ENGINEERING @

Northeastern

SPRING 2019

BIG DATA

DEAN'S MESSAGE

"We are creating the next generation of engineering leaders, prepared to address the complex challenges of the 21st century and beyond."

As the newly appointed interim dean of the College of Engineering, it is my pleasure to unveil our Spring 2019 edition of the *Engineering @ Northeastern Magazine*, packed with research conducted by our faculty across multiple engineering fields in the area of Big Data. From analyzing and predicting the effect of climate change and environmental factors, to making cities safer and "smarter," and inventing ways to handle the volume of data through artificial intelligence and machine learning, our researchers describe the many initiatives underway to invent, expand, and enhance capabilities with the ultimate goal of improving people's lives in the areas of health, sustainability, and security.

Joining Northeastern in 1995, I look forward to leading the College of Engineering as an international search for a new dean takes place. Previous to my current role as interim dean, I served as associate dean for Faculty Affairs within the College of Engineering since 2017, and as acting chair of the Department of Mechanical and Industrial Engineering from January 2012 through August 2013. I am also an associate director of the Center for High-rate Nanomanufacturing (CHN), and have an affiliation with the School of Public Policy and Urban Affairs.

In addition to the many impressive research projects, the College is leading the way in experiential learning—from cooperative education for undergraduate and graduate students—to global opportunities, entrepreneurship experiences, and award-winning student clubs and national competitions, as can be seen throughout the magazine.

With our commitment to diversity, we are extremely proud that Assistant Dean Richard Harris was a recipient of two awards this year from the National Society of Black Engineers (see page 2).

The College is very fortunate to have such a supportive community of alumni and friends. Your ongoing commitment and generosity is truly making a difference, helping us to further excellence in all we do and create the next generation of engineering leaders who are prepared to address the complex challenges of the 21st century and beyond.

With kind regards,

Jacqueline Isaacs
Interim Dean
College of Engineering
Northeastern University
dean@coe.neu.edu

ENGINEERING @ Northeastern
Spring 2019

Questions and Comments

dean@coe.neu.edu
College of Engineering
230 Snell Engineering Center
Northeastern University
360 Huntington Avenue
Boston, MA 02115
617.373.6300

Managing Editor
Janet LeClair

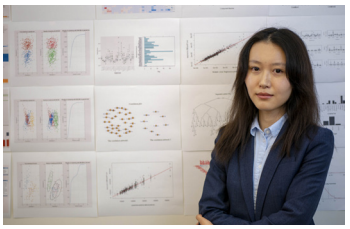
Editorial
Nia Beckett
Cindy Fusco
Jesse Goodman
Kathrin Havrilla
Sofiya Kryvych
Joyce Melikian

Editorial Credits
News@Northeastern

Design
Alexandra Berleus

Photography Credits
Adam Glanzman
Matthew Modoono
Thomas Spierto

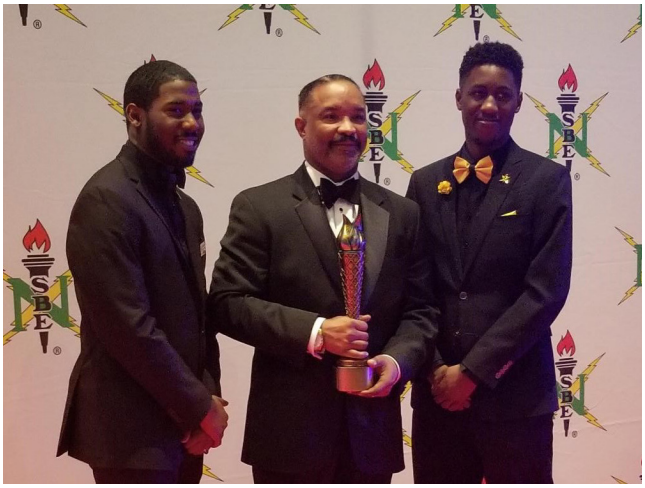
FEATURES INSIDE



Cover

Zhuohan Yu is pursuing a Master of Science in Data Analytics Engineering, ME'21, and has an ambition to be a data scientist upon graduation.

Honored for Innovative **Diversity Programs**



Richard Harris (center), assistant dean, accepts The NSBE Golden Torch award.

Richard Harris, assistant dean, Academic Scholarship, Mentoring and Outreach and director of NU Program in Multicultural Engineering (NUPRIME), Diversity Programs, was selected as a Golden Torch Award honoree by the National Society of Black Engineers (NSBE) and an NSBE Boston Professionals STEM Advocate 2019 honoree.

NSBE, a non-profit organization founded 45 years ago, is dedicated to the academic and professional success of black engineering students and professionals, while linking the African American community and the world of technology. NSBE Boston Professionals was chartered as its first National Alumni chapter 30 years ago.

The NSBE Boston Professionals honored Harris's dedication to pioneering opportunities for black engineering students with their 2019 STEM Advocate – Excellence in Educational Leadership award at the NSBE Boston STEM Benefit: Inspiring Black Innovators of Tomorrow. The NSBE Golden Torch Awards at the society's national level, recognize high achievements among technical professionals, corporate, government and academic leaders, and university and pre-college students. Harris was honored by NSBE for this award at the 45th Annual Convention in Detroit, MI.

> ***"If you really want to encourage diversity, you need to provide formal and informal mentoring, networking opportunities, organizations, and clubs that make underrepresented students feel they're part of a larger community."***
>
> Richard Harris, assistant dean, Academic Scholarship, Mentoring and Outreach, and director of NUPRIME, Diversity Programs

Harris, a two-time Husky, is a pioneer for diversity within the College of Engineering, establishing the College of Engineering's Diversity Council in January 2018, which he co-chairs with Rachelle Reisberg, assistant dean for Enrollment and Retention, and director of Women In Engineering. He is also a co-principal (co-PI) investigator for a $5 million National Science Foundation program called S-POWER (Student Pathways Opening World Energy Resources), which provides transfer scholarships at Northeastern for underrepresented minority students at colleges that do not offer a traditional engineering degree. Additionally, as a co-PI of a $3.5M grant from the Louis Stokes Alliances for Minority Participation (LSAMP) program, he led an undergraduate research trip to China in collaboration with five other U.S. universities. Harris's efforts also led to Northeastern being a host site for LSAMP's 2018-2020 Bridge to the Doctorate program under a $1 million NSF grant.

"While it's important to increase awareness among K through 12 students, we also need to support those college students who want to pursue an engineering degree, but may have lacked the right information or opportunities when they chose a college and a major," Harris said.

NUPRIME, which Harris directs, provides support for Northeastern's chapters of SHPE (Society of Hispanic Professional Engineers) and NSBE referred to on campus as BESS (Black Engineering Student Society). It also links historically underrepresented students to engineering opportunities and aids with transitioning from high school to college, to graduate school or the professions.

"If you really want to encourage diversity, you need to provide formal and informal mentoring, networking opportunities, organizations, and clubs that make underrepresented students feel they're part of a larger community," remarked Harris.

Hui Fang, assistant professor of electrical and computer engineering

Mapping the Brain

Silent and invisible—yet incredibly powerful—the human brain is still largely a mystery. Recently awarded a prestigious CAREER Award from the National Science Foundation, Assistant Professor Hui Fang, electrical and computer engineering, is at the forefront of bringing further clarity to the inner workings of the brain. He is developing implantable electrode arrays that map the electrical activities inside the brain to create a bridge between neural function and the outside world.

While neural implants already exist, most of the current devices are made of silicon, which is rigid and thus not suited for long-term study. Fang, in contrast, is developing next-generation stretchable arrays that are composed of ultra-soft materials, enabling the implants to remain in the brain for long periods of time—supporting the most comprehensive study of neural activity to date.

In addition, Fang's novel materials are transparent, enabling brain researchers to combine optical, light-based neural investigation with electrical mapping, resulting in brain maps with unprecedented scale and resolution. "What we're doing is producing the highest-quality picture of neural activity that has ever been achieved," explains Fang. "Solving the mysteries of the human brain represents arguably the single biggest scientific challenge today, and I'm excited to play a role in this leading-edge research."

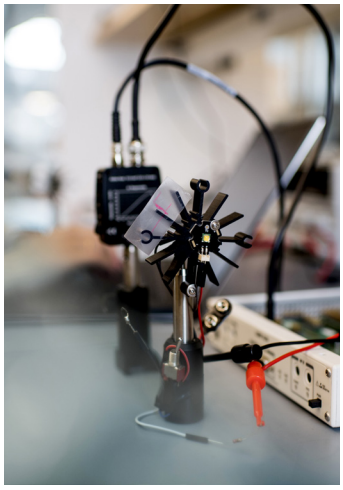
Fang's research will not only deliver a better understanding of neural activity in general, but could also have a life-changing impact on the 3 million Americans who suffer from paralysis, limb loss, or epilepsy. For instance, by harnessing the power of brain activity, Fang may help these patients benefit from new neuroprosthetic limbs that are controlled only by thought.

Working to perfect his innovative materials and successfully build implantable electrode arrays, Fang says, "It's gratifying to feel that, after centuries of fascination with the brain, we may be finally achieving a clear picture of the brain's complex secrets."

Expanding the Research Enterprise

College of Engineering faculty are leading three new university-wide research institutes in cutting-edge areas with broad societal impact in many areas of people's lives.

Institute for the Wireless Internet of Things

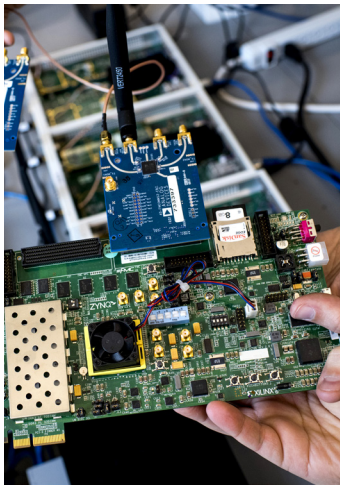


With the establishment of Northeastern's new Institute for the Wireless Internet of Things, Founding Director Tommaso Melodia, William Lincoln Smith Chair Professor of electrical and computer engineering, sees faster wireless networks as just the beginning.

The institute conducts interdisciplinary research in the broader areas of Internet of Things and networked wireless systems. It brings together Northeastern researchers with expertise in sensors, low-power circuits, wireless communications and networking, machine learning, smart cities, digital health, and innovative business ideas.

Groups will work to design more effective sensors that interact with the physical environment, develop artificial intelligence and machine learning programs to interpret data, and secure that information.

"What we're envisioning and trying to do here is more of a broad systems approach, not just exclusively the communication component," said Melodia.



The institute is hoped to be a liaison between academic researchers, industry, and government to create marketable products that aid novel ways for everyone to connect with peers, the environment, and themselves.

"I would like for this institute to be a point of reference, nationwide and internationally, for the next generation of Internet of Things and smart wireless networked systems," Melodia said.

Institute for the Chemical Imaging of Living Systems

Chemistry isn't the first thing that comes to most people's minds when imagining how doctors can view images within the body. To Bioengineering and Chemistry Professor Heather Clark, it's just what the doctor ordered.

As director of the new Institute for the Chemical Imaging for Living Systems (CILS), Clark facilitates focus on finding ways to image the chemistry within the body.

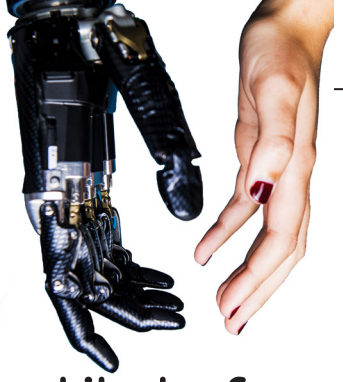
"That's what makes us unique," Clark said. "Most people don't reduce the body to chemistry."

While tools such as x-rays, MRIs, CT scans, and ultrasounds allow doctors to view images within the body, each method has limitations. The institute's researchers are developing technology that is able to zoom in on minute interactions between cells that other machinery cannot track. This more precise advancement will aid better understanding of diseases, faster avenues to diagnosis and treatment, and technologies that harness the brain-machine interface.

Within the institute, researchers collaborate across probe development, animal models, probe delivery, imaging technologies, embedded systems, and signal processing to develop breakthrough imaging tools.

Clark leads one of the teams designing synthetic particles that bind to a specific chemical and give off a traceable signal in order to track chemicals in the body. Other groups are focusing on how to deliver these particles, how to detect them, and how to see if they work before they're injected into a human.

"What an institute enables us to do is bring in people from all across campus to tackle different pieces of the problem," Clark said.



Institute for Experiential Robotics

With the addition of several engineering faculty since 2016 with diverse robotics research backgrounds, and interdisciplinary collaborations across the university, Northeastern's robotics program has become highly recognized. Recently, the university established the Institute for Experiential Robotics, led by Taskin Padir, associate professor of electrical and computer engineering.

The institute focuses research in the development of robots able to learn and adaptively execute autonomous behaviors from human partners and/or other robots. Faculty researchers identify and study use-driven research problems at the intersection of collective human-robot experience, from safe and reliable manipulation of tools and objects to socioeconomic impact of collaborative robots on human work.

Padir said, "Our research addresses interdisciplinary research questions to advance the capabilities of autonomous robots to perform everyday tasks in collaboration with humans. Through innovation we are enabling future widespread adoption of autonomous robots in a broad range of human environments that can adapt to uncertainties inherent in everyday human experience—allowing for endless opportunities to better society and improve people's lives."

Researchers Receive $13.2 Million to Continue Study of Health Challenges Facing Women, Children in Puerto Rico

By Aria Bracci

From left to right: Roger W. Giese, Phil Brown, Emily Zimmerman, Akram Alshawabkeh, David Kaeli, Thomas Sheahan, Justin Manjourides

For the past 10 years, Northeastern-led research teams have been studying how the environment affects the health and development of mothers, infants, and children living on the island of Puerto Rico. Although Puerto Rico is fewer than 1,000 miles from Miami, its preterm birth rate is among the highest in the world. Studies show that the region's children also suffer disproportionately from obesity, autism, and asthma.

Now, the researchers have received a $13.2 million grant from a program of the National Institutes of Health to build on their study and begin exchanging information and findings with other health centers around the country. Through this NIH program, Environmental Influences on Child Health Outcomes, the health data of 50,000 diverse children in cohorts across the United States will be aggregated to understand the effects of a broad range of early environmental influences on child health and development from birth through childhood and adolescence.

The researchers want to "see how chemicals and other influences contribute to the health challenges on the island," said Akram Alshawabkeh, director and principal investigator of the program, associate dean for research for Northeastern's College of Engineering, and George A. Snell Professor of civil and environmental engineering at Northeastern. When they began their study in 2008, the preterm birth rate was about 20 percent, he said. Because of intensive campaigns to reduce the rate, it is now about 12 percent, but that is still among the highest in the world.

Alshawabkeh said that Puerto Rico, which is smaller than Connecticut, is home to 18 large plots of land that have been contaminated by hazardous waste. Exposure to the chemicals at these locations, known as Superfund sites, has the potential to cause serious health problems for the island's three million people.

"In our analysis of the 1,600 women and 600 children who have participated in this research to date, we have found exposure to certain chemicals is higher than that in the mainland U.S.," said Alshawabkeh.

Alshawabkeh said that many pregnant women have been exposed to phthalates, which are chemicals that are added to plastics to make them flexible and durable. "These are present in almost everything: a shower curtain, makeup, some food containers," he said.

Using the new funding, the team will interview an additional 1,100 pregnant women about their daily habits and collect urine, blood, hair, and nail samples to measure levels of exposure to chemicals and to understand where those chemicals are coming from.

Alshawabkeh's interdisciplinary group of researchers at Northeastern is working with experts at the University of Michigan, the University of Georgia, and the University of Puerto Rico to improve the health and quality of life for women and their children in Puerto Rico. These researchers, who work for two Northeastern-based centers, include engineers, environmental epidemiologists, social workers, sociologists, biostatisticians, toxicologists, pediatricians, and communication neuroscientists.

"What's unique is that we have interdisciplinary research that involves scientists from different disciplines, and we are working on an important problem that could not otherwise be addressed without contributions from all of these areas," said Alshawabkeh.

Northeastern faculty include David Kaeli and Thomas Sheahan of the College of Engineering; Roger Giese, Justin Manjourides, and Emily Zimmerman of the Bouvé College of Health Sciences; and Phil Brown, who holds joint appointments in Bouvé and the College of Social Sciences and Humanities.

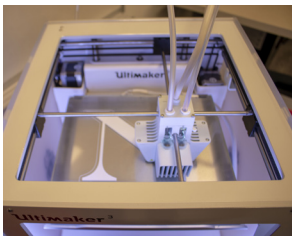
"Over the past 10 years, our team has worked with the community in Puerto Rico to share information about environmental pollution, and given pregnant women guidance on ways to protect their pregnancies and children," Alshawabkeh said. "That helps educate them and make them less exposed, and eventually contributes to reducing the rates of preterm birth."

View Northeastern's College of Engineering 2019 **highlight video** from our celebration of National Engineers Week
https://bit.ly/2VlSTDJ

CONNECT WITH #NUEWEEK2019

National Engineers Week 2019

From the College of Engineering's PhD Research Expo and a Robotics Showcase to distinguished guest speakers, a Women in Engineering Day, K-12 STEM fair, 3D printing demonstrations, and hands-on fun for students and prospective students, National Engineers Week inspired the wonder of engineering at Northeastern.



PIONEERING INVENTIONS ON CO-OP

Grace Carroll, E'20, Computer Engineering

Like many, Grace Carroll came to Northeastern for its renowned co-op program.

"I learn a lot better doing things hands-on than just in the classroom," Carroll said. "The fact that they schedule [co-op] into your degree for you to go learn hands-on—I really thought that was a big difference between Northeastern and a lot of other schools."

While she took computer science classes in high school, Carroll didn't want to just study computer science in college. She found the combination of computer and electrical engineering more interesting and efficient.

On her first co-op in 2018, Carroll joined the consumer electronics company, Bose Corporation, as an electrical engineer in the Consumer Wellness Research area. The first half of her co-op was spent working with her supervisor on a more independent project, while the second half was spent working with a team of people trying to target more complicated issues and determine the feasibility of solutions.

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Leading the Way in Experiential Learning

Lorraine Mountain works with one goal in mind: to help engineering students find the perfect co-op.

As the assistant dean for cooperative education for the College of Engineering at Northeastern, Mountain leads a team of 35 faculty and staff who are dedicated to connecting students with employers all over the world.

"My favorite part of working in this role is the opportunity to work with students and help them determine the best path," said Mountain, who recently received a national award from the American Society for Engineering Education for her outstanding contributions to cooperative education.

Mountain is the second Northeastern faculty member to receive the Alvah K. Borman Award since its inception in 1979, when the former Northeastern dean of graduate placement services was honored 40 years ago.

Mountain started by working with students one-on-one to help them find co-op jobs. Now she helps to expand Northeastern's international co-op program in the College of Engineering and create more options that broaden students' knowledge in multiple fields.

In 2018, more than 2,500 students in the College of Engineering participated in the co-op program with nearly 900 employer partners, spanning 62 countries. Unique to Northeastern is the opportunity for graduate students to also participate in co-op. Over the past two years, the number of graduate engineering students who go on co-op has increased by 62 percent.

"I came to Northeastern seeking ways to mentor students," said Mountain. "I've gotten to use my engineering background to connect with employers and create opportunities for students."

"My favorite part of working in this role is the opportunity to work with students and help them determine the best path."

Lorraine Mountain, assistant dean for cooperative education

GLOBAL IMPACT

Discover the many COE student stories **coe.northeastern.edu/blog**

SERVICE LEARNING

During winter break, bioengineering students Isabel Arthur, E'20, Julia Rhyins, E'21, Kerry Eller, E'21, and Mariette Sargios, E'20, traveled to Addis Ababa, Ethiopia for two weeks to work with biomedical technicians in St Paul's hospital.

COOPERATIVE EDUCATION

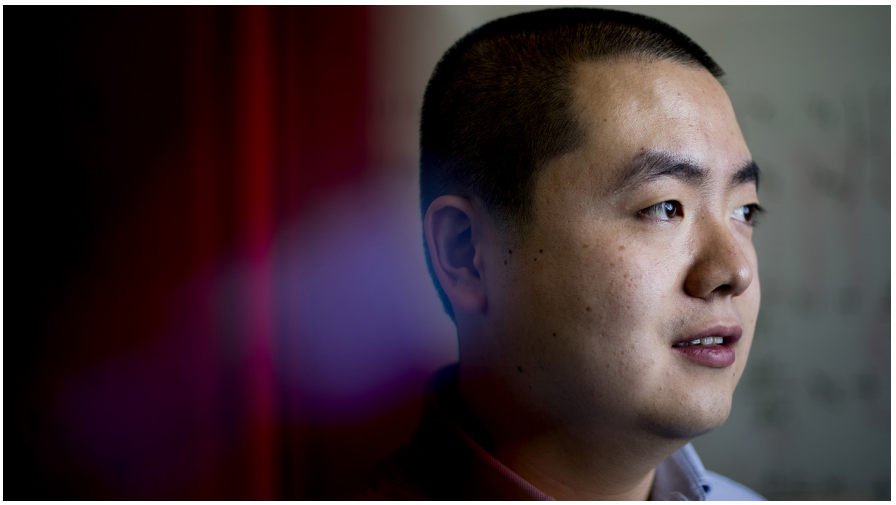
Environmental engineering student Madeline DuBois, E'20, spent her co-op in Panama studying how the anole lizard is adapting to climate change.

DIALOGUE OF CIVILIZATIONS

Michael Tormey, E'20, civil engineering, completed a Dialogue of Civilizations program in India focusing on climate change with Professor Auroop Ganguly.

"The fact that they schedule [co-op] into your degree for you to go learn hands-on—I really thought that was a big difference between Northeastern and a lot of other schools."

Grace Carroll, E'20, computer engineering student



After developing a prototype and getting it to function as a demo, Carroll's supervisor told her to present it to the research and development team. This led to her writing an invention disclosure for the prototype, working with Bose's general counsel team, and then filing for a U.S. patent.

"Even if it doesn't get approved as a patent, it was still very cool to write it all up and go through the process," Carroll said.

Prior to her co-op, Carroll received an Early Research/Creative Endeavor Award from Northeastern. She did research in the Augmented Cognition Laboratory with Assistant Professor Sarah Ostadabbas, electrical and computer engineering, working to rehabilitate stroke patients using augmented reality headsets.

"Research was sort of a bridge between what I was doing in classes and what I would end up doing in co-op," she said. "It was a really good basis for what I was doing at Bose because I was using a lot of the same sensors and software. The platforms we were doing [our projects on] were similar."

Working for Bose solidified Carroll's interest in her field. "Going to work as an electrical engineer for six months actually proved that that's what I want to be," she said.

Yifan Sun, PhD Student, Electrical and Computer Engineering

When Northeastern doctoral student Yifan Sun worked on co-op as a software engineer at Dell EMC in 2016, he invented a method to enable multiple clients to use the same graphics processing unit simultaneously in order to save money.

Now, Dell EMC has received a patent from the U.S. Patent and Trademark office for Sun's project. This is one of five patent applications that have been submitted by the company listing Sun as a co-inventor. Sun is pursuing his PhD in electrical and computer engineering and he is a member of Northeastern's Computer Architecture Laboratory.

Sun's invention involved relocating the graphics processing unit from an individual employee's computer to a server in the company's data center. When users want to complete a task, they send a request to a centralized graphics processing unit. The server then sends the completed results back to the user, freeing up the graphics processing unit to complete another request.

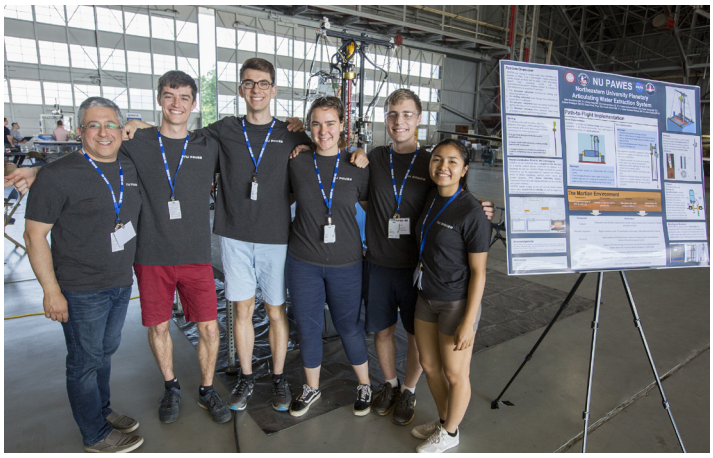
Before Sun invented this method, companies had to install expensive graphics processing units in the personal computers of each of their employees, but now they need just one centralized graphics processing unit.

Sun created the code and then helped to test the code before Dell EMC filed three patents for the project, two of which are still awaiting approval.

Dell EMC now offers a subscription service based on Sun's invention: Clients pay to use software that the company created to process computing requests from multiple users through a single graphics processing unit.

"It's been two years now, but it feels great to have an acknowledgement of my hard work on that project," said Sun. "I'm happy to see it turned out to be something."

Northeastern Team Wins 2018 NASA RASC-AL Mars Ice Challenge



Taskin Padir, left, associate professor of electrical and computer engineering, with Northeastern's Mars Ice Challenge team

A team of Northeastern students won the 2018 NASA Revolutionary Aerospace Systems Concepts - Academic Linkage (RASC-AL) Mars Ice Challenge—a competition to help discover ways to access underground rivers on Mars trapped beneath thick layers of dirt and ice to make manned Martian missions possible.

Six Northeastern engineering students built a remote-operated robotic device called the Northeastern University Prospecting Underground Distilling Liquid Extractor (NU-PUDLE) to penetrate the dirt, melt the ice, and pump clean water up to the surface.

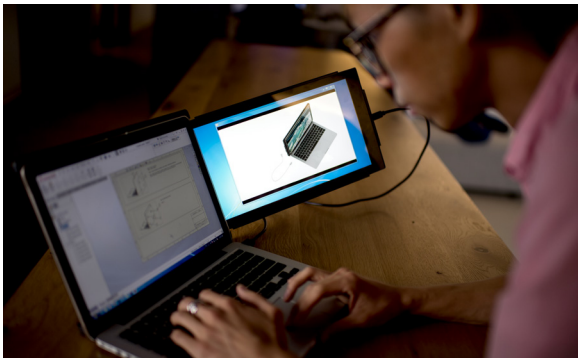
The team tested their system at the NASA Langley Research Center in Hampton, Virginia, competing against eight other universities to see which device could extract the greatest amount of water from a simulated Martian surface.

Northeastern won by a landslide, collecting 3,209 milliliters of water while the second-place team collected around 800 milliliters of water. In addition to winning the competition, the team received $3,000 to continue their research to improve the device.

"NASA and the other international space organizations are serious about getting man to Mars, and harvesting water is a critical capability," said Taskin Padir, associate professor of electrical and computer engineering, who serves as the team's faculty advisor. "This is the beginning of a major journey to make that real."

The Northeastern team is now also a finalist for the NASA's 2019 RASC-AL Special Edition: Moon to Mars Ice and Prospecting Challenge, which is at NASA's Langley Research Center in June.

From Lab to Market



One start-up accelerator. Two start-up winners. A total of $150,000 in awards. That was the exciting result for the Northeastern College of Engineering community in the 2018 MassChallenge Boston Accelerator competition. Mobile Pixels and Boston Materials, founded by Northeastern engineering students, faculty and alumni, were two of 26 finalists for MassChallenge Boston in 2018.

Boston Materials, founded by mechanical alums Michael Segal, E'16, and Anvesh Gurijala, E'16, with Assistant Professor Randall Erb, mechanical and industrial engineering, produces light yet durable carbon fiber composite materials for use in sports equipment, aircraft components, and other products. The startup secured a gold level win, earning a $50,000 award.

Boston Materials intends to use its award to purchase equipment for testing the composite materials, which will reduce material development time from months to weeks.

Mobile Pixels, founded by mechanical engineering student Stephen Ng, ME'19, along with MIT alumni Jack Yao and Shruti Banda, created a portable secondary monitor designed to attach to a laptop for increased productivity. The company received $100,000 as one of the top four winners of the competition which make up the diamond level.

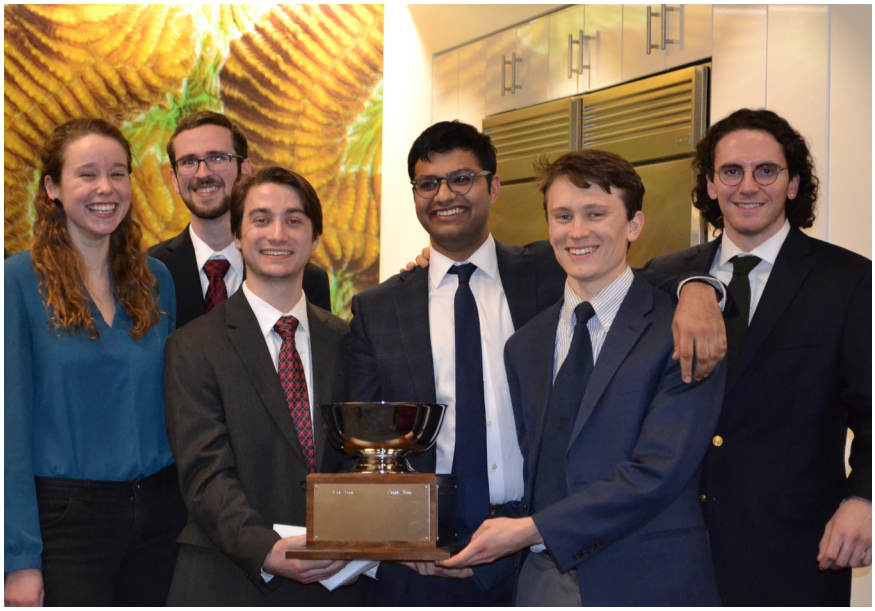
Leading up to its MassChallenge victory, Mobile Pixels received funding from IDEA, Northeastern's student-run business accelerator, and MIT's Sandbox innovation fund program. Its DUO monitor, since renamed DUEX monitor, was selected as a winner at the 2019 Edison Best New Product Awards™, which globally recognizes and honors innovation.

CONNECT

The Uganda team leaves today to take their second assessment trip to Nakyenyi, Uganda to collect additional data for a drinking water distribution system! Luckily it won't be snowing in Uganda. Safe travels and best of luck to Nicole, Kimberly, David, Will, and professional mentor Kelsey!

Northeastern COE Information Systems students from the Silicon Valley regional campus toured the Tesla headquarters and met with a team of engineers, giving the students an opportunity to bridge a relationship with a leading industry partner.

BIOENGINEERING CELEBRATES First Capstone Design Cohort



From left to right: Hannah Worden, Kyle Miller, Benjamin Gincley, Siraaj Dhru, Zach Flinkstrom, and Gabriel Goodman, all E'19

Northeastern established a Department of Bioengineering in 2014 and this year celebrated the efforts and achievements of its first full cohort of capstone design students.

These pioneers have embraced the challenge of completing a design project over two semesters, starting with a project request from a sponsor (research faculty, individual of the Northeastern community, or industry) and taking it through to a functional prototype.

Bioengineering had a rich diversity of projects, ranging from creating engineered cell lines with particular mutations to study acute myeloid leukemia to a mechanical assist device to help an aging caregiver lift a teenager out of a wheelchair by applying no more than 4 pounds of force.

A panel of external judges shared thoughtful insights with the students and selected this year's winner: The Microbescope: a low-cost, autonomous portable imaging platform that uses machine learning to detect microbes in drinking water, completed by Siraaj Dhru, Zach Flinkstrom, Benjamin Gincley, Gabriel Goodman, Kyle Miller, and Hannah Worden.

Many of these students spent long hours in the Bioengineering Capstone Collaborative, a newly-built prototyping facility in Richards Hall, equipped with state-of-the-art 3D printers and other tools. This hands-on prototyping, along with seeking out knowledge beyond what is covered in other coursework, has given the students a sense of pride and ownership over their projects and invaluable engineering experience to propel them into their careers.

Fighting Cardiovascular Disease

Chemical Engineering Assistant Professor Eno Ebong realized early on that her interest in fluid and how it flows through pipes could be applied to studying blood vessels and disease. She also discovered that she had a passion for mentoring and a commitment to building a diverse STEM workforce.

Her twin interests mesh seamlessly with her current research project, which recently earned her the prestigious National Science Foundation (NSF) CAREER Award. Ebong and her team are studying endothelial cells that line blood vessels to better understand how the blood flow environment and stiffness of the underlying tissue contribute to cardiovascular disease risk.

“Exploring the endothelial cell response to the combined stimuli of blood flow and the tissue the cells sit on is going to be our main focus,” she says. “It’s something that hasn’t been looked at before.”

Endothelial cells were primarily studied in the context of response to blood flow; however, cells exist on different tissue surfaces, depending on health or disease conditions. They navigate the blood flow environment and different surfaces much like runners who navigate wind forces and a variety of surfaces. “A runner’s pace depends on wind speed and direction along with the surface they’re running on,” Ebong says. “A more fit athlete might be able to navigate these environments differently, and we expect to find cells behave the same way.”

Ebong believes the research results could contribute to improved diagnostics, preventative measures and treatment. “A lot of time and financial resources have been dedicated to understanding cardiovascular disease,” she says, “but more development is needed, making our work extremely important.” Moreover, the project is personal for her. “Many people are affected by blood vessel diseases, especially in communities of color,” she says. “I’m familiar with cardiovascular disease in my family, so I am doing something to contribute to solving this problem.”

Eno Ebong, assistant professor of chemical engineering

A culture of mentoring

As part of the NSF CAREER Award, research is closely integrated with STEM education and outreach activities designed to expand interest among students at all levels and to broaden the diversity of the STEM workforce to bring in varied perspectives that will spark innovation. Underpinning the focus on nurturing interest in STEM is an active mentoring culture, which Ebong sees as part of her role as an educator. “Everyone on my team serves as a mentor on this project.”

Demonstrating productivity is also a requirement for all participating students, from elementary through graduate school. “At every level, there is something to be done,” says Ebong, whether that’s publishing a peer-reviewed paper, presenting at a scientific conference, applying for funding, developing a hypothesis for a science project, or participating in a precollegiate science fair. “It’s all about getting familiar with the cycle of a research project.”

A Force of Nature

COLLEGE OF ENGINEERING RESEARCHERS ARE USING BIG DATA TO BETTER UNDERSTAND AND TRY TO PREDICT CLIMATE CHANGE RAMIFICATIONS

While there is debate about how exactly weather extremes are being altered under a changing climate, it's inarguable that understanding how to protect and improve quality of life around the world is a top concern today.

"There are innate uncertainties in the sciences and engineering—particularly in weather extremes and urban sustainability," says Auroop Ganguly, professor, civil and environmental engineering (CEE), and director of Northeastern's Sustainability and Data Sciences Laboratory. "The role of data-driven sciences in all this is that it can help unravel to researchers like myself the fundamental drivers of change, and what engineering or societal adaptation may be motivated."

Over the last several decades, Ganguly has increasingly incorporated data-driven science into his research on infrastructure resilience, water resources, urban sustainability, and climate change. With his background and experience in small and big data problems, much of Ganguly's work has focused on dynamic patterns of weather extremes and their impacts across sectors such as critical infrastructure, water resources, and energy.

He is a principal investigator on a $1.2 million grant from the National Science Foundation's (NSF) Big Data program. Along with collaborators from the University of Minnesota and other universities, national laboratories, and federal agencies, Ganguly works to examine Big Data from remote sensors and archived model simulations and relatively small data about infrastructures and natural resources. He uses machine learning and nonlinear dynamics, including complex networks science, to develop predictive understanding and generate actionable insights for stakeholders.

Ganguly was a co-principal investigator on a five-year, $10 million grant from NSF's Expeditions in Computing program, which focuses on adapting and developing new methods for climate and ecological data mining, and on a $2.5 million NSF grant on critical infrastructure resilience. Ganguly also received funding from NASA Ames via the Bay Area Environmental Research Institute (BAERI) for machine learning in earth sciences and engineering. This award will support NASA Earth Exchange (NEX) by utilizing artificial intelligence to analyze satellite imagery.

Ganguly has also received funding from the U.S. Department of Energy's ARPA-E, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory for research in climate modeling, remote sensing, and networked infrastructures under compound extremes.

STUDYING THE WORLD'S WATER

Like Ganguly, CEE Associate Professor Edward Beighley uses data to learn more about the interplay between the Earth's water resources and climate change on a large scale—very large.

"My research looks at huge amounts of Big Data on rainfall, temperature, surface water, and other landscape variables collected on a global scale from satellites and data collection sites around the world," explains Beighley, who is also an affiliated faculty member in Marine and Environmental Sciences and the Global Resilience Institute. "We use this information in hundreds of different climate and hydrologic modeling ensembles to simulate possible future shifts in the distribution of water."

Beighley's work can help communities around the globe better predict these hydrologic changes and the impacts they may have. In a paper recently published in *Climatic Change*, Beighley and his team discuss their project using data assessment and modeling to help the city of Santa Barbara, California, plan for adaptability over the next 50 years, for everything from habitat restoration to beach conservation to flooding risks.

Auroop Ganguly, professor of civil and environmental engineering

Beighley is also part of a comprehensive satellite development project funded by NASA's Surface Water and Ocean Topography (SWOT) mission and Applied Sciences program. Launching in 2021, the SWOT mission combines oceanographers and hydrologists from the U.S., France, Canada, and UK to make the first global survey of the Earth's surface water. In anticipation of the collection of terabytes of data per day for hopefully three or more years, Beighley and his team are currently building applications and tools that will be able to assimilate and use this vast quantity of information.

PROTECTING COASTAL COMMUNITIES

Q. Jim Chen, a CEE professor with a joint appointment in marine and environmental sciences, is another researcher using Big Data to help protect society from climate and ecological changes. Chen's interests are in the areas of coastal engineering and science, particularly in the development and application of state-of-the-art numerical models to address resiliency and sustainability.

"Coastal engineering is a promising area of research in which to utilize Big Data and machine learning," says Chen. "With the ability to deploy new sensors into the field in greater number and in new ways, we can collect a huge volume of data that can then be analyzed with the increased levels of computing power we have available today."

Chen's research is part of a multi-university project recently funded by the National Science Foundation (NSF) Cyber SEES program. He is the principal investigator leading the Coastal Resilience Collaboratory, which seeks to unite coastal engineers, earth scientists, and cyberinfrastructure specialists by sharing access to the open-source numerical model repository, high-performance-computing (HPC) resources, and large volumes of computational and observational data. This information, collected from real-time observational network and modeling of hurricanes, ocean waves, storm surges, and more, can be analyzed using machine learning to develop strategies for coastal sustainability.

Chen has also received funding from NSF's Convergence Research program, in which he and a team of researchers from five institutions with specialties from oceanography to hydrology to geomorphology will collect data during extreme events at the land and water interface and use machine learning to reduce the negative impact of storms on coastal communities. This three-year project is based in the Outer Banks, North Carolina, with a network that extends throughout the East and Gulf coasts, with the hope to include even more universities across the U.S. to gather more robust data.

INDUSTRY IMPACTING ENVIRONMENT—AND VICE VERSA

Matthew Eckelman, CEE associate professor and associate chair for research, uses Big Data analysis to look at the interplay of industrial processes—such as chemical processing, building materials, and consumer products—and the environment.

"It's a two-way street," says Eckelman. "On one side, we have the implications of how new industrial products or processes affect the environment, through energy use or emissions. But on the other, we need to know how climate change will impact the global industrial system and the supply chains for all the things we use on a daily basis."

To that end, Eckelman takes a Big Data approach to both sides of this equation, working with scenario modeling to predict future outcomes, such as what green building technologies will be most effective in certain parts of the world because of changing environmental factors.

"...We need to know how climate change will impact the global industrial system and the supply chains..."

Matthew Eckelman, associate professor and associate chair of research for civil and environmental engineering

"In general, building codes are extremely conservative, especially when you're talking about making alterations to materials that are critical to the structure," explains Eckelman. "Our work uses a suite of different global climate models in an attempt to be very conservative about our approach and our suggestions for 'future-aware' improvements."

Eckelman's research has garnered funding from the NSF and Environmental Protection Agency, as well as smaller grants to work with groups that are interested in climate impacts, such as in the healthcare and art conservation sectors.

Big Data in the Big City

From smart manufacturing to safer infrastructure, College of Engineering researchers are using Big Data to improve urban environments

While scientists haven't quite perfected the flying cars that 1950s sci-fi cartoons envisioned, the "city of the future" is becoming more than just a fantasy. In addition to the technological and computational advances that have manifested over recent decades, the Big Data boom is helping researchers at Northeastern's College of Engineering and beyond make strategic choices about facilitating urban life.

Take Haris Koutsopoulos, professor and associate chair for graduate studies, civil and environmental engineering (CEE), who uses Big Data to make getting around city environments easier and more efficient.

Koutsopoulos's research on next-generation transportation and mobility uses pseudo-anonomized data pulled from smart cards—like Boston's CharlieCard or New York City's MetroCard—to learn about passengers' entries, exits, and transit and wait times to improve public transportation in metropolises like Hong Kong and London.

"By discovering how people move throughout these systems, we can learn how the system operates from the user's perspective," says Koutsopoulos. "Our machine learning algorithms consider these hundreds of thousands of data points and notice patterns that we cannot, informing changes to the system."

In the future, Koutsopoulos's work could feasibly use predictive analytics to develop more informative and better communication between the public transit system and the user, such as offering personalized updates about incidents on a passenger's typical route and suggesting alternate transportation or delaying their trip by 10 minutes to clear congestion.

Koutsopoulos also looks at ways new mobility paradigms, such as mobility on demand systems, can be combined with traditional transit services to provide more sustainable and seamless transportation in urban areas. The broader context is how alternative operating models for ride hailing companies can increase the likelihood that two or more trips can be matched and share the same vehicle.

MAKING CITIES SAFER WITH SMARTPHONE DATA

CEE Assistant Professor Hao Sun is utilizing one of the most ubiquitous devices around—our smartphones—to tackle built environment issues, specifically to address the resilience, sustainability, and safety issues of civil infrastructure systems.

"By using the multiple embedded sensors in our phones, as well as other sensors installed on buildings and bridges, we can get cloud sourcing data from many different buildings throughout a city during a particular event, like an earthquake or a hurricane," says Sun.

Sun and his team seek to see how civil infrastructure performs during natural disasters, using machine learning and artificial intelligence to understand how buildings, bridges, and transportation systems will withstand outside forces. If enough of the correct data is collected and analyzed, urban planners will have more information to create safer, more resilient cities.

"Our work seeks to create a platform to collect and analyze this huge volume of data to assist disaster response planning and management," says Sun. "This is the future of low-cost sensing for structural engineering."

Sun's research is already collecting data in urban areas in California, Japan, and Kuwait.

Matteo Rinaldi, associate professor of electrical and computer engineering

Pioneering 'Smart' Farms

Electrical and Computer Engineering Associate Professor Matteo Rinaldi is passionate about using technology to make our lives safer, easier, and more efficient. For the next three years, he and his team will tackle one of the world's most urgent issues—inadequate food production—under a $1.7 million grant awarded by the U.S. Department of Energy Advanced Research Projects Agency.

As the world's population grows, available land is decreasing and crop yields are not at optimum levels, a trend that will likely lead to food shortages. Contributing to this situation, according to Rinaldi, is an "energy-constrained environment" and a lack of access to comprehensive data that would help farmers maximize their crop yields, specifically their ability to monitor in real-time when plants need water.

Based on the zero-power infrared sensor technology, originally developed for security purposes under a Defense Advanced Research Projects Agency grant, the Northeastern team proposes a network of zero-power sensors that will continuously monitor the infrared radiation emitted or reflected by a plant—surface temperature or spectral reflectivity of the leaves—to detect the need for water; once detected, the sensor, which is essentially in sleep mode and thus not consuming energy, turns on and sends a wireless signal that tells the farmer which plants need water.

"If we can develop these networks of sensors, which can be manufactured and deployed at low cost, it would enable farmers to install these sensors virtually everywhere with the unprecedented capability of acquiring comprehensive and real-time data of plant health and environmental conditions, with high granularity," explains Rinaldi. "Translating them into actionable items would maximize the crop yield while conserving natural resources."

Rinaldi sees the result of his team's research in zero-power sensors as "a foundational technology" and an enabler for a wide variety of applications. "I hope there are going to be even more programs focusing on digital agriculture and 'smart' farms, and we can join forces with other disciplines to address this incredible challenge. We created a little revolution in how people think about wireless sensing and communication, and Northeastern will have a leadership role in this revolution because of it."

MASS PRODUCTION GETS A PERSONAL TOUCH

Mohsen Moghaddam, an assistant professor of mechanical and industrial engineering (MIE), is using his applied data science background to improve smart manufacturing from two main angles.

The first is augmented design, in which Moghaddam uses machine learning to cull data from online product reviews to identify the personalization that purchasers might want for everything from cell phones to sneakers. These likes and dislikes are then applied to identify groups of individuals with shared idiosyncratic needs—for example, those who prefer to select canvas instead of leather for their shoes—and can be translated into better mass-customization options, as well as altogether new designs.

"Researchers and companies already collect customer preferences and demands through surveys and focus groups," explains Moghaddam. "Product reviews are an underutilized resource for this exact same information, and the use of artificial intelligence and deep learning can help us mine these rich data sources."

Moghaddam's research is also working to make manufacturing more flexible to enable robust processes in response to sudden changes in customer demand or unforeseen problems with machinery. This level of adaptability means that each element of the manufacturing process needs to be able to make real-time decisions and adapt to changes locally, not through a central control system.

This reconfigurable manufacturing involves collecting data from sensors throughout the production line and applying deep reinforcement learning methods to allow each machine to optimize its own performance.

"We're setting up an experimental test lab—a micro-factory that is a small shop floor—to facilitate experiments on reconfigurable manufacturing," says Moghaddam, who is working on this project in collaboration with colleagues in Europe, at Dartmouth College, and at the National Institute of Standards and Technology.

With this technology gaining momentum and intelligence, Moghaddam foresees personalized

and responsive manufacturing techniques translating into many other consumer areas, such as pharmaceuticals and nutrition.

MAKING SMART MANUFACTURING EVEN SMARTER

MIE Professor Sagar Kamarthi is another College of Engineering researcher working to improve the efficiency, performance assurance, and resiliency of modern manufacturing processes and systems. Funded by the National Institute of Standards & Technology, Kamarthi is developing machine learning and data processing methods to collect information—such as vibration, sound, and machining force—from sensors on manufacturing equipment to diagnose their mechanical condition or the quality of the product being produced, or even predict when the machine might need maintenance.

"This level of monitoring allows manufacturers to ensure quality of product, saving both lost time and money previously spent on costly repairs or inferior production due to machine malfunctions," explains Kamarthi.

Another of Kamarthi's projects, funded by the Digital Manufacturing and Design Innovation Institute (DMDII), is on a concept called "artificial intelligence design advisor," in which manufacturing data is streamlined and processed through cloud-based technologies to extract useful product design rules that ensure the efficient and cost-effective manufacture of quality products.

"In the past, designers would create a product and send it to the manufacturer to make, only to discover that something was too expensive, or too difficult, or outright impossible," says Kamarthi. "In this project, we're partnering with Raytheon to use their manufacturing data and develop a machine learning agent that examines the data to pre-screen designs for potential errors and difficulties in manufacturing."

This artificial intelligence design advisor can cut the cycle time between design and manufacturing from between two and five years to several weeks or months. While the data is specific to Raytheon, the methodology and algorithms will be open and applicable to other companies and can be customized to their needs.

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Haris Koutsopoulos, professor of civil and environmental engineering

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JUST THE BEGINNING

With the explosion of sensor technology over the last few years, the urban environment has potential to become an even richer source of data to fuel further improvements.

"If you think about the sensors that we install in cities, and then add in opportunistic sensors—those that were originally installed for other purposes, such as taxi GPSs or smartphones, but that we can mine for information—we have large amounts of real-world data that tells us a practical story of how people move in urban areas," says Koutsopoulos.

As researchers continue to apply robust computing tools and more advanced artificial intelligence modeling to this data, society is only beginning to realize the capabilities that Big Data can impose on the urban environment.

"We've opened up a whole new field: the data-driven discovery of the engineering world," says Sun. "We will continue to discover areas where, in the past, conventional approaches haven't worked—but Big Data will."

Bringing GPS Indoors

For the past decade, Electrical and Computer Engineering Assistant Professor Pau Closas has focused on a unique technological challenge in navigation: increasing the sensitivity and accuracy of Global Navigation Satellite System (GNSS) receivers, a key step in overcoming limitations of the GNSS—the umbrella system that encompasses the Global Positioning System (GPS).

Closas's work recently earned him the prestigious National Science Foundation CAREER Award, a five-year grant for research and education and outreach programs. The award will help Closas—who joined Northeastern in 2017—and his team address some of the most common GNSS receiver challenges, including indoor usage, signal spoofing, and disruption by malicious actors.

Based on his research, Closas proposes an architecture for GNSS receivers that will increase accuracy and sensitivity on a higher range of scenarios. "The current receiver architecture uses two steps," he explains. "Satellites send signals and the receiver processes each satellite's signals independently, extracting information to estimate position and then combining them all. We propose moving to a one-step process by optimally combining all these signals directly to determine position more accurately."

One of the groundbreaking applications of the new architecture, according to Closas, is "to bring GPS indoors," which would provide the ability to navigate with a phone and GPS receiver inside a building. More robust GNSS receivers can also address current navigation limitations with self-driving cars and thwart jamming devices that, for example, have the potential to cause catastrophic damage to the power grid, which is synchronized with GNSS timing. "We can combat these effects with this technology," he says.

"We'll incorporate our findings into the Open Source project implementing GNSS receivers, so the knowledge we generate is public and available to the scientific community. Everyone can benefit."

Pau Closas, assistant professor of electrical and computer engineering

As principal investigator for the research project, Closas oversees a four-person team of doctoral students that he plans to grow. Because the educational component of the NSF CAREER award is tightly linked to an Open Source project that Closas has worked on for several years, researchers both inside and outside of Northeastern will benefit. "We'll incorporate our findings into the Open Source project implementing GNSS receivers," he says, "so the knowledge we generate is public and available to the scientific community. Everyone can benefit."

Teaching Machines to Think Like Us—Or Maybe Even Better

How the advent of Big Data is leading to artificial intelligence that will help society

As the world of Big Data grows, society continues to produce and collect massive amounts of data and create computational systems of unprecedented scale. Now the question becomes: **How do we create artificial intelligence and machine learning that can handle the sheer volume of information in a timely manner?**

Stratis Ioannidis, assistant professor, electrical and computer engineering (ECE), is designing algorithms that can make inferences from large data sets and multiple machines much faster than ever before—in minutes instead of days.

"Using these algorithms, we can solve a problem that involves 20 million variables in 79 minutes on 350 CPUs, instead of the 48.3 hours that a single machine would require," says Ioannidis.

Ioannidis' research in this exciting area has been funded by a $2 million grant awarded by the National Science Foundation's (NSF) BIGDATA program, which includes $350K of Google Cloud credits, as well as a $460K NSF CAREER grant. Ioannidis and his team work at the state-of-the-art high performance computing Discovery Cluster housed in the Massachusetts Green High Performance Computing Center (MGHPCC), a joint venture between Northeastern and several other area universities.

DEEP LEARNING: SMALLER, BETTER, FASTER

Another researcher considering the problem of volume in Big Data is Assistant Professor Yanzhi Wang (ECE). Wang works with deep learning—a highly complicated form of machine learning that uses classifications of data instead of task-specific algorithms and requires massive amounts of both computations and storage. He seeks to make deep learning and other artificial intelligence systems hundreds of times more energy efficient and smaller without sacrificing quality.

Wang is working on both sides of this efficiency issue: First, by creating software that reduces the model size of deep neural networks by up to 1,000 times without reducing accuracy, thereby significantly enhancing the implementation efficiency. Organizations across industries, such as Intel, IBM, Warner Media, DiDi Inc., SenseTime, and the U.S. Department of Defense (DoD), are working to implement this software to multiple platforms ranging from graphic processing units (GPUs), field-programmable gate arrays (FPGAs), and embedded systems.

On the hardware side, Wang and his team are working to develop novel deep learning approaches to enable efficient design and operations of deep neural networks using Big Data. With funding from NSF, DoD, and industry sources, Wang's research is creating drones and other unmanned aerial vehicles (UAVs) that possess better sense-and-avoid capability, as well as respond to speech recognition in real time.

FROM BIOPHARMACEUTICAL SUPPLY CHAINS TO SMART POWER GRIDS

In complex stochastic systems, hundreds of factors—at least one or more parts of which have an element of randomness—dynamically interact with each other. This innate unpredictability impacts the ability for machines to make systematic and optimal decisions. Wei Xie, assistant professor, mechanical and industrial engineering, is working to develop an intelligent decision support platform using Big Data analytics and interpretable AI to mitigate this risk.

Using data-driven stochastic optimization, Xie and her team are working to improve the biopharmaceutical supply chain on FDA-approved personalized cancer medication. Throughout the production process of this highly complex drug, even small changes—such as cell culture temperature or pH—will have major impact on product effectiveness and safety. Xie's work helps to identify and monitor the drug critical quality attributes throughout the process through sensor data, and then real-time control the critical process parameters to prevent any damaging risk from occurring.

Xie is also working with Argonne National Laboratory on improving smart power grids with high renewable energy penetration. Her research team is developing predictive analytics and AI to study

Kaushik Chowdhury, associate professor of electrical and computer engineering

Device Fingerprinting

Every individual device in the global wireless Internet of Things—estimated to reach over 20 billion devices by 2020—communicates via radio transmitters and receivers. Even when multiple devices are transmitting the same information, each device imprints its own unique signal pattern on the transmission that makes it possible to identify individual smartphones or laptops.

"Due to manufacturing variances, each electronic device has minor hardware differences in its processing chain, which makes it slightly different from every other device," explains Kaushik Chowdhury, an associate professor of electrical and computer engineering at Northeastern. "You can think of these distinct characteristics as a fingerprint. By studying the unique properties of a received radio signal, you can identify which device is sending it."

Identifying the source of a signal has important implications for both cyber security and emergency preparedness. By impersonating the signal of an authorized device, cyber terrorists could disrupt the safe operation of an airplane or access critical national security data. In the realm of emergency preparedness, rapidly identifying nearby devices could aid in alerting emergency responders, saving crucial seconds and potentially saving human lives.

Based on these and other important implications of device fingerprinting, the U.S. Defense Advanced Research Projects Agency (DARPA) recently awarded $1.5 million in funding to an interdisciplinary team in the Department of Electrical and Computer Engineering to optimize this capability. Led by Chowdhury, the team, composed of Professors Stratis Ioannidis, Jennifer Dy and Tommaso Melodia, has a range of interdisciplinary expertise from machine learning, wireless networking to signal processing. They will apply machine-learning algorithms to make signal identification practical on a massive scale.

The research team has a shared goal of adapting machine learning techniques such as deep convolutional neural networks—which are already proven for image recognition—into the domain of wireless signal pattern recognition. They will also develop new methodologies and machine-learning architectures that can correctly classify 10,000 devices with an accuracy rate of 99 percent.

Chowdhury notes. "The College of Engineering at Northeastern has worked hard to develop leading expertise in the Internet of Things and related topic areas, recognizing the huge importance of the IoT to society, industry, and the military. It's gratifying to see all this expertise coming together to solve a practical problem and achieve a common goal."

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both customer behaviors and the changing energy environment; improve the prediction of usage and renewable energy generation (e.g., solar and wind power); and further automatically guiding the scheduling and upgrading decisions for reliable and efficient smart power grids.

THE "SMALL DATA" PROBLEM

While having access to the massive amounts of data is assumed to be the norm for many AI applications, Sarah Ostadabbas, an ECE assistant professor, is using AI in what she calls the "small data" domains. In these domains, such as many medical and military applications, data collection and labeling is expensive, individualized, and protected by very strong privacy or classification laws. Her research attempts to bridge the gap between powerful AI algorithms, including deep learning techniques and areas that lack the amount of training data necessary to create advanced machine learning models.

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Sarah Ostadabbas, assistant professor of electrical and computer engineering

Moving Deep Learning to the Next Level

Deep learning models, a subset of traditional machine learning algorithms, use a network structure composed of multiple layers known as Deep Neural Networks. These DNNs are designed to be able to extract features at multiple levels of abstraction. Deep learning requires training DNNs by feeding them a lot of data, which they can then use to become more intelligent and make decisions about new data.

The algorithms applied by Google for image recognition and article searches or by Amazon in its recommendations of future consumer purchases based on past purchase history are among the most familiar examples of deep learning systems in use today.

"DNNs require millions of parameters to perform complicated tasks. That in turn demands a lot of computation and parameter storage resources from the computing platform, which can potentially limit the use of deep learning in many applications," explained Assistant Professor Xue (Shelley) Lin, electrical and computer engineering.

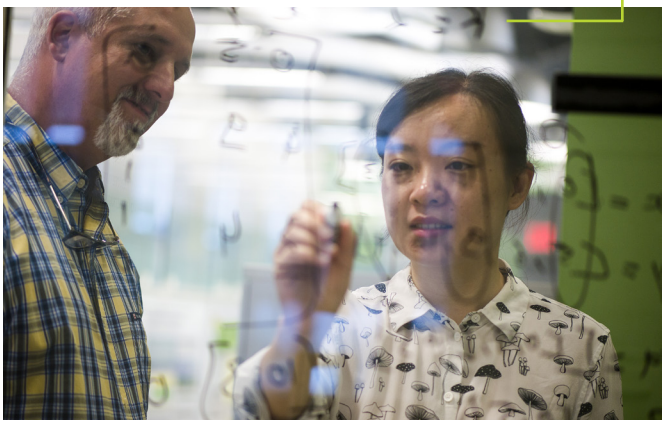
To address this limitation, the National Science Foundation awarded Lin, principal investigator, and College of Engineering Distinguished Professor David Kaeli, co-principal investigator, an $800K grant in collaboration with City University of New York and Rutgers University to design an efficient deep learning system.

Lin stated, "Our project will provide for efficient implementation in terms of computation speed and parameter storage such that we can seat deep learning systems into computing platforms that don't have enough computing or storage resources."

Ultimately the research project will promote wider applications of deep learning systems such as self-driving cars, unmanned aerial vehicles, and wearable devices. "These applications may need deep learning to perform specific tasks, but they are limited by their storage and computing power," says Lin, "so we need to compress the model and accelerate computation. The project is an important first step in the development of future autonomous systems and future 'smart spaces' such as smart homes and buildings."

"The project is an important first step in the development of future autonomous systems and future 'smart spaces' such as smart homes and buildings."

Xue (Shelley) Lin, assistant professor of electrical and computer engineering



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"We address this problem by incorporating domain knowledge into a synthetic data generation process using physics-based simulators to expand available datasets, " explains Ostadabbas. "We then use the synthetic data in place of real-world data to train the machine learning models with deep structure."

One example of Ostadabbas's work, recently presented with an NSF CRII pre-CAREER award, is estimating human poses while sleeping in natural settings, which has applications in sleep apnea, epileptic seizures, and pressure ulcer diagnosis and prevention. Because not much visual data exists of humans sleeping without blankets or with the lights off, Ostadabbas uses 3D scans of human body, physics behind human movements and imaging, and game engines to synthesize enough in-bed pose data to create a robust deep learning-based pose estimation model. This project has already initiated a partnership with the Comprehensive Epilepsy Program at Beth Israel Deaconess Medical Center.

TEACHING MACHINES TO TEACH US

Scientists are always looking for ways to use complex data to develop models that can make powerful predictions—such as how molecules interface with one another, or how drugs interact with systems in our body—to help clinicians predict successful courses of treatment. One challenge is to find natural ways of describing these systems that capture their essence while dismissing irrelevant details.

Erel Levine, associate professor, bioengineering, knows that machines can be very successful in extracting useful and relevant features from complex data to perform tasks such as image classification and speech recognition—and he's hoping to put that talent to use for analyzing biomedical data.

"In the biological sciences, making predictions is difficult because biological systems are both very complex and lacking in structure," says Levine. "What we hope to do is take machine systems that we have already taught how to extract essential features—meaning we know we already have efficient AI—and introduce them to complex biological data to guide the development of informative models with a strong predictive power."

If successful, this advanced AI will help researchers analyze complex data in real-life situations that involve multiple biological systems. For example, models built on data collected from patients about how drugs are affecting them individually will be used to predict outcomes and create protocols for future patients. In another application, simultaneously recorded neural and gut activities will be studied in different environments with the AI's help to advance our understanding of the connection between gut and brain.

Levine is in the process of developing a team to continue working on this multifaceted problem with far-reaching implications.

BETTER DATA ANALYSIS; BETTER TREATMENT

ECE Professor Jennifer Dy researches machine learning and develops novel data analysis algorithms that help medical collaborators discover relationships among large volumes of data to improve disease diagnoses.

Funded by the National Institutes of Health (NIH), Dy and her novel machine learning algorithms are helping doctors at Brigham & Women's treat Chronic Obstructive Pulmonary Disease (COPD), an umbrella term for lung diseases that cause shortness of breath due to noxious particles. Utilizing data collected from 21 clinical sites throughout the U.S., this multidisciplinary team seeks to identify subtypes of COPD to

better diagnosis and plan treatment for different manifestations of the disease.

For the past 10 years, Dy has also been collaborating with the Memorial Sloan Kettering Cancer Center (MSKCC) to combine human and machine knowledge to more effectively detect skin cancer. An MSKCC optical engineer has created a reflecting microscope that allows doctors to see under a patient's skin to identify lesions without cutting; however, the images are not very clear. Dy and her team are working to augment the tool by building algorithms to apply to the data to search for interesting features on the boundary between the epidermis and dermis, where cancer usually starts.

PERSONALIZED MEDICINE

Another researcher working to help improve disease treatment is Professor Sagar Kamarthi, mechanical and industrial engineering. Kamarthi is working with Partners Health Care and Connected Health to use machine learning to analyze 20 years of data on breast cancer patients.

"Our task is to determine the type of treatment that works best for subgroups of patients," says Kamarthi. "By assessing factors like age, race, hormones, and lifestyle and looking for similarities in outcomes, we can be more predictive in the future."

Kamarthi also works with Massachusetts General Hospital and Institute for Technology Assessment (ITA) on improving the diagnosis of non-alcoholic fatty liver disease (NAFLD), an illness that affects 25% of the U.S. population. Previously, the only way to identify NAFLD was through an expensive and painful liver biopsy. Using a machine learning model, Kamarthi and his team are now using non-invasive lab results to predict whether a biopsy is necessary—with an 85 percent accuracy.

Funded by a $1.2 million grant from the NSF, Kamarthi, co-principal investigator, is working with Associate Professor of Mechanical and Industrial Engineering Yingzi Lin, principal investigator, and Brigham & Women's Hospital to better and more accurately measure pain. The only current method is self-reporting, which is inherently subjective, and high-variance. Kamarthi's machine learning algorithm seeks to identify true pain levels by measuring and analyzing concrete physiological parameters like heart rate, skin conduction, and brain signals.

LIMITLESS POTENTIAL

As data collection and computational power continue to improve, engineers and scientists will continue to create technology that automates solutions to more and more real-world problems. From self-driving cars that can process terabytes of data in an instant to personalized medication that treats your exact symptoms, machine learning can make an impact across all facets of life.

"AI has the potential to change way people work and thrive, and what is considered a difficult task or one that only takes a few moments," says Ioannidis. "Society will continue to benefit from intelligent machines that can consider problems in a scale humans simply cannot."

> ***"Society will continue to benefit from intelligent machines that can consider problems in a scale humans simply cannot."***
>
> Stratis Ioannidis, assistant professor, electrical and computer engineering

Senior Spotlight

Bioengineering student Minhal Ahmed, E'19, was drawn to Northeastern by the University Scholars Program, the tight knit community, and extensive support for research and creative endeavors of which he took full opportunity of in the lab and on co-op.

Early on, Ahmed secured an Honors Early Research Award, and immediately began working in Assistant Professor Abigail Koppes' Advanced Biomaterials for NeuroEngineering Laboratory (ABNEL) the summer after his freshman year. There he studied the enteric nervous system, or ENS, which is sometimes referred to as "the brain in the gut" for its reflexes independent of the brain. He studied the ENS because he eventually wanted to research its interactions with the gut microbiome.

He then received an Undergraduate Advanced Research/Creative Endeavor Award in 2017 for his research project at ABNEL entitled, "The Gut-Brain-Axis: Exploring the Interface Between Enteroendocrine Cells and the Enteric Nervous System." As part of the project, he developed a microfluidic device, which is a plastic chip that has small channels to culture cells that can mimic the way sensory cells in the gut communicate with the brain.

In 2018, Ahmed received the highly competitive Barry Goldwater Scholarship, the United States premier award for outstanding young researchers in STEM fields.

All three of Ahmed's co-ops involved research giving him experience in several areas. Following his interest in neuroscience, he first worked in Duke's neurobiology department in an academic lab, leading a pilot project studying cerebellar circuit function during locomotion. Next, he was hired at a gene editing tech company, Editas, where he researched novel gene therapies based on CRISPR/Cas9 technology. And, for his final co-op, he decided to try his hand at clinical research at Massachusetts General Hospital. While looking up researchers in his field, Ahmed found a doctor doing research on the enteric nervous system. "[He was] someone I wanted to get to know because he's exactly what I want to be in the future—an M.D. who practices in the clinical, but also does research," he said.

After sending the doctor an email, he was able to meet him and secure the position. "It was as easy as that," he said.

Another large aspect of Minhal's experience at Northeastern was his involvement with Peer Health Exchange, a student organization trying to combat health inequity by teaching health workshops at high schools in underserved Boston communities.

"I'm really passionate about empowering people to lead healthy lives," he said. "I believe I can do that through research, but also through stuff like what Peer Health Exchange is doing."

Through his work in the lab and on co-ops, Ahmed feels that his expansive resume will give him an advantage in his field.

"All of this experience really makes graduates from Northeastern especially competitive in research," he said. Ahmed was recently one of only 12 students nationally selected as a George J. Mitchell Scholar, a competitive one year graduate program sponsored by the US-Ireland Alliance. He hopes to continue his research on the gut microbiome at University College Cork. He also received the 2019 Harold D. Hodgkinson Achievement Award—one of the highest honors a senior can receive.

Minhal will apply to medical school this June to start fall of 2020 after his return from the Ireland.

BREAKING NEW GROUND **TO FIGHT CANCER**

Sidi Bencherif, assistant professor of chemical engineering

Immunotherapy is one of the most promising approaches for cancer treatment in recent years, and it's generating a high degree of interest among researchers in the engineering community.

For Chemical Engineering Assistant Professor Sidi Bencherif, finding a way to address some of immunotherapy's current limitations is key to adding to the treatment arsenal against cancer—and saving more patients' lives. Bencherif's research represents a potentially significant advancement in the field of immunoengineering, recently earning him the National Science Foundation (NSF) CAREER Award.

Limited and often ineffective treatment options for cancer spurred the development of immunotherapy, which treats disease by activating the immune system. According to Bencherif, current approaches are limited in part due to immunosuppression within the local tumor microenvironment, driven by lack of oxygen—a condition known as hypoxia.

"Hypoxic tumors are usually very aggressive and metastatic, characteristics associated with poor prognosis and patient outcomes," he says. "To propose more effective immunotherapies, it's crucial to understand and regulate the interactions between the hypoxic tumor microenvironment and immune cells. Our work addresses fundamental questions regarding these interactions and how oxygen supply can boost cancer-fighting immune cells."

Bencherif believes the research conducted at Northeastern could eventually lead to a better understanding of immune cell suppression and how an engineered oxygen-releasing biomaterial could reverse local tumor hypoxia, boost anti-cancer immunity, and potentially save millions of lives.

"Cancer remains a devastating disease," he says. "This award will make it possible for us to break new ground in cancer immunotherapy at Northeastern."

Welcome New Faculty

The College of Engineering has hired over **80** faculty since 2012, and **12** in 2018.

CRISTIAN CASSELLA

PhD, Carnegie Mellon University

Assistant Professor of Electrical and Computer Engineering

BABAK HEYDARI

PhD, University of California, Berkeley

Associate Professor of Mechanical and Industrial Engineering

EREL LEVINE

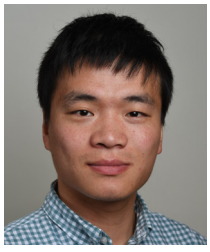
PhD, Weizmann Institute of Science

Associate Professor of Bioengineering

HERBERT LEVINE

PhD, Princeton University

University Distinguished Professor of Physics, jointly appointed in Bioengineering



JIAHE LI

PhD, Cornell University

Assistant Professor of Bioengineering

KAYSE LEE MAASS

PhD, University of Michigan

Assistant Professor of Mechanical and Industrial Engineering

MOHSEN MOGHADDAM

PhD, Purdue University

Assistant Professor of Mechanical and Industrial Engineering

ALIREZA RAMEZANI

PhD, University of Michigan

Assistant Professor of Electrical and Computer Engineering

SARA ROUHANIFARD

PhD, Albert Einstein College of Medicine

Assistant Professor of Bioengineering

HAO SUN

PhD, Columbia University

Assistant Professor of Civil and Environmental Engineering

YANZHI WANG

PhD, University of Southern California

Assistant Professor of Electrical and Computer Engineering

WEI XIE

PhD, Northwestern University

Assistant Professor of Mechanical and Industrial Engineering

Faculty Promotions

UNIVERSITY DISTINGUISHED PROFESSOR

Dagmar Sternad
electrical and computer engineering

PROFESSOR

Andrew Gouldstone
mechanical and industrial engineering

Tommaso Melodia
electrical and computer engineering

Mehrdad Sasani
civil and environmental engineering

Rifat Sipahi
mechanical and industrial engineering

Ming Su
chemical engineering

Ashkan Vaziri
mechanical and industrial engineering

ASSOCIATE PROFESSOR

Matthew Eckelman
civil and environmental engineering

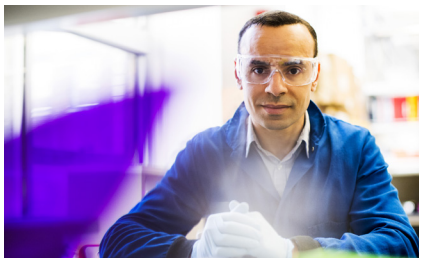
Yongmin Liu
mechanical and industrial engineering

Marvin Onabajo
electrical and computer engineering

Richard West
chemical engineering

Young Investigator Recognitions

*These faculty recognitions bring the total young investigator awards in the college to **88**, including **47** NSF CAREER and **18** DOD Young Investigator awards.*



Assistant Professor **Sidi Bencherif**, chemical engineering, received a CAREER Award from the National Science Foundation for "Modulating Local Tumor Hypoxia using Cryogel Scaffolds to Regulate Dendritic Cell Function and Activity." See page 28. Bencherif also received a King Abdulaziz City of Science and Technology Award for his project, entitled "Biomaterials for Wound Healing and Diabetic Ulcer Treatment."

Assistant Professor **Pau Closas**, electrical and computer engineering, received a CAREER Award from the National Science Foundation for "Secure and ubiquitous position, navigation and timing." See page 20.

Assistant Professor **Eno Ebong**, chemical engineering, received a CAREER Award from the National Science Foundation for "EMBRACE STEM (Endothelial MechanoBiology Research And multiCultural Education in STEM)." See page 12.

Assistant Professor **Adam Ekenseair**, chemical engineering, was recognized with the 2018 Nano Research Young Innovator Award (NR45) in nanobiotech from the journal *Nano Research* for his notable accomplishments and potential to make significant contributions to the field of nanobiotechnology.

Assistant Professor **Hui Fang**, electrical and computer engineering, has been awarded a CAREER Award from the National Science Foundation for the project, "Transforming Neural Interfaces Using Stretchable, Transparent, Multifunctional Nanomesh Microelectrodes." See page 3.

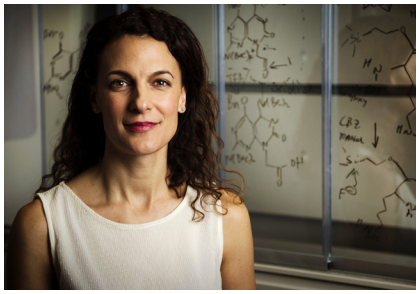
Recent Fellows

Selected engineering faculty who have been elected as Fellows of national professional societies.

Professor **Debra Auguste**, chemical engineering, has been selected as a Fellow of the Biomedical Engineering Society (BMES) for her exceptional achievements and significant contributions within the biomedical engineering field.

William Lincoln Smith Chair and University Distinguished Professor **Ahmed Busnaina**, mechanical and industrial engineering, has been selected as a Fellow of the National Academy of Inventors for having demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on the quality of life, economic development, and welfare of society.

Associate Professor **Guohao Dai**, bioengineering, was one of nine selected as a Fellow of the American Heart Association (FAHA) by the Council of Basic Cardiovascular Sciences of AHA.



Professor and Associate Chair of Research **Rebecca Carrier**, chemical engineering, has been elected as a Fellow of the American Institute of Medical and Biological Engineering (AIMBE) for her exceptional achievements and significant contributions within the medical and biological engineering fields.

Professor **Hicham Fenniri**, chemical engineering, has been elected a Fellow of the American Institute of Medical and Biological Engineering (AIMBE) for his exceptional achievements and significant contributions within the medical and biological engineering fields.

Associate Professor **Raymond Fu**, electrical and computer engineering jointly appointed in the Khoury College of Computer Sciences, has been elevated to an IEEE Fellow for his contributions to manifold learning and face and gesture recognition. He was also named a Fellow of the Optical Society for his "outstanding and sustained achievements in image and video processing, optical pattern recognition, and imaging and sensing."

Professor **Auroop Ganguly**, civil and environmental engineering, has been selected as a Fellow of the American Society of Civil Engineers in recognition of his outstanding contributions to the profession.

Professor **Mehrdad Sasani**, civil and environmental engineering, has been elected a Fellow of the American Concrete Institute for his contributions to ACI and the concrete industry.

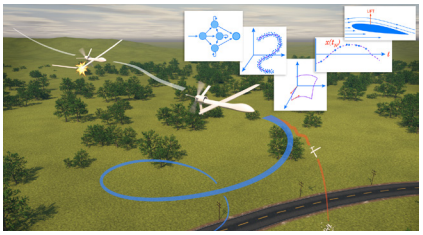
Professor **Mario Sznaier**, electrical and computer engineering, was elevated to an IEEE Fellow for his contributions to identification of switched systems and multi-objective control.

Professor and Chair and Art Zafiropoulo Chair in Engineering **Thomas Webster**, chemical engineering, was recently elected as an Overseas Fellow to the Royal Society of Medicine (RSM) of the United Kingdom.

FACULTY NEWS

Selected Highlights

Professor **Ozlem Ergun**, mechanical and industrial engineering, has been appointed to a national committee tasked with capturing key lessons about supply and distribution networks under strain during Hurricanes Harvey, Irma and Maria. The FEMA-sponsored committee, was established by the National Academies of Sciences, Engineering, and Medicine, and the Chair of Policy and Global Affairs (PGA).



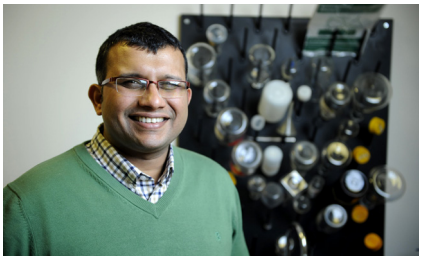
Professor **Mario Sznaier**, electrical and computer engineering, is a co-PI for a $7.5M DoD grant, in collaboration with The University of Texas at Austin and Princeton University, for a Multidisciplinary University Research Initiative (MURI) project aimed at developing artificial intelligence for UAVs.

Associate Professor **Raymond Fu**, electrical and computer engineering jointly appointed in the Khoury College of Computer Sciences, was selected as a distinguished member of the Association for Computing Machinery for his outstanding scientific contributions to computing.

FACULTY NEWS

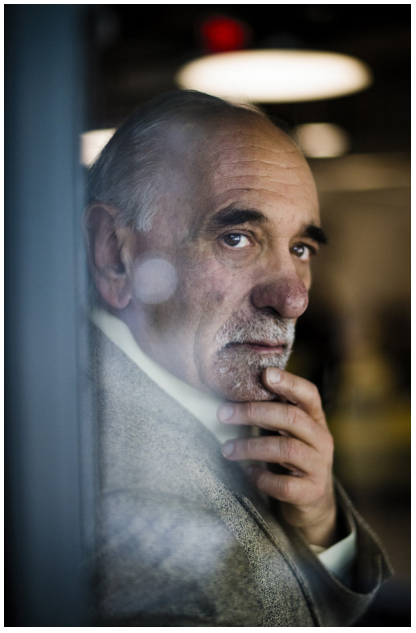
Continued

First Year Engineering Teaching Professor **Bala Maheswaran** received the Outstanding Teaching Award at the Northeast Section of the American Society for Engineering Education, and was elected as the Chair-elect/Chair of the ASEE-NE.



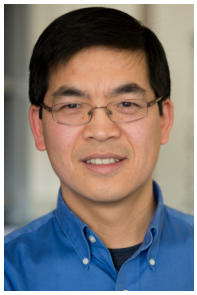
Assistant Professor **Ameet Pinto**, civil and environmental engineering, was selected as the recipient of the 2018 International Symposium on Microbial Ecology/ International Water Association (ISME/IWA) Bio Cluster Award in the Rising Star Category.

Professor **Rebecca Carrier**, chemical engineering, was awarded a four-year $1.57M renewal NIH grant for "Impact of Lipids and Food on Oral Compound Absorption: Mechanistic Studies and Modeling."



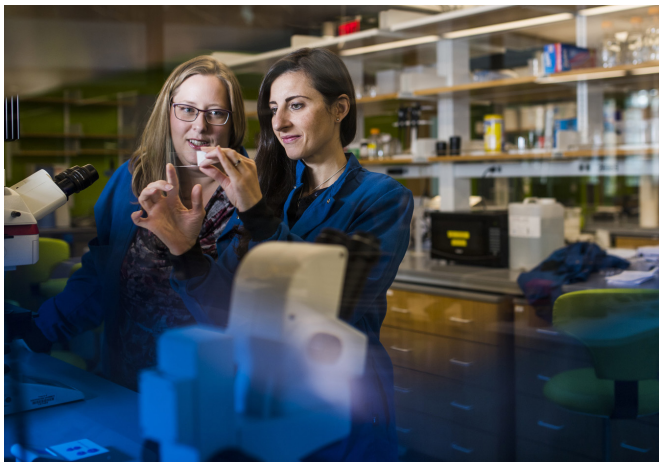
University Distinguished Professor **Eduardo Sontag**, electrical and computer engineering and bioengineering, in collaboration with MIT and the University of Minnesota-Twin Cities, was awarded a $1.5M three-year grant jointly funded from the National Science Foundation and Semiconductor Research Corporation for "Very Large-Scale Genetic Circuit Design Automation."

William Lincoln Smith Chair Professor **Tommaso Melodia** and Associate Professor **Matteo Rinaldi**, both of the Department of Electrical and Computer Engineering, in collaboration with Rutgers University, were awarded a $1M National Science Foundation grant for "Reliable Underwater Acoustic Video Transmission Towards Human-Robot Dynamic Interaction."



Professor **Nian Sun**, Associate Professor **Marvin Onabajo**, and Assistant Professor **Aatmesh Shrivastava**, of the Department of Electrical and Computer Engineering, were awarded a $1.34M NIH collaborative grant with Massachusetts General Hospital to work on nano-scale neural radio frequency identification (NanoNeuroRFID) devices for wireless neural magnetic modulation and recording.

Assistant Professor **Jose Martinez-Lorenzo**, mechanical and industrial engineering and electrical and computer engineering, is leading a $1.5M Air Force Research Laboratory (AFRL) grant for "Robust Decentralized Classification and Coordination Algorithms for Swarms of Small Unmanned Aerial Systems."



Assistant Professors of Bioengineering **Jessica Oakes** and **Chiara Bellini** (multiple PIs) received a $1.5M collaborative award from the Assistance to Firefighters Grant Program, administered through the Department of Homeland Security (DHS) Federal Emergency Management Agency's (FEMA) Grant Programs Directorate, for examining the "Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke."

Associate Teaching Professor **Lucas Landherr**, chemical engineering, was awarded the AIChE Education Division's Award for Innovation in Chemical Engineering Education, which recognizes an individual who has, according to the AIChE, "implemented a pedagogical innovation into a class or course that has made a significant and documented positive impact on teaching effectiveness and has enhanced student learning." He also received the Ray W. Fahien Award by the American Society for Engineering Education (ASEE) Chemical Engineering Division.

Professor **Bahram Shafai**, electrical and computer engineering, received the Lifetime Achievement Award from the World Automation Congress 2018 for Outstanding Contributions to Robust Stability and Control of Multi-variable Systems and Observer Design for Fault Detection.

Professor **James Benneyan**, mechanical and industrial engineering, and director of the Healthcare Systems Engineering Institute, was awarded a $1.8M R18 award from the Agency for Healthcare Research and Quality (AHRQ) in collaboration with Brigham and Women's Hospital (lead) for a Patient Safety Learning Lab (PSLL) to develop real-time predictive/detection models of patient misdiagnoses.

Professor **Heather Clark** (left), bioengineering, chemistry and chemical biology, was awarded a $1.5M grant from the National Institute of Neurological Disorders and Stroke for "Nanosensors for Chemical Imaging of Acetylcholine Using MRI."

STUDENT NEWS

National Science Foundation Graduate Research Fellowship Student and Alumni Award Recipients

Award Offered

Cassandra Nickles, PhD'22, civil engineering

Victoria D'Agostino, E'19, bioengineering

Alexander Piers, E'17, electrical and computer engineering, and physics

Yasmeen Farra, PhD'22, bioengineering

Katherine Vilardi, PhD'22, civil engineering

Honorable Mentions

Kate Duffy, PhD'22, interdisciplinary

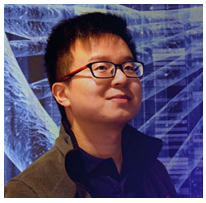
Anas Abou Allaban, E'19, electrical and computer engineering

Michael Tormey, E'20, civil engineering, received the prestigious **2018 Presidential Scholarship** awarded by the American Council of Engineering Companies of Massachusetts Education Corporation. At the National Competition, Tormey also received a $5,000 scholarship from the American Society of Civil Engineers and was one of three students nationally invited (and sponsored) to accept the award in person at the conference. Additionally, Tormey received Northeastern University's 2019 President's Award, which is given annually to the ten students with the highest GPA in the University class to recognize outstanding academic achievements. Tormey was also nominated by Northeastern for the prestigious Truman Scholarship.

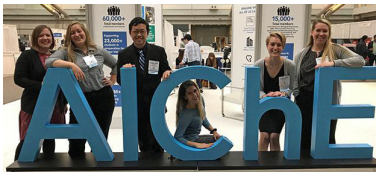
INFORMS Receives Student Chapter Cum Laude Award

For the second year in a row, and the third since the club's formation, the Institute for Operations Research and the Management Sciences (INFORMS) at Northeastern was one of the schools awarded the Student Chapter Cum Laude Award.

The club grew from 72 graduate students in 2016 to 273 in 2018. Club President, Ann Suhaimi, a PhD candidate in industrial engineering, stated, "INFORMS is the world's largest professional society for practitioners in the field of operations research, management science and analytics. The Student Chapter Cum Laude Award acknowledges the achievements of our INFORMS student chapter, and motivates us to keep promoting the work of Operations Research and Analytics."



PhD student **Yujie Yan**, civil engineering, was named a 2018 O.H. Ammann Research Fellow in Structural Engineering by the American Society of Civil Engineers.



The Northeastern University student chapter of the American Institute of Chemical Engineers (AIChE) was selected as an Outstanding Student Chapter for the 2017–2018 school year. The award is presented to student chapters of AIChE that demonstrate an "exceptional level of participation, enthusiasm, program quality, professionalism, and involvement in the university and community."

Bioengineering student **Erica Wagner**, E'20, and chemical engineering student **Gavin Winter**, E'20, were two of four students nominated for the Barry Goldwater Scholarship by Northeastern University.

PhD student **Jon Soucy**, chemical engineering, won an American Heart Association Fellowship. This competitive fellowship supports doctoral students with career aspirations to make an impact on global cardiovascular health; Soucy is working to develop an innervated heart on a chip.

Kritika Singh E'20, has been named a 2019 Truman Scholar, the United States' premier graduate fellowship for those who intend to devote their careers to serving the public good. Singh is an aspiring physician scientist, and policymaker committed to fighting emerging infectious diseases. She is one of 62 Scholars selected from a record pool of 840 candidates nationwide.

ONE TO WATCH

Carlos Fuentes, E'18, balances a job at Amazon with a startup born of his passion for vintage timepieces

For his sixteenth birthday, Carlos Fuentes, E'18, received an unusual gift from a family friend: a broken vintage watch movement. "My dad's friend knew I was enamored with mechanical stuff," explains Fuentes. "I'd always loved watches and their tiny moving parts—all the gears and the springs. From a very young age, I'd always wondered, 'Wow, how does this work? How can this collection of parts keep time accurately?'"

After fixing the movement by designing and making a new spring, Fuentes bought a dial, a case and other components—learning a lot about the global business of watches. As a University Scholar with a full tuition scholarship, Fuentes brought the watch with him when he arrived at Northeastern a few years later.

"I initially declared a major in physics because I enjoy studying *why* things work," Fuentes explains. "But I missed the hands-on aspect—I also wanted to learn *how* things work. So I added a second major in mechanical engineering, and it was the perfect outlet for that desire to take things apart and put them back together."

Fuentes' passion for mechanical systems led him to a co-op at Amazon Robotics in his third year. There, Fuentes and a group of fellow students developed a new robotic arm design capable of picking specific products from a bin, based on their size and shape.

"It was an engineering problem that had plagued Amazon for a long time," recalls Fuentes. "We saw that it would have a huge pay-off in terms of saving time and money. This project not only fulfilled me as an engineer, but also showed me that engineers can do more than solve technical problems—they can support financial results and create a real competitive advantage."

Back on the Northeastern campus, Fuentes had been hearing a lot about engineers and entrepreneurship. "There were all these programs like IDEA, Generate, and the Sherman Center, which reflected Northeastern's growing support for merging engineering and business," says Fuentes. He became a project leader at the student-run Build studio, part of the College of Engineering's Generate program—where he helped other founders solve product-related technical problems. He also became a technical analyst for Northeastern's IDEA program, helping to choose student-led projects for funding based on their product's technical merit.

Fuentes also used the opportunity to combine his passions for watches and mechanical engineering to develop a new product: a vintage-inspired watch produced via modern manufacturing methods. He did much of the research and development himself and was awarded funding through Northeastern's entrepreneurial ecosystem, as well as through the Scholars Independent Research Fellowship.

All the while, Fuentes continued to work for Amazon Robotics and, upon graduating last year, he moved to Seattle to work for Amazon as an automation hardware engineer. Notes Fuentes, "I replicate product designs in the virtual world and make recommendations about how to improve them. It's very rewarding, as it ties directly to my love of problem-solving."

Equally gratifying, Fuentes continued development of his watch design and founded Fuentes Watch Company. He hopes to launch his first design, the Bethany, later this year.

"What I learned at Northeastern is to believe in myself and follow my goals, no matter how nontraditional they may seem," Fuentes says. "'If you look at my path—physics, engineering, robotics, watches, entrepreneurship—it might make absolutely no sense to others. But it makes perfect sense to *me*."

DEAR ALUMNI AND FRIENDS,

We look back on a year of incredible growth and transformation here at Northeastern's College of Engineering (COE). An intensive curriculum prepares today's students to become tomorrow's engineering leaders. Our world-class co-op program matches highly talented students to top companies throughout the globe. Cutting-edge research pushes the boundaries of innovation in world-changing areas from spurring the internet of things and driving the robotics revolution to fighting cancer and predicting the effects of climate change for a more resilient world.

As we set the stage for these accomplishments and more, we have you, our donors, to thank.

COE alumni and friends are models in philanthropy, volunteering, and ambassadorship. You have supported undergraduate scholarships, graduate fellowships, and state-of-the-art educational and research programs. You empower a faculty devoted to breaking new ground, and offer your services as advisors and leaders as we bridge the College with the broader community. Your support has helped COE become the institution it is today, and we are thankful for all of your efforts, commitment, and generosity.

The following pages highlight just a few of the many ways your dedication to the College is advancing our mission. Whether it is the creation of undergraduate scholarships, the funding of graduate fellowships, or the advancement of the faculty, programs, and student organizations that so enrich campus life, you are a crucial part of the Northeastern community. We hope these stories inspire you as much as they do us.

From all of us in COE, thank you for your support!

With appreciation,

The COE Development Team

From left to right: Michael O'Brien, Matt Kirby, Sarah Batista-Pereira, Mike Booras, Kit McCarthy, Taylor Brown, and not pictured, Laurie Bowater

KEY
*Deceased
† indicates new Speare Society member
PNT designates parent(s) of a current student or 2018 graduate

BENEFACTORS

The following donors are College of Engineering alumni and friends who have made a lifetime commitment of $1 million or more to Northeastern University by December 31, 2018. Benefactors are members of The Huntington Society.

Maureen Egan
Edward G., E'73, and Catherine Galante
Francis A., E'59, and Joan A. Gicca
Robert H. Goodale, E'55
Bernard M., H'07, and Sophia Gordon
James W., E'54, and Sandra R. Healy
Charles J., ME'73, and Josephine Hoff
Martha E. Hurtig
Ellen Kariotis
Irving M., E'57, and Lenore Levine
Francis A., E'63, and Marlene Long
Anthony R., E'67, H'08, and Michele F. Manganaro
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Lorraine C. Snell
Sy, ME'68, H'12, and Laurie Sternberg
Arthur W., E'61, and Lisa Zafiropoulo
Anonymous (2)

THE HUNTINGTON SOCIETY

Current members through December 31, 2018

The following donors are College of Engineering alumni and friends who have given a gift in support of the College, and qualifies for a five-year term in The Huntington Society. Members of the Huntington Society have made one-time commitments of $100,000 or more.

Jean-Michel R. Ares and Sherrill E. McMaster, PNT
John W., Jr., and Katharine Cipolla
John J. Cochrane, E'60
Rose M. Correia
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Chaitanya Kanojia, ME'93, and Tracie Longman
Robert R., E'73, and Louise Kursmark
Michael M., E'55*, and Arlene Lanes
Linda M., E'82, and Robert B. MacIntosh
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Georges A. Melhem, E'84, ME'86, PhD'88
Timothy P. Moore, SET'87, E'88
Vilas Mujumdar
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Dennis J., LI'59, UC'62, H'89, and Dolores Picard
Eugene M., Jr., E'60, MEd'65, H'95, and Corinne C. Reppucci, LA'64, MEd'71
George P. Sakellaris, ME'75, MBA'82, and Caterina Papoulias-Sakellaris
Winslow L., E'86, and Ikanyeng Sargeant
Michael B. Silevitch, E'65, ME'66, PhD'71
Gordon H., Jr., E'66, ME'73, and Jane Slaney
James P., E'88, and Amie M. Smith, AS'87
Francis L., E'62, ME'64, and Marilyn Tempesta
Gregory L. Waters, MS'89
Mohamad A. Zameli and Dina Tabbara
Anonymous (4)

FRANK PALMER SPEARE SOCIETY

The Frank Palmer Speare Society is named for Northeastern's first president and recognizes donors who have made estate provisions or other planned gifts in support of the university. The list below honors alumni and friends of the College of Engineering who are members of the Frank Palmer Speare Society.

Robert B., E'47, and Sara Angus
George J. Antonucci, E'63
Charles T. Barooshian, E'59
Harry R. Bedell Jr., E'50
Richard J., E'63, ME'65, and Sandra W. Blaha, Ed'65
Robert Blank, E'80
Richard B., Jr., E'69, and Lennie Bourne
Laurie W. Bowater †
Thomas W. Brahms, E'71
Donald M. Brown, E'52*
Ralph R. Burwell, E'50*
Peter M. Bzowski, E'68, and Orla J. Uber
Anthony J., E'48, and Ann E. Caggiano
Lynne S. Champion, E'69
Peter C., ME'87, and Leslie C. Chatel
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George F. Dawson Jr., E'53
Robert F., E'61, ME'68, and Susan R. Daylor, PNT
Robert A. Derrah, E'55*
Thomas J., Jr., E'73, MBA'78, and Marie Falvey DeSisto, N'77
David A., E'59, and Louise Doane
Roger J., E'63, and Rochelle K. Dolan, E'63
Elisabeth M. Drake
Richard, E'52, and MJ Ebens
Donna Ellsworth
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Mark D. Epstein, E'10, MBA'11
William E. Epstein, E'72
Rita F. Fahy, LA'78, ME'89
Robert R. Feier, MS'64, ME'69
Yves J. Fournier, ME'67, ME'72
N. Paul Galluzzi, ME'58
Francis A., E'59, and Joan A. Gicca
Robert M., E'62, and Deanne Glorioso
Robert L., E'59, and Frances Z. Goldberg
Richard A. Grenier, LI'76
Louis L., E'59, and Janice M. Guerriere
Stephen P., E'78, and Kathryn Hannabury
William T., IV, ME'70, and Joan L. Hathaway
James W., E'54, and Sandra R. Healy
Kenneth W., E'56, and Barbara P. Hiseler
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David P., E'86, and Paula Hunter
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John D. Morrissey, E'59
Ramesh K. Motwane, E'77
Vilas Mujumdar
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William H. Newman III, E'77
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Steven, E'64, and Helice Picheny
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KEY
*Deceased
PNT designates parent(s) of a current student or 2018 graduate

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Vinod Sahney
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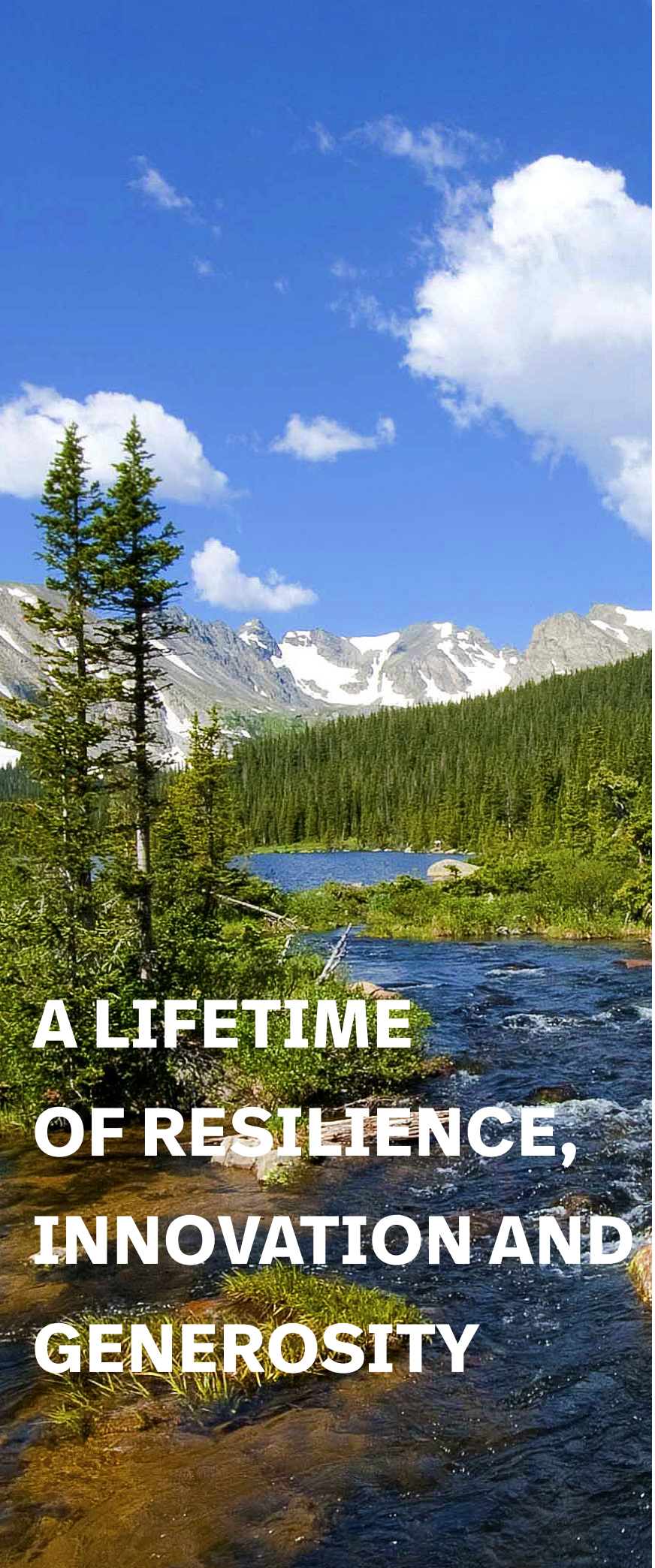

A LIFETIME OF RESILIENCE, INNOVATION AND GENEROSITY

Growing up in Braintree, Massachusetts, in the 1940s, Bob Goodale (E'55) dreamed of becoming an engineer. He also knew that college represented a huge financial challenge.

"My dad died when I was six years old. My mother, brother, and I had to move in with my grandfather and bachelor uncle," he recalls. "My mom was a single parent and worked as a bookkeeper. She had to commute to Boston from Braintree, and that involved both bus and train transportation. Maintaining a house and working every weekday was a physical challenge."

Prior to his graduation from high school in 1950, Goodale was lucky to get a job at Blue Hill Cemetery for $1.00 an hour. Initially he pushed a lawnmower, then progressed to digging monument foundations and graves. It was hard physical work. This exposure made him realize that he had to succeed in engineering school. Goodale logged a lot of overtime, earning enough money to pay board at home and meet the first-year tuition requirements for Northeastern University.

Northeastern's co-op program provided the perfect solution for Goodale, allowing him to work 10 weeks to earn money for tuition, then attend classes for the next 10 weeks. "Without the opportunity to work as a co-op student, I couldn't have earned an engineering degree," says Goodale. "Not only was I able to pay for my own tuition, but I learned the importance of having a degree in entering the corporate world."

Upon graduating with a degree in chemical engineering, Goodale accepted a job at Firestone's home office in Akron, Ohio—first as a trainee in textiles and adhesives, then as a technical salesperson for Firestone Plastics. One day, while Goodale was attending a meeting at competitor BF Goodrich, a young secretary named Betty brought coffee into the conference room. Goodale later asked her to a dance, and the rest is history. The couple married in 1960 and have two daughters, Holly and Jayme.

From Firestone, Goodale moved on to General Electric's Silicone Products Division, based on experience he had gained working with silicone-based coatings during a Northeastern co-op.

AN ENTREPRENEURIAL IDEA TAKES FLIGHT

While working as a product planner for industrial liquid silicones, as well as medical and dental products, Goodale met with a doctor at Harvard Medical School who was looking for a liquid silicone that could replace blood in animal studies.

Goodale purchased a used paint mill for $1000 and made the product himself. Several months later, Goodale launched his product– Microfil™–with the first order going to Harvard Medical School. The product is now over 50 years old and has proven an effective research tool to measure the effects of diet, medication, and disease on research animals.

While at GE, Goodale also introduced a high-strength liquid silicone for industrial applications. The product, called RTV-630, became the division's highest-selling product. When Neil Armstrong took his first steps on the moon in 1969, his shoes were actually made from RTV-630.

While Goodale made a huge impact at GE, he wanted to start his own company. He read a marketing study on future applications for silicone in the laboratory, which led to an idea for a new business venture. He partnered with a GE technician to manufacture and make high-temperature seals for gas chromatography samples. While existing seals were made entirely of silicone, Goodale's solution added a thin film of Teflon to minimize the risk of contamination. This product, Microsep™, was an instant success. It allowed their company, Canton Biomedical Products, to market products to key instrument sellers including Hewlett-Packard, Varian, and Perkin Elmer.

HIGH RISK, HIGH REWARD

In 1970, Goodale and his young family moved to Boulder, Colorado, where they bought a house. Goodale used the basement as an office and manufacturing space for Microfil production. "My goal was to earn $100,000 in annual sales, with a potential salary of $15,000," explains Goodale. "I did all the manufacturing, and Betty did all the invoicing and bill paying. It was a team effort."

Twenty years later, when the business was sold to Loctite Corporation, sales were over $4.3 million.

Today, at age 87, Goodale is not slowing down. He now owns a company, Monic (www.monic.com), that makes a product near and dear to his heart: fly-fishing line. He began working on this product back in 1988, using new polymers rather than polyvinyl chloride materials. By combining his passion for materials innovation and his love of fly fishing, Goodale has developed a product that he says is environmentally friendly and offers significant benefits over traditional line designs that have been in use for 60 years.

PAYING IT FORWARD

While Bob Goodale has forged an incredibly successful career as an entrepreneur, he has never forgotten his roots in Boston or his struggle to earn a college degree. For that reason, he has donated generously to Northeastern's College of Engineering, including gifts to the Engineering Dean's Fund, Financial Aid, and the Chemical Engineering Department.

Goodale's donations have enabled the creation of the Robert H. and Betty Goodale Engineering Scholarship Fund, which provides tuition support for chemical engineering students from New England with a demonstrated financial need. Recently, Goodale enhanced the future of this scholarship via a $2 million charitable remainder unitrust.

"My gifts to Northeastern and its students are based on profits from my business ventures," states Goodale. "I've been very fortunate, and I believe it's only right to give something back—and ensure that others have an opportunity to attend Northeastern and achieve their own success."

> ***"I've been very fortunate, and I believe it's only right to give something back—and ensure that others have an opportunity to attend Northeastern and achieve their own success."***
>
> Bob Goodale, E'55

Committed to Helping the Next Generation of Engineers

For Akira Yamamura, a 1967 meeting with the late Professor Arthur Foster, then chairman of Northeastern's Department of Mechanical Engineering, turned out to be a life changing encounter—one that set him on a path to professional success and with a commitment to help future engineering students succeed.

After earning a bachelor's degree in mechanical engineering from Keio University in his native Japan, Yamamura travelled to the U.S. to find a university where he could continue his studies. His close high school friend, also studying in the U.S., introduced Yamamura to his aunt, who was the owner of a Japanese grocery store in Cambridge, Mass. She, in turn, encouraged him to visit Northeastern where he met Foster. Impressed by the young man's potential and drive, Foster offered Yamamura a teaching assistantship, and the opportunity to pursue a master's degree in mechanical engineering.

In Yamamura's view, "It worked out quite well." That turned out to be an understatement. Today, he serves as president and representative director of Ferrotec Holdings Corporation, a successful international technology company which he founded and has led since 1980. Based in Tokyo with customers in the U.S., Europe, and Asia, Ferrotec is a pioneer in magnetic fluids and a key supplier in the electronics industry.

Finding success, giving back

Looking back at his two years at Northeastern, Yamamura chuckles as he recalls the day he learned that Japanese and U.S. students were a bit different. Unable to teach a class because of illness, he assumed his students would be happy for the break. "In Japan, they would welcome a day off to play mahjong or something," he says, "but my students were upset they were missing class, and a few of them demanded a refund."

Yamamura persevered, and when he graduated from Northeastern in 1969, Foster steered him towards the thermoelectric field. Yamamura soon joined Cambridge Thermionic Corporation where he wrote the first thermoelectric handbook. The job sparked Yamamura's lifelong interest in the field and eventually led him several years later to establish Ferrotec whose core technology is thermoelectric modules, which today represent 25 percent of the company's sales.

"I am a very lucky man," he says, "and I am grateful to Professor Foster for pointing me in the direction I was meant to travel. I learned not only thermoelectrics. I learned what I should be doing."

His decision to give back by funding the Akira Yamamura Fellowship for PhD students in mechanical engineering, as well as an engineering scholarship in his name, is an expression of the gratitude he feels for the opportunities he had at Northeastern. "I have been given many things because of the teaching assistantship Professor Foster gave me," he says. "I am happy to do as much as possible to support those students."

Yamamura returned to campus in 2018 for a brief visit. "I was impressed with Northeastern when I was a student, and I'm impressed now, particularly by how much the university has grown," he says. While visiting the school, he was especially gratified to meet one of the students who benefitted from his generous support. "The student thanked me for his scholarship and told me he was able to start his own business," he says. "I'm glad what I'm doing is helping Northeastern students."

> ***"I was impressed with Northeastern when I was a student, and I'm impressed now, particularly by how much the university has grown… I'm glad what I'm doing is helping Northeastern students. "***
>
> Akira Yamamura, ME'69

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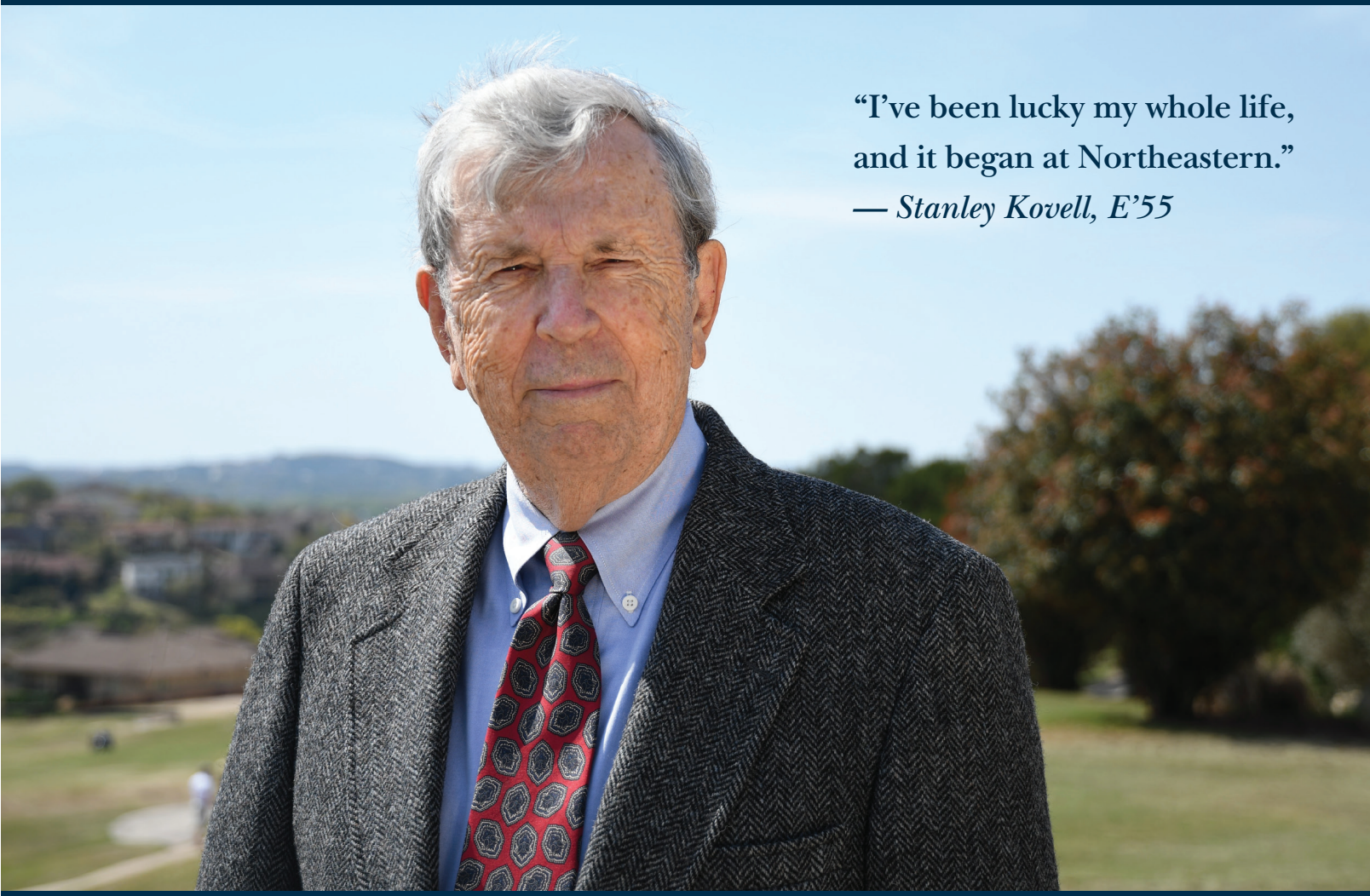

At age 22, Stanley Kovell, E'55, landed an impressive first management job: overseeing more than 100 military and civilian personnel at Sandia Special Weapons Depot, the U.S. Department of Defense's nuclear weapons installation in New Mexico. Kovell credits his success to his own fortitude–and to a scholarship from Northeastern, where he studied chemical engineering during the Korean War.

"I was the first person in my family to go to college," says Kovell. "My scholarship made it possible for me to afford my education, get experience, and study my interests."

At Northeastern, Kovell made the most of his co-ops and the university's Reserve Officers' Training Corps program, which prepared him for opportunities that followed. His first post-graduation job at Pratt & Whitney Aircraft required a top secret security clearance, an advantage when he was later drafted by the Army and assigned to Sandia Special Weapons Depot. There, a seasoned Air Force major mentored him and helped him quickly hone his leadership and decision making skills.

"I learned not to ask for something, but instead say what's needed," he explains. "That was a big life lesson." Kovell carried those experiences with him throughout his career in the aerospace industry.

Grateful for Northeastern's support of his academic pursuits, Kovell wants to do the same for today's students. Through a gift in his estate plan that will set up an endowed scholarship, he hopes to give chemical engineering students the chance to study free of financial burdens and stress.

"When you give a deserving student a chance, they will accomplish great things." Kovell says.

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Xupeng Zhu, electrical engineering graduate student, ME'20, works in the new robotics laboratory on the fifth floor of the Interdisciplinary Science and Engineering Complex. The new space enables interdisciplinary research in a variety of areas, including manipulation of novel objects, field robotics, aerial robotics, and assistive robotics. With more than 12,000 square feet of space dedicated to robot fabrication, testing, and prototyping, the facility is the home for 16 principal investigators and more than 100 graduate students. It has state-of-the-art robot systems, including collaborative manipulator arms, drones, human support robots and field robots.