields of technology or making major advancements in traditional fields of engineering. Ostendorf was elected to the National Academy of Engineering (NAE) for "contributions to statistical and prosodic models for speech and natural language processing and for advances in conversational dialogue systems."

"I am tremendously honored to be selected as a member the NAE and humbled to be joining a group of colleagues who have made such important contributions to the field of engineering," said Ostendorf. "It is especially a privilege to be listed with my distinguished ECE colleagues, Professors Emeriti Akira Ishimaru and Irene Peden."

A prominent researcher in the areas of speech and language technology, Ostendorf's current research focuses on conversational artificial intelligence, exploring dynamic and context-aware models for understanding and generating speech and text, particularly in multi-party contexts. This work contributes to a variety of applications, from education to clinical and scientific information extraction, and has been used in automatic analysis of human-human call center conversations, automatic extraction of information from clinical notes, and natural language processing to support development of more accurate STEM assessments.

Ostendorf earned her bachelor's, master's, and doctoral degrees in electrical engineering from Stanford University, where she studied under information theorist and professor Robert M. Gray. Prior to joining the University of Washington, she worked at BBN Technologies and as an electrical and computer engineering faculty member at Boston University for a number of years.

Ostendorf joined the UW ECE department in 1999. In addition to holding an endowed professorship of system design methodologies there, she is an adjunct professor of computer science and engineering, and of linguistics. She also has served as associate dean for research and graduate studies in the College of Engineering and as associate chair for research in electrical engineering.

Ostendorf is also a Fellow of the IEEE, the International Speech and Communication Association, the Association for Computational Linguistics, and is a member of the Washington State Academy of Sciences, a Corresponding Fellow of the Royal Society of Edinburgh, and a former Australian-American Fulbright Scholar.

In the early 1990s, Ostendorf was one of several speech recognition experts who became involved in the computational linguistics community through a series of DARPA programs bringing together speech and language processing researchers in the development of spoken dialog systems. From 1991 to 1994, she was instrumental in designing the ToBI standard for transcribing and annotating the prosody of speech, and computational modeling of prosody has been a long-standing interest of hers.

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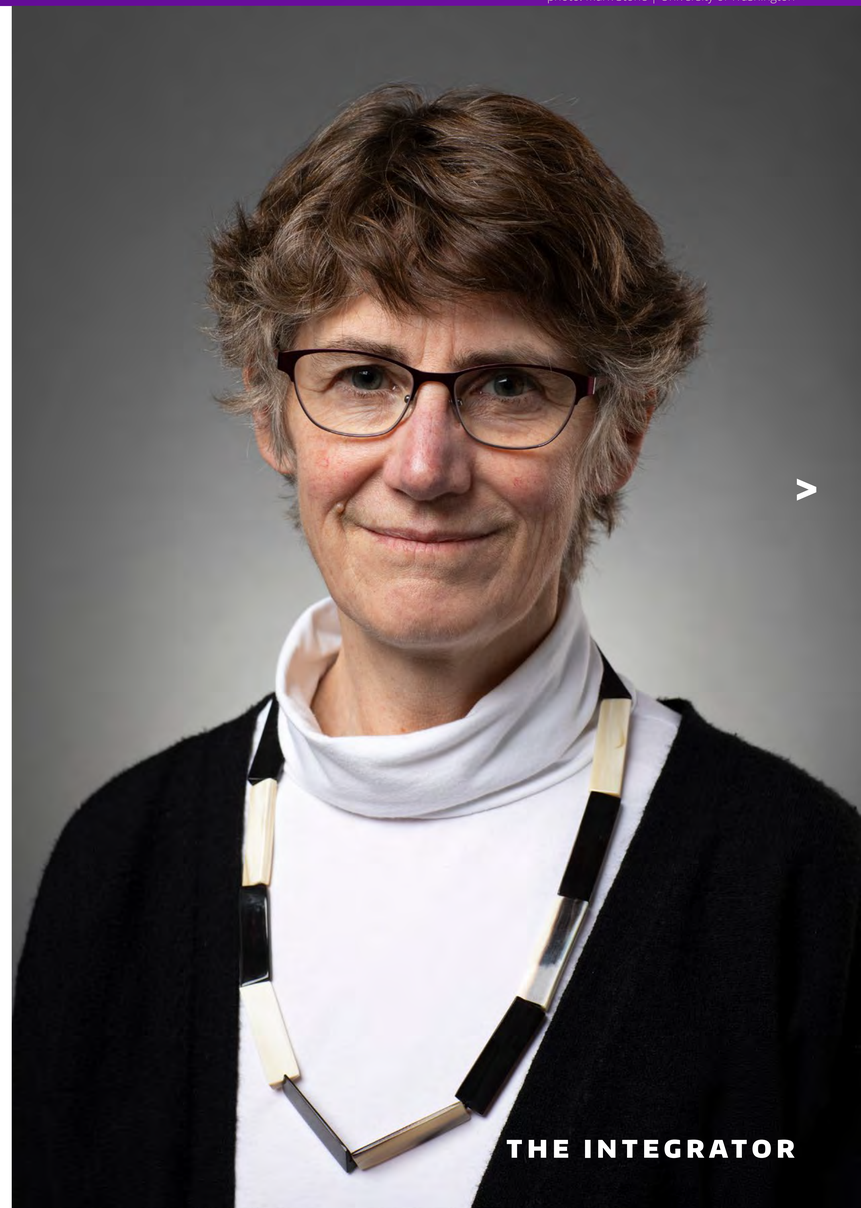
photo: Mark Stone | University of Washington



"I see prosody as a key to extracting the intended meaning of language from speech, which will be important in the next generation of conversational AI systems, where more human-like interactions are expected by users," Ostendorf explained. "With the NAE recognition, I am gratified to know that others appreciate the work that I am so passionate about."

Having published over 290 papers on a variety of topics related to speech and language processing over the course of her career, Ostendorf was awarded the 2018 IEEE James L. Flanagan Speech and Audio Processing Award, a Technical Field Award presented by the IEEE for an outstanding contribution to the advancement of speech and/or audio signal processing.

In 2017, Ostendorf served as a faculty adviser for the winning student team at the inaugural Amazon Alexa Prize competition, a multi-million-dollar university challenge to build a conversational AI "socialbot" on the Alexa platform for advancing human-computer interaction. UW's Team Sounding Board received a $500,000 prize for their winning entry.

Additionally, Ostendorf heads the Transformation, Interpretation and Analysis of Language (TIAL) Group at the UW, which uses data-driven machine learning and linguistically motivated system architectures to develop computational models of language to solve challenges in speech and language interpretation and analysis.

Newly elected NAE members were formally inducted on October 3 during the academy's annual meeting in Washington, D.C.

This past July, UW Provost Mark Richards also announced the appointment of Ostendorf as Vice Provost for Research, which began September 1. Ostendorf had been serving as Associate Vice Provost for Research in the Office of Research since 2017.

> "With the NAE recognition, I am gratified to know that others appreciate the work that I am so passionate about."
>
> — Mari Ostendorf,
> Endowed Professor of System Design Methodologies

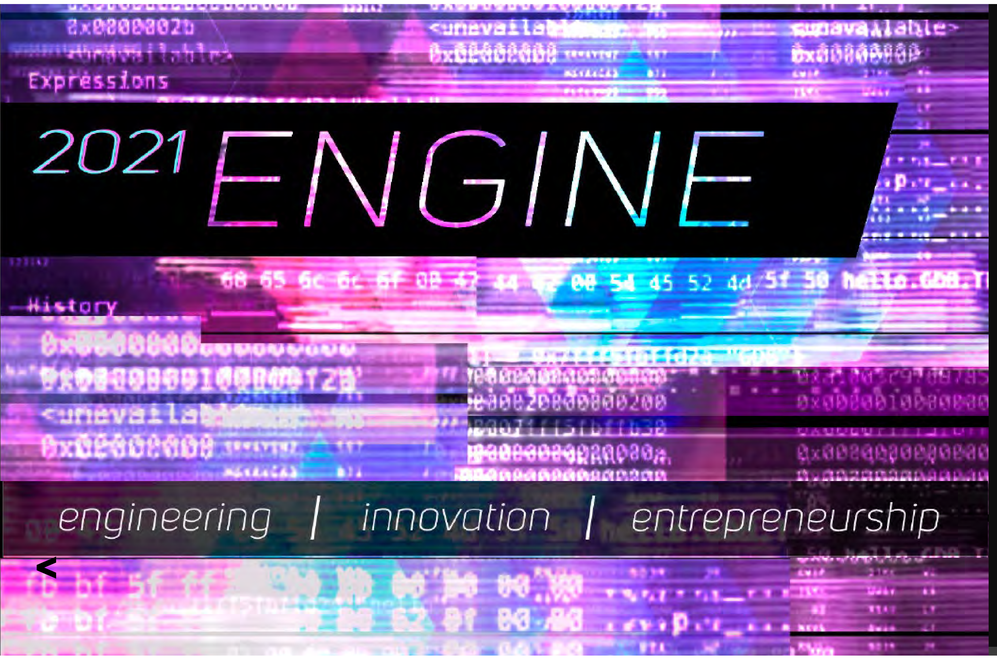
Ostendorf assumes leadership of the UW's premier and growing research enterprise from Mary Lidstrom, who has served for 15 years as Vice Provost for Research. Lidstrom stepped down from the role August 31 and returned to the faculty to focus on her research in chemical engineering and microbiology.

Over the past 16 years, the University's research portfolio has grown from $996 million to an astounding $1.63 billion in 2020. Since 2010, the UW has received more externally sponsored research funding than any other U.S. public university. Recent global rankings that emphasize research place the UW in the range of sixth to 16th in the world.

"Because the Office of Research partners with leaders and units across the university, Dr. Ostendorf's demonstrated vision and collaborative leadership will be critical to advancing our interdisciplinary research efforts, as well as our ongoing diversity, equity and inclusion initiatives," Richards said.

Collaborative research has grown, with 27% of UW research funding involving partnerships with other entities. The Office of Research has evolved and grown as well, with additional units and programs and a host of initiatives focused on serving the research community.

"I look forward to supporting the Provost's diversity, equity and inclusion initiatives, recognizing that diverse perspectives foster innovation, and to helping build partnerships that strengthen the UW ecosystem for interdisciplinary research," Ostendorf said.



From June 3 to 4, 2021, UW ECE hosted a virtual exhibition of its annual ENGineering INnovation and Entrepreneurship (ENGINE) capstone program showcase. Working in teams of three to five, the program offers students the opportunity to tackle projects with real-world societal impact.

This year, roughly 140 students worked hard to develop nearly 40 industry-sponsored projects, helping to provide solutions to a wide range of challenges. Working under faculty and industry mentorship, their projects covered a number of electrical and computer engineering areas including healthcare, power and energy, transportation, the environment, and artificial intelligence.

Initiated in 2016, ENGINE is the first year-long entrepreneurial system design course sequence of its kind in the department, and develops students' skills in innovation and entrepreneurship, systems engineering, project management, and product development. The program offers select companies an opportunity to benefit from the vibrant innovation culture in the UW ECE department.

Teams work on hardware and software system design challenges that emphasize depth of analysis and synthesis in all areas of electrical and computer engineering and computer science. During the course of a full academic year, students spend over 1,200 hours per team on their projects, presenting their final results to faculty, industry leaders, peers and researchers at the ENGINE showcase.

The past academic year continued to pose unique challenges due to the ongoing COVID-19 pandemic, with students continuing to work in virtual settings. Despite these hurdles, the projects were completed successfully, and our department is proud of our students' ability to adapt to such real-world challenges. We are very grateful to our sponsors for their flexibility and dedication to mentoring our ENGINE program students.

UW ECE is also enormously grateful for the vision and generosity of Milt (BSEE '60) and Delia Zeutschel, and Milt's business partner, John Reece, which has enabled us to develop the ENGINE program to its current scale. Through the magnitude of the Zeutschels' endowment of the ENGINE program, they are helping to secure the futures of UW ECE engineers and promote continued local and statewide innovation.

Learn more about the ENGINE program: www.ece.uw.edu/news-events/capstone-fair/

WINNING TEAMS

1 Human-Powered Submarine Autopilot

Sponsored by Booz Allen Hamilton in collaboration with the UW Applied Physics Laboratory and Naval Undersea Warfare Center Division Keyport

Students:
James Lee, Chase Deitner, Peter Tsanev, Miller Sakmar
Faculty Advisers:
Blake Hannaford and Sam Burden
Industry Advisers:
Cassandra Riel and Benjamin Maurer (UW-APL), Eric Jones, Joe Reck, Nick Valladarez, and Ryan Edwards (BAH), Cooper Bowen and Jacob Yakawich (NUWC)

2 AI Behavior System for Minecraft

Sponsored by Microsoft

Students:
Samuel Kim, Batina Shikhalieva, Alaa Sleek
Faculty Adviser:
Rania Hussein
Industry Advisers:
John Seghers, Adrian Orszulak, Halishia Chugani

2 Interactive Layout of Passenger Accommodation Tool

Sponsored by Alaska Airlines

Students:
Sandesh Banskota, Michelle Chuang, Alyssa Weed
Faculty Adviser:
Ken Eguro
Industry Advisers:
Jaci Bartol, James Seagraves, Jim Pattison, Damon Zirkler, Chris Barber, Tony Heupel, Colleen Piper, and Lisa Roderiques

3 Managed Electric Vehicle Charging

Sponsored by Seattle City Light

Students:
Carmen Twitchell, James Clough, Kelsey Foster, Tran Quach, Reese O'Craven
Faculty Advisers:
Daniel Kirschen and Jan Whittington
Industry Adviser:
Lucie Huang

The 14th annual Lytle Endowed Lecture featured Muriel Médard, professor of Electrical Engineering and Computer Science (EECS) at the Massachusetts Institute of Technology (MIT), as this year's keynote speaker. At MIT, Professor Médard leads the Network Coding and Reliable Communications Group in the Research Laboratory for Electronics. Her lecture, "Deviation from the standard — toward opening up 5G telecommunications", was held on Monday, October 18, 2021 followed by a technical seminar, "Guessing Random Additive Noise Decoding (GRAND)". Watch the videos: (Lytle Lecture | Technical Seminar)

The Lytle Lecture Series is the department's premier annual event, featuring internationally-renowned researchers in the fields of communications, networks and signal processing. The series was established in 2006, the Centennial Year of UW EE, through fundraising efforts led by Louis Scharf, in collaboration with Marilyn Lytle and the Lytle family, Dean's graduate students, his colleagues at Honeywell's Marine Systems Center and the UW ECE community.

Virtual Town Halls

Continuing upon the tradition of connecting alums, industry partners and friends from around the world to stay informed with UW ECE's cutting-edge research, two exciting virtual town hall events were held this year.

STARTUP SPOTLIGHT

The Startup Spotlight event was held on May 18, and provided guests with an in-depth look at successful, faculty-led startup companies generated from UW ECE, the #1 startup generator at the UW. Alums, industry partners and friends from around the world heard from a panel of our faculty, postdocs and CoMotion partners about commercialized cutting-edge technologies emerging from UW ECE labs. Our panel included Claire Watts of ThruWave, Inc., Laura Dorsey of CoMotion, and UW ECE Professors Josh Smith (Wibotic / Jeeva Wireless / Proprio) and Arka Majumdar (Tunoptix). Watch it here.

Claire Watts
Co-founder / Co-CTO
ThruWave, Inc.

Laura Dorsey
Associate Director / Senior Technology Manager / Technology Manager
CoMotion

Josh Smith
Milton and Delia Zeutschel Professor in Entrepreneurial Excellence
UW ECE / Paul G. Allen School of Computer Science & Engineering
Wibotic / Jeeva Wireless / Proprio

Arka Majumdar
Assistant Professor / WRF Distinguished Investigator
UW ECE / UW Department of Physics
Tunoptix

Maryam Fazel
IFDS Director, Moorthy Family Inspiration Career Development Professor

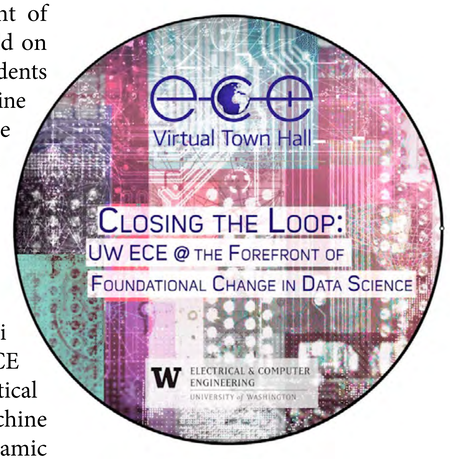
Lillian Ratliff
IFDS faculty collaborator, recipient of the Dhanani Endowed Faculty Fellowship

Omid Sadeghi-Meibodi
UW ECE graduate student

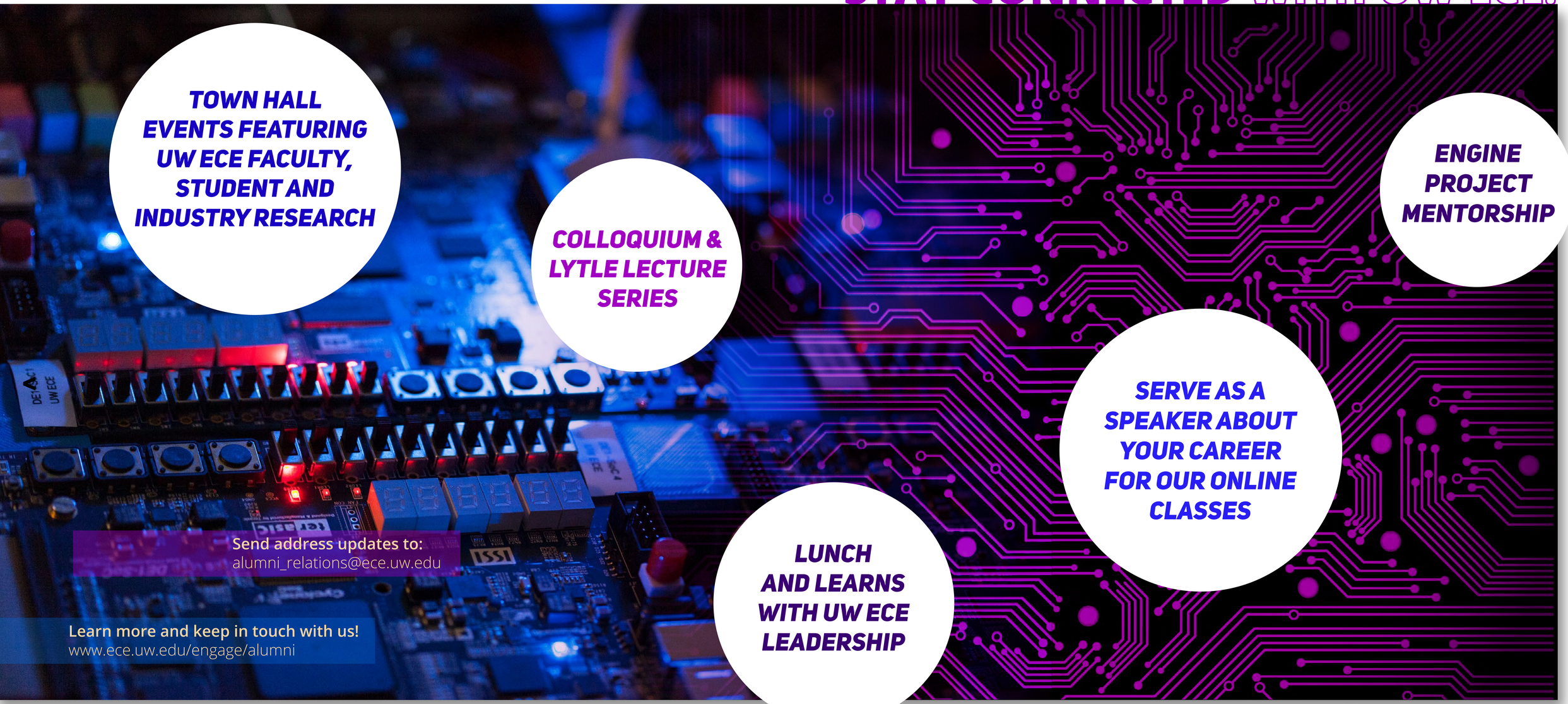
Tanner Fiez
UW ECE graduate student

CLOSING THE LOOP: UW ECE AT THE FOREFRONT OF FOUNDATIONAL CHANGE IN DATA SCIENCE

Closing the Loop: UW ECE at the Forefront of Foundational Change in Data Science was held on September 30. The event featured faculty and students who are at the forefront of the data revolution, machine learning and artificial intelligence through the Institute for Foundations of Data Science (IFDS). Through an exclusive conversation with IFDS Director and Moorthy Family Inspiration Career Development Professor Maryam Fazel, IFDS faculty collaborator and holder of the Dhanani Endowed Faculty Fellowship, Lillian Ratliff, and UW ECE graduate students Omid Sadeghi-Meibodi and Tanner Fiez, attendees learned how UW ECE interdisciplinary research is advancing the theoretical foundations of data science, aiming to make machine learning processes more robust and fair in dynamic and complex environments. Watch the video.



STAY CONNECTED WITH UW ECE!



TOWN HALL EVENTS FEATURING UW ECE FACULTY, STUDENT AND INDUSTRY RESEARCH

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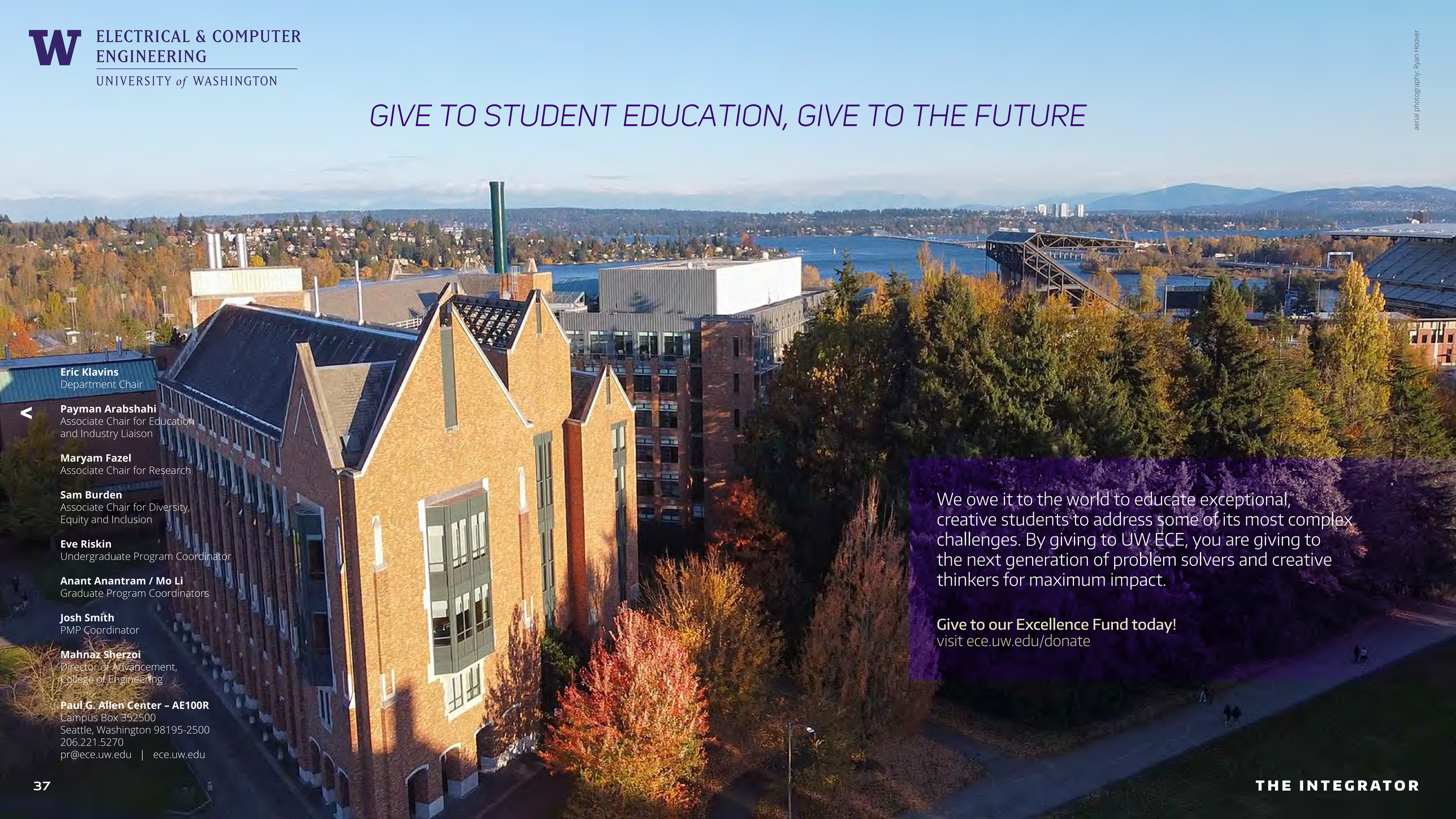
aerial photography: Ryan Hoover



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Department Chair

Payman Arabshahi
Associate Chair for Education and Industry Liaison

Maryam Fazel
Associate Chair for Research

Sam Burden
Associate Chair for Diversity, Equity and Inclusion

Eve Riskin
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Anant Anantram / Mo Li
Graduate Program Coordinators

Josh Smith
PMP Coordinator

Mahnaz Sherzoi
Director of Advancement, College of Engineering

Paul G. Allen Center – AE100R
Campus Box 352500
Seattle, Washington 98195-2500
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