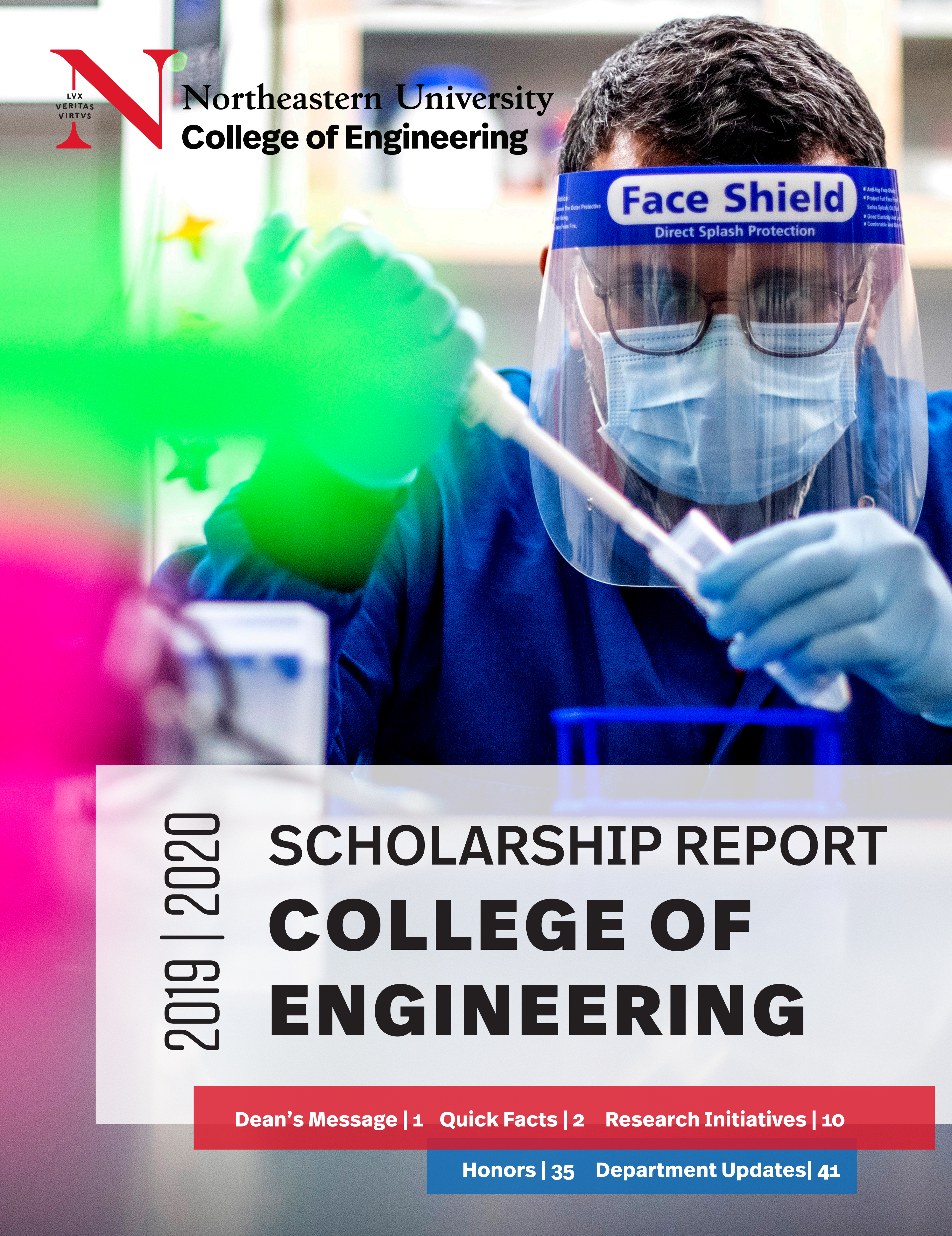
Northeastern University
College of Engineering



2019 | 2020

SCHOLARSHIP REPORT
COLLEGE OF ENGINEERING

WE ARE A LEADER IN EXPERIENTIAL EDUCATION AND INTERDISCIPLINARY RESEARCH, FOCUSED ON ENGINEERING FOR SOCIETY

Dear Colleagues, Friends, and Students,

A Rhodes Scholar. A Jefferson Science Fellow. And five Young Investigator Awards. These are just some of the impressive accomplishments of our faculty and students during the 2019-2020 academic year. Our College of Engineering at Northeastern University also continued its strong performance; *U.S. News and World Reports* ranked our graduate engineering program at 31, a three-place improvement for the second year in a row.

Despite the pandemic, our research operations continued as we embraced the new normal with creativity, innovation, and passion to make a difference in the world. Many of our faculty quickly shifted gears to address COVID-19 challenges, receiving 10 RAPID grants from the National Science Foundation. For the year, our college received $86 million in external research awards, up 139% as compared to fiscal year 2014. Highlights include a $10.7 million renewal grant from the National Institutes of Health to continue the bold environmental health work of our Puerto Rico Testsite to Explore Contamination Threats (PROTECT) research center; $5 million in funding from the National Science Foundation to support the move to Northeastern of the Defense Advanced Research Project Agency's (DARPA's) Colosseum, the world's largest wireless emulator, which is now managed by our Institute for the Wireless Internet of Things; and nearly $5 million in awards for our Awareness and Localization of Explosives-Related Threats (ALERT) research center from the U.S. Department of Homeland Security Science and Technology Directorate.

With our strong research enterprise, new multidisciplinary graduate degrees meeting real-world evolving needs, and innovative experiential learning opportunities—such as cooperative education for master's students and the Experiential PhD program—graduate students now comprise more than half of our total student body.

Our faculty are the heart of our success. This year we welcome 13 new tenured/tenure-track faculty to our community. I am also proud to share that over the past academic year our faculty received 21 external national awards, including young investigator awards and being named fellows of their professional societies.

These are just some of the many accomplishments and initiatives happening in the College of Engineering. I invite you to explore this Scholarship Report and to contact us for more information.

Sincerely,

Jacqueline A. Isaacs, PhD
Interim Dean
College of Engineering
Northeastern University

QUICK FACTS

COLLEGE OF ENGINEERING

Five-year performance 2014 to 2019

ENROLLMENT AND OUTCOMES

GRADUATE DEGREE CONFERRALS

1525

up **132%**

1490

Mean 2-part SAT score up 44 points

TOTAL ENROLLMENT

8460

53% Graduate
47% Undergraduate

Enrollment Growth
(2014 to 2019)

115% MS
36% PhD
24% BS

36%

Freshmen are women, up from 26%

INTERDISCIPLINARY AND EXPERIENTIAL LEARNING

GRADUATE CO-OP PLACEMENTS

1038

Up 62% vs. 2016

GLOBAL CO-OP PLACEMENTS

72%

Increase since 2016

105 Degree programs, minors and graduate certificates on three campuses and online

459

PlusOne pathways including interdisciplinary with other Northeastern colleges

41

Academic programs interdisciplinary with other Northeastern University colleges

TRANSFORMATIONAL RESEARCH

$86M

2020 External Research Awards up **139%** vs. 2014

95

Young Investigator Awards (YIAs) including **50** NSF CAREER Awards and **18** DOD YIAs

138

Patents (2014-August 2020)

Welcome New Faculty

RUOBING BAI
Assistant Professor
(joining January 2021)
Mechanical and Industrial Engineering, Bioengineering
PhD, Harvard University, 2018
Scholarship focus: solid mechanics and large deformation, soft active materials: hydrogels, liquid crystal elastomers, and biomaterials, fracture and adhesion of materials, multi-physics of materials: mechanics, thermodynamics, chemistry, optics, and electromagnetism, instability of materials

SIDDHARTHA GHOSH
Assistant Professor
(joining January 2021)
Electrical and Computer Engineering
PhD, Carnegie Mellon University, 2015
Scholarship focus: Acousto-optic and acousto-electric signal processing devices, integrated photonics, piezoelectric MEMS, oscillator-based computing, nanofabrication techniques and heterogeneous material integration

JULIA HOPKINS
Assistant Professor
Civil and Environmental Engineering
PhD, Massachusetts Institue of Technology, 2017
Scholarship focus: Coastal morphodynamics, including effects of extreme weather events on sediment transport in the surf zone; wave-current interactions in the nearshore; developing and implementing field-verified numerical models to study coastal processes, informing coastal management with process-based research

DIMITRIOS KOUTSONIKOLAS
Associate Professor
(joining January 2021)
Electrical and Computer Engineering
PhD, Purdue University, 2010
Scholarship focus: Experimental wireless networking and mobile computing, with a current focus on millimeter wave networking, high-bandwidth applications (VR, 360o video streaming) over wireless networks, LTE/WiFi coexistence, energy-aware protocol design for smartphones, and wireless sensing

LAURENT LESSARD
Associate Professor
Mechanical and Industrial Engineering
PhD, Stanford University, 2011
Scholarship focus: Control theory, linear systems, optimization algorithms, machine learning

ELIZABETH LIBBY
Assistant Professor
(joining January 2021)
Bioengineering
PhD, University of Pennsylvania, 2011
Scholarship focus: Synthetic biology, microbiology, biosensor development

MINGYANG LU
Assistant Professor
Bioengineering
PhD, Baylor University, 2010
Scholarship focus: Computational systems biology, an integration of mathematical modeling and bioinformatics for studying gene regulatory networks, single cell genomics, epithelial-mesenchymal transition, coarse-graining, reverse engineering, machine learning, stochasticity and heterogeneity in gene expression

FRANCESCO RESTUCCIA
Assistant Professor
Electrical and Computer Engineering
PhD, Missouri University of Science and Technology, 2016
Scholarship focus: Next-generation wireless communications, artificial intelligence, embedded systems, wireless security

LILI SU
Assistant Professor
Electrical and Computer Engineering
PhD, University of Illinois, 2017
Scholarship focus: Distributed machine learning, security and fault-tolerance, neural computation, bio-inspired distributed algorithms, blockchains, autonomous cars, algorithm design

HONGWEI SUN
Professor
Mechanical and Industrial Engineering
PhD, Institute of Engineering Thermophysics, Chinese Academy of Sciences, 1998
Scholarship focus: Multiphase thermal transport phenomena, acoustic wave bio and chemical sensors and actuators, thermal management of fibers and films, thermal energy storage materials and processing, microchannel cooling systems, nanoimprinting process and applications, MEMS/NEMS fabrication, microfluidics and bioMEMS; nanoscale magnetic assembly and applications

XIAOYU TANG
Assistant Professor
(joining January 2021)
Mechanical and Industrial Engineering
PhD, Princeton University, 2018
Scholarship focus: Fluid mechanics, soft matter, microfluidics, active colloidal systems, electrokinetic flow, interfacial phenomena, complex fluids, reactive flow, biological flow; additive manufacturing, material synthesis and processing in flow, oil/gas recovery and remediation

REBECCA KUNTZ WILLITS
Professor and Chair
Chemical Engineering
PhD, Cornell University, 1999
Scholarship focus: Neural regenerative strategies, neural mechanosensing, diversity and inclusion in engineering

XIAOLIN XU
Assistant Professor
Electrical and Computer Engineering
PhD, University of Massachusetts Amherst, 2016
Scholarship focus: Hardware security and trust, high-performance VLSI, computer architecture, and embedded systems

189 **TENURED/ TENURE-TRACK** faculty

18 Multidisciplinary Research Centers and Institutes
FUNDING BY EIGHT FEDERAL AGENCIES

ALERT Awareness and Localization of Explosives-Related Threats; a multi-university Department of Homeland Security Center of Excellence

BTIC Beyond Traffic Innovation Center; designated by the U.S. Department of Transportation, BTIC leads interdisciplinary research on transportation challenges of the next three decades for the Northeast region

CHEST Center for Hardware and Embedded Systems Security and Trust; a multi-university National Science Foundation Research Center, part of the Industry-University Cooperative Research Centers Program

CHN Center for High-rate Nanomanufacturing; a multi-institution National Science Foundation Nanoscale Science and Engineering Center

CIBC Center for Integrative Biomedical Computing; a National Institutes of Health university collaborative Research Center producing open-source software tools

CRECE Center for Research on Early Childhood Exposure and Development; a U.S. Environmental Protection Agency and National Institute of Environmental Health Sciences multi-project, multi-institution Research Center

CURENT Center for Ultra-wide-area Resilient Electric Energy Transmission Networks; a National Science Foundation and Department of Energy multi-university Engineering Research Center

GORDON-CenSSIS Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems; a National Science Foundation graduated multi-university Engineering Research Center

HSyE Healthcare Systems Engineering Institute; a Department of Health and Human Services Center through the CMMI program; a university-level institute focused on healthcare improvement

IIA Institute of Information Assurance; a National Security Agency/Department of Homeland Security Center of Academic Excellence

INSTITUTE FOR CHEMICAL IMAGING OF LIVING SYSTEMS An interdisciplinary Northeastern University institute focused on creating technologies to view chemical processes in the brain and body in real time

INSTITUTE FOR EXPERIENTIAL ROBOTICS An interdisciplinary, Northeastern University institute focused on designing machines that adapt to people in real time for a more collaborative human-robot experience

INSTITUTE FOR THE WIRELESS INTERNET OF THINGS An interdisciplinary, Northeastern University institute focused on advancing wireless technologies for next-generation networked systems

NORTHEASTERN SMART CENTER A Northeastern College of Engineering research center aimed at conceiving and piloting disruptive technological innovation in smart devices and systems to make everyday life safer, easier and more efficient

PROTECT Puerto Rico Testsite for Exploring Contamination Threats; a National Institute of Environmental Health Sciences multi-project, multi-institution Research Center

SPIRAL Center for Signal Processing, Imaging, Reasoning, and Learning; a federation of collaborating research laboratories

TANMS Center for Translational Applications of Nanoscale Multiferroic Systems; a National Science Foundation university collaborative Research Center

VOTERS Versatile Onboard Traffic Embedded Roaming Sensors; a graduated multi-institutional National Institute of Standards and Technology (NIST) Technology Innovation Program project

Research Conferences

SELECT HIGHLIGHTS

College of Engineering faculty host a variety of research conferences throughout the year to foster collaboration and knowledge sharing among industry, government, and academia.

ACM SIGMETRICS 2020

Northeastern's electrical and computer engineering (ECE) faculty led the organization of ACM SIGMETRICS 2020. The conference, originally scheduled to take place on the Northeastern campus, was successfully held online June 9-12, 2020 and was attended by more than 730 participants. ECE Professor Edmund Yeh served as general chair; Associate Professors Ningfang Mi and Stratis Ioannidis served as local arrangements chair and student activities co-chair, respectively. Graduate student Faruk Volkan Mutlu served as web chair. SIGMETRICS is the flagship conference of the ACM in the area of performance analysis of computer systems, and the development of tools and innovative application of tools towards this end.

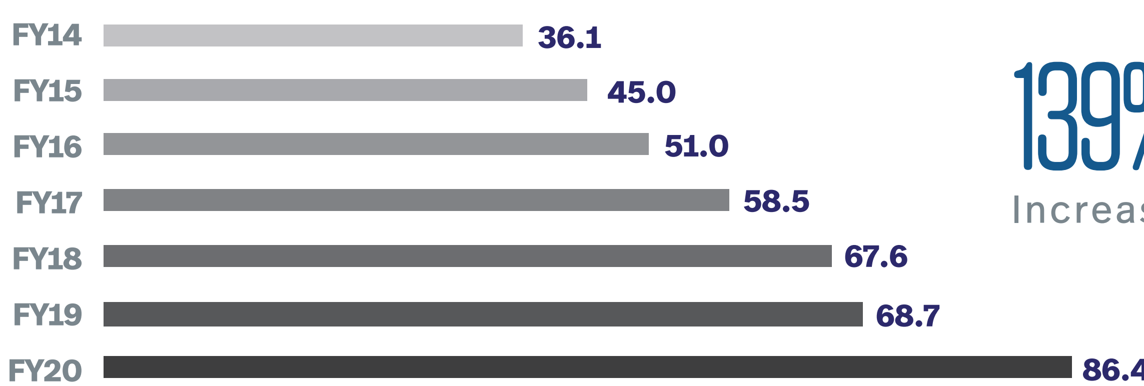
2020 Single Cell Proteomics Conference

The third annual Single Cell Proteomics Conference was held virtually August 18-19, 2020, led by Nikolai Slavov, assistant professor of bioengineering at Northeastern University. Slavov recently received the prestigious Paul. G. Allen Distinguished Investigator award for his pioneering research in the single cell proteomics field. 300 attendees from around the world joined the meeting designed to promote the scientific exchange of ideas, results, and emerging technologies. Single cell proteomics allow quantifying thousands of proteins in very small samples, down to single mammalian cells. This progress is poised to transform biomedical research, from fundamental biological research to biomedical engineering and clinical applications.

2020 NSF/NIH Principal Investigator Workshop on Advancing Health Through Science

Professor of Mechanical and Industrial Engineering Yingzi Lin, who is director of Northeastern's Intelligent Human-Machine System Laboratory, hosted the 2020 Smart and Connected Health (SCH) Principal Investigator Meeting and Workshop, titled "Advancing Health Through Science" at the National Science Foundation in Alexandria Virginia January 6-7, 2020. Drawing 250 attendees, the meeting discussed and promoted advances in smart health research and aimed to foster partnerships for the future of smart health. The workshop's focus was on connections within and between communities, and included a diverse group of researchers, including, but not limited to, current Principal Investigators (PIs) of SCH-funded projects from the NSF and National Institutes of Health (NIH), biomedical researchers, and industry participants. The meeting discussed research progress, challenges, and future directions.

External Research Award Growth ($M)



139% Increase

NACME

NATIONAL ACTION COUNCIL FOR MINORITIES IN ENGINEERING

Northeastern Partners with National Action Council for Minorities in Engineering

A new partnership between Northeastern University and the National Action Council for Minorities in Engineering (NACME) will provide scholarship opportunities for highly talented undergraduate engineering students from historically underrepresented populations. NACME is the largest provider of college scholarships for underrepresented minorities pursuing degrees at schools of engineering. Northeastern is the only university partner in Massachusetts out of 38 university members nationwide.

Meet Our 2020 Rhodes Scholar

Kritika Singh, E'20, bioengineering, is one of only 32 students from the U.S. selected as a 2020 Rhodes Scholar. She was also named the winner of the Harold D. Hodgkinson Achievement Award for 2020, one of the highest honors a senior can receive, as well as named an NIH OxCam Scholar. See page 39.

5 ENGINEERING DEPARTMENTS

Department Research Areas

BIOENGINEERING

Biomechanics, Biotransport and MechanoBiology

Computational and Systems Biology

Imaging, Instrumentation & Signal Processing

Molecular, Cell and Tissue Engineering

CHEMICAL ENGINEERING

Advanced Materials Research

Biological Engineering

CIVIL AND ENVIRONMENTAL ENGINEERING

Civil Infrastructure Security

Environmental Health

Sustainable Resource Engineering

ELECTRICAL AND COMPUTER ENGINEERING

Communications Control and Signal Processing

Computer Networks and Security

Computer Systems and Software

Computer Vision, Machine Learning, & Algorithms

Electromagnetics and Optics

Microsystems and Devices

Power Electronics, Systems and Controls

Robotics

MECHANICAL AND INDUSTRIAL ENGINEERING

Biomechanics and Soft Matters – Solids & Fluids

Energy Systems

Healthcare Systems

Impact Mechanics

Mechatronics and Systems – Control, Robotics, and Human Machines

Multi-phase Structured Matter

Multifunctional Composites

Resilient Systems

Smart and Sustainable Manufacturing

Upon Graduation, Masters and PhD Students Take Positions at Top Organizations

RESEARCH

National Institutes of Health

Boston Children's Hospital

Brigham and Women's Hospital

Draper Laboratory

NASA Jet Propulsion Lab

NASA Ames

MIT Lincoln Lab

Merck & Co.

Takeda

National Labs such as Argonne, Brookhaven, Oak Ridge, Pacific Northwest, Sandia

Pfizer

Children's Hospital – Philadelphia

Massachusetts General Hospital

ACADEMIA

University of California (Berkeley, Los Angeles, San Francisco)

Massachusetts Institute of Technology

Johns Hopkins University

Boston University

Rensselaer Polytechnic Institute

Harvard Medical School

Harvard University

University of Maryland

University of Minnesota

University of Wisconsin

University of Toronto

Baylor College of Medicine

University of Massachusetts, Lowell and Amherst

Columbia University

INDUSTRY

Google, Microsoft, Bristol-Myers Squibb, Caterpillar, Cisco, Ford Motor Company, Johnson & Johnson, Samsung, Intel, Dell, Amazon, BAE Systems, Raytheon, IBM, PayPal, Apple, Schneider Electric, Proctor & Gamble, General Electric, Wayfair, JetBlue, Facebook, SpaceX, Tesla, Akamai, iRobot, Pratt & Whitney, Lockheed Martin, Hasbro, Biogen, Fidelity, Liberty Mutual, Thermo Fischer Scientific, PwC, Eversource, National Grid, Air National Guard, Naval Sea System Command, Oracle, Sanofi

Alice Peiying Wang, PhD'19

CIVIL ENGINEERING

Advised by Loretta Fernandez, Associate Professor, Civil and Environmental Engineering, jointly appointed in Marine and Environmental Sciences in the College of Science

While pursuing her PhD in Civil Engineering (CEE) at Northeastern University, Alice Peiying Wang worked closely with researchers at the U.S. Army Corp of Engineers' Environmental Research and Development Center (USACE ERDC). She learned how various potential remedies for PCB contaminated sediments perform in terms of protecting aquatic species from taking up toxic compounds from their environment, and how those remedies respond to ongoing contamination. Through her research she became an expert in the application of passive sampling methods for analyzing transport of contaminants between environmental media. She and Associate Professor Loretta Fernandez collaborated on various publications of this work including "Bioaccumulation in Functionally Different Species: Ongoing Input of PCBs with Sediment Deposition to Activated Carbon Remediated Bed Sediments," which was recognized for the 2019 Top 10 Exceptional Papers Award by *Environmental Toxicology and Chemistry* (ET&C) journal, published by the Society of Environmental Toxicology and Chemistry (SETAC). She presented her work at various professional conferences hosted by organizations including SETAC, American Chemical Society (ACS) and International Passive Sampling Workshop (IPSW). She received Northeastern University conference funding awards from the Graduate Student Government (GSG), Graduate Women in Science and Engineering (GWISE) and the PhD Network. She was one of the founding members of the CEE Graduate Student Council, which helps create a community among the graduate student body through social and professional networking events. She joined Geosyntec Consultants after graduation and now applies her expertise in passive sampling and contaminant transport modeling at project sites across the United States and beyond.

Jessica Faust, PhD'20

MECHANICAL ENGINEERING

Advised by Associate Professor Randall Erb, Mechanical and Industrial Engineering

As a community college student, Jessica Faust was selected for the National Science Foundation's (NSF) Research Experiences for Undergraduates (REU) in summer of 2010 at Northeastern's Center for High-Rate Nanomanufacturing working in the George J. Kostas Nanoscale Technology and Manufacturing Research Center clean room. As an REU the following summer, she worked in the Heterogeneous Materials Multi-scale Mechanics Laboratory in the Mechanical and Industrial Engineering (MIE) department. In 2011, Faust transferred to Worcester Polytechnic Institute (WPI) to continue her undergraduate education, and while there, worked as a research assistant at Northeastern on a collaborative project with the Macromolecular Innovations in Nano-materials Utilizing Systems Laboratory (MINUS Lab) and the Directed Assembly of Particles and Suspensions Laboratory (DAPS Lab), from 2014-2016. Receiving a prestigious NSF Graduate Research Fellowship in 2016, Faust began her PhD at Northeastern in the DAPS Lab. Her doctoral research focused on fundamental breakthroughs in interphase assembly within mechanical and thermal composite materials, one of the most important and complicated topics of study in composite materials such as designing materials for bone graft applications. She also worked at the frontier of RF and telecommunications materials. Her recent dissertation examined three different composite systems, two of which are focused on improving the strength of mechanical properties and the third on thermal properties. Her thermal composite study aims to create an electrical insulating thermally conductive composite that has very high thermal conductivity but will not short circuit the circuit board. Her PhD research resulted in a patent in 2019, titled, "Methods for Creating Thermally Conductive Boron Nitride Films and Coatings on Composite Surfaces," as well as more than 12 conference presentations. Other recognitions include Northeastern's Outstanding Graduate Student Award for Research (2020), the Akira Yamamura MIE Department Award for Research (2020), the John and Katharine Cipolla Early Student Career Award (2019), and the Ferretti Academic Excellence Award (2018). She is currently a post-doctoral researcher at Northeastern in the MIE department.

Jonathan Soucy, PhD'20
CHEMICAL ENGINEERING

Advised by Assistant Professor Ryan Koppes, Chemical Engineering

After receiving his bachelor's degree in chemical engineering from Rensselaer Polytechnic Institute in 2015, Jonathan Soucy joined Northeastern University pursuing a PhD in chemical engineering. His research has focused on neurochemistry, specifically on the sympathetic and parasympathetic nerve systems—the mechanisms by which the brain controls the speed and function of the heart directly and indirectly via the adrenal gland, the "fight or flight" response. Using *in vitro* models of an organ-on-a-chip platform to mimic neural systems, Soucy has studied the nervous system's responses to a wide variety of stimuli, ranging from drug compounds to electric shocks. His research has led to some breakthroughs as well—a biomaterial he developed to encourage regrowth of heart cells was found to work far better with neurons, as well as having strong adhesive properties, effectively acting as nerve superglue in lieu of sutures for repairing nerves and more. His publication on this is one of the most highly cited manuscripts in *Tissue Engineering A*. Overall, Soucy has published seven manuscripts, three as first author, with several more in submission. He also contributed to two filed patents, received Northeastern's Outstanding Graduate Research Award, and an American Heart Association Predoctoral Fellowship. Upon graduation, Soucy joined Harvard Medical School as a postdoctoral fellow, and his career ambition is to become a professor.

Morris Vanegas, PhD'21
BIOENGINEERING

Advised by Associate Professor Qianqian Fang, Bioengineering

Morris Vanegas obtained his BS and MS degrees from MIT before joining the Computational Optics and Translational Imaging Lab (COTI Lab) in the Department of Bioengineering as a PhD student in the Fall of 2016. Since then, he has been the driving force for a number of research projects. In a project funded by the U.S. Agency for International Development (USAID), Morris applied his extensive skills in digital fabrication to develop mobile phone oximeters prototypes for use in low-income countries. He also contributed to a successful NIH BRAIN Initiative R01 grant submission to develop a wearable optical brain imaging system that has since led to a patent application. Morris has been leading the hardware and software design, fabrication, and testing of the probe, resulting in exciting progress toward building a one-of-a-kind modular, non-invasive brain imaging probe for monitoring stroke recovery. Outside of academia, Morris co-founded The Second L, which provides new professionals and those seeking transitions in careers and personal life with exposure to growth and wellness tools through experience-based mentorship models. He is also the acting director of TDC Makerspace, MIT's first residential-based fabrication shop. Morris is a 2019 Latino 30 Under 30 recipient, a 2018 MIT Impact Fellow, and a 2017 Dent the Future Scholar.

Rozhin Doroudi, PhD'20

INDUSTRIAL ENGINEERING

Advised by Ozlem Ergun, Professor of Mechanical and Industrial Engineering

While pursuing her PhD in Industrial Engineering, Rozhin Doroudi leveraged artificial intelligence techniques to understand behavior of human decision makers in a pharmaceutical supply chain and how these behaviors drive drug shortages. She modeled a pharmaceutical supply chain with boundedly rational artificial decision makers capable of reasoning about the motivations and behaviors of others. Such realistic models of human behavior enable studying the effects of trust dynamics in disrupted supply chains. She also focused on another important aspect of pharmaceutical supply chains as part of healthcare systems: equity. She demonstrated how coordination between supply chain decision makers can result in a more equitable system. In her last chapter, Doroudi used Deep Reinforcement Learning to suggest inventory replenishment policies for healthcenters.

During her PhD, Doroudi published two first-author papers and was co-author of another paper. She also presented her research at prestigious conferences. She received the Yaman Yener Memorial Graduate Scholarship from Northeastern University College of Engineering in 2019.

Doroudi was president of INFORMS (Institute for Operations Research and the Management Sciences) student chapter for a year and half. During this time the student chapter won INFORMS 2017 cum laude best student chapter award and Doroudi won the Judith Liebman Award for leading the student chapter. She was also awarded the Alfred J. Ferretti Excellence in Leadership Award in Spring of 2020.

During her graduate program, Doroudi worked as a data scientist intern at Liberty Mutual Insurance for two summers. After receiving her PhD, she joined Liberty Mutual Insurance as a data scientist.

Setareh Ariafar, PhD'20

ELECTRICAL ENGINEERING

Advised by College of Engineering Professors Jennifer Dy and Dana Brooks, Electrical and Computer Engineering

Setareh Ariafar joined the Machine Learning Lab and the Bio-Medical Imaging and Signal Processing Lab to pursue her doctoral studies at Northeastern University in 2015, after finishing her master's degree from Boston University, and a BS and MS from the University of Tehran, Iran. She followed an unusual path to earning a PhD as her undergraduate degree is in industrial design. Enjoying math and passionate about research, her main area of PhD study was in machine learning with a research focus on Bayesian optimization.

Many design problems involve optimization of an unknown, or partially unknown, objective function that can be costly to evaluate. For example, in drug design, the evaluation of drug efficacy across multiple drug formulations requires producing and testing new drugs, which would be subject to resource and cost limitations. Another example is minimizing the validation error of a machine learning model, such as hyperparameter tuning of a deep neural network, which involves many evaluations of the objective function. Bayesian optimization methods enable solving optimization problems whose objective functions are only available as black box functions and are expensive to evaluate. Ariafar was inspired to work on Bayesian optimization from working on the skin cancer detection from reflectance confocal microscopy image project at Northeastern. Deep learning methods work well in this application, however, tuning the hyperparameters of such approaches is challenging.

During her studies at Northeastern, Ariafar won first place in the ACM Student Research Competition Graduate Level Finals at the Grace Hopper Celebration of Women in Computing (the world's largest gathering of women in computation and science with over 15,000 attendees). After presenting her work at a NeurIPS Bayesian Optimization Workshop, the organizers and attendees were impressed by her work which led her to be recruited as an intern at Sigopt. After completing her PhD program, Ariafar joined Google Brain and continues her research in machine learning.

COVID-19 Research

To combat the COVID-19 pandemic, Northeastern's College of Engineering researchers are conducting interdisciplinary research in four strategic areas:

- Vaccines and Diagnostics
- Healthcare and Pharmaceutical Optimization
- Human-Machine Interaction
- Harnessing Data

10 National Science Foundation RAPID Grants Awarded to College of Engineering Faculty

Ozlem Ergun (PI)

"Collecting Supply, Demand, and Matching Data for Assigning Medical Staff to Long Term Care Facilities During the COVID-19 Pandemic"

Jacqueline Griffin (PI), David Kaeli, Ozlem Ergun

"Rapid Monitoring and Assessment of Critical Pharmaceutical Supply Chains"

Laura Lewis (PI)

"Lattice- Defective Copper Oxides as a Biocidal Tool for COVID-19 and Beyond"

Mona Minkara (co-PI)

"Undergraduate Research in Modeling and Computation for Discovery of Molecular Probes for SARS-CoV-2 Proteins"

Taskin Padir (PI)

"Accelerating the Future of Work? Understanding Future Shifts in Technology Adoption in the Seafood Industry in Response to the COVID-19 Pandemic"

Ameet Pinto (PI), Kelsey Piper, Aron Stubbins

"Extreme Water Use Patterns and Their Impact on the Microbial and Chemical Ecology of Drinking Water"

Jeffrey Ruberti (co-PI)

"Low- Cost, Non-invasive, Fast Sample Collection System for COVID-19 Viral Load Level Diagnosis: Point-of-Care and Environmental Testing"

Nian Sun (PI)

"New Handheld Gas Sensors for Airborne SARS-CoV-2 Virus: Instant COVID-19 Diagnosis from Exhaled Breath"

Qi "Ryan" Wang (PI)

"High-Frequency Data Collection for Human Mobility Prediction During COVID-19"

Qi "Ryan" Wang (co-PI)

"Infection Transmission of COVID-19 in Urban Neighborhoods"

Making a Homemade Mask as Good as an N95

Excerpt of full article by Roberto Molar Candanosa

Chemical Engineering Associate Professor Steve Lustig and Professor Ming Su's research on "Effectiveness of Common Fabrics to Block Aqueous Aerosols of Virus-like Nanoparticles" was published in the American Chemical Society journal, Nano. It was also featured articles in *U.S. Army Defense One and Science News Service.*

After testing how nanoparticles penetrated more than 70 combinations of fabrics, the team found several combinations of common materials that can be as effective at blocking coronavirus particles as N95s—or better. The trick, Lustig says, is that the fabrics must be layered tactically.

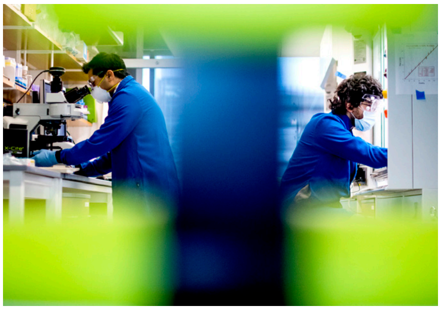
"Most fabrics aren't as good as the official, certified N95 respirators." Lustig says. "But no one had really asked the question of how many layers it would take for cotton, for example, to be as good as an N95."

One of the most important aspects of how to lay fabric that can block viral particles is to combine materials that have enough fibers to increase their chances of trapping, or absorbing, germs.

Another key part of that puzzle is to use at least one layer with hydrophobic properties, which would repel aqueous substances such as respiratory droplets from someone's airway and prevent them from passing through the mask. If the liquid wets the fabric, it can move viral material through it.

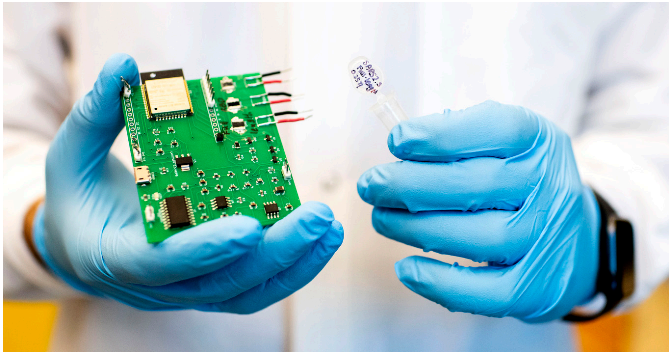
That combination of layers, in addition to a snug fit around the face and proper physical distancing, can make for a significant defense system, Lustig says.

The research is published at: https://pubs.acs.org/doi/10.1021/acsnano.0c03972



Doctoral students Devyesh Rana and John Biswakarma spray fluorescent nanoparticles (virus simulant) through fabrics onto glass slides to measure the concentration in Associate Professor Steve Lustig's lab.

Handheld Gas Sensor for Rapid SARS-CoV-2 Virus in Air Detection



Professor Nian Sun, electrical and computer engineering, was recently awarded a $200K National Science Foundation RAPID grant for "COVID-19: New Handheld Gas Sensors for Airborne SARS-CoV-2 Virus: Instant COVID-19 Diagnosis from Exhaled Breath." In collaboration with Jeremy Luban from UMass Medical School, Sun aims to streamline the COVID-19 detection and diagnosis process.

The two will develop a handheld gas sensor for SARS-CoV-2 virus in air detection, using each of their fields of expertise. Sun specializes in sensors and electronics engineering, while Luban brings his virus, proteins, biochemistry and molecular pharmacology knowledge. They are working to develop clinical trials and want to gain emergency use approval from the Food and Drug Administration (FDA), he says.

The SARS-CoV-2 sensors are unique in that they are sensitive enough to specifically detect varying mutated strains of COVID-19, Sun explains. "Whether it is the Wuhan reference strain, or the mutated strain from the U.S., we can detect that," he says. "There are spike protein variants with tiny changes, and our sensors can differentiate them."

Sun has been working on building sensors that can detect and diagnose diseases for several years. A woman from Scotland made headlines when it was revealed that she could smell Parkinson's disease, he notes. Researchers subsequently used a mass spectrometer to mimic that approach and help to detect Parkinson's in patients. Similarly, dogs are used for their sense of smell to detect drugs, weapons, and bombs, Sun states.

"Why can we not do this?" he says.

That was six years ago, and he has since been perfecting his development and design of sensors that can detect disease. With the rise of the COVID-19 pandemic, it just made sense to pivot what he wanted the sensors to detect, Sun says.

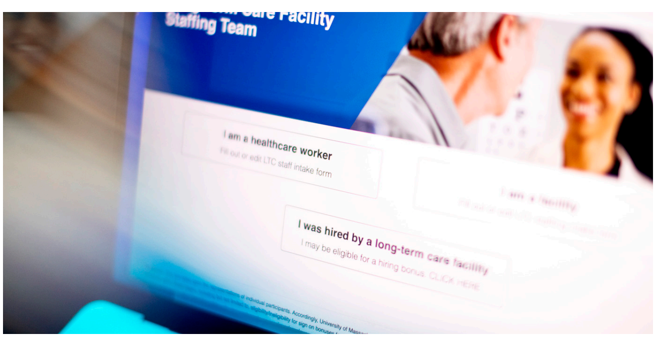
The electromechanical sensors are significantly advanced compared to current testing measures. The gas sensor "will instantly detect SARS-CoV-2 in 1~2 seconds in exhaled breath and on surfaces, based on their demonstrated success on different gas sensors," according to the grant.

Currently, the fastest COVID-19 detection tests take about five to ten minutes, Sun explains. With re-opening plans in effect across the country, he stressed the importance of being able to guarantee quick, accurate testing.

"When we open universities and schools, shopping malls, movie theaters, people want to know whether someone is a carrier of the disease or if they're contagious," he says. "When you can measure one person in two seconds, you can measure a lot of people in a very short time."

The research is extremely promising toward ensuring a virus-free environment, he adds.

Matching COVID Care Workers to Open Massachusetts Jobs



Ozlem Ergun, professor of mechanical and industrial engineering, has partnered with the Commonwealth's Executive Office of Elder Affairs (EOEA) to help match qualified workers to healthcare facilities with open positions around the state of Massachusetts.

With the outbreak of COVID-19, healthcare centers are experiencing a huge surge in need for qualified professionals to care for patients, but each facility has different needs—in terms of open positions, availability, and capabilities—and each applicant has constraints, such as how far they are willing to travel.

In late March, Ergun received a request from the EOEA to see if she and the PhD students in her lab could create a process to facilitate hiring for more than 300 long-term care facilities throughout the entire Commonwealth.

Ergun and her team, in collaboration with the state of Massachusetts, created a matching optimization algorithm and on online portal called COVID-19 Long Term Care Facility Staffing Team. The portal coordinates the intake of job applicants' information and matches it automatically to an ever-changing list of facility staffing needs.

"We designed the questions for the applications to match up with the needs of the facilities so we can screen for location, job skills, and transportation needs to match workers up with jobs almost immediately," explains Ergun. "Facilities receive a report of applicants and have a 24-hour window to hire who they need; after that time frame, the applicants go back into the pool and are offered to other facilities because the demand for workers far outweighs the supply at the moment."

Ergun and her team also receive daily urgent requests for specific facilities that come through the Commonwealth's command center. They are able to enter them into the system with a preference so that site's needs are given a higher weight.

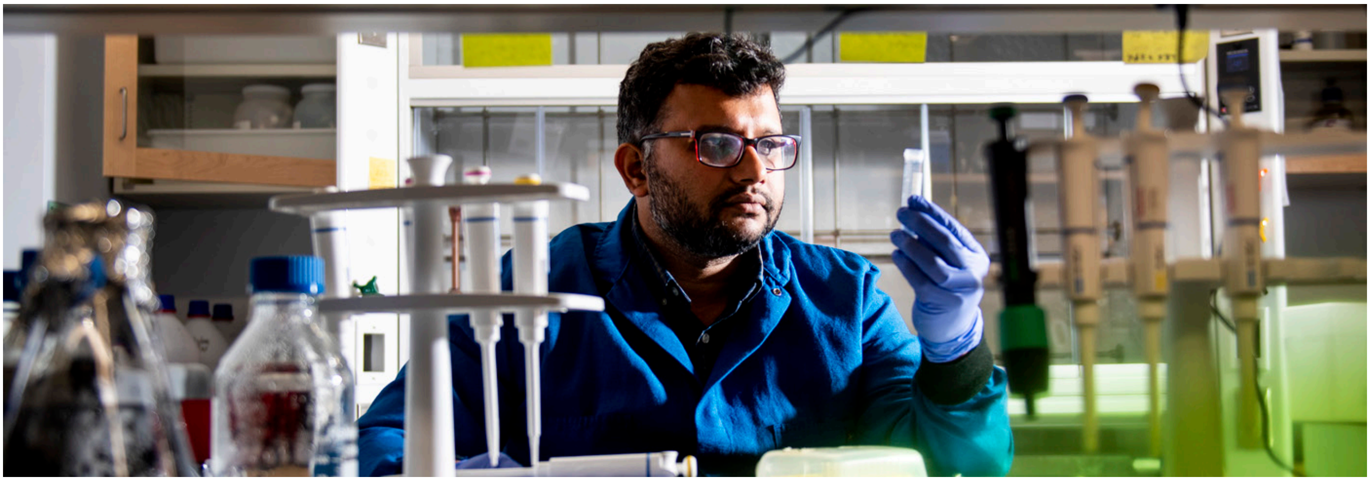
The portal is highly efficient, with approximately 1,000 applicants in the pool at any given time. The number of roles filled per day varies, but an example day in mid-April saw 826 people matched to jobs at 161 different facilities.

"The PhD students in my lab are running the whole project," says Ergun. "They built the algorithm, acquire the data and make sure it's clean, run the matching—everything. They are doing an excellent job."

Ergun and her team will be working on the COVID-19 LTC project for the foreseeable future to ensure that the healthcare needs of the Commonwealth are being met during these unprecedented times. She has been awarded a RAPID grant for this work from the National Science Foundation.

Effects of COVID-19 on Water Supply Usage

Original article by Roberto Molar Candanosa, News @ Northeastern



Ameet Pinto, assistant professor, civil and environmental engineering

Northeastern researchers are trying to determine how the lifestyle changes caused by COVID-19 might be helping harmful bacteria grow in drinking water. Many buildings have been largely unoccupied for months, and their water supplies have been sitting relatively still. That stagnation means that water stays warm for longer periods of time, and because of changes in the flow of water, disinfectants are added to limit microbial growth decay.

As people slowly repopulate large buildings for work, school, and other activities, the potential overgrowth of pathogens in the water of those buildings could put people at risk, says Ameet Pinto, an assistant professor of civil and environmental engineering.

The growth of microbes in water is a very natural process that occurs everywhere. The problem is when the *wrong* types of microbes—the ones that can make people sick—start gaining prominence inside the pipes, Pinto says.

To deal with microbes that grow over hours or days of stagnation, engineers flush the water from the plumbing system. Under normal circumstances, public water systems also use small amounts of disinfectants such as chlorine to limit the concentrations of those pathogens.

But how to handle potential microbial contamination in water that has stagnated for longer times is still very much an open question, Pinto says. If enough of these organisms start colonizing and forming a biofilm on the inner surface of the pipes, then ridding the plumbing system of those pathogens becomes much more of a challenge.

That's partly because plumbing systems are complex networks of pipes that consist of different designs and materials, made specifically to meet the needs of each type of building. "We have not been able to generalize microbiological principles across complex buildings," says Pinto.

Kelsey Pieper, assistant professor, civil and environmental engineering

Drastic changes in the demand for water within a building can also cause corrosion in pipes, valves, and other materials that make up its plumbing. That corrosion can lead to higher levels of other contaminants, such as lead and copper, which can leach into the water, says Kelsey Pieper, an assistant professor of civil and environmental engineering who is working with Pinto.

For engineers like Pieper who specialize in how corroded materials influence water quality, the problem of prolonged stagnation is also a fairly new and complex challenge that COVID-19 has brought to the attention of researchers.

"It's also thinking about the mains," says Pieper. "The water use patterns in these mains are going to be different, and that's going to subsequently impact the building water quality."

Pieper's team has also been working with researchers from Virginia Tech, Purdue University, and Polytechnique Montréal to review the reopening guidelines and protocols that public health agencies are recommending to building owners across the U.S. and Canada. Unfortunately, Pieper says, there isn't enough data for researchers to assess those recommendations.

"We're working through it to understand what's the scientific basis behind all of this," she says. "How do we reopen? Is it flushing? Is it a mix of flushing and disinfection? Is it disinfection only?"

To answer those questions, Pieper and Pinto also joined forces with Aron Stubbins, an associate professor of marine and environmental sciences, jointly appointed in civil and environmental engineering at Northeastern.

The team, who received a RAPID grant from the National Science Foundation, is sampling water from Northeastern's buildings and several residences across the Boston area in an effort to track the quality of water at each location, and how it might change as people begin repopulating large buildings. The project is based on an existing initiative of Pinto's lab, which has been conducting a comprehensive study of drinking water throughout Northeastern's Boston campus. His team has been determining the genetic material of the microbes within those samples to investigate the diversity of organisms in water—harmful or not.

Pinto says that although he knows the gargantuan task of defeating the coronavirus is the top priority for the research community, the pandemic also offers a unique opportunity to study how the quality of water might change in schools, offices, and other types of large buildings under extreme situations.

Hopefully, he says, the team's research will help other engineers recondition buildings during natural disasters, public health crises, and other future extraordinary circumstances.

ADVANCING NANOTECHNOLOGY THROUGH INNOVATION IN MATERIALS ENGINEERING

The Advancing Nanotechnology through Innovation in Materials Engineering (ANIMatE) initiative combines modeling and experiments with materials design and nanomanufacturing to enable manufacturing at the nanoscale through innovative design of functional and structural materials at the atomistic level.

- Materials design
- Nanomanufacturing
- Sensors

Researching How Gravity Impacts Gel Materials with Tests in Space

Safa Jamali, assistant professor, mechanical and industrial engineering

Assistant Professor Safa Jamali, mechanical and industrial engineering, is leading a $500K National Science Foundation grant, in collaboration with the University of California-Irvine, which will consist of research on how gravity impacts gel-like systems. Jamali hopes to better understand how the gel particles and polymers interact under different conditions.

Polymer fields include soft materials, such as plastics, Jamali explains. Everything from TVs to cars consists of types of plastic, and the science of plastics and how they react to other materials has become increasingly critical over the past few decades.

"It's important to think about how they're formed, how you can fabricate those materials, and how they behave over time," he says. "We know about metals, and fluids that are regularly used. But we don't know as much about soft materials and plastics [and gels] the way we know about other classic examples of materials."

Gel is specifically a difficult material to define, Jamali adds. For example, it is neither a liquid nor a solid: it sits somewhere in between. Furthermore, gels are being used in numerous types of everyday necessities. Gels—or gelatins—can be implemented into hand sanitizers, shampoos, yogurt, and even medicines. But because gels are a different type of material, it is important to know how they will react to certain types of additives, such as adding in aromas for shampoos.

"The problem with these particles is that on the ground, on Earth, everything is subject to gravitational force," Jamali says. "If I want to study how these particles behave under a microscope, gravitational force complicates it. We want shampoo to smell better, so we add aromatic particles. Now, how does one behave versus another? I don't know, because of gravity."

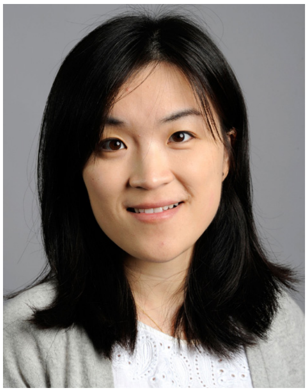
Through the NSF grant, researchers will be able to send the same materials being studied on Earth into space, to the International Space Station (ISS) to test how they react to certain additives without gravitational force. That way, the role of gravity can be ruled out on what researchers see with anything from shampoos to hand sanitizers.

Along with the micro-gravity experiments aboard ISS, there will be computer simulations and control ground experiments performed, Jamali explains.

There are myriad applications for colloidal gelation studies. For example, with medicines, gel tablets are being more commonly used for dosages. "When you swallow that gel, the product dissolves in your body and a drug is released slowly over a certain period of time," he says. "If we can understand exactly how that gel forms, understand it's properties, then we can better understand the release time, which is an important biomedical application."

Additionally, crude oil is a gel. When crude oil is clogged in the pipelines of deepwater extraction rigs, it can cost hundreds of millions of dollars to shut down an operation for clean up. . Jamali says, "If we can understand how [those clogs] form, then we can know how to prevent them, or make them form the way we want them to, and we can potentially prevent those events."

NSF CAREER Award to Enhance High Precision Micromanufacturing



Xiaoning "Sarah" Jin, assistant professor, mechanical and industrial engineering

Today's advanced manufacturing technology demands greater efficiency, reliability, and precision. That's where Mechanical and Industrial Engineering Assistant Professor Xiaoning "Sarah" Jin believes her research can play a critical role. A recent recipient of a five-year, $500K National Science Foundation (NSF) CAREER Award for "Unifying Sensing, Machine Perception and Control for High-Precision Micromanufacturing," Jin's goal is to develop an artificial intelligence and machine learning-assisted technology framework for high precision, advanced manufacturing processes.

With a focus on emerging products—biosensors, micro/nano-scale electronics, batteries and flexible electronics, for example—Jin's solution is to leverage data to understand process dynamic behavior and performance in real time. This information, in turn, will improve the precision and effectiveness of process controls to meet product quality targets and make products faster, with higher throughput and minimal defects.

"Our goal is to use the abundant sensor data from complex manufacturing equipment and processes to make reasonable inferences and reveal what's going on," she explains. "We are trying to reveal the hidden behavior existing in high throughput, high speed processes of micro-scale device fabrication to maintain high reliability and mitigate defect rates. If there are tiny defects or errors at the beginning of a process, and you don't have enough visibility into the process to make a timely correction, you will see a higher defect rate, which can generate significant waste in materials and energy. If we can use all available information to infer what's happening, we can then provide proactive, adaptive action."

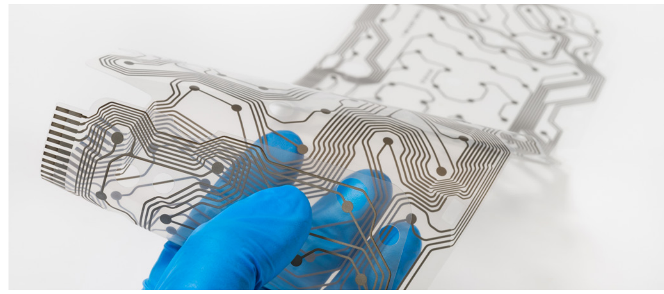
Jin's innovative approach goes beyond traditional model-based control and design using the power of sensing technologies and advanced data analytics to enable real-time decision-making for meaningful action. "Using a more data-driven approach with engineering knowledge provides us an avenue of mass production for more precise, more reliable products with more complexity and less waste, and a significant improvement in efficiency," she says.

Under the NSF award, Jin will experimentally demonstrate and validate the framework and methods on two micromanufacturing processes—ion mill etching and roll-to-roll printing—to show the real-world impact of her research. "I want to develop a general methodology and algorithms to apply to a broader range of manufacturing processes," she says.

Assistant Professor of Mechanical and Industrial Engineering Hongli Zhu was awarded a $1 million grant from the Department of Energy's Advanced Manufacturing Office to work on "Enabling Advanced Electrode Architecture through Printing Technique." It is one of 55 projects nationwide awarded by the DOE to support innovative advanced manufacturing research and development, and her whole project team, led by Western Michigan University, received $12 million to work on printing batteries. She is also leading a $480K National Science Foundation award for a study of solid-state electrolytes. Additionally, Zhu's research on solid state batteries was featured on the cover of *Advanced Materials*, and her research on aqueous flow batteries was featured on the cover of *Advanced Functional Materials*.

William Lincoln Smith and University Distinguished Professor Ahmed Busnaina, mechanical and industrial engineering, has received the 2020 William T. Ennor Manufacturing Technology Award from the American Society of Mechanical Engineers "for the development of a scalable directed assembly-based nanoscale technology to print bio and chemical sensors, power electronics, and light emitting diodes using inorganic or organic materials on flexible or rigid substrates."

Improving Roll-to-Roll Printing of Multilayer Flexible Substrate Electronics



A promising advanced manufacturing technology for high-volume production of electronic devices, like solar panels and transistors, is roll-to-roll printing—a technique that can continuously transfer a printed electronic pattern onto multi-layer flexible substrates.

"Compared to traditional manufacturing, roll-to-roll printing is much more efficient and even has a hand in nanoscale products," says Mechanical and Industrial Engineering Assistant Professor Xiaoning "Sarah" Jin. "It's a huge input, high-yield manufacturing process which is different from traditional sheet-by-sheet and the batch-based manufacturing process. It's also particularly efficient for large-scale manufacturing of electronic devices."

But the process to refine roll-to-roll printing continues and it is a complicated one. Multilayer electronics need tight alignment and one of the problems is in how to make it stay within specifications.

Jin is principal investigator of a $544K National Science Foundation grant, working with Hongli Zhu, an assistant professor in the same department, to improve this very issue through modeling and virtual sensor-based control.

Jin brings her focus on industrial artificial intelligence technology for smart manufacturing to the project, while Zhu offers a specialty in material sciences for paper electronics and printing materials for advanced and electronic devices. They are in collaboration with the University of Massachusetts-Amherst.

"Due to limitation of current technology for real-time monitoring, we don't have visibility into what's going on in this printing process," Jin explains. "We want to collect from the controllers, optical sensors, and multiple sources of data to estimate and review the actual state of the process in what we call virtual sensing. That will help us resolve the problem of misalignment because the whole process is in multiple stages of one roller to another. We want to attack the real-time errors in terms of position of geometry errors in the printing process." This, she says, will provide adaptive control to avoid error from propagation of accumulation and the hope is the end-of-line printed products will get a lower defect rate and achieve a higher through-put and yield alignment.

For a proposed multilayer transistor, the goal is to have the resolution of a function device within 20 micro. "If we can control the deviation within that limit then we can guarantee the normal functionality or performance of the printed device," Jin notes.

"Paper is a historic substrate used for roll-to-roll printing," Zhu mentions. She also points out that there is a possible crucial ecological effect if the study is successful. "If we can improve paper electronic for manufacturing, then it improves the usage of sustainable materials, which is biodegradable in the environment," she says. "The issue of plastic pollution can't be ignored."

Jin reminds that this is a high-yield manufacturing process which can even stretch to the biomedical world through devices. "The process of how electronics are being created is fascinating and often overlooked," Jin says. "Many people are hoping for a better way."

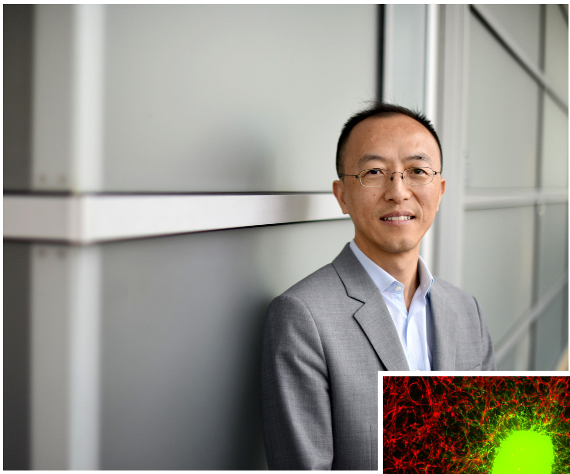
BIOMACHINE INTEGRATION

BioMachine Integration tackles grand challenges that span health, security, and sustainability with engineering solutions to involve an integration of advanced materials, devices and machines with living systems to yield synthetic bio-machine technologies.

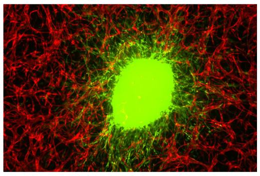
- Molecular to human scale
- Living sensors
- Cell technologies
- Medical robotics
- Human/machine dynamics
- Environmental health factors

3D-Printed Brain to Understand Tumor Growth, Discover New Drugs to Fight It

by Laura Castañón, News @ Northeastern



Guohao Dai, associate professor, bioengineering



Glioblastoma is the deadliest form of brain tumor—less than 10 percent of people who are diagnosed with it will survive more than five years.

A group of researchers has devised a new way to study this rapidly spreading cancer, using a three-dimensional structure made of an agglomeration of human brain cells and biomaterials. Their work, published in *Science Advances*, could help medical professionals better understand how the tumor grows and to speed up the potential discovery of new drugs to fight it.

"This is a very difficult brain tumor to treat," says Guohao Dai, an associate professor of bioengineering at Northeastern and corresponding author on the study. "And it's also difficult to do research on the brain tumor, because you cannot really see what's happening."

Inside a living brain, researchers can't directly observe how tumor cells grow and respond to treatment. Studies are typically done in mice or rats. Animal studies are expensive and time-consuming, Dai says, and they don't allow for day-to-day observations of the same tumor in living tissue.

To be able to study glioblastoma more directly, Dai, whose lab specializes in 3D printing live tissue, grew a three-dimensional model to act as brain tissue for tumor cells to infiltrate.

"We use human brain blood vessel cells, and connect them with all the neurons, pericytes, astrocytes, the major cell types in the human brain," Dai says. A water-based substance known as a hydrogel serves as a matrix to hold these cells in place. "Then we use 3D printing to stack them in three-dimensional fashion."

In the middle of the structure, which is only a few millimeters thick, the researchers place glioblastoma tumor stem cells. The cells are derived from brain tumor patients with the help of Jenny Zou, a neurosurgeon, and Roland Friedel, a neuroscientist, at Mount Sinai's medical school.

"We can observe how the brain tumor cells aggressively invade, just like what we see in patients," Dai says. "They invade everywhere."

To get an accurate picture of what's happening inside the 3D model without disrupting it, Xavier Intes, a biomedical engineer at Rensselaer Polytechnic Institute, used a laser to scan the sample and quickly create a three-dimensional snapshot of the cellular structure, an imaging technique developed in his lab.

This combination of techniques allowed them to evaluate the effectiveness of a commonly used chemotherapy drug, temozolomide.

"We treated the tumor with the same kind of drug you give to a patient when they undergo chemotherapy," Dai says. "We monitored this chemotherapy over two months. And what we found was the chemotherapy was not able to kill the tumor."

Initially, the tumor shrank in response to the drugs, but then it grew back swiftly and aggressively. The drug did not work in the long term, which lines up with the experience of patients with glioblastoma.

"This particular chemotherapy is not effective for the brain tumor," Dai says. "We need to develop and screen other chemotherapy drugs."

This model may be able to speed up that process. Temozolomide was able to kill glioblastoma cells in two-dimensional models, but when put into a three-dimensional one, the tumor rebounded. This method could be used to weed out unsuccessful drugs early, ensuring that only the most promising ones move to animal, and eventually human, trials.

"You have a tremendous amount of time and cost associated with animal research," Dai says. "With our 3D glioblastoma model and imaging platform, you can see how the cells respond to radiation or chemotherapy very quickly."

The First Implementation of Analog of Integral Feedback Controllers in a Synthetic "Test Tube" Gene Circuit

It is critical for biological systems to maintain tightly regulated levels of physiological variables, such as temperature and pressure at the organism level, or chemical concentrations at the cellular level. This phenomenon is often referred to as homeostasis. In mechanical and electrical engineering, a mechanism called "integral feedback" is known to play a key role in homeostasis, and it is question of great theoretical and practical interest to know whether this mechanism can also operate in cells.

In a paper published in *Nature Communications* on "In vitro implementation of robust gene regulation in a synthetic biomolecular integral controller," supported by grants from the National Science Foundation and the Defense Advanced Research Projects Agency, a team led by University Distinguished Professor Eduardo Sontag, electrical and computer engineering, jointly appointed in bioengineering, was able to implement, for the first time, an analog of integral feedback controllers in a synthetic "test tube" gene circuit. The successful implementation was preceded by a careful mathematical analysis and constitutes a "proof of principle" for the systematic computer-aided design of such circuits in cells.

NIH Trailblazer Award to Treat Osteoarthritis Early

Ambika Bajpayee, assistant professor, bioengineering

For many people suffering from osteoarthritis—a debilitating disease that gradually destroys the cartilage that provides a "cushion" between our bones—the only available remedies are pain control and, eventually, joint replacement. Drugs designed to treat osteoarthritis often fail because of challenges inherent in delivering them to the cartilage and keeping them there long enough to be effective.

Imagine if doctors could treat osteoarthritis early on—repair cartilage and prevent additional tissue destruction—with an effective, targeted drug delivery mechanism. That's the goal Ambika Bajpayee, assistant professor of bioengineering, and her team are pursuing as part of a three-year, $628K NIH Trailblazer R21 Award for New and Early Stage Investigators from the National Institute of Biomedical Imaging and Bioengineering.

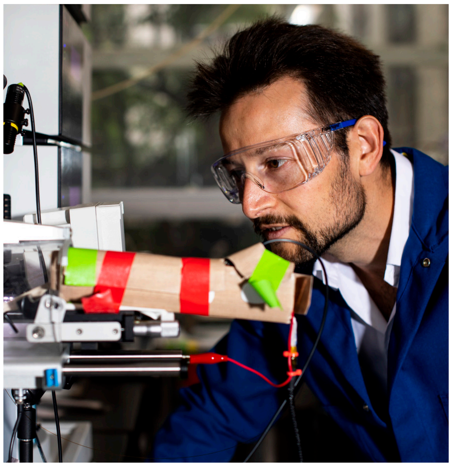
Because cartilage lacks blood vessels and is the most negatively charged tissue in the body, it is difficult to penetrate. The potential solution may lie in harnessing the body's internal electrical fields. "In our lab, we design electrically charged biomaterials for delivering drugs and contrast agents to tissues that are hard to penetrate," says Bajpayee. "It's important that drugs reach their cell targets. By using the electrostatic interactions—engineering drugs at the molecular level to make them positively charged—we can enhance their uptake into the tissue by 200-400 times."

Bajpayee and her team are also proposing to use a new class of cell-like materials known as exosomes to aid in drug transport. Once viewed as cell debris, exosomes are now considered to be important structures in the body. "They can travel, from one cell to another, one tissue to another, and they carry the basic cell signature, whether healthy or diseased," says Bajpayee.

Exosomes, however, are negatively charged. In a groundbreaking application, Bajpayee and her team are making the exosomes cationic or positively charged, enabling them to penetrate into the negatively charged cartilage.

Bajpayee envisions using her proposed technology for other negatively charged tissues in the body, for example, in oral drug delivery to penetrate the mucosal barrier lining of the gastrointestinal tract. "There are multiple applications," she says. "This is a platform technology so we can use it to deliver a wide range of drugs to a wide range of tissues. I'm very excited about that."

Slavov Named Paul G. Allen Distinguished Investigator for Pioneering Single Cell Proteomics Research



Nikolai Slavov, assistant professor, bioengineering

Bioengineering Assistant Professor Nikolai Slavov was recently named a prestigious Allen Distinguished Investigator, and was awarded a $1.5 million three-year grant to further his novel research on single cell proteomics. The Paul G. Allen Frontiers Group supports early-stage research with the potential to reinvent entire fields. Slavov is the first from Northeastern to receive the award.

Previously, Slavov's group developed mass spectrometry technologies for quantifying thousands of proteins across many single cells. The technology, Single Cell ProtEomics by Mass Spectrometry, offers a cheaper and faster technique enabling researchers to analyze a much larger number of single cells and gain much more accurate data.

The proteins in our cells are complex molecules working in synchrony. They orchestrate multifaceted chemical reactions resulting in the high-level functions that keep people alive and well, from growing tissue to fighting disease. Our bodies house thousands of different types of cells, which contain tens of thousands—if not millions—of different proteins.

With many proteins responsible for biomechanisms involved in crucial functions like the development of cancer cells, scientists need to increase the number of analyzed protein copies to thousands to capture single cell protein levels accurately.

With the new grant, Slavov will further his research in quantifying protein dynamics in single cells, which can help us better understand the exact sequence of signaling events that guide cells during development. "What I'm really most excited about is having the ability to carry out the research," Slavov says. "What I have proposed is very ambitious, but also very promising."

"All complex organisms start from a single cell, which then divides, and the cells differentiate," he says. "We haven't been able to trace this path of differentiation and information processing in complex organisms."

While there are many methods to measure single cells, all of these methods tend to measure only one snapshot of a cell, Slavov says. They capture the way a cell looks at one or two points in time. Computational approaches indirectly infer what the cell dynamics might be, but they're indirect.

"This research will directly measure up to a dozen and more time points that can give us information not just about the state of a cell at particular time, but give us information about its history," he explains. "It's not just the abundance of proteins, but how synthesis and degradation rates are regulated in its history."

While there has been exciting progress in DNA- and RNA-based methods, with a certain degree of tracing cells, this is still only an indirect way to measure signaling mechanisms that regulate those changes. Slavov hopes to directly identify the signals that instruct cells to become different cell types.

"When we understand the signals, how they occur in normal development, we should be in a better position to 'replay this music' in stem cells, for example," he says. "We could engineer cell types of specific properties, or engineer them for regenerative therapies. "

Working toward a brighter future

Slavov stressed that his immediate goal is to further basic research, continuing to learn more about what the proteins in specific cells do and how the methods can be replicated. But the research offers the potential for direct medical applications in the future.

"We could study how immune cells interact with cancer cells," Slavov says. "We could have a single snapshot of an interaction and follow it in time. It could resolve longstanding controversies where we haven't had direct data to determine what the mechanism is."

"Allen Distinguished Investigators are pioneers who aim to upend how we 'crack' hard biological mysteries," says Kathy Richmond, Ph.D., M.B.A., Director of The Paul G. Allen Frontiers Group. "Such technological breakthroughs could reveal the protein 'drivers' in disease and help further the development of more effective cancer therapies and treatments for autoimmune diseases."

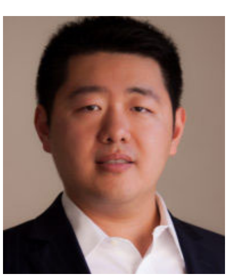
"I hope this novel research and its impact attracts more people to the emerging field of single cell protein analysis," Slavov says. "There is a tremendous amount of potential in this field, but currently there are not enough people to develop it to its full potential."

This research was supported by an Allen Distinguished Investigator Award, a Paul G. Allen Frontiers Group advised grant of the Paul G. Allen Family Foundation. Visit allenfrontiersgroup.org.

CRITICAL INFRASTRUCTURE SUSTAINABILITY AND SECURITY

Critical Infrastructure Sustainability and Security will promote the development of fundamental engineering to embed resilience into the design strategies, standards and regulatory frameworks of critical infrastructure systems through predictive understanding of climate and security hazards with geospatial Big Data and computational solutions. It will develop a framework for establishing translational solutions in collaboration with academic partners, industry leaders and startups, as well as national laboratories and federal agencies.

- Resilient water/energy systems
- Hazard Identification and risk management



Using Deep Learning to Transform the Design and Analysis of Structures Subjected to Hazardous Events

Assistant Professor Hao Sun, civil and environmental engineering (CEE), is leading a $599K National Science Foundation grant, along with CDM Smith Professor and CEE Department Chair Jerome Hajjar, and Assistant Professor Yanzhi Wang, electrical and computer engineering, to develop physics-reinforced deep learning metamodels for structural systems.

"There is a traditional approach that we take in structural engineering to make estimations of what damage is across a region due to a hazardous event like an earthquake," says Hajjar. "But it is expensive to do a detailed simulation of each structure for the impact of all types of hazardous events."

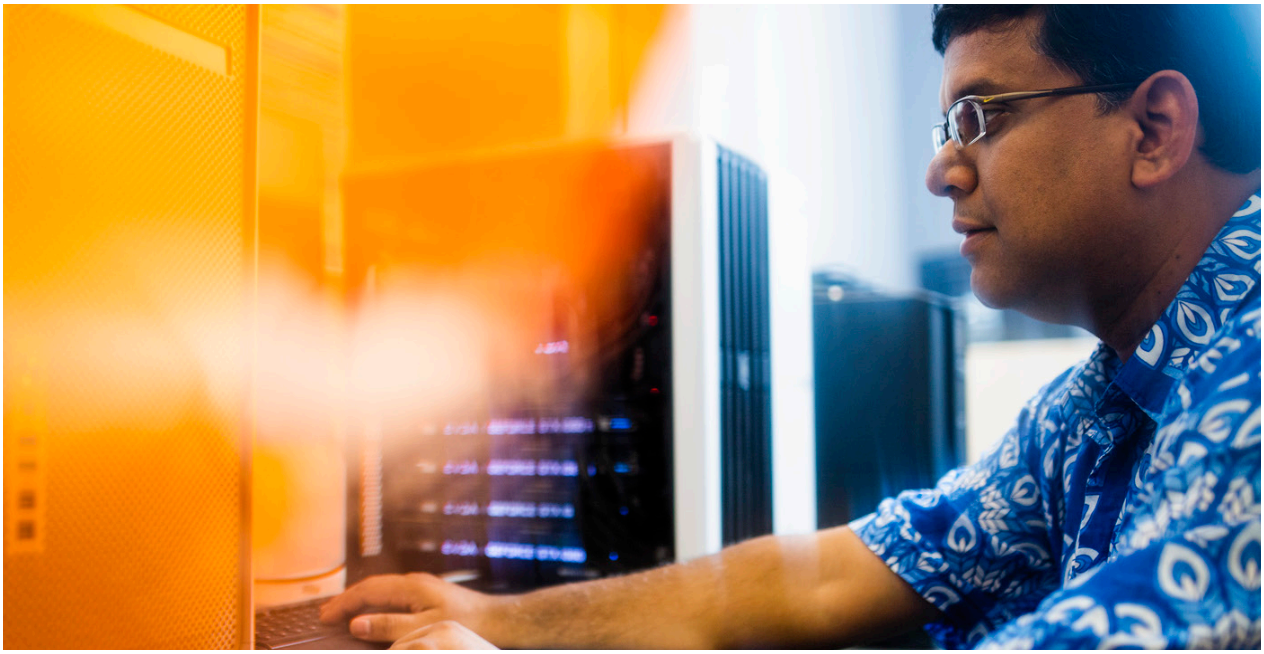
Given the time-consuming process of analyzing each building, structural engineers have relied on quicker methods to estimate the damage for individual structures, and therefore aggregate that damage across a region to understand the seismic risk across a metropolis. The research team looks to transform structural engineering practices by integrating them with computer science approaches related to deep learning.

"Structural engineers and computer scientists can collaborate to develop groundbreaking new methodologies to facilitate and transform the traditional design and analysis of our structures," says Sun. "Deep learning methods allow the traditional analysis of a building to be conducted in mere seconds, as opposed to the hours or days sometimes required for complex structures."

The new deep learning modeling technique is reinforced by traditional physics principles to train it for better modeling and understanding of nonlinear structural behavior under seismic loads. Additionally, Wang's research into deep learning will help make the method quicker and leaner. Deep learning models require many complex layers and nodes. Wang's work involves "pruning" such a network, getting rid of unnecessary nodes, making the metamodel much faster and with greatly improved computational efficiency.

Sun says, "The resulting approach will scale up well for analysis, from individual buildings to urban applications."

$3 Million DOD Grant for Researching Networked Infrastructures Under Compound Extremes



Auroop Ganguly, professor of civil and environmental engineering

Professor Auroop Ganguly, civil and environmental engineering, is leading a $3 million grant for "NICE: Networked Infrastructures under Compound Extremes" from the U.S. Department of Defense (DOD) Strategic Environmental Research and Development Program (SERDP). The project, in collaboration with the University of California at Berkeley, U.S. Department of Energy's Pacific Northwest National Lab, the U.S. Army Corps of Engineers, and the U.S. Naval Research Lab, will fund research into networked infrastructures under compound extremes.

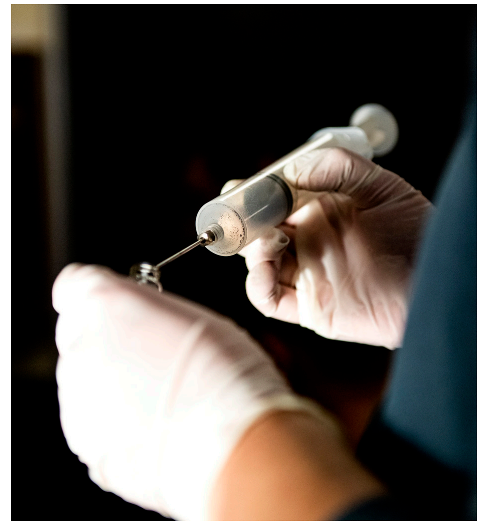
There are many public and private structures important to national security. These can be privately-owned structures such as the nation's many water treatment and power plants. The DOD itself maintains a large constellation of military installations across the world. Protecting these locations and ensuring they may continue to function under threat conditions is integral to national security. The evolving security challenges of the 21st century means these risks go beyond traditional threats by hostile powers from land, sea, or air.

In addition to traditional risks from state actors, locations critical to national security must be on alert for nonconventional threats. These include terrorism and cyber-attacks, but also non-human threats, such as natural disasters, extreme weather strengthened by climate change, or disease. A major concern is when the pressures caused by one of these extremes is compounded by the co-occurrence of another. "The possibility that nations with sophisticated cyberspace operational capabilities may choose to time the launch of a cyber-attack on the nation's critical lifelines while the nation is facing a debilitating hurricane or riverine flood or wildfire, can no longer be ruled out," says Ganguly

Due to the increased interconnectivity of the world, there is a danger that pressure placed by extreme events on one facet of infrastructure could cause a cascade of failures across others. Ganguly and his team plan to develop a framework for mapping failure and recovery pathways of critical infrastructure. The government and military will be able to use the framework to predict the effect of various compound extremes on important infrastructure, and direct resources for strengthening them appropriately.

Yiannis Levendis Selected Fellow of the National Academy of Inventors

Excerpt of full article by Laura Castañón, News @ Northeastern



Yiannis Levendis, College of Engineering Distinguished Professor of mechanical and industrial engineering, was recently elected as a Fellow to the National Academy of Inventors, an honor reserved for individuals whose inventions "have made a tangible impact on quality of life, economic development, and the welfare of society." He has spent his career creating reusable products, cleverly repurposing waste, and researching fuel alternatives.

"We're looking to substitute coal with renewable biomass and waste biomass for fuel," says Levendis.

When coal is burned, it releases a number of harmful pollutants, including mercury, arsenic, and other heavy metals, as well as gases that can cause respiratory problems or create acid rain. It also produces carbon dioxide and other gases that enter our atmosphere and act like a blanket, trapping heat that should radiate out into space and causing the planet to warm.

Many of the potential fuels come from unused parts of plants such as corn or rice. The husks and stalks that are not eaten could be burned as fuel. This would still release carbon dioxide, Levendis says, but since plants take in carbon dioxide as they grow, the total amount in the atmosphere wouldn't change.

"Growing the fuel absorbs carbon from the atmosphere," Levendis says. "Then when you burn it, it releases it back. So, it's a zero sum game."

But what about pollutants? What else is being released when these plants are burned? Levendis has built two unique furnaces in his lab to find out. Levendis and his colleagues use the first one to understand the combustion of different materials. They put in a single particle of pulverized rice husk, for example, and measure how quickly it burns and at what temperature. In the second furnace, Levendis measures the gasses and particulates that are produced as streams of biomass particles burn.

"With that information, we can get an idea of how much energy we get out of it and how the temperature affects emissions," Levendis says. "And we can see how to change the combustion behavior so we can affect the emissions."

The emissions of a material can change depending on the speed and temperature at which it burns. Levendis is trying to find the cleanest way to get energy out of various biofuels.

One possible fuel source that is not from plant materials is waste plastic, Levendis says. By heating plastics to high temperatures without the presence of oxygen, Levendis and his colleagues are able to turn the plastics into a gas that burns cleanly. Most of the plastic turns to gas, and that gas can be used to grow carbon nanotubes—thin, strong structures that are being used to design flexible electronics and other new materials. The remaining gas can be burned for energy, just like natural gas.

But Levendis isn't just focused on fuel. He has previously designed an environmentally friendly ceramic oil filter for cars, which can be removed, cleaned, and re-installed. It could eliminate the waste from the millions of oil filters that are currently thrown away every year.

And he is also looking at new ways to put out fires. The firefighting foams used on industrial fires pollute the atmosphere and contaminate groundwater. Levendis showed that a single cup of liquid nitrogen can put out square meter of burning diesel fuel, and then simply evaporate back into the air (our air is 78 percent nitrogen).

"Dangerous fires can be extinguished instantaneously with direct application of liquid nitrogen," Levendis says. "And there's no environmental damage because it vaporizes back to nitrogen gas immediately."

ENGINEERED CYBER-SOCIAL-PHYSICAL SYSTEMS

Research in this area will use engineering solutions to develop the Engineered Resilient Cyber-Social-Physical Systems needed to design, operate, and evolve complex cyber-physical systems upon which people can confidently depend to perform both mundane and safety critical tasks, and that can better withstand, rapidly recover from, and adapt to local, regional, and global disruptions at multiple timescales.

- Sensing
- Control
- Communications/networking
- Big Data analytics
- Embedded systems
- Man-machine interface

$2.2 Million Department of Energy Grant for Smarter Occupant-Centric Building Control Algorithms

Air conditioners and heat pumps are a significant load on the electric grid, yet they could serve as an important tool for balancing the variability of renewable electric generation. By pre-cooling or preheating buildings at hours when renewables are plentiful and continuously adjusting thermostat temperatures for efficiency, the total amount of carbon-based power needed can be reduced. However, current models cannot predict how these devices respond when quickly controlled to follow changing grid conditions. Buildings exist to serve occupants, yet such complex automation for grid-interactive efficient buildings currently confuse occupants and make them uncomfortable, resulting in overrides that affect grid reliability.

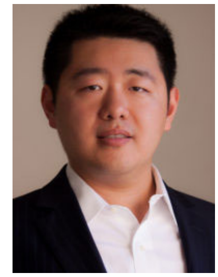
To address this, the U.S. Department of Energy recently awarded a $2.2 million grant to create an open dataset characterizing occupant-centric control of grid-interactive efficient buildings. Principal Investigator Michael Kane, assistant professor of civil and environmental engineering, is working with David Fannon, associate professor of architecture, jointly appointed in civil and environmental engineering, and Affiliated Faculty Misha Pavel, electrical and computer engineering, who is also a professor of practice in Khoury College of Computer Sciences and the Bouvé College of Health Sciences. The National Renewable Energy Laboratory (NREL); ecobee, a leading thermostat manufacturer; and Packetized Energy, an IoT-based autonomous demand-response startup, are collaborators on the project.

Kane and his team are looking to design smarter occupant-centric building control algorithms that learn user behavior, are easy to use, and can correctly predict HVAC performance and power draw. The project takes a novel approach to cost-effectively produce and share a large dataset on characterizing grid-interactive efficient buildings and occupant behavior. Laboratory thermal-chamber experiments of heat-pumps will be synchronized with full building-simulators to test the devices' performance in different homes and weather conditions. Data collected from volunteers in homes under simulated future grid conditions will help build the occupant thermal comfort behavior models used in the building simulations.

Researchers estimate that usage of occupant-centric grid-interactive efficient buildings could lower peak electricity demand in the U.S. by about 10 percent, representing a significant decrease in energy spending and carbon usage. In turn, this would cause additional savings through the decreased need for new power plants and transmission lines, or the need to bring online older, dirtier plants to meet constantly changing demand.







$1 Million NSF Award for Real-Time Learning for Next-Generation Wireless Systems

Current wireless systems need to drastically improve data rates and have ultra-low latency to support pioneering applications such as shared virtual reality experiences and autonomous cars, says Stratis Ioannidis, associate professor of electrical and computer engineering (ECE). He's the principal investigator on a $1 million National Science Foundation (NSF) grant to meet these goals, in collaboration with ECE Professors Jennifer Dy, Tommaso Melodia, and Kaushik Chowdhury, and Assistant Professor Yanzhi Wang.

Next-generation wireless applications crucially rely on the ubiquitous availability and real-time reconfigurability of high-speed wireless links—and this requires wireless devices to perform a broad variety of inference tasks in real-time. "You need systems that are reactive—so they can basically operate under rapidly changing conditions," says Ioannidis. "For example, part of the channel that's available right now might stop being available in milliseconds. Or the quality at a certain band may deteriorate because of interference. So, you need systems that understand the wireless environment, and can quickly react to changes in it."

The research team's proposed solution, "Efficient and Adaptive Real-Time Learning for Next Generation Wireless Systems," will address the need for faster data and lower latency with a multi-pronged approach that uses the specialties of everyone on the project. "We are a diverse team of Northeastern engineering faculty," says Ioannidis. "It's a team of people that work on machine learning, like Jennifer Dy and I; people that work on wireless technologies, like Kaushik Chowdhury and Tommaso Melodia; and Yanzhi Wang who works on speeding up machine learning algorithms using hardware accelerators. Basically, we occupy the entire stack of things you would need in order to perform this research."

As suggested by Ioannidis, the core of the proposed solution is the machine learning done by wireless systems. It's not just that the systems need to learn, though—it's that the algorithm by which they learn needs to adapt to changes just as quickly as the wireless environment itself changes. This is what Ioannidis and other machine learning researchers call "lifelong learning," or the ability for artificial intelligence to build upon its past knowledge—rather than forgetting what it's learned before. Lifelong learning adjusts learning algorithms based on this collective knowledge, ultimately optimizing the experience for the end user as learning improves performance and efficiency.

With unprecedented efficiency improvements in next-generation wireless systems so that wireless systems are capable of handling the volume, speed, and unpredictability inherent in the environment, the future of pioneering applications—for consumers and industry—moves closer and faster to reality.

ENGINEERED WATER, SUSTAINABILITY, AND HEALTH

The Engineered Water, Sustainability and Health initiative will develop engineered solutions for sustainability and health, focusing on clean water and environmental protection as key grand challenges.

- Surface and groundwater contamination
- Impact of climate change and environmental hazards on health
- Water quality and health
- Management and protection of the environment

Protecting Residents from Road Salt and Lead Contamination in Drinking Water

Excerpt of full article by Aria Bracci, News @ Northeastern

Kelsey Pieper, assistant professor, civil and environmental engineering

Kelsey Pieper, assistant professor of civil and environmental engineering, was part of the search for a cause, uncovering why dishwashers were breaking down with interiors corroded and surfaces pock-marked with white in a community in New York, known as Fisher's Landing. The reason: salt. Her previous work in Flint, Michigan, exposed her to how corrosive the chloride in salt can be, and how, in some cases, it led to lead contamination.

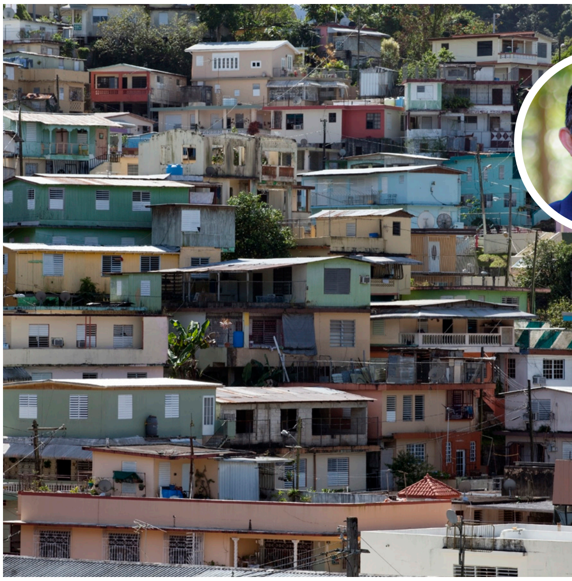
To prove that road salt and the chloride from that was to blame for the contamination in the area, Pieper and her research team offered to test the water for free, and the results showed that chloride levels were highest in the places closest to where the salt was stored. Additionally, one in five homes used water that exceeded the Environmental Protection Agency's limit, not only for chloride, but for lead or copper as well. And, as Pieper and her co-authors showed in follow-up lab experiments, when water has high enough levels of chloride, it corrodes lead solder joints.

Since high chloride levels can be a warning sign of lead to come (or lead that did come but went unnoticed), Pieper, and her fellow researchers, Marc Edwards and Rebecca Kriss of Virgina Tech, are working to improve at-home lead-detection tools, distributing them to residents, and assessing whether they work better than standard detection kits.

While comprehensive solutions are proving necessary in some parts of the United States, in others, a problem with lead can stem from road salt, which New York uses more of than any other state. Residents of Fisher's Landing were uniquely vulnerable to salt because of their small-town proximity to where it was stored and their reliance on unregulated wells, but other people throughout the state are vulnerable, too. As part of their research, Pieper and her fellow researchers estimated that a similar risk could be faced by other private well users in New York—some 495,000 of them.

To the majority of U.S. residents, whose water comes from public sources, salt saturated water is an emerging concern as well, but the water supply is regulated under the Safe Drinking Water Act. People who get their water from private wells, natural springs, or cisterns—that's an estimated 47 million Americans—are solely responsible for making sure their drinking water is safe.

"Residents are engaged, they're knowledgeable about these systems, and they can play a very important part," says Pieper. "We need to provide them better tools, better resources, so they can better protect themselves."



Northeastern University PROTECT Center Faculty

AKRAM ALSHAWABKEH
Director of PROTECT, University Distinguished Professor, Snell Professor of Engineering and Senior Associate Dean for Research and Graduate Education

TOM SHEAHAN
Sr. Vice Provost for Curriculum and Programs, and Professor of Civil and Environmental Engineering

DAVID KAELI
College of Engineering Distinguished Professor of Electrical and Computer Engineering

PHIL BROWN
University Distinguished Professor of Sociology and Health Sciences

JUSTIN MANJOURIDES
Associate Professor of Biostatistics

JENNIFER DY
Professor of Electrical and Computer Engineering, and Education Director, Experiential AI Postdoctoral Program, Roux Institute

PHIL LARESE-CASANOVA
Associate Professor of Civil and Environmental Engineering

ALISA LINCOLN
Professor of Health Sciences and Sociology, and Associate Dean of Research for the College of Social Sciences and Humanities

$10.7 Million NIH Grant to Continue a Bold Mission for Environmental Health

Puerto Rico is an island community with a poverty rate quadruple that of the overall U.S. The island faces severe environmental pollution and is home to 18 Superfund sites—areas identified by the U.S. government as contaminated with hazardous chemicals that require clean up. These sites, along with hundreds of other non-Superfund contaminated sites, have resulted in extensive contamination of drinking water resources. Rates of preterm births and infant mortality in Puerto Rico are among the highest of all U.S. states and territories, and there is evidence that this contamination is a contributing factor. Moreover, frequent natural disasters, such as Hurricane Maria in 2017 and a 6.4 magnitude earthquake in 2020, may result in elevated exposures to Superfund chemicals, further compounding the adverse health outcomes.

Since 2010, the PROTECT multidisciplinary and multi-institutional research center has provided much-needed understanding of the relationship between several suspect chemicals and adverse pregnancy outcomes, including the exact mechanisms by which these chemicals act on the body. PROTECT (short for Puerto Rico Testsite to Explore Contamination Threats) is led by Northeastern University under the direction of Akram Alshawabkeh, University Distinguished Professor, Snell Professor of Engineering, and Senior Associate Dean for Research and Graduate Education, in collaboration with colleagues from three colleges at Northeastern, the University of Puerto Rico, University of Georgia, and University of Michigan.

Since PROTECT's inception, the research center has built detailed and extensive data sets on environmental and prenatal conditions of over 1,500 pregnant mothers—close to 3,000 data points per participate in areas such as exposure, socioeconomic, and health data. The data shows a compelling link between suspect chemical classes (chlorinated volatile organic compounds and phthalates) and adverse pregnancy outcomes. Analysis of tap water collected by PROTECT after Hurricane Maria showed significantly elevated detection frequency and levels of many contaminants compared to pre-hurricane data.

"Extreme weather conditions are an unfortunate part of life for the people of Puerto Rico with the devastation left behind beyond what can be seen with the human eye," says Alshawabkeh. "Our research findings indicate that not only do chemicals from Superfund sites contaminate drinking water, but natural disasters such as hurricanes are causing heightened toxic environmental conditions by exposing people to dangerous chemicals."

In March 2020, PROTECT was awarded a five-year $10.7 million grant from the National Institutes of Health to continue and expand its work. This next phase of PROTECT research will include the study of an additional 1,000 pregnant women and look at a mixture of chemicals beyond the initial two suspect chemical classes. The impacts of natural hazards on contaminant transport and exposure will be studied further, as will the underlying biological mechanisms by which contaminant exposure can lead to adverse pregnancy outcomes. Additionally, new water treatment technologies will be developed for portable water treatment systems. New statistical methods and data mining, machine learning, and visualization tools will be developed to allow PROTECT researchers to analyze data sets. PROTECT will also employ innovative approaches to engage and educate the community, and a broad suite of training, and professional and tailored activities will be provided to trainees to meet their needs and goals.

Alshawabkeh says, "Through improved understanding of the link between adverse pregnancy outcomes and contamination, together with sustainable technologies to reduce risk, our goal is to help improve health outcomes in Puerto Rico and beyond."

INTEGRATED MODELING, INFERENCE, AND COMPUTING

Integrated Modeling, Inference, and Computing will focus on the advancement of the integration of core areas of engineered modeling approaches, machine learning, and computation to address barriers in smart modeling with applications in bioengineering for health and disease, environmental health monitoring and climate change, and engineering and design of advanced material systems. It will identify testbeds that define broad application areas that demand new developments in our three fundamental core areas to address barriers in smart modeling.

College of Engineering Distinguished Professor David Kaeli, electrical and computer engineering, has been appointed to serve as Editor-in-Chief of ACM Transactions on Architecture and Code Optimization. ACM, the world's largest educational and scientific computing society, delivers resources that advance computing as a science and a profession. ACM provides the computing field's premier Digital Library and serves its members and the computing profession with leading-edge publications, conferences, and career resources.

Artificial Intelligence Algorithm to Detect Retinopathy of Prematurity Receives FDA Breakthrough Status

Deniz Erdogmus, professor, electrical and computer engineering

Professor Deniz Erdogmus, electrical and computer engineering, is working with Massachusetts General Hospital (MGH) and Oregon Health & Science University (OHSU) on research, funded by the National Institutes of Health and the National Science Foundation, to use artificial intelligence algorithms to automatically diagnose and assess the severity of Retinopathy of Prematurity (ROP)—a retina condition in prematurely born infants. ROP can be treated if detected but leads to blindness otherwise. The algorithm, called i-ROP DL system, received breakthrough status by the FDA. The FDA Breakthrough Device Program aims to accelerate development—and potentially approval—of medical devices for "more effective treatment or diagnosis of life-threatening or irreversibly debilitating diseases." 16,000 premature infants in the U.S. are affected by the disorder annually.

ARO Young Investigator Award to Bring Deep Neural Network Machine Learning to Mobile Devices

Yanzhi Wang, professor, electrical and computer engineering

A Deep Neural Network (DNN) teaches a computer how to think like a human mind, both flexible and complex. The machine learning of DNNs has previously been thought to require computations and memory storage capacity too large for mobile delivery. To address this, Assistant Professor Yanzhi Wang, electrical and computer engineering, has been awarded a prestigious Young Investigator Program Award from the Army Research Office (ARO) on ultra-efficient, real-time DNN acceleration on mobile platforms. The ARO YIP is awarded to outstanding scientists beginning their independent careers to attract them to pursue fundamental research in areas relevant to the Army, to support their research in these areas, and to encourage their teaching and research careers.

"Previously the coding and compilations required of DNN performance and accuracy were too much for mobile," says Wang. "Our work enables the machine learning to automate the coding and reduce DNN storage by up to 6,645x on the mobile platform, saving manpower and processing power, and sacrificing no speed or accuracy."

Wang's work achieves end-to-end mobile DNN connectivity previously only thought possible within the computational and storage capabilities of desktop devices. Using a unique methodology of model compression, compilation, and design, the research offers a flexible model for DNN machine learning on the mobile platform.

Wang and his team focused first on pruning and quantization of Neural Networks based on the ADMM (Alternating Direction Methods of Multipliers) framework. Pruning requires researchers to train dense algorithmic networks, trim out the less important connections, then retrain the compressed neural networks. Wang's work combines a depth of pruning and quantization that makes DNN-level mobile storage viable.

The compiler, based on the ADMM solution framework, acts as a bridge from the data set compression to hardware application, allowing for acceleration of the DNN process. At theory, algorithm, compiler, and hardware levels, the research demonstrates the potential of accurate end-to-end data transfer in real-time.

Wang's research opens up unprecedented possibilities for mobile devices. "Extremely high-resolution object detection and recognition will be achievable," he notes. "I can envision real-time translations and question-answering, automated license plate detection, and immediate access augmented reality and virtual reality applications."

With just a phone or tablet, individual soldiers in the field will be able to more accurately recognize friendly or non-friendly objects, day or night, and give drones and helicopters more fidelity in target mapping. "In some cases, the processing speed can be up to 50x faster with the same accuracy," Wang notes. "For populations without reliable internet, if we can provide high performance processing power on hundreds of billions of devices we can make access more equitable and have a big impact."

ARO is an element of the U.S. Army Combat Capabilities Development Command's Army Research Laboratory.

NSF Grant to Create New Techniques for Storage System Data Benchmarking and Optimum Performance

Ningfang Mi, associate professor, electrical and computer engineering

Associate Professor Ningfang Mi, electrical and computer engineering, was awarded a $500K National Science Foundation grant for "New Techniques for I/O Behavior Modeling and Persistent Storage Device Configuration." Collaborating with Florida International University, Mi will work to develop new techniques for benchmarking data. The research will also focus on configuring storage systems to obtain the best possible performance and reliability.

"We want to derive new input/output (I/O) models to accurately capture I/O behaviors when running multiple applications with different workloads on storage systems, like in flash-based solid-state drives (SSDs)," Mi says.

Different storage devices have different drivers and parameters, she adds. Using default parameters does not always achieve the best performance.

"We will leverage the benchmarks to see how to set up and select good algorithms on devices to better manage them and optimize their performance," Mi explains.

The challenge though is to not simply emulate an I/O application. It's important to emulate multiple I/O workloads or applications running at the same time.

"Simple benchmarks cannot capture real applications in real systems. We want to ask the question, can good benchmarks emulate the real workloads in real systems?" she says.

The research will "analyze the impact of various system components while running multiple workloads on emerging storage systems," according to the NSF grant. Furthermore, the project centers on helping "to configure storage systems with respect to their workloads and data processing requirements."

Mi adds that this is an ideal opportunity to learn new storage techniques. Devices like laptops have flash memory and are capable of processing data quickly. But new storage techniques are being created. This research can potentially help make computers, smart phones, and other devices move even faster, she says.

SECURITY, SENSING, AND SURVEILLANCE

Security, Sensing and Surveillance Systems will focus on providing engineering solutions to outstanding mission-critical challenges in areas of surveillance, reconnaissance, imaging, and detection enabled by innovative advances in next-generation radar, sonar, video, optical/IR and communication platforms. It will build upon the current international reputation and success of Northeastern's College of Engineering in the broad area of physical threat sensing, detection, imaging, and remediation in the field of security systems.

- Resilient infrastructure
- Cybersecurity
- Transportation security

Designing Secure Deep Learning Systems by Benchmarking Vulnerabilities

Excerpt of full article by Laura Castañón, News @ Northeastern

Shelley Lin, assistant professor, electrical and computer engineering

Shelley Lin, assistant professor of electrical and computer engineering, in collaboration with IBM and Massachusetts Institute of Technology, is working with deep neural networks (DNNs) trained as object detectors. She and her colleagues are trying to benchmark vulnerabilities of these systems so that they can then design secure deep learning systems.

DNNs are a type of artificial intelligence that is often used to identify and classify images, sounds, or other inputs, by recognizing patterns. Researchers train these algorithms with millions of examples until they are able to identify an individual's voice or add decades to the face in a photo.

But knowing the details of how a specific network has been trained makes it possible to work backwards to create images that could cause the neural network to misidentify an object.

To identify DNN vulnerabilities, Lin and her research team designed an image that would make a person undetectable: a white T-shirt with a brightly colored, abstract pattern centered on the front worn by a person as they are walking.

In a digital space, researchers can relatively easily find and alter the value of specific pixels within an image to confuse the neural network. Making these attacks work in the real world is harder, but researchers have already shown that a few well-placed stickers on a stop sign could make an artificial-intelligence system see inaccurate information that could be harmful, such as a road speed limit that is not safe.

But a stop sign is a flat, stationary surface. Designing a pattern that can twist and warp with a T-shirt and still deceive a neural network is significantly more challenging.

"We had to model the transformation of the shirt while people walk, and use that in our calculations," Lin says. "Our mathematical problems had to model how the shape changes."

Lin and her colleagues recorded a person walking in a T-shirt printed with a checkerboard pattern. By tracking the corners of each square, they were able to map out how the shirt moved and wrinkled. Then they factored that information into their adversarial design before printing it.

The result was a shirt that kept the wearer from being spotted more than 60 percent of the time. Not perfect, but impressive nonetheless.

Of course, the researchers aren't trying to create a T-shirt that would allow the ultimate superspy to stroll past the surveillance cameras of tomorrow. They want to find these holes and fix them.

"The ultimate goal of our research is to design secure deep-learning systems," Lin says. "But the first step is to benchmark their vulnerabilities."

Professor Nian Sun, electrical and computer engineering (ECE), has been named an IEEE Fellow for his contributions to integrated magnetic and magnetoelectric materials and devices. The IEEE Grade of Fellow is conferred by the IEEE Board of Directors upon a person with an outstanding record of accomplishments in any of the IEEE fields of interest. IEEE Fellow is the highest grade of membership and is recognized by the technical community as a prestigious honor and an important career achievement.

ALERT Research Center Spotlight: Task Orders Awarded to Make Airports Safer

Northeastern's ALERT (Awareness and Localization of Explosives-Related Threats) is one of nine Department of Homeland (DHS) Security Centers of Excellence (COEs) located across the country. A multi-university center, ALERT conducts research and development for effective responses to explosives-related threats.

ALERT is funded by a core grant from the U.S. Department of Homeland Security Science and Technology Directorate that equates to roughly $3.6 million a year. In addition to the Center's ongoing core research award, DHS also provides each COE with an ability to obtain task order contracts targeted to develop specific security technologies and methods.

Since June 2019, five such task orders involving initiatives to make airports safer have been awarded to ALERT at Northeastern. These projects focus on making baggage and cargo scanning processes more effective, streamlined, and cost-effective; improving the experience of people traversing airport security checkpoints; and developing consistent and measurable methods for explosives detection.

The first task order is focused on improving the detection capabilities of airport passenger screening systems to make physical pat-downs in the airport security checkpoint less necessary. This project is funded at $1.2 million, with Carey Rappaport, ALERT researcher and College of Engineering Distinguished Professor, electrical and computer engineering, serving as technical lead.

"Airports spend millions of dollars over the course of every year double-checking the information that agents receive from personal screening devices, so making this process better and faster is a win for both the public and the industry," says ALERT Director and College of Engineering Distinguished Professor Michael Silevitch, electrical and computer engineering.

A second task order looks at improving a crucial piece of secondary airport screening by systematizing the swabbing of hands, liquid containers, shoes, and the like, looking for traces of chemicals or explosives. With this $650K grant, ALERT is seeking to compare and evaluate the performance of all of the swab kits used by airports across the country.

"If we can benchmark the performance of these swabs and create a gold standard, we can better define the protocol to measure the performance from airport to airport—apples to apples," says Silevitch.

Enhancing the efficiency of airport security checkpoints is the focus of the $1.3 million task order leveraging video analytics to improve the airport checkpoint process. This project's aims include understanding checkpoint wait times, supporting risk-based screening to improve throughput rates, and helping identify when someone may have forgotten an item at the checkpoint, or a possible theft.

"Not only could we possibly make the process more user-friendly and streamlined, but we could also catch anomalies, such as theft and accidental leave-behinds," says Silevitch. "The TSA can't just throw those items away, so the documentation, as well as handling and storage, is time-consuming and costly—I even heard of someone who left a snake behind, which then had to be cared for by TSA! If we can flag events like that in real-time, we can eliminate the issue altogether."

Out of the terminal and into the parts of the airport most of us never go are the areas impacted by the fourth and fifth task orders: an $800K grant to create simulation tools to visualize the contents of air cargo containers, and a $690K grant to develop a more effective system to detect opioids transmitted through international mail.

"More than one million international postal items come through JFK Airport every day—and that's just a single airport," says Rappaport. "Most of it is legitimate, but it's our job to better judge which ones have the bad stuff in them."

There are several approaches to tackle the problem, but Rappaport and technical lead Silevitch are seeking a non-invasive way to screen packages that optimizes worker safety and minimizes sensing time. One option is to use millimeter wave scanning devices to search relatively small packages for loose pills or powder and target them for closer inspection.

"Throughout all five of these task orders, DHS wants the U.S. and the world, in general, to be safer," says Rappaport. "At ALERT, we try to develop expertise to address these hard problems."

This work was funded by DHS, Science and Technology Directorate, Office of University Programs, under Grant Award 2013-ST-061-ED0001 and Task Orders 70RSAT18FR0000115,70RSAT18FR0000141, 70RSAT19FR0000041, 70RSAT19 FR0000155, 70RSAT19FR0000115.

Professor and Chair of the Department of Electrical and Computer Engineering Srinivas Tadigadapa received the 2020 IEEE Sensors Council Meritorious Service Award. This award honors a person with outstanding long-term service to the IEEE Sensors Council. It is based on dedication, effort, and contributions.

EXPERIENTIAL ROBOTICS

Autonomous Kayak Robot Measures Large Iceberg Pieces in Motion to Assess Melt Rate

Excerpt of full article by Roberto Molar Candanosa, News @ Northeastern

Hanumant Singh, professor, electrical and computer engineering. Photo courtesy of Hanumant Singh

Scientists know icebergs breaking from the Greenland ice sheet are melting fast in response to climate change, but the specifics of how quickly they are melting are still unclear. Professor Hanumant Singh, electrical and computer engineering, says the problem is figuring out how to measure large pieces of ice that are in constant motion.

"That's very poorly understood," he says. "The icebergs move, and they're moving fast, some 10 kilometers a day."

But mapping an object in constant motion is a robot's Achilles heel. Singh has made it his goal to get around that challenge with calculations that account for the movement of an iceberg simultaneously as the robot navigates around it and maps it.

In a recent paper published by the IEEE, "Multi-Sensor Mapping for Low Contrast, Quasi-Dynamic, Large Objects," Singh and a team of researchers describe the technology and algorithms they used in a kayak-sized robot so it could correct for the movement of a dozen icebergs floating in Sermilik Fjord, a 50-mile inlet into the shoreline of Eastern Greenland to render sharp 3D maps of the icebergs.

The algorithm's 3D reconstructions of icebergs show high-resolution details of the geometry and relief of the ice, which is sometimes impossible to capture even with raw images snapped by an ocean drone. Compared to the real-life ice, the accuracy of those models is remarkably close, Singh says. "Within a few centimeters, maybe 10," he says.

That's a level of detail that has been long overdue for scientists trying to determine how fast Earth's ice is vanishing, and how that change will influence the rest of the planet. As icebergs melt, tons of freshwater are being ushered into the sea. In the long run, such changing ocean dynamics can disrupt the way water flows and circulates around the globe, transporting essential heat and nutrients to frigid and temperate ecosystems alike.

"Our role was the mapping, but other co-authors are interested in the data," Singh says. "They're all physical oceanographers, and will use it to actually make models of what's happening to the freshwater, how these icebergs are melting, and how that's being affected by climate change."

Put simply, Singh's robotic system is just a camera and a sonar sensor mounted on a commercially available, gas-powered kayak. That's a break from tradition, Singh says, since ocean robots tend to be expensive.

With its camera, the robot takes raw images of the part of the icebergs exposed above the water. The robot then uses those pictures to navigate strategically around the iceberg and help the sonar sensor take high-quality measurements of the submerged ice, which accounts for more than 90 percent of the ice structure.

"We get a three-dimensional shape of the whole iceberg on the top, and then we can use that as navigation to correct stuff on the bottom," Singh says. "That data has a broad overlap, and it also gives us navigation, which allows us to correct the other sensor."

For decades, researchers have struggled to get up close and personal with icebergs. These ice formations can be several times bigger than a large parking garage, and have protruding ice above and under the water that can be dangerous if the iceberg capsizes or breaks.

That's the whole point of using clever, but relatively cheap drones, Singh says. Robots are expendable, and they can sometimes take risks that people can't.

Singh says that understanding climate change is one the best things his robots can do. That includes a list of campaigns that have studied environments such as coral reefs and archeological sites underwater. Next, it could be comets and asteroids moving in the expanse of outer space.

Enabling Remote Operation of Robots in Nuclear Facilities

Taskin Padir, associate professor, electrical and computer engineering

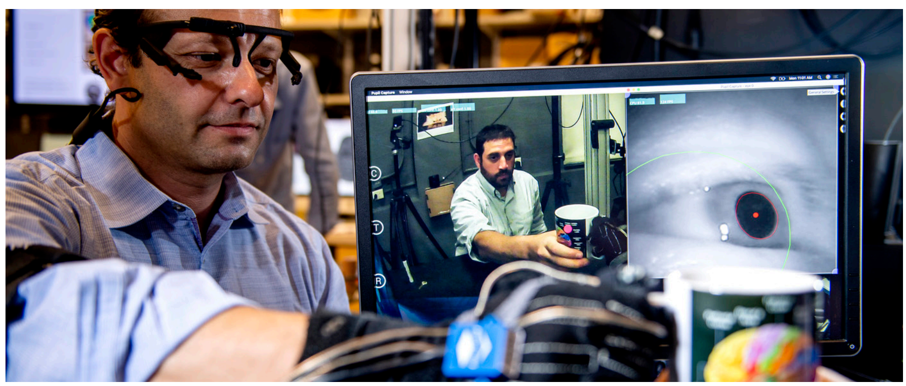
Performing any operation in a nuclear facility is a dangerous, painstaking process. What if a robot with human-like capabilities could be guided by humans to safely and effectively carry out the most dangerous tasks?

That's the goal of Electrical and Computer Engineering Associate Professor Taskin Padir whose research project, "Cooperative Control of Humanoid Robots for Remote Operations in Nuclear Environments," recently earned him and his counterpart at University of Massachusetts Lowell a one-year, $400K National Science Foundation grant. Padir and his team seek to enhance the capabilities of NASA's Valkyrie robot to perform operations in science "glove boxes" prevalent in nuclear facilities. These glass boxes feature two ports through which a human operator, wearing thick plastic gloves to prevent exposure to lethal materials, can insert his hands to run experiments, for example.

"Glove boxes are intended to provide safety for humans, but so many accidents can happen," says Padir. The solution: embody the specific skill set required to use glove boxes in the robot avatar, then enable the human supervisor to safely control the robot from a distant location. "A robot like Valkyrie can put its hands in the glove ports and perform experiments guided by humans," he says.

Controlling a complex humanoid robot is no small task, according to Padir, with safety being a primary concern. "On the robot side, we need to create safe behaviors," he says, "for example, being able to walk to the ports, putting its hands in the glove ports, avoiding obstacles, not colliding with the environment. Converting human action to robot actions to guarantee no failures and completion of the task—that's the research challenge; it's what we're trying to advance on the robotics side."

For Padir, his ultimate goal is using robotics technology to create a better quality of life, whether that's saving time and resources, increasing productivity, or aiding in the monumental task of nuclear waste cleanup. "If we can develop capabilities on both the robot side and human-robot side—to enable seamless human-robot collaboration, to understand human action and intent, to replicate useful robot actions in a distant location—this scenario can be a game changer."

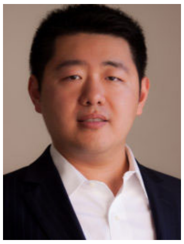


Bringing Human-Robot Object Handover to New Performance Levels

Professor Eugene Tunik (PI) of Northeastern's Bouvé College of Health Sciences, along with Professor Deniz Erdogmus and Associate Professor Taskin Padir of electrical and computer engineering, and Bouvé's Associate Research Scientist Mathew Yarossi, were awarded a $760K National Science Foundation grant for the "Coordination of Dyadic Object Handover for Human-Robot Interactions."

Picture the deftness with which people handover objects to each other during everyday interactions, whether in ordinary environments such as shops or charged high-stakes circumstances such as operating rooms. Object handover is effortless for us because we are adept at inferring and anticipating shared intentions and actions. As robots enter our lives, their ability to assist us will depend on their ability to enable natural human engagement. Although engineering advancements have improved robot dexterity for independent actions, human-robot interactions for collaborative physical tasks remain deficient for practical application.

The research team's goal is to bring human-robot collaboration for object handover to new levels of performance, where the bi-directional interaction between the pair is holistic and intuitive. To do this, the team will (i) perform a systematic investigation to identify the spatiotemporal characteristics of dyadic coordination that allow us to understand our collaborator's intentions, anticipate their actions, and coordinate our movements with theirs during object handover tasks, and (ii) operationalize this knowledge to develop robots with whom we can collaborate on physical tasks as readily as we do with humans.



$1 Million DARPA Award to Pioneer Faster, Low Power Wireless Communications with Deep Neural Networks

A powerhouse team of machine learning, signal processing and wireless communications experts led by Electrical and Computer Engineering Professor Deniz Erdogmus is collaborating on a project that aims to significantly improve wireless communications in our increasingly interconnected world.

Erdogmus and his fellow ECE researchers, Professor Kaushik Chowdhury, Assistant Professor Pau Closas, Professor Tommaso Melodia and Assistant Professor Yanzhi Wang, will partner on an 18-month, $1 million contract awarded by the Defense Advanced Research Projects Agency (DARPA) for Signal Processing in Neural Networks (SPINN) for Wireless Internet of Things (IOT).

"DARPA wants a solution at a high level for wireless communications and radar systems using deep neural networks (DNNs) or deep learning-based solutions," says Erdogmus.

Neural networks are computational mathematical models which mirror the organization of the human brain and its millions of processing units. "We can solve really complex problems by appropriately training these neural networks," explains Erdogmus.

"For wireless communication receivers, we will take classical module units and replace them with DNNs in Phase 1 of the project and then improve those neural network solutions in Phase 2." The team will use DNN models to enhance three basic receiver components: channel estimation and equalization; demodulation; and error correction decoding.

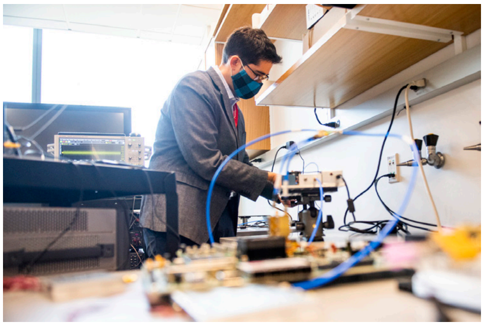
Erdogmus notes that while the concept of using DNNs in wireless communications is not new, the team's approach is novel. "What is unique is the way we're actually constructing the DNN architecture we'll be using and the way we're training the networks," he says.

According to Erdogmus, there is typically not enough data to train large neural network models for practical applications. The team's proposed solution is to build data systems to produce realistic data that imitate real data. "We'll take real data from Northeastern's Institute for the Wireless Internet of Things, set up an infrastructure, then train a generative transmitter/channel model of this Wi-Fi setup so we can produce any amount of realistic data," he says.

"Basically, the innovations we're bringing here on the receiver side are the design of neural networks and choices about what type of structure, says Erdogmus. "On the training side, we will be looking at realistic data synthesizers that can produce real data, so that we can cut down on the need for real data acquisition, which is an expensive, cumbersome process."

Ultimately the benefit of the team's research will be better wireless communications through higher data transmission rates with lower power consumption. "That means your cellphone can stream Netflix more effectively," Erdogmus explains. "That's basically what we're trying to accomplish. You need higher communications bandwidth to support more users and be able to transmit more data."

$900K NSF Award to Develop New Terahertz Devices and Control Algorithms for 6G Networks



Josep Jornet, associate professor, electrical and computer engineering

Associate Professor Josep Jornet, electrical and computer engineering, was recently awarded a $900K grant from the National Science Foundation (NSF) to be part of a collaborative project ($2.7 million total) focused on developing new Terahertz (THz) devices and their control algorithms. The project "Scaling WLANs to TB/sec: THz Spectrum, Architectures, and Control" focuses on improving the capacity of wireless networks to Terabits per second (a trillion of bits per second) to potentially strengthen communication protocols.

Specifically, the THz spectrum can help enable wireless 6G networks, which can speed up the connection process to the internet. With more devices connecting to the internet than ever before, 6G is becoming more of a reality.

Jornet will be working with researchers at Rice University and Brown University and said that the project aims to develop technology to enable the use of THz signals on a regular basis in society for communication.

"Imagine we're in a conference room and people are between us. What will we do?" he asks. "We take a step to the side to see each other. What we're going to do [with the NSF grant] first is define the ways in which we can change the direction in how we send our THz signals."

THz signals cannot go through obstacles, such as pieces of furniture or even human beings, Jornet says. But when the direction from which THz signals are perceived is controlled, then the signals can be properly utilized.

The second part of the research centers on furthering the control of THz signals at the transmitter and the receiver, as well as along their way. Walls themselves are obstacles, Jornet noted, and can absorb THz signals and interfere with the communication process.

"Can we do something, place something, on the walls to help control the direction that the signal is reflected? Think of a mirror: you shine a light and see the light go in another direction. Depending on the angle that the light is pointed on, you will see the light in a different direction," he explains.

Essentially, the NSF research hopes to create a type of smart mirror for THz signals. Creating an intelligent reflecting surface will bounce the signals in a controlled fashion, ensuring that the THz signals could be turned in any direction.

"We want to define the rules by which the transmitter reflects on surfaces, and the receiver will be able to close the communication link," Jornet says. "5G is already being implemented. We're doing fundamental research and looking at what's next."

The third part of the research is finding out how to orchestrate everything together.

Tommaso Melodia, William Lincoln Smith Professor, electrical and computer engineering

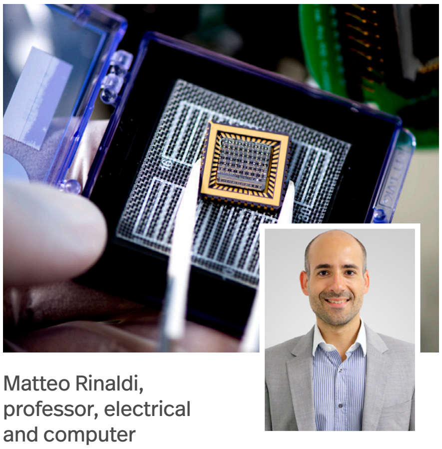
DARPA, NSF Massive 'Colosseum' Wireless Testbed at Northeastern

The Defense Advanced Research Projects Agency and the National Science Foundation relocated Colosseum, the world's most powerful emulator of wireless systems, to Northeastern University in November 2019. The massive data center can process more information in a single second than is estimated to be held in the entire print collection of the Library of Congress. It enables researchers around the country to build and test the next generation of wireless technology and find new ways to use artificial intelligence to shape the smart devices of the future.

Colosseum is located at Northeastern's Innovation Campus in Burlington, Massachusetts, joining the Platforms for Advanced Wireless Research Project Office. PAWR, which is co-led by U.S. Ignite and William Lincoln Smith Professor Tommaso Melodia of electrical and computer engineering at Northeastern, provides researchers with facilities to experimentally evaluate wireless networked systems in real-life testing scenarios. The addition of Colosseum allows researchers to virtually test their ideas before taking them to one of the program's real-world testing sites. Colosseum joins Northeastern's Institute for the Wireless Internet of Things, under the leadership of Melodia and his research team.

Visit: **northeastern.edu/colosseum**

Developing 'Off but Alert' Smart Wireless Sensors



Matteo Rinaldi, professor, electrical and computer engineering

Professor and SMART Center Director Matteo Rinaldi (PI), electrical and computer engineering (ECE), has received a $550K grant from the National Science Foundation, titled, "Zero-Power Wireless Flame Detector for Ubiquitous Fire Monitoring." The project, which centers on developing a smart wireless sensor that continuously monitors its environment, only turning on when a relevant event is detected, can be used to improve fire detection, among many other applications. ECE Research Assistant Professor Zhenyun Qian is a co-investigator on the project, which is being conducted in collaboration with United Technologies Corporation (UTC).

"We built a sensor that is always monitoring the environment but is not consuming power," Rinaldi says. "Only when it detects a specific infrared signal that comes from the target, then it turns on and can communicate the presence of the event of interest."

Rinaldi and his team will be developing zero-power digitizing infrared sensors, which "can selectively harvest the energy" from specific infrared signatures that warm objects emit and use it to activate a wireless transmitter to communicate the presence and the location of the target event. This allows the sensors to operate without using any electrical power when in stand-by.

A particularly interesting application for the sensor is with enabling ubiquitous fire monitoring, Rinaldi says.

"Residential buildings have smoke detectors to detect the smoke from potential hazards," he explains. "They are easy to make, cheap, and easy to install. They work, but there are also issues."

On a larger scale, such as with commercial buildings and construction sites, existing smoke and flame detectors encounter even more issues.

"The existing flame detectors are expensive and consume power continuously," Rinaldi says. "Imagine deploying hundreds of these flame sensors to perform fire monitoring in a large, complex environment. When we deal with so many sensors deployed in large and complex environments, frequent battery replacement is not only impractical, but it can even be dangerous and certainly it is not sustainable from a cost perspective."

"The beauty of our technology," explains Rinaldi, "is that we developed this unique approach for wireless sensors to be 'off-but-alert.' They can continuously monitor, but are only 'on' when there is a flame. You can go from having to replace the battery in a few weeks to 10 years."

The same technology could be applied to numerous areas though, Rinaldi adds. For example, the sensors could also potentially detect energy emitted from the human body. This could be applied in office settings to perform people counting, allowing companies to optimize the use of their air conditioning systems.

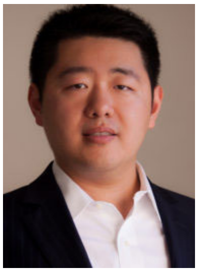
Furthermore, Rinaldi says the technology could be applied to environmental sensing and used in smart farming. The sensors could potentially detect when crops are "stressed" and need water. "It's extremely important to maximize the yield of a crop, while also minimizing use of natural resources, such as water and fertilizer," he says. "This is a known problem."

The NSF grant is a fantastic opportunity to demonstrate a minimum viable product prototype of the zero-power wireless flame sensor technology, Rinaldi concludes.

Faculty Honors and Awards

Selected Highlights

Yiannis Levendis, College of Engineering Distinguished Professor of mechanical and industrial engineering, was recently elected as a **Fellow to the National Academy of Inventors**, an honor reserved for individuals whose inventions "have made a tangible impact on quality of life, economic development, and the welfare of society." See page 21.



Assistant Professor **Yanzhi Wang**, electrical and computer engineering, has been awarded a prestigious **Young Investigator Program Award from the Army Research Office** (ARO) on ultra-efficient, real-time DNN acceleration on mobile platforms. The ARO YIP is awarded to outstanding scientists beginning their independent careers to attract them to pursue fundamental research in areas relevant to the Army, to support their research in these areas, and to encourage their teaching and research careers. See page 27.

Ambika Bajpayee, assistant professor of bioengineering received a three-year, $628K **NIH Trailblazer R21 Award** for New and Early Stage Investigators from the National Institute of Biomedical Imaging and Bioengineering, entitled "Anti-Catabolic Drug Anchored Cationic Exosomes for Cartilage Targeting and Repair." See page 17.

Associate Professor **Luca Caracoglia**, civil and environmental engineering, was awarded a $438K **National Science Foundation grant** for "Exploiting the Wind Energy Resource through Aeroelastic Vibration and Torsional Flutter."

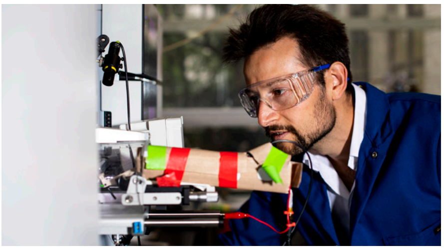
Rebecca Kuntz Willits, professor and Chair of the Department of Chemical Engineering, has been elected a **Fellow of the Biomedical Engineering Society**. Fellows demonstrate exceptional achievements and make significant contributions within the biomedical engineering field. They also have extensive leadership within the field but also have served within the Society.

Affiliated Faculty **Peter Desnoyers** (PI), Khoury College of Computer Sciences, and Professor **Miriam Leeser** (co-PI), electrical and computer engineering, are the Northeastern University leads of **$1.55 million five-year National Science Foundation grant** that is part of a $5 million total award in collaboration with the University of Massachusetts Amherst (lead) and Boston University to construct and support a testbed for research and experimentation into new cloud platforms. The new testbed will combine proven software technologies with a real production cloud enhanced with programmable hardware–Field Programmable Gate Arrays (FPGA)–capabilities not present in other facilities available to researchers today.

Srinivas Tadigadapa, professor and chair of the Department of Electrical and Computer Engineering, is the recipient of the **2020 IEEE Sensors Council Meritorious Service Award** for his outstanding long-term service to the IEEE Sensors Council.

William Lincoln Smith and University Distinguished Professor **Ahmed Busnaina**, mechanical and industrial engineering, has received the 2020 **William T. Ennor Manufacturing Technology Award** from the American Society of Mechanical Engineers "for the development of a scalable directed assembly-based nanoscale technology to print bio and chemical sensors, power electronics, and light emitting diodes using inorganic or organic materials on flexible or rigid substrates."

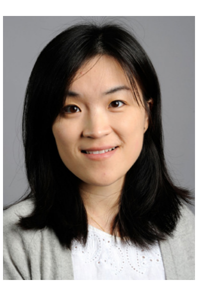
Professor **Sandra Shefelbine**, mechanical and industrial engineering, jointly appointed in bioengineering, was awarded a **Fulbright Futures Scholarship** to study skeletal mechanobiology at the University of Melbourne. She was also named a **Fellow of the American Institute for Medical and Biological Engineering** (AIMBE) in recognition of "her distinguished and continuing achievements in medical and biological engineering." Additionally, Shefelbine, in collaboration with Northeastern's College of Science, was awarded a **$650K National Science Foundation grant** for "Manipulating Fluid Flow in Mechanoadaptation of Bone."



Assistant Professor **Nikolai Slovav**, bioengineering, was recently named a prestigious **Paul. G. Allen Distinguished Investigator**, and was awarded a $1.5 million three-year grant to further his novel research on single cell proteomics. The Paul G. Allen Frontier program supports early-stage research with the potential to reinvent entire fields. See page 18.

Professor **Surendra M. Gupta**, mechanical and industrial engineering, was awarded the 2019 IEOM Society International Distinguished Professor Award in "recognition and appreciation of his dedication in teaching, learning and mentoring, and achievements in the field of industrial engineering and operations management."

Professor **Debra Auguste**, chemical engineering, was selected as an **American Institute for Medical and Biological Engineering (AIMBE) Fellow** in recognition of "her distinguished and continuing achievements in medical and biological engineering."



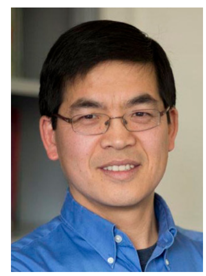
Mechanical and Industrial Engineering Assistant Professor **Xiaoning "Sarah" Jin** is a recipient of a five-year, $500K **National Science Foundation CAREER Award** for "Unifying Sensing, Machine Perception and Control for High-Precision Micromanufacturing." See page 14.

University Distinguished and William Lincoln Smith Professor **Vincent Harris**, electrical and computer engineering, has been named a 2020-2021 **Jefferson Science Fellow from the National Academies of Sciences and Engineering** with the U.S. Department of State, Office of Environmental Quality and Transboundary Issues with the Bureau of Oceans and International Environmental and Scientific Affairs. He was also selected as a Distinguished Fellow of the International Engineering and Technology Institute.

Associate Professor **Stratis Ioannidis** was **awarded a fellowship by the Greek Diaspora Fellowship Program** (GDFP) to travel to Greece. He will work at the Computation and Reasoning Laboratory (Corelab) of ECE Department of the National Technical University of Athens on Machine Learning and Learning Theory, focusing on ranking regression and learning from ranked data, under theoretical and experimental viewpoints.

Mechanical and Industrial Engineering Professors **Sagar Kamarthi**, Interim Dean **Jacqueline Isaacs**, Assistant Professors **Xiaoning Jin**, **Mohsen Moghaddam**, and Assistant Vice Chancellor for Digital Innovation and Enterprise Learning Kemi Jona were awarded a **$2 million National Science Foundation grant** for the Integrative Manufacturing and Production Engineering Education Leveraging Data Science program to develop free online courses to help people working in manufacturing modernize and retool their skills.

ITC Endowed Professor **Fabrizio Lombardi**, electrical and computer engineering, in collaboration with George Washington University, was awarded a four-year **$1.2M National Science Foundation MEDIUM grant**, split evenly between Northeastern University and George Washington University, for "Neural-Network-based Stochastic Computing Architectures with applications to Machine Learning."



Professor **Nian Sun**, electrical and computer engineering, was awarded the prestigious **Humboldt Research Award** by the Alexander von Humboldt Foundation. Sun was also named **IEEE Fellow** for his contributions to integrated magnetic and magnetoelectric materials and devices.

Professor **Milica Stojanovic**, electrical and computer engineering, was awarded the **2019 IEEE Women in Communications Engineering (WICE) Outstanding Achievement Award** for having done outstanding technical work in the broad field of communications engineering, and achieving a high degree of visibility in the field.

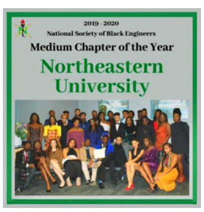
Associate Professor and Director of the Institute for Experiential Robotics **Taskin Padir**, electrical and computer engineering, has been elected for a three-year term to the **Executive Committee of the Robotics and Remote Systems Division of the American Nuclear Society**.

Abigail Koppes, assistant professor of chemical engineering, has received the **Rita Schaffer Young Investigator Award from Biomedical Engineering Society** for 2020. The award is offered each year to stimulate research careers in biomedical engineering. The recipient presents the 20-minute Rita Schaffer Young Investigator Lecture and publishes the text of the lecture in the *Annals of Biomedical Engineering*. The award recipient must be within seven years of receiving his/her highest degree at the time of award nomination submission.

Associate Professor **Josep Jornet**, electrical and computer engineering, in collaboration with the University of Pennsylvania and Duke University, has theoretically designed and experimentally demonstrated the first on-chip tunable laser for orbital angular momentum modulation and multiplexing. His research was published in ***Science***.

Student Honors and Awards

Selected Highlights

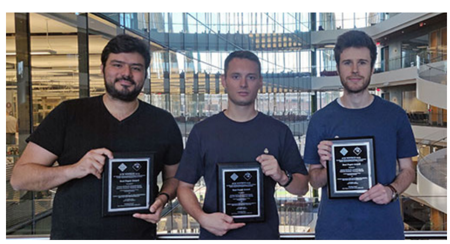


Northeastern's Black Engineering Student Society (BESS) was selected to receive the 2019-2020 National Society of Black Engineers Medium Chapter of the Year award.

Northeastern's Engineers Without Borders chapter was selected for the 2019 Premier Chapter Award from EWB-USA.

Northeastern's Society of Women Engineers student chapter received the Gold Mission Award–an honor given to SWE groups that embody the organization's core values of integrity, inclusivity, mutual support, professional excellence, and trust, and demonstrate continuous improvement in their efforts.

The **Northeastern Graduate Structural Engineering Association** (NGSEA) was selected by the Structural Engineering Institute (SEI) Local Activities Division as the **Graduate Student Chapter of the Year**. They were chosen for their "excellent mix of technical and social activities" that engage students and "help them transition into the workforce."



Computer Engineering PhD student **Lorenzo Bertizzolo**, along with co-authors Computer Engineering PhD student **Leonardo Bonati**, Electrical and Computer Engineering (ECE) Research Assistant Professor **Emrecan Demirors** (far left), and ECE Professor **Tommaso Melodia** won the Best Paper Award at the 13th ACM Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization (WiNTECH) in Los Cabos, Mexico.

Zach Rogers, a chemical engineering PhD student in Assistant Professor Sidi A. Bencherif's lab, was selected to join the Northeastern node of the **National Science Foundation's I-Corps program** for his novel proposal "Hypoxia-inducing cryogels as a fast and inexpensive technology for hypoxic cell culture conditions."

Jake Potts, BS/MS'20, bioengineering, was awarded a prestigious **Fulbright Fellowship**. He will conduct research at Sorbonne University in Paris to try to determine how certain cancerous mutations happen as DNA is "misrepaired,"–a process that occurs when radiation or harsh chemicals break the two strands of our DNA, and our cells respond by trying to repair this damage.

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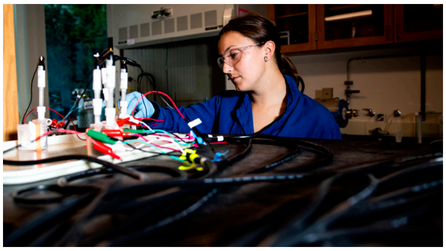
Electrical engineering PhD student **Jared Miller** was awarded a 2020-2021 **Chateaubriand Fellowship** offered by the Embassy of France in the United

States. It supports outstanding PhD students from American universities who wish to conduct research in France for a period ranging from 4 to 9 months.

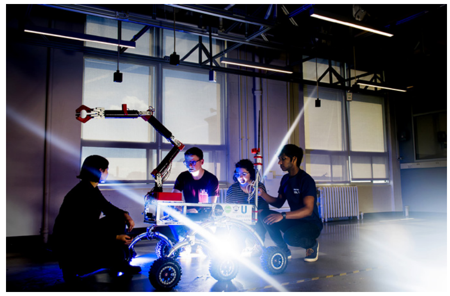


Sofia Catalina, E'20, chemical engineering, was awarded a **GEM Fellowship** for her research in renewable energy which will fund her doctoral studies at Stanford University.

PhD student **Chang Liu**, mechanical engineering, was **awarded first place** in the American Society of Mechanical Engineers Noise Control and Acoustics Division student paper competition for the paper "Preliminary Results of Microwave – Induced Thermoacoustics Imaging in Geological Media," which was presented at the 2019 International Mechanical Engineering Congress & Exposition.

Kerry Eller, E'21, bioengineering, received the **Truman Scholarship**, the most prestigious award for junior-level undergraduate citizens of the United States who possess outstanding leadership skills and are interested in a career in public service.

PhD candidate **Adel W. Fadhel**, mechanical and industrial engineering (MIE) and MIE Professor **Surendra M. Gupta's** paper titled "Carbon Emissions and Energy Balance in the Design of a Sustainable Food Waste Network Model" won the **Best Track Paper Award** in Waste Management at the International Conference on Industrial Engineering and Operations Management.



The Northeastern student team, advised by Associate Professor and Director of the Institute for Experiential Robotics Taskin Padir, electrical and computer engineering, was one of ten teams **selected as finalists** for the **NASA 2020 RASC-AL Special Edition**: Moon to Mars Ice and Prospecting Challenge. Northeastern students were also one of eight student groups from U.S. colleges **selected to compete** in NASA's Breakthrough, Innovative and Game-changing (BIG) Idea Challenge. With a $90K grant and access to testing facilities at different NASA centers the students are developing a new robotic system with four legs vs. wheels which could be part of a Lunar Mission by 2023.

Madeline DuBois, E'20, environmental engineering, was awarded a 2020 **Fulbright scholarship** at the University of Copenhagen, Denmark to study agriculture with a specialization in production and the environment.

Chemical Engineering student **Myra Afzal**, BS/MS'20, was awarded a **one-year research grant by the German Academic Exchange Service (DAAD)**. She will be working at the Helmholtz Centre for Environmental Research on bioreactor engineering for sustainable chemical production and organic waste reutilization using microorganisms.

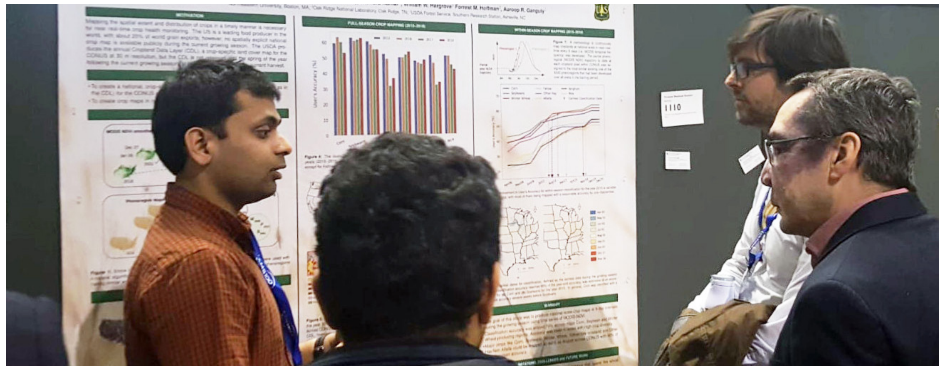
Electrical and Computer Engineering (ECE) PhD students **Kai Li** and **Ufuk Muncuk**, ECE Principal Research Scientist **Yousof Naderi**, and ECE Professor **Kaushik Chowdhury** were awarded the **Best Paper Award** at the IEEE GLOBECOM 2019 conference for their paper "SoftSense: Collaborative Surface-based Object Sensing and Tracking Using Networked Coils."

Data Analytics Engineering student **Aparna V. Alavilli**, ME'20, was awarded Northeastern's **Outstanding Graduate Student Award** for Experiential Learning for showing an extraordinary capacity to integrate academics and professional work and establishing herself as an emerging leader in their field. She received a full-time job offer from New Balance as a data scientist.

PhD student **Zhao Chen**, civil and environmental engineering, was awarded a 2020 **Thornton Tomasetti Student Innovation Fellowship** for his exceptional submittal for innovative research to investigate "Efficient Seismic Meta-modeling of Highly Nonlinear Structures with Scarce Data."

PhD student **Katie Hoyt**, chemical engineering, won the prestigious national **Ford Foundation Fellowship** to support her doctoral research. Working in Assistant Professor Benjamin Woolston's lab, her research focuses on using metabolically engineered acetogenic microbes to convert renewable single-carbon feedstocks into chemicals and fuels.

Michael Tormey, E'20, civil engineering, was awarded the prestigious **Marshall Scholarship**, which will allow him to study transport engineering for two years in the United Kingdom. He was also one of just 10 students nationwide named to the 2020 **list of New Faces of Civil Engineering** Collegiate Edition by the American Society of Civil Engineers.



Interdisciplinary PhD student **Shashank Konduri**, civil and environmental engineering, received the **First Place Poster Presentation Award** for his poster on "In-season Crop Mapping for the Continental United States" at the American Meteorological Society's 100th Annual Meeting.

Bioengineering Student Named 2020 Rhodes Scholar

Kritika Singh, E'20, Bioengineering

When Kritika Singh, E'20, bioengineering, was announced as one of 32 Rhodes Scholars for 2020, she achieved the rare distinction of being named a Rhodes Scholar, Truman Scholar, and Goldwater Scholar.

Singh, a member of the University Scholars and Honors Programs at Northeastern, will leverage full financial support from the Rhodes Scholarship to pursue a doctorate in biomedical sciences at Oxford University. Following her studies in the UK, Singh hopes to return to the U.S. and attend medical school. Her ultimate goal is to address critical emerging diseases as a physician, scientist, and advocate.

"In order to conquer the world's most pressing health challenges, we need to bring together biomedical research, clinical practice, and health policy. By being at the intersection of those fields, I hope to assume a leadership role and encourage professionals to collaborate more freely, across disciplines and national boundaries," she explains.

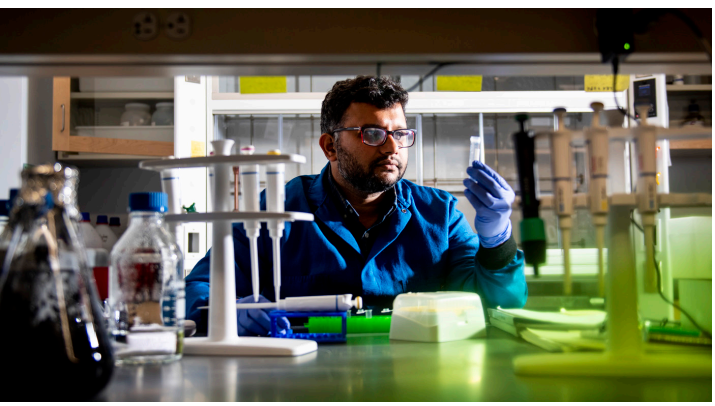
"We're incredibly proud of Kritika for winning these three major awards in three years—but even more proud of the person she is," says Jacqueline Isaacs, interim dean of Northeastern's College of Engineering. "With an infectious passion to make a difference in people's lives, Kritika has continuously forged ahead, embracing all that Northeastern has to offer to reach her bold and admirable ambitions. She embodies our mission of developing the next generation of engineering leaders to solve global challenges, and we are so excited to see where her career path will take her."

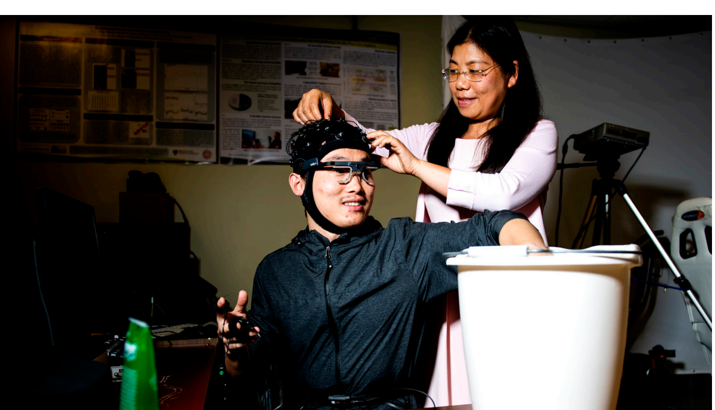
While in high school, Singh founded a non-profit, Malaria Free World, to raise awareness and funds to advocate for malaria research and eradication. With support from Northeastern's Office of Undergraduate Research and Fellowships and the cooperative education program, Singh has continued to focus on the science behind malaria while expanding her scope to conduct research at the intersection of chemical biology and bioengineering at Massachusetts General Hospital, under the direction of Ralph Mazitschek. Singh's research there has focused on studying patients' resistance to antimalarial drugs in order to develop new pharmaceuticals, as well as investigating the role of genetics in determining malaria outcomes.

At Northeastern, Singh founded the NU Global Health Initiative (NUGHI), which fosters interdisciplinary collaboration among students, medical practitioners, and public policy experts. Leveraging a Service/Research Project Award from the University, Singh organized the Northeastern Global Health Initiative Conference in October 2018—largest student-led undergraduate global health conference in the nation.

"Kritika is a unique individual because she innately understands that public health issues cannot be addressed via science alone," notes Lee Makowski, professor and chair of the Department of Bioengineering at Northeastern. "Her skills in public policy, advocacy, and leadership have distinguished her from a young age. She truly embodies the multidisciplinary mindset of the College of Engineering at Northeastern."







DEPARTMENTS

Bioengineering

Chemical Engineering

Civil and Environmental Engineering

Electrical and Computer Engineering

Mechanical and Industrial Engineering

BIOENGINEERING CHAIR MESSAGE

The Department of Bioengineering is the newest department in Northeastern's College of Engineering. Building on the success of its PhD program, our department added BS and MS degree programs in the 2015-2016 academic year. We are now in an era of rapid growth with plans to continue to increase faculty size as our student body expands.

Our research into the fundamentals of cell and tissue engineering, biomedical device design, biomedical imaging and signal processing, biomechanics and biocomputing is providing a foundation on which a vibrant bioengineering community is developing—a community that spans the entire university. With over 40 affiliated faculty, the bioengineering department offers research opportunities that encompass the entire breadth of biological and biomedical engineering.

Our co-op program is working with companies across the sector to provide our students with a broad range of opportunities within the Boston biotech industry and beyond. Through the co-op program, we identify opportunities that make it possible for our students to work in research and development areas that most excite them.

I invite you to learn more about our new and fast-growing Department of Bioengineering. Our Scholarship Report provides a window into the many activities of our faculty and the energy and breadth of their research.

Sincerely,

Lee Makowski
Department Chair
Bioengineering
l.makowski@northeastern.edu

See Bioengineering's full Scholarship Report at
bioe.northeastern.edu/sr

RESEARCH AREAS

Imaging, Instrumentation, and Signal Processing

Biomechanics, Biotransport and MechanoBiology

Computational and Systems Biology

Molecular, Cell, and Tissue Engineering

747 Students

54% Students are Women

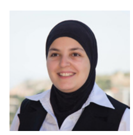
32%

Graduate Enrollment Growth
(2018 to 2019)

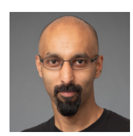
RECENT HIRES

Elizabeth Libby
PhD, University of Pennsylvania

Mingyang Lu
PhD, Baylor University



Mona Minkara
PhD, University of Florida



Mohammad Abbas Yaseen
PhD, Rice University

5 Young Investigator Awards

71 TENURED/ TENURE-TRACK
Including T/TT Affiliated Faculty

National Academy Member
Herbert Levine, University Distinguished Professor

CHEMICAL ENGINEERING CHAIR MESSAGE

We face significant challenges in our society that will shape our future. Innovations are required to reduce the impact of environmental disasters and climate change, increase healthcare equity through scale and cost control, and use of predictive technology for safety and health monitoring. Northeastern's Department of Chemical Engineering trains our students to be active participants in engineering for society and leaders for our evolving world.

Our department scholarship is focused in advanced materials and biological engineering. These broad areas provide a wealth of opportunity for students to have an impact on the environment, healthcare, and technology. Additionally, our highly accomplished, diverse faculty are recognized for their research and educational impact through Young Investigator and Trailblazer awards, American Society for Engineering Education awards, and National Science Foundation CAREER awards. Several are also Fellows of a variety of professional societies.

Northeastern's top-rated (and one of the nation's largest) cooperative education (co-op) program plays an important role in our success. Chemical engineering co-op positions span the areas of consumer products, plastics, biotechnology, nanotechnology, alternative energy, and petrochemicals, with students placed in positions both domestically and internationally. Through a combination of rigorous academics, research excellence, and professional experience, recent graduate students have taken industry and research positions at leading organizations such as Pfizer, Harvard University, Takeda, Sanofi, Lockheed Martin, and Intel, to name a few.

I invite you to explore highlights of the many aspects of our Department of Chemical Engineering and research of our faculty through our Scholarship Report.

Sincerely,

Rebecca Kuntz Willits, PhD
Professor and
Department Chair
Chemical Engineering
r.willits@northeastern.edu

See Chemical Engineering's full Scholarship Report at
che.northeastern.edu/sr

RESEARCH AREAS

Advanced Materials Research

Biological Engineering

629

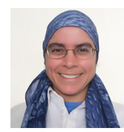
Students

45% Students are Women

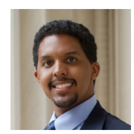
76%

Increase in graduate students (2014-2019)

RECENT HIRES



Sara Hashmi
PhD, Yale University



Andrew Jones
PhD, MIT

Benjamin Woolston
PhD, MIT

70%

Increase in research expenditures since 2017

20 Young Investigator Awards, including **8** National Science Foundation CAREER Awards

33 **TENURED/ TENURE-TRACK** Including T/TT Affiliated Faculty

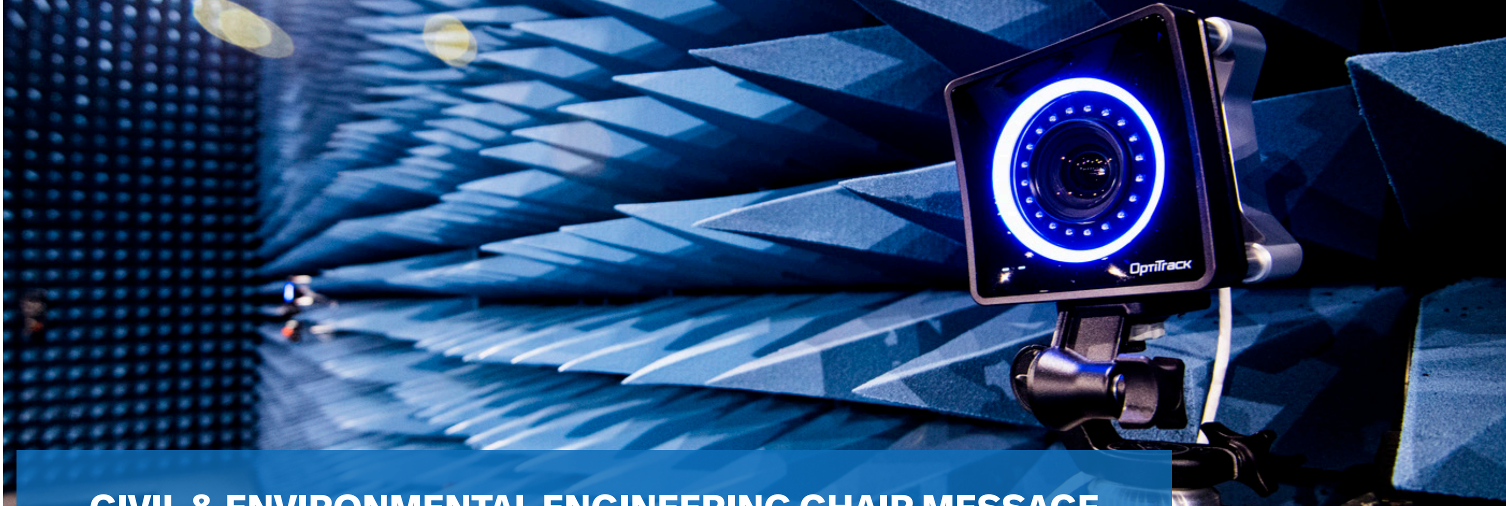
17

Professional Society Fellowships

54

Visiting Scholars (2017-2020)

National Academy Member
Arthur Coury, University Distinguished Professor



CIVIL & ENVIRONMENTAL ENGINEERING CHAIR MESSAGE

As we begin a new decade, current events stress for us the undeniable interconnectivity of our world. We continue to confront pressing, ongoing, and evolving global issues such as climate change, urban coastal sustainability, environmental justice, and the design of holistic urban regions. These are joined by novel threats, such as the COVID-19 pandemic. As civil and environmental engineers, we recognize these challenges as imperatives and opportunities for our profession to serve as leaders in building a more resilient world.

At Northeastern University, civil and environmental engineering education and research are focused on Urban Engineering: the interconnected topics of environmental health, civil infrastructure security, and sustainable resource engineering. Guided by these topics, we are training students with the interdisciplinary knowledge necessary to succeed in a rapidly changing world. Our focus on experiential education, both in the classroom and through our signature co-op and experiential PhD programs, ensures that our students graduate with real-world expertise and connections.

This year, we are pleased to launch our new Concentration in Data and Systems for our MS and PhD degrees in Civil Engineering. Private industry and government are increasingly reliant on data, and our profession is a key leader in this trend. This is an umbrella program that serves all civil and environmental engineering disciplines by providing a solid foundation in data-driven machine learning and artificial intelligence methods. It aims to promote a systems perspective, train students in modern programming languages, and develop a student's disciplinary fundamentals. We are also pleased to welcome three new faculty members, with expertise in atmospheric modeling, coastal engineering, and drinking water contamination.

Our scholars are engineering a resilient and sustainable future through leading-edge research. Our seventh annual scholarship report details the exceptional academic and professional accomplishments of our faculty and PhD candidates for the 2019-2020 academic year. We look forward to building a better world together.

Sincerely,

Jerome F. Hajjar, Ph.D., P.E.
CDM Smith Professor
Department Chair
Civil and Environmental Engineering
jf.hajjar@northeastern.edu

See Civil and Environmental Engineering's full Scholarship Report at
cee.northeastern.edu/sr

RESEARCH AREAS

Sustainable Resource Engineering

Environmental Health

Civil Infrastructure Security

TECHNICAL AREAS

Construction Management

Environmental Engineering

Geotechnical/ Geoenvironmental Engineering

Structures

Transportation

RESEARCH THRUSTS

Civil Infrastructure Security

Environmental Health

Sustainable Resource Engineering

44 **TENURED/ TENURE-TRACK** Including T/TT Affiliated Faculty

14 **Young Investigator** Awards

9 **National Science Foundation** CAREER Awards

11 **Professional** Society Fellowships

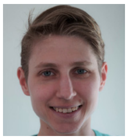
3 **Federally Funded** Research Centers

PROTECT, Puerto Rico Testsite for Exploring Contamination Threats, funded by NIEHS

CRECE, Center for Research on Early Childhood Exposure and Development, funded by EPA and NIEHS

ECHO, Environmental Influences on Child Health Outcomes, funded by NIH

RECENT HIRES



Julia Hopkins
PhD, MIT

Kelsey Pieper
PhD, Virginia Tech

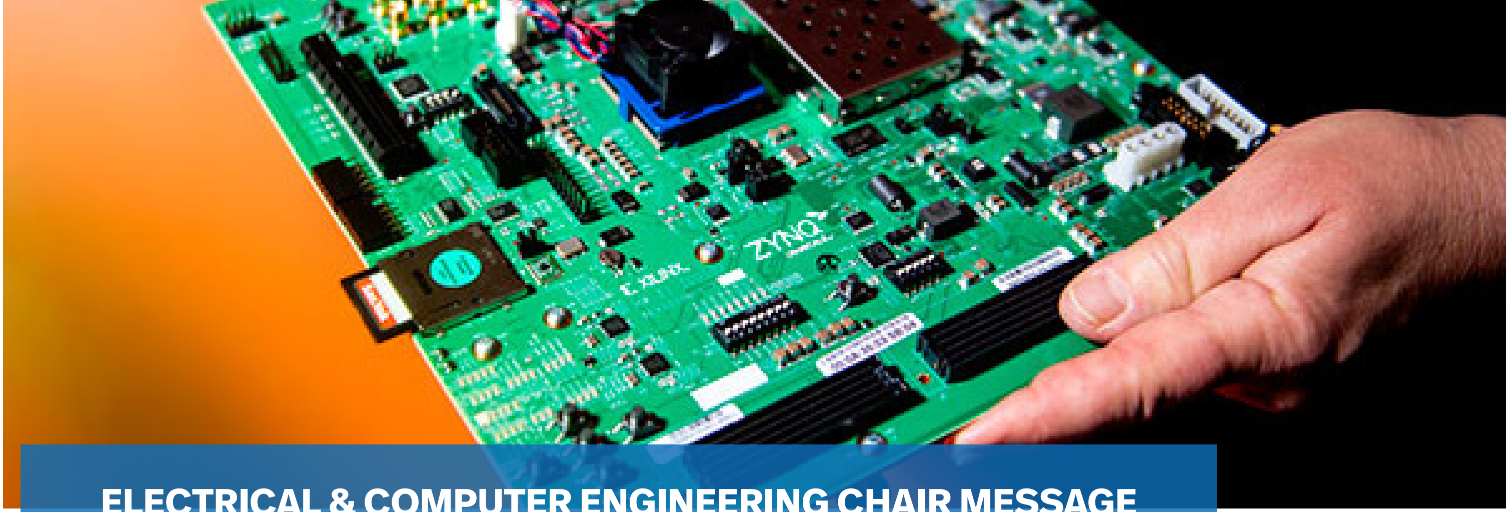
Yang Zhang
PhD, University of Iowa

164 **Masters Students**

78 **Doctoral Students**

35% Graduate Students are Women

Akram Alshawabkeh has been appointed University Distinguished Professor for his accomplishments and achievements in the field of geoengineering and environmental health.



ELECTRICAL & COMPUTER ENGINEERING CHAIR MESSAGE

Advances in research and innovations in the rapidly evolving fields of cybersecurity, robotics, internet of things, next-generation wireless networks, and smart devices are profoundly reshaping the world around us. The rapid and seamless transition to online working, teaching, and social interaction thrust upon us by COVID-19 lockdowns, have been made possible by the enormous progress in the fields of information storage, processing, and transmission and the many transformative technologies in Electrical and Computer Engineering (ECE). Northeastern University's ECE department is at the forefront of all these and many more rapidly evolving areas of research and is leading the way in educating the next-generation workforce through comprehensive training and outstanding experiential learning programs.

Continuing with the strategic vision and building on the success of the previous year where three new institutes and centers in the areas of robotics, internet of things, and smart devices were formed, the faculty and researchers in ECE were successful in getting several new high-profile initiatives funded. Chief among these are the Center for Hardware and Embedded Systems Security and Trust (CHEST)—a National Science Foundation (NSF) Industry-University Cooperative Research Center (IUCRC), the successful installation of COLOSSEUM—the world's most powerful wireless emulator awarded through the support of DARPA and NSF, and the acquisition of state-of-the-art Evatec® Aluminum Nitride deposition cluster tool and ULVAC NLD 550 oxide etcher in the Kostas Nanofabrication Center. Through these infrastructural developments and institute/center initiatives, the department is forging ahead with pioneering research at the intersection of machine learning, artificial intelligence and networking, materials and devices, computer vision, adaptive robotics, hardware and cybersecurity, and more.

This year, the department added five new tenure-track faculty in the areas of IoT, Hardware Security, Smart Devices, and Artificial Intelligence. Three new research faculty and two new teaching faculty appointments were made to augment the strategic growth and vision of the department. The year also saw the addition of a new MS program in Machine Learning. To further strengthen the experiential teaching and training initiatives, the department has undertaken extensive renovation of the existing laboratory spaces including the creation of a new ECE Makerspace.

In the last year, our faculty have been the recipient of several prestigious awards including an Army Research Office Young Investigator Program Award, a Jefferson Science Fellow, and the Alexander von Humboldt Research Fellow, amongst several others. Our annual scholarship report details the exceptional academic and professional accomplishments of our faculty and PhD candidates for the 2019-2020 year.

With excellence as our focus, we look forward to training a more equitable and inclusive engineering workforce around the world.

Sincerely,

Srinivas Tadigadapa, PhD
Chair of Electrical and
Computer Engineering
s.tadigadapa@northeastern.edu

See Electrical and Computer Engineering's full Scholarship Report at
ece.northeastern.edu/sr

RESEARCH AREAS

- Communications, Control and Signal Processing
- Computer Networks and Security
- Computer Systems and Software
- Computer Vision, Machine Learning, and Algorithms
- Electromagnetics and Optics
- Microsystems and Devices
- Power Electronics, Systems and Controls
- Robotics

The department offers **8** research concentrations and is either the lead or partner of **11** federally-funded research centers and institutes.

New Research Institutes and Centers:

- Center for Hardware and Embedded Systems Security and Trust
- Institute for Experiential Robotics
- Institute for the Wireless Internet of Things
- Northeastern SMART Center

$34M Annual Faculty Research Expenditures

DHHS
DOD
DOE
NSF
Federal/Other
Foreign
Foundation/Non-Profit
Industry/Corporation

Masters Students
365

20% Students are Women

Doctoral Students
283

25% Students are Women

63 **TENURED/TENURE-TRACK** Faculty

28 **Professional Society Fellowships** Including **14** IEEE Fellows

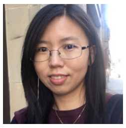
38 Young Investigator Awards, including **15** National Science Foundation CAREER Awards

NEW HIRES

Siddhartha Ghosh
PhD, Carnegie Mellon University

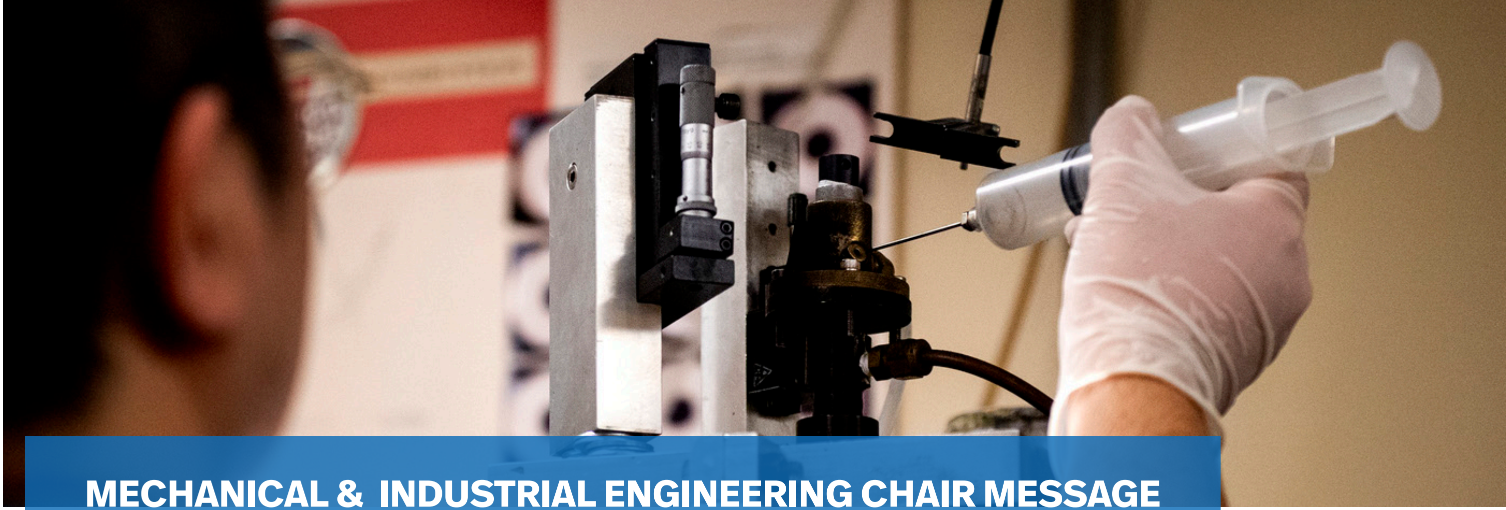
Dimitrios Koutsonikolas
PhD, Purdue University

Francesco Restuccia
PhD, Missouri University of Science and Technology



Lili Su
PhD, University of Illinois

Xiaolin Xu
PhD, UMass Amherst



MECHANICAL & INDUSTRIAL ENGINEERING CHAIR MESSAGE

As we navigate through an unprecedented time, we are reminded in engineering of the many opportunities and challenges that need to be addressed and realized. At Northeastern University, the Department of Mechanical and Industrial Engineering (MIE) is educating our students to address complex problems, advance the science and practice of engineering, engage in service activities, and promote ethical behavior, all to enhance the well-being of society. Our faculty are also recognized global leaders in their fields, and the department continues to leverage these strengths to address societal needs through engineering in an evolving and complicated world.

Addressing engineering challenges, such as climate change, data science, rethinking/reshaping cities, sustainable manufacturing, improving infrastructure, refining health and well-being, and identifying new energy resources, in the coming decade is profoundly important. To this end, the MIE department has identified key collaborative research areas, including Healthcare Systems, Energy Systems, Resilient Systems, Smart and Sustainable Manufacturing, Impact Mechanics, Multifunctional Composites, Multi-phase Structured Matter, and Biomechanics and Soft matter. Our department is comprised of over 70 tenured/tenure-track and teaching faculty, where more than 30 percent of the MIE tenured/tenure-track faculty have received prestigious Young Investigator Awards. This speaks to the quality of our faculty and research. Our department is also home to two major research centers, the Center for Healthcare Systems Engineering Institute and the Center for High-Rate Nanomanufacturing.

Faculty research efforts are broad, interdisciplinary, and current. Some of these research areas include the transformation and modernization of manufacturing to remain competitive globally, development of modeling tools for healthcare to help hospitals produce projections and consider possible shortage scenarios, origami-inspired engineering, prevention of opioid addiction, combating human trafficking, and the development of robots able to learn and adaptively execute autonomous behaviors.

This past academic year the MIE department has also seen continual growth in our program offerings, with the addition of a combined BS degree in Mechanical Engineering and Design as well as MS programs in Human Factors and Robotics-ME. These new programs bring together our disciplinary concentrations of mechanics, mechatronics, and industrial engineering. MIE is the largest disciplinary department within Northeastern's College of Engineering, with a total student enrollment of over 3,000 in fall of 2019. These new programs and degrees join our over 20 MIE programs at the BS, MS, and PhD levels.

Our annual scholarship report details the exceptional academic and professional accomplishments of our faculty and students for the 2019-2020 academic year.

Sincerely,

Marilyn Minus
Professor and
Department Chair
Mechanical and
Industrial Engineering
m.minus@northeastern.edu

See Mechanical and Industrial Engineering's full Scholarship Report at
mie.northeastern.edu/sr

RESEARCH AREAS

Biomechanics and Soft Matters – Solids and Fluids

Energy Systems

Healthcare Systems

Impact Mechanics

Mechatronics and Systems – Control, Robotics, and Human Machines

Multifunctional Composites

Multi-phase Structured Matter

Resilient Systems

Smart and Sustainable Manufacturing

55

TENURED/ TENURE-TRACK Faculty

25

Professional Society Fellowships

1657

Graduate Students Enrolled

2

Federally Funded Research Centers

NSF/DHHS Healthcare Systems Engineering Institute

NSF Center for High-rate Nanomanufacturing

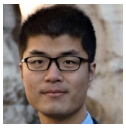
21

Young Investigator Awards, including **16** National Science Foundation CAREER Awards

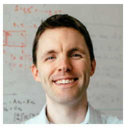
National Academy Member

Vinod Sahney, University Distinguished Professor

NEW HIRES

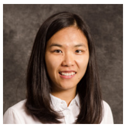


Ruobing Bai
PhD, Harvard University



Laurent Lessard
PhD, Stanford University

Hongwei Sun
PhD, Institute of Engineering Thermophysics, Chinese Academy of Sciences



Xiaoyu Tang
PhD, Princeton University

COLLEGE OF ENGINEERING

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Northeastern University
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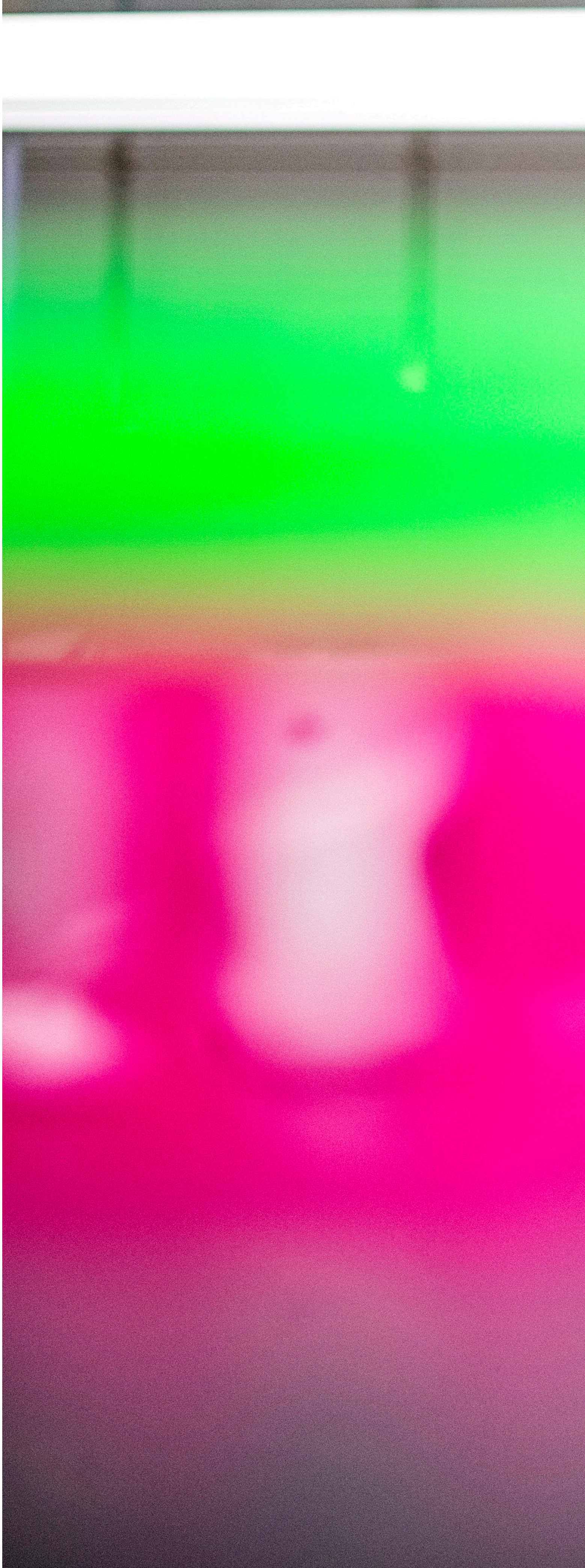
coe.northeastern.edu



COVER IMAGE

Ameet Pinto, assistant professor of civil and environmental engineering, and his team of researchers have partnered with the city of Somerville, Massachusetts to screen the community's wastewater to gauge whether COVID-19 cases are increasing or decreasing, information that could help the city prepare for potential outbreaks. Genetic material from SARS-CoV-2, the coronavirus that causes COVID-19, can be found in the feces of infected individuals. Even after the waste travels all the way to the wastewater treatment plant, the virus's genetic material is still detectable in the water.