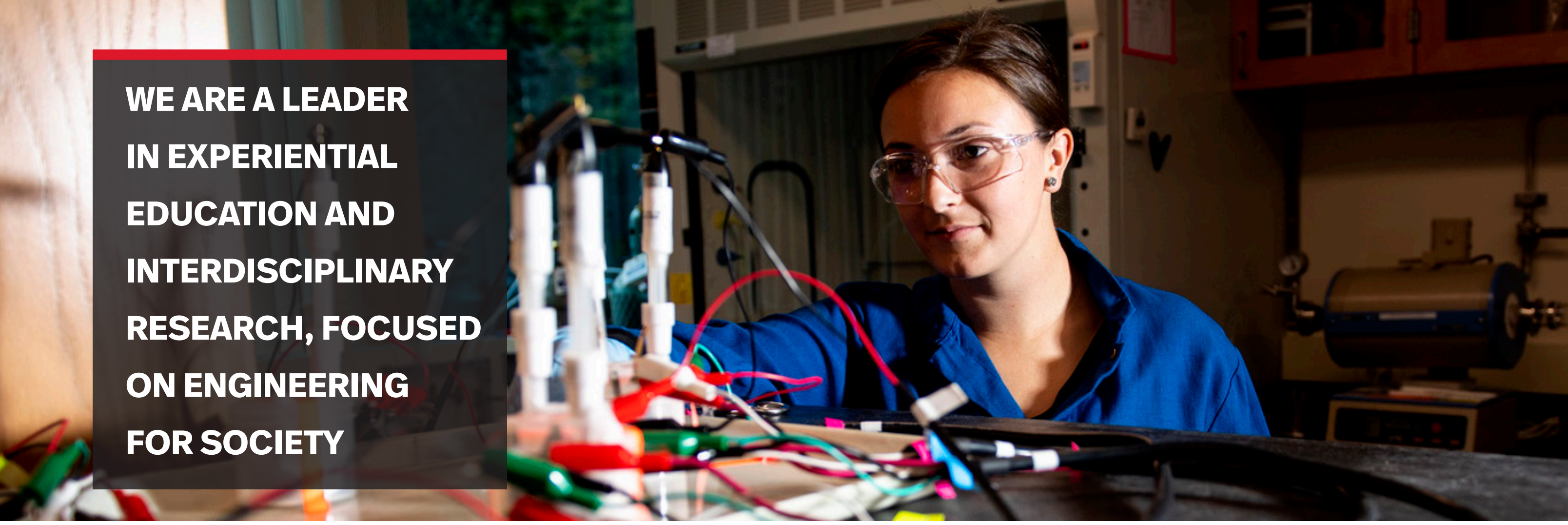
Northeastern University
College of Engineering

2018 | 2019

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,

It is my pleasure to share with you the Scholarship Report for the College of Engineering at Northeastern University for the 2018-2019 academic year. I am delighted to report that our College has continued its upward trajectory of growth and performance.

With an innovative approach to experiential education and focus on interdisciplinary research to address global challenges in health, sustainability and security, our total student body rose to 8080, up 66% from 2013. For the first time, graduate students comprised over half of students enrolled. Building on core engineering disciplines, we introduced several multidisciplinary master's degrees in cutting-edge areas such as Data Analytics Engineering, Robotics, Cyber-Physical Systems, and new concentrations in Information Systems. This year we added an MS in Data Architecture and Management and an MS in Human Factors. We also extended program offerings to campus locations in Seattle and Silicon Valley to create more opportunity for students. Additionally, Northeastern is one of only a few universities to offer cooperative education experiences to graduate students. I am excited to share that during the last academic year, the College of Engineering placed nearly 1,000 graduate students on co-op.

Our research enterprise also continues to experience strong growth. In 2019, we received $67 million in external awards, up 94% since 2013. Additionally, in just the past year, our college launched five multidisciplinary research centers and institutes, bringing together expertise from across the college, university, and partners to drive discovery in areas of pressing societal need, including "smart" devices, wireless communications, the internet of things, robotics, electronic hardware and embedded security, and the chemical imaging of our bodies. These new programs build upon the work of our established multi-institutional research centers, including over $5 million in annual funding for the Puerto Rico Testsite for Exploring Contamination Threats (PROTECT), and over $4 million annually for Awareness and Localization of Explosives-Related Threats (ALERT).

Our highly accomplished 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 in just one academic year, our faculty received 25 external national awards, including young investigator awards and being named fellows of their professional societies.

In recognition of the College's success, we have once again been ranked among the top graduate engineering colleges by *U.S. News and World Report*, placing No. 34, up from 62 in 2013.

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 2013 to 2018

ENROLLMENT AND OUTCOMES

GRADUATE DEGREE CONFERRALS

1403

up **114%**

1495

Mean 2-part SAT score up 68 points

TOTAL ENROLLMENT

8080

52% Graduate
48% Undergraduate

ENROLLMENT GROWTH

151%

Master of Science

BS increased by **31%**, and PhD by **29%**

36%

Freshmen are women, up from 28%

INTERDISCIPLINARY AND EXPERIENTIAL LEARNING

GRADUATE CO-OP PLACEMENTS

993

Up 55% vs. 2016

GLOBAL EXPERIENCES

212%

Increase since 2014

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

62%

Increase in students taking non-engineering minors

41

Academic programs interdisciplinary with other Northeastern University colleges

TRANSFORMATIONAL RESEARCH

$67M

2019 External Research Awards up 94%

90

Young Investigator Awards

48

NSF CAREER Awards

116 Patents (2013-August 2019)

Journal Papers in 2018

670

283

Conference Proceedings in 2018

Welcome New Faculty

ROUZBEH AMINI
Associate Professor
(joining January 2020)
Jointly appointed in Mechanical and Industrial Engineering, Bioengineering
PhD, University of Minnesota, 2010

Scholarship focus: Biomechanics, mechanobiology, biotransport

YANING LI
Associate Professor
Mechanical and Industrial Engineering
PhD, University of Michigan, 2007

Scholarship focus: Mechanics of materials, bio-inspired engineering, and additive manufacturing; mechanics of innovative architectured materials; mechanical metamaterials; biological materials

BENJAMIN WOOLSTON
Assistant Professor
(joining January 2020)
Chemical Engineering
PhD, MIT, 2017

Scholarship focus: Metabolic engineering and synthetic biology for sustainable biochemical production and human health

SARA HASHMI
Assistant Professor
Chemcical Engineering
PhD, Yale University, 2008

Scholarship focus: Complex fluids, biomaterials & soft materials: manipulation of nanoscale and single-particle properties to control macroscale transport & assembly; microfluidics for biomedical, pharmaceutical & energy applications

MONA MINKARA
Assistant Professor
Bioengineering
PhD, University of Florida, 2015

Scholarship focus: Theoretical physical chemistry; computational biochemistry and interfacial chemistry; biological physics; novel studies of surfactants using Monte Carlo algorithms

MOHAMMAD ABBAS YASEEN
Assistant Professor
Bioengineering
PhD, Rice University, 2008

Scholarship focus: Advanced microscopy for minimally invasive, in vivo characterization of brain function

ANDREW JONES
Assistant Professor
Chemical Engineering
PhD, MIT, 2018

Scholarship focus: Systems engineering approaches to understand the impact of engineered and environmental stresses on bacteria life cycles with applications in health, ecology, water and wastewater treatment

KELSEY PIEPER
Assistant Professor
Civil and Environmental Engineering
PhD, Virginia Tech, 2015

Scholarship focus: Applied environmental chemistry; corrosion; drinking water quality, treatment, and infrastructure; post-disaster drinking water recovery; public health engineering

YI ZHENG
Associate Professor
Mechanical and Industrial Engineering
PhD, Columbia University, 2014

Scholarship focus: Thermo-fluids, multifunctional composites, multiphase structured matter, micro/nanoengineering

JOSEP M. JORNET
Associate Professor
Electrical and Computer Engineering
PhD, Georgia Institute of Technology, 2013

Scholarship focus: Terahertz communications, wireless nano-biocommunication networks, internet of nano-things

MILAD SIAMI
Assistant Professor
Electrical and Computer Engineering
PhD, Lehigh University, 2017

Scholarship focus: Sparse sensing and control in cyber-physical networks and robotics, distributed systems theory and applications, network optimization and control, hard limits and tradeoffs in large-scale dynamical networks

185 **TENURED/ TENURE-TRACK** faculty

17 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

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

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

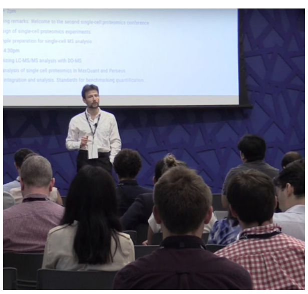
Research Conferences

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.

French American Innovation Day

CDM Smith Professor and Chair Jerome Hajjar and Associate Professor Andrew Myers, of Northeastern's Department of Civil and Environment Engineering, along with the Office for Science and Technology of the French Consulate in Boston, Professor Franck Schoefs from the University of Nantes, and the Sea and Littoral Institute IUML, hosted French American Innovation Day at Northeastern to share information and ideas on the innovation potential of Floating Offshore Wind Technology.



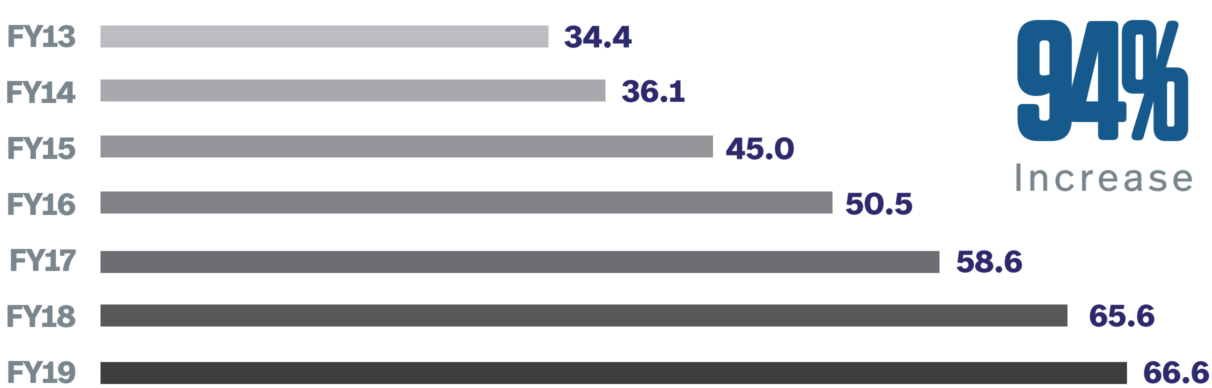
Single Cell Proteomics Conference

The second annual Single Cell Proteomics conference, led by Assistant Professor of Bioengineering Nikolai Slavov of Northeastern and in collaboration with Harvard University, brought together pioneers in the field from industry, academia and government from around the world. It provided a stimulating platform of scientific exchanges, poster sessions, and talks from leaders in the field.

I-PrACTISE – Improving PrimAry Care Through Industrial and Systems Engineering

Offered in partnership with Northeastern's Healthcare Systems Engineering Institute, led by Professor James Benneyan, and the University of Wisconsin Department of Family Medicine and Community Health. It brought together a growing community of clinicians, systems engineers, and researchers interested in collaborative research to improve the quality of primary care processes for patients, families, and caregivers.

External Research Award Growth ($M)



94%
Increase

Lorraine Mountain Receives ASEE Borman Award

Assistant Dean and Senior Co-op Coordinator **Lorraine Mountain** was selected as the Alvah K. Borman Award recipient for 2019 by American Society for Engineering Education for her significant contributions to the advancement of Engineering Cooperative Education.

ASEE Diversity Recognition Program

The College of Engineering has been selected as a recipient of the 2019 American Society of Engineering Education Diversity Recognition Program – Bronze Level. The Bronze level recognition means that Northeastern University is among the nation's leaders in inclusive excellence.

Harris Receives Two NSBE Honors

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

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

Aidin Panahi, PhD'19

MECHANICAL ENGINEERING

Advised by Yiannis A. Levendis, College of Engineering Distinguished Professor, Mechanical and Industrial Engineering

Aidin Panahi received his PhD in Mechanical Engineering in 2019. While pursuing his PhD in the Combustion & Air Pollution Laboratory, Panahi worked on the fundamentals of "clean energy" and "alternative fuels" for combustion technologies in order to lower the emissions of pollutants and net greenhouse gases, in addition to generating carbon nanostructures from pyrolysis of waste plastics through thermochemical conversion and combustion. Panahi conducted collaborations with research teams in Germany (University of Bochum), England (University of Leeds), Canada (McGill University), Turkey (Middle East Technical University), China (Harbin Institute of Technology) as well as with Northeastern's Department of Chemical Engineering. His graduate studies were supported by the MIE department's Teaching Assistant Award, the National Science Foundation Research Award, and Alfred J. Ferretti Conference Travel Awards. Collectively, his doctoral work has led to over 20 publications in top-tier journals and conference presentations. Panahi received the Akira Yamamura Award for Research Excellence in Mechanical and Industrial Engineering from Northeastern University in 2017 and 2019. Panahi currently works as a post-doctoral research associate at Massachusetts Institute of Technology and is leading a project in collaboration with British Petroleum.

Fritz Previlon, PhD'19

COMPUTER ENGINEERING

Advised by College of Engineering Distinguished Professor David Kaeli, Electrical and Computer Engineering

After participating in Northeastern University's Summer Academic Enrichment Program while a student at Roxbury Community College, Fritz Previlon, who completed high school in Port au Prince, Haiti, earned a half-tuition scholarship and transferred to Northeastern's Department of Electrical and Computer Engineering. During his undergraduate studies, he began doing research at the Northeastern University Computer Architecture Research (NUCAR) laboratory. He graduated magna cum laude with a BS in Computer Engineering in 2012. He then continued to pursue his MS and PhD degrees, working in the NUCAR group. Previlon's PhD thesis work focused on vulnerability analysis for graphics processing units (GPUs). Given their raw computing horsepower, GPUs are used to accelerate a wide class of today's workloads, including machine vision algorithms used for vehicle navigation, and machine learning algorithms used for cancer detection. These devices are highly susceptible to transient errors (i.e., random bit flips) caused by high energy particle strikes from the atmosphere. In his research, Previlon characterized the vulnerability of a variety of GPU applications, developing state-of-the-art methods to improve the reliability of future GPU systems.

During the graduate program, Previlon worked on co-ops at both Advanced Micro Devices and ARM—experiences directly related to his MS and PhD thesis work. He enjoyed mentoring Northeastern undergraduates in their research projects with NUCAR. Upon graduating, he started full-time work at ARM as a software engineer in July 2019.

Meryem Öznur Pehlivaner, PhD'18

CHEMICAL ENGINEERING

Advised by Assistant Professor Adam Ekenseair, Chemical Engineering

While pursuing her PhD in Chemical Engineering, Meryem Pehlivaner developed sprayable thermoresponsive hydrogel coatings for tissue regeneration and investigated the role of polymer chemistry on cell viability and behavior. Her graduate studies were supported by a Distinguished Dean's Fellowship, Outstanding Graduate Research Award, and Biomedical Engineering Society Innovation and Career Development Award. Additionally, Pehlivaner was awarded third place for her poster presentation at the Society for Biomaterials Conference (2017). During her PhD, she published three first-author papers and her collaborative research with Massachusetts General Hospital was featured on the cover of *Tissue Engineering Part C*. Prior to her PhD, Pehlivaner worked on a project where she created an electrode with an interdisciplinary team from Cornell University. This cutting-edge research led to a story in *R&D Magazine*, titled "Bacteria-Coated Nanofiber Electrodes Digest Pollutants." After completing her PhD, Pehlivaner joined Saint-Gobain Research North America as a senior research engineer. Currently, she is responsible for developing next-generation resin and grinding aid technologies for Coated Abrasive product platforms.

Rana Azghandi, PhD'19

INDUSTRIAL ENGINEERING

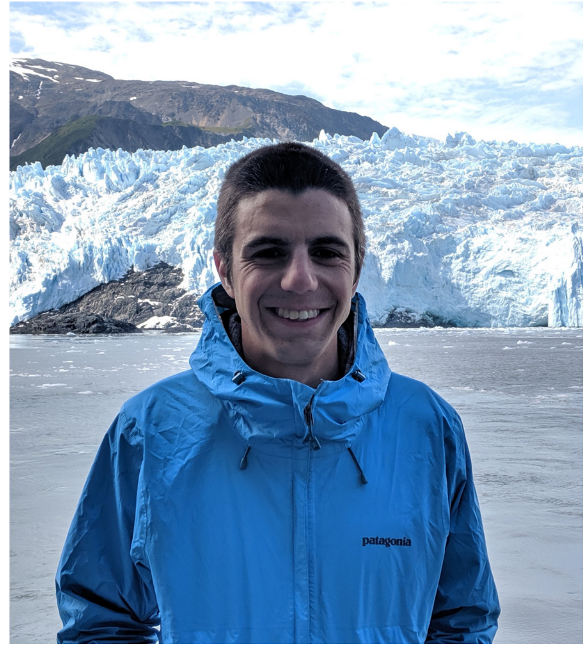
Advised by Assistant Professor Jacqueline Griffin, Mechanical and Industrial Engineering

Rana Azghandi received her PhD in Industrial Engineering in June 2019. Her research has focused on defining innovative models that address significant societal challenges. Azghandi has concentrated on analytic models for effective planning in response to sudden disruptions, with a focus on the role of complex systems. Her models center on contemporary events posing critical challenges, e.g. the evacuation of vulnerable populations during natural disasters and drug shortage management. Multiple industrial engineering news outlets have highlighted her research. Azghandi was granted multiple travel awards to present her research at various conferences. During her studies, she completed Santa Fe Institute's complex system summer school. Her research won the Akira Yamamura Award for Excellence in Mechanical and Industrial Engineering from Northeastern University. After completing her PhD, Azghandi joined Liberty Mutual as a senior analyst.

Thomas J. Vandal, PhD'18

INTERDISCIPLINARY ENGINEERING

Advised by Professor Auroop Ganguly, Civil and Environmental Engineering



Thomas J. Vandal received his PhD in Interdisciplinary Engineering from the Department of Civil and Environmental Engineering in 2018. At Northeastern, he was a member of the Sustainability and Data Science Laboratory, applying innovative deep machine learning techniques to problems in climate science. Vandal completed his dissertation based on his award-winning research on Bayesian Deep Learning for Statistical Downscaling in Climate. Upon graduation, he joined the NASA Ames Research Center in California as a research scientist, having interned with NASA while completing his PhD. Vandal's work focuses on artificial intelligence for the Earth Sciences, and he is a member of the NASA Earth Exchange team (NEX).

Graduate 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
MIT Lincoln Lab
Merck & Co.
Shire
National Labs such as Argonne, Brookhaven, Oak Ridge, Pacific Northwest

ACADEMIA

University of California (Berkeley, Los Angeles, San Francisco)
Massachusetts Institute of Technology
Johns Hopkins University
Boston University
Rensselaer Polytechnic Institute
Harvard Medical School
University of Maryland
University of Wisconsin
University of Toronto
Baylor College of Medicine

INDUSTRY

Google, Microsoft, Bristol-Myers Squibb, Caterpillar, Cisco, Ford Motor Company, Johnson & Johnson, Visa, Samsung, Intel, Dominion Energy, MITRE, PepsiCo, Dell EMC, Amazon, BAE Systems, Raytheon, IBM, PayPal, Siemens, Apple, EMD Millipore, Schneider Electric, Proctor & Gamble, General Electric, Wayfair, Leidos Engineering, JetBlue, Facebook, SpaceX, Tesla

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

Laura Lewis, Distinguished University Professor, chemical engineering, and mechanical and industrial engineering

Patent for Creating Rare Earth-free Permanent Magnets

Distinguished University Professor Laura Lewis, jointly appointed in the Department of Chemical Engineering, and the Department of Mechanical and Industrial Engineering, was awarded a U.S. patent for an invention that provides rare earth-free permanent magnetic materials and methods of making them. The materials can be used to produce magnetic structures for use in a wide variety of technological applications, such as motors, generators, and other electromechanical and electronic devices. Magnets fabricated using the materials described in the patent can be substituted for magnets requiring rare earth elements that are costly and in limited supply.

Solutions to Global Energy Problems May Exist in the World's Smallest Materials

Associate Professor Yi Zheng, mechanical and industrial engineering, is examining some of the world's biggest problems—such as climate change and dependency on fossil fuels—and finding solutions in the world's smallest materials. His research focuses on nanomaterials, which generally range in size from 1 to 100 nanometers (a nanometer is one billionth of a meter).

Recently, Zheng has been awarded a $500K prestigious CAREER Award from the National Science Foundation to create new fundamental knowledge about nanoscale radiative heat transfer, which is needed to solve pressing problems in energy harnessing, conversion, and cooling. The project aims to design nanomaterials that can be integrated into solar cells to increase their effectiveness and make solar energy a more appealing and viable prospect against other forms of power. In addition, it will explore radiative cooling, a process by which energy from the sun is harnessed to lower temperatures.

Yi Zheng, associate professor, mechanical and industrial engineering

While the general public is aware of the sun's ability to generate heat, it's not yet a mainstream idea that it can also be used to cool things down. "When people talk about cooling, all they know is

continued from page 10

water-based cooling, where you have water circulating to reduce temperatures," says Zheng. "But this radiative cooling material I'm working on could replace traditional air conditioning units."

Traditional ACs use an immense amount of electricity to provide their users with cooler temperatures and using electricity causes greenhouse gases to enter the atmosphere. By contrast, the radiative cooling technology Zheng is working on cools things down without using nearly as much energy, reducing the carbon footprint of temperature regulation.

Zheng knows that solving global energy difficulties needs to be a collaborative effort. "What I'm doing is just a small piece of the puzzle," he says. To that end, his project also intends to foster young people's interest in the potential of nanomaterials, paving the way for future engineers to work toward solving these problems. "I want to show the public how cool nanomaterials are, especially high school students," Zheng says. "I want to bring them into nanoengineering, where they can come up with their own solutions to these problems."

Improving Designs for High-Energy and Safe Solid-State Batteries

With a critical need for improved energy storage safety for electric vehicles and large-scale integration of renewable electricity grid storage to improve domestic energy security, Assistant Professor Hongli Zhu, mechanical and industrial engineering, and Assistant Professor Joshua Gallaway, chemical engineering, have received a $480K grant from the National Science Foundation, titled, "Engineering the Metal Sulfide Interface in All-Solid-State Batteries through Operando Study."

State-of-the-art battery storage technologies, such as liquid electrolyte lithium-ion batteries, do not meet performance requirements, including safety and high energy density for broad use; however, solid battery chemistries using high-energy-density electrodes and solid-state electrolytes could provide an avenue toward gains in energy density and safety. As such, Zhu and Gallaway will study all-solid-state batteries—a promising strategy that enables high-energy-density battery chemistries along with safety and durability benefits. While sulfide composites are promising as solid electrolytes in all-solid-state batteries due to their high ionic conductivity and favorable mechanical strength features, sulfide solid electrolytes still face challenges that limit their use, including limited electrochemical window, compatibility with electrodes, and stability in air. The study will result in a fundamental understanding of the mechanisms and material interactions of metal sulfides in all-solid-state batteries. The research will guide improvements to material design, interface engineering between electrolytes and electrodes, and eventually enhanced designs for high-energy solid-state batteries.

Hongli Zhu, assistant professor, mechanical and industrial engineering

Joshua Gallaway, assistant professor, chemical engineering

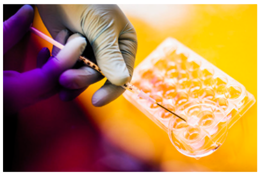
BIOMACHINE INTEGRATION

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

CAREER Award to Develop Advanced Biomaterials and Help the Body Fight Cancer

One of the reasons cancer is so hard to treat is that cancerous cells come from our own bodies. Our immune system has trouble distinguishing them from healthy cells. “We can teach our immune system to attack cancer cells,” says Sidi A. Bencherif, an assistant professor of chemical engineering, but to do their job, immune cells need a steady supply of oxygen.



Sidi A. Bencherif, assistant professor, chemical engineering

When cancer cells form tumors, their growth outpaces the available oxygen, creating hypoxic (low oxygen) areas. In a hypoxic environment, cancer cells can adapt their metabolism to survive, and even become more aggressive. But immune cells struggle to function. To study how low-oxygen environments alter the various functions of immune cells and ways to reverse it, Bencherif has designed a porous, gel-like material that gives off oxygen. He recently received a CAREER Award from the National Science Foundation to support this work.

Bencherif did not originally build the gels to produce oxygen. He designed them as part of a cancer vaccine platform: a microenvironment which would be loaded with cancer cells along active biomolecules and injected under the skin to act as training camps for immune cells. The porous gels would attract and activate dendritic cells (the information-gathering spies of the immune system), expose them to cancer cells so they know what to target, and then send them back to the lymph nodes to share that knowledge with T-cells (the little soldiers in the body).

“It really is a lot like a training camp: recruit, train, activate and release,” Bencherif says. “And when we release dendritic cells, they will activate T-cells and mount a strong and specific immune response against cancer.”

But a gel filled with cancer cells acts a lot like a tumor—it creates a low-oxygen environment, which could make it harder for the dendritic cells to do their jobs. “Even if you are recruiting immune cells and trying to educate them, if you have a hypoxic environment, you’re not going to trigger a strong immune response,” Bencherif says. “You have to overcome hypoxia first.”

Now Bencherif has incorporated small particles that react with water into the matrix of the gels. This reaction produces a steady supply of oxygen. The oxygen-producing gels will allow his team to study how an oxygen-rich environment affects the various functions of dendritic cells as they interact with hypoxic cancer cells.

“This is basic science. I’m trying to understand how these immune cells are affected by the tumor microenvironment and, if they are inhibited, how can we reverse it,” Bencherif says. “Down the road, this research may help us to make a better vaccine and potentially save millions of lives.”

Editorial Credits, Laura Castañón

$1.34 Million NIH Grant to Transform Brain-to-Computer Communication

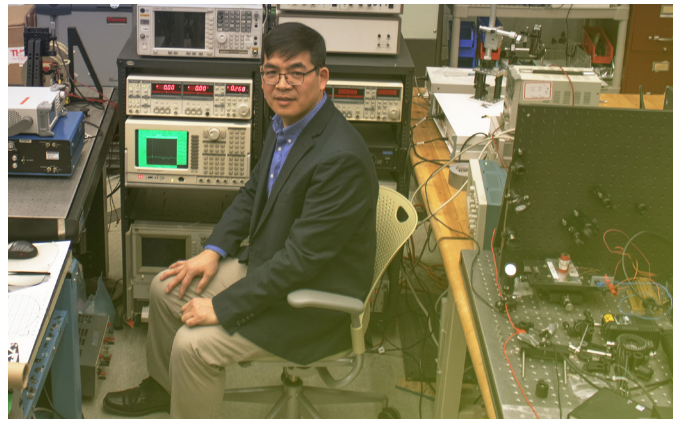
The National Institutes of Health awarded a three-year, $1.34 million grant to Northeastern University Electrical and Computer Engineering Professor Nian Sun, Associate Professor Marvin Onabajo and Assistant Professor Aatmesh Shrivastava, in collaboration with Massachusetts General Hospital (MGH), to develop a wireless microscale neuronal recording and stimulation system that may lead to improved treatments for those with brain dysfunction and transform brain-to-computer communication for both healthy and impaired individuals.

"Basically, we are building a brain-computer interface," says lead investigator Sun, "and the potential applications are enormous." The project is unique, he explains, because it uses a mechanical antenna for wireless communication between the brain and a computer. He notes that the antenna's extremely small size makes it more suitable for implanting in the brain without causing much damage.

Under the grant, Northeastern researchers will engineer the system and deliver the hardware, including brain implants and external transceivers; MGH, under the leadership of Dr. Sydney Cash, will conduct biological tests—both in vitro and in vivo—using mice.

A NEW AND TRANSFORMATIVE APPROACH

The system will be useful for patients with brain dysfunction ranging from Epilepsy to Alzheimer's disease or, for example, those who have brain damage due to sports injuries or accidents. In addition, the team's research may enable an individual to communicate his or her thoughts directly to a computer without the need to type on a keyboard.



Nian Sun, professor, electrical and computer engineering

The brain-machine interface is "a two-way communication channel," explains Sun. "Using this interface, we can sense what that person wants to do. The brain thinking can tell the computer what he wants to do through the brain-computer interface; for example, he may want to go out, eat something or get help with a task."

Sun cites the strong contributions of both the Northeastern and MGH team and its synergy as "critical" to the success of the project. He notes that in the field of brain-computer interface research, there are different approaches being explored by engineers, scientists and clinicians. "The question is: which one will be the winning approach? We have an opportunity to propose something new and transformative. It sounds like sci-fi now, but we're working very hard to make it real."

$1.2 Million National Science Foundation Grant to Develop a Brain-Computer Interface System Implemented in an Augmented Reality Environment for Unilateral Spatial Neglect

Unilateral spatial neglect is a perceptual disorder that is one of the most common consequences of right-side brain damage after stroke, occurring in 29% of the 15 million people who sustain stroke worldwide. Patients with neglect demonstrate inattention to objects or events on the side that is opposite to the damaged part of the brain. They often miss food on one side of the plate, missing words on one side of the page, bumping into the left door jamb, getting confused by moving objects, and being fearful of walking in crowded places. The current gold standard for detecting and rehabilitating neglect lacks generalizability to dynamic tasks and contexts encountered during activities of daily living.

Assistant Professor Sarah Ostadabbas, electrical and computer engineering, is the Northeastern principal investigator of a $1.2 million National Science

CAREER Award to Develop Implantable Electrode Arrays to Map the Brain

Silent and invisible—yet incredibly powerful—the human brain is still largely a mystery. Recently awarded a prestigious CAREER Award from the National Science Foundation, Electrical and Computer Engineering Assistant Professor Hui Fang, who is also affiliated faculty with bioengineering and mechanical and industrial engineering, is at the forefront of bringing further clarity to the inner workings of the brain. His group is developing implantable electrode arrays that map the electrical activities inside the brain to create a bridge between neural function and the outside world.

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

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

Hui Fang, assistant professor, electrical and computer engineering

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

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

Foundation grant in collaboration with the University of Pittsburgh (lead), titled "SCH: INT: Collaborative Research: Detection, Assessment and Rehabilitation of Stroke-Induced Visual Neglect Using Augmented Reality (AR) and Electroencephalography (EEG)."

The project team will develop a brain-computer interface (BCI) system that will be implemented in an augmented reality environment for detection, assessment and rehabilitation of unilateral neglect during activities of daily living. More specifically, the system will in real-time monitor the brain activity recorded through EEG for the detection and assessment of visually neglected extra-personal space. Moreover, the system will also include haptic, auditory and visual stimulation while the users are engaged in real-world tasks conducted during rehabilitation for reducing neglect-related disabilities.

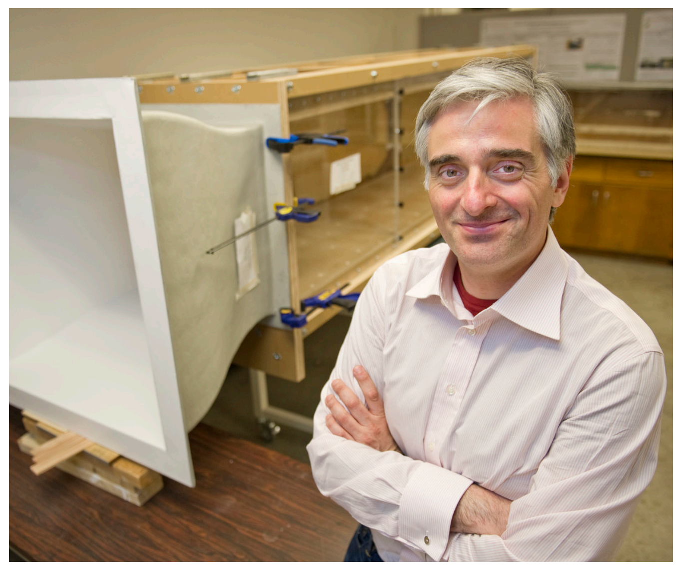
Sarah Ostadabbas, assistant professor, electrical and computer engineering

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

Performance-Based Wind Engineering for Super-Tall Buildings and Towers



Luca Caracoglia, associate professor, civil and environmental engineering

The progressive increment of structural complexity and sensitivity to wind-induced vibration and damage in building structures leads to the need for more accurate and more efficient methods for structural analysis and estimation of structural response. Associate Professor Luca Caracoglia, civil and environmental engineering, was awarded a National Science Foundation grant for "Stochastic Approximation Algorithms for Wind-Induced Dynamics of Next-Generation Tall Buildings and Tower Structures."

Performance-based wind engineering (PBWE) has received considerable attention in recent years, especially for the study of building structures. PBWE is necessary to advance the analysis of the next-generation, super-tall buildings and tower structures, in which a core lateral resisting system is combined with a three-dimensional system of lateral bracings through stay-cables. The three-dimensional arrangement of the stays, which may reach unprecedented lengths, makes this type of structure particularly complex.

One of the technological challenges is the need for forming a cable network by connecting the stays using transverse restrainers that can reduce sensitivity to wind-induced vibration. This unique structural configuration is particularly interesting for future building construction, but the wind-induced dynamics of this configuration is not fully understood. Understanding the performance of tall structures in the setting of PBWE can lead to better structural configurations for a given set of loading conditions, consistent with desired levels of safety, thus promoting cost-effective building solutions.

Research to Mitigate the **Impact** of Extreme Weather on Coastal Communities

Q. Jim Chen, professor, civil and environmental engineering

As a coastal engineer, Professor Q. Jim Chen, civil engineering and marine and environmental sciences, runs the Coastal Hydrodynamics Lab located at Northeastern's Marine Science Center in Nahant, Massachusetts, where he and his team study the development and application of state-of-the-art computational models to address coastal resiliency and sustainability.

Mathematical modeling is crucial to understanding the ways in which hurricanes will impact coastal communities. Chen collects data from sites on the East and Gulf Coasts and creates comprehensive mathematical models to understand ocean movement during storms and the ways in which vegetation and natural barriers can be used to mitigate their effect on coastal communities.

His research often involves innovating new methods. In a grant through the Treasury Department RESTORE Act, Professor Chen integrates computer modeling and innovative remote sensing techniques to understand storm impacts on Louisiana's shoreline and deltaic systems. The grant involves international collaboration with engineers from Deltares, a Dutch research institute.

Chen is also working with the Army Corp of Engineers to assess the effectiveness of "living shorelines" in combating water surges and waves caused by coastal storms. Living shorelines are a form of green infrastructure that utilize natural and natural-based solutions to engineering problems, such as maintaining vegetated coastal wetlands and growing oyster castles to disrupt wave movement. A challenge with using living shorelines to fight storm surges and waves is that no reliable methodology currently exists to evaluate their capacity to do so. Chen's team is developing the necessary numerical models to calculate the benefits of vegetated shorelines. Through a separate award from the U.S. Geological Survey, Chen collects ecological and hydrodynamic data from living shoreline projects in Maryland, New Jersey, New York and Virginia to calibrate and validate computer models of nearshore wave processes.

Chen is part of a team led by the Woods Hole Oceanographic Institute that was awarded a $992K National Science Foundation grant, entitled "Convergence: RAISE Nearshore Water-Land Interface During Extreme Storms." He will conduct cyber-enabled coastal resilience research and continue to study the role that natural landscapes play in attenuating storm surges and waves. Chen was also awarded an $866K National Science Foundation CyberSEES grant to lead the "Coastal Resilience Collaboratory: Cyber-enabled Discoveries for Sustainable Deltaic Coasts." In collaboration with Louisiana State University and Texas A&M University, the project will foster cooperation among coastal engineers, earth scientists, computer scientists and cyberinfrastructure specialists towards building sustainable deltaic communities and help coastal regions address flooding hazards.

Editorial Credits, David Deeter

Hao Sun, assistant professor, civil and environmental engineering

Making Cities Safer with Smartphone Data

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

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

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

"Our work seeks to create a platform to collect and analyze this huge volume of data to assist disaster response planning and management," says Sun. "This is the future of low-cost sensing for structural engineering." Sun's research is already collecting data in urban areas in California, Japan, and Kuwait.

Optimizing Thin-Walled Tubes to Further Civil Infrastructure and Mechanical Systems

Associate Professor Andrew Myers, civil and environmental engineering, in collaboration with Johns Hopkins University and Vestas Wind Systems, was awarded an $899K National Science Foundation grant for "Optimization of Infrastructure-Scale Thin-Walled Tube Towers including Uncertainty."

Andrew Myers, associate professor, civil and environmental engineering

Thin-walled tubes are a high-performing and efficient structural element with versatile applications in mechanical systems and civil infrastructure, such as wind turbine towers. Such tubes, however, can be fragile: when made of stiff materials and subjected to compression, their failure is acutely sensitive to imperfections that inevitably arise during manufacturing and to complex loading that inevitably occurs in the field.

A lack of understanding of the fundamental nature of this sensitivity has been a longstanding barrier to advancement of structural engineering and manufacturing. The enormous scale of civil infrastructure and some mechanical systems present additional challenges, as tubular elements can be too large to be prototyped, iteratively designed and tested at full-scale. For these reasons, structural strength is estimated using unsatisfactory methods, either extrapolating test results with overly conservative or inaccurate simplifications of the governing mechanics or using computational methods that are unreliable. Both approaches mostly ignore the strong links between manufacturing, material selection, and structural behavior and this restricts the potential for structural and manufacturing innovations.

This Grant Opportunities for Academic Liaison with Industry (GOALI) Program award provides a path to overcome these limitations. The research project will help engineers better understand thin-walled tube imperfections and the relationship between their structural behavior and the manufacturing and material selection process. Building on Myers' larger body of work developing the necessary technical knowledge and policy framework to make the U.S. a leader in onshore and offshore wind energy, the award involves "first-of-its-kind" cooperation with a wind turbine tower production factory.

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

$1.2 Million NSF Grant to Understand the Algorithmic Workplace

The emergence of the digital platform economy in recent years is rapidly transforming various economic activities. Professor Ozlem Ergun, mechanical and industrial engineering, and Assistant Professor Michael Kane, civil and environmental engineering, are co-PIs of a $1.2 million National Science Foundation grant, along with Northeastern's School of Law (lead), College of Social Sciences and Humanities, and Boston College, for creating an "Understanding the Algorithmic Workplace: A Multi-Method Study for Comprehensive Optimization of Platforms."

The project will develop new evidence and understanding about the behavior and interactions of workers, business organizations, and government institutions that are involved in the "algorithmic workplace" or "gig economy". The multidisciplinary research team will conduct interviews with workers to document their experiences, attitudes, and needs. These qualitative results will be fused in quantitative analysis of data from platform operators to build mathematical models and tools that will help predict the impact of algorithmic innovations and regulation. Furthermore, the team will use field experiments to test the model predictions.

The results of this project will be new knowledge for businesses that need to retain and motivate their workforce, new evidence for policymakers that seek to understand how neighborhoods and communities are affected by the growth of platform work, and new empirical evidence about the benefits and risks of platform work for the U.S. workforce. This project is part of larger efforts by Ergun and Kane to advance the science and application of automation and algorithms in our everyday lives.

Ozlem Ergun, professor, mechanical and industrial engineering

Michael Kane, assistant professor, civil and environmental engineering

$7.5 Million DoD Grant to Develop AI for Unmanned Aerial Vehicles

Professor Mario Sznaier, electrical and computer engineering, is a co-PI for a $7.5 million Department of Defense (DoD) grant, in collaboration with the University of Texas at Austin and Princeton University, for a Multidisciplinary University Research Initiative (MURI) project aimed at developing artificial intelligence (AI) for Autonomous Systems.

continued from page 18

While almost all AI technology is reliant on the availability of massive amounts of data, the project team has been charged with the task of developing machines that can learn "on the fly" in situations where there is little prior data to inform them, and the system must make decisions while operating in an unknown, uncertain environment. The interdisciplinary team hopes their combined efforts will assist the DoD in the development of truly autonomous, learning enabled systems that can not only operate in challenging environments but also survive and adapt to unforeseen disruptions.

Integrating the Engineering Design Process with the Socio-economic Ecosystem

The technology revolution is having a profound effect on the engineering design process, moving it from static and predictable to enabling more dynamic and evolving systems that require greater degrees of independent decision-making.

For Mechanical and Industrial Engineering Associate Professor Babak Heydari, this trend offers an opportunity to help tech companies make strategic decisions about the architecture of their systems and products that balance innovation and competitive advantage. Heydari's research, which earned him a National Science Foundation CAREER Award in 2016, represents a potentially groundbreaking approach to integrating the engineering design process with the socio-economic ecosystem.

Babak Heydari, associate professor, mechanical and industrial engineering

Looking at the R&D process and the innovation process during the design phase, Heydari notes that "in most traditional systems, it's done by a set of R&D people or teams of R&D people in different organizations. With development moving towards open source/open innovation, many systems now rely on what we refer to as 'distributed innovation.'" Case in point: Apple's decision to open app development to external developers for its iPhone created a massive distributed innovation network and, within a short period, a large number of new apps that would have been otherwise unimaginable.

"Think of a product as a two-sided platform where the owner creates an architecture that matches the two sides of a platform, for example, app developers and innovators on one side and users/consumers on the other side," says Heydari. "We want to formalize that process. What are the parameters of such decisions? When and under what conditions and how much should the platform owner open up part of the platform architecture for external use?" Heydari notes that opening the platform too much could negatively impact a company's ability to maintain its competitive advantage.

FINDING THE SWEET SPOTS

"There is a sweet spot when we decide on the optimal architecture of a platform," explains Heydari. "Part of my work is to create formal models that could give us an understanding of how to find those sweet spots.

"If we can find a formal methodology to integrate the engineering design process with the socio-economic ecosystem, it will be groundbreaking because as we move forward with developments in AI and IoTs in the coming decades, we'll deal with systems where the technical and social sides co-evolve with each other. That co-evolution determines much of the behavior of these systems and if they'll be successful or not, if they'll create a desirable social outcome."

Heydari believes his research will ultimately help companies make better decisions about the architecture of their products, integrating ecosystem parameters into their architecture and reducing trial-and-error. Society will also benefit when attributes normally left to after-the-fact regulation are integrated through platform governance during the design stage.

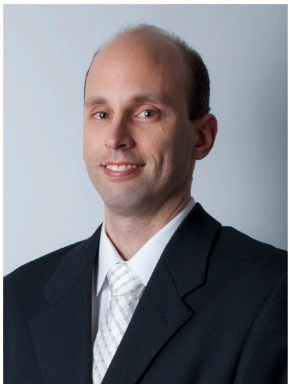
Working with faculty across a variety of disciplines—engineering, computer science, law, business and public policy—is vital to Heydari's research on complex socio-technical systems. "Within Northeastern, we are well positioned to create research and educational programs on these complex technical systems because of the interdisciplinary culture of the university," he says. "Northeastern has great potential to become a leader in this field."

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

Innovative Strategies for Treating Explosives Manufacturing Waste Streams



Philip Larese-Casanova, associate professor, civil and environmental engineering

Associate Professor Philip Larese-Casanova (PI) was awarded a $760K grant for "Electrochemically-Induced in situ Degradation of Legacy Munitions and Insensitive High Explosives in Manufacturing Wastewater." The grant is from the Department of Defense's Strategic Environmental Research and Development Program (SERDP). Co-PIs include Civil and Environmental Engineering Assistant Professor Loretta Fernandez, and Snell Professor of Engineering and Associate Dean for Research and Graduate Education Akram Alshawabkeh.

The presence of new insensitive high explosives co-mingled with legacy munitions constituents has posed new challenges to treating explosives manufacturing waste streams and has prompted a demand for innovative treatment strategies. To meet the need for improved, cost-effective water treatment technologies for munitions constituents, the investigators have developed a flow-through electrochemical reactor that generates reductants and reactive oxygen species in situ based on reactive electrode surfaces and electrolysis of water. The reactor unit uses low power and is capable of sustained, long-term operation without chemical additives. The research project will adapt the current electrochemical design for the indiscriminate degradation of munitions constituents.

This project will support the treatment strategies for liquid wastes containing multiple munitions constituents from diverse source streams. If successful, the technological development will result in an electrochemical reactor that delivers a sustained in situ generation of several reductants and reactive oxygen species for the rapid and complete degradation of legacy munitions constituents and insensitive high explosives. The technology will generate nonspecific reductants and oxidants applicable to a variety of contaminants in mixture simultaneously without the need for chemical reagent addition. Changes in solution pH, redox conditions, and reactants are self-contained within the reactor which precludes the need for effluent chemical adjustment prior to discharge or further treatment. Reaction conditions will be created using inert and cost-effective materials (stainless steel, graphite, activated carbon) under low electric power.

When the technology is fully realized, managers will be able to deploy modular reactor units adaptable to a variety of waste sources, chemistries, and flow conditions. The project will also serve the scientific community by providing insight to munitions constituents transformation mechanisms by reactive oxygen species, sorbed atomic hydrogen, and modified electrode surfaces.

Ameet Pinto, assistant professor, civil and environmental engineering

Ameet Pinto Receives 2019 Paul L. Busch Award from Water Research Foundation

Microbial communities and their activities are consequential for the health of the environment and humans. Assistant Professor Ameet Pinto, civil and environmental engineering, researches microorganisms in the engineered water cycle, including drinking water and wastewater systems, and their interface with the environment and public health. His research group works on understanding how microbial communities are influenced by treatment processes and how they in turn impact process performance and what can be done to manage these communities more reliably and efficiently. Recently, Pinto was recognized with the prestigious 2019 Paul L. Bush Award from the Water Research Foundation for his research.

Supported by the Paul L Busch Award, he is developing a low-cost platform for real-time microbial community analyses. A combination of machine learning approaches trained using microscopic images paired with DNA sequencing data may allow for image-only based predictions of microbial community in a sample. To do this, he is using a combination of two portable technologies—a low-cost microscope and nanopore sequencing.

Leveraging recent advances in miniaturized microscopy, his research group has been developing a device that can achieve micron level resolution to distinguish microbes from other particles without any fluorescent dyes or stains. Further, the use of light scattering properties of imaged microbes of different wavelengths and incidence angle may allow their group to move from simply counting microbes towards identifying them.

Just like microscopes have become smaller and cheaper, so have DNA sequencing instruments. His research group is working with the MinION sequencer, a handheld DNA device developed by Oxford Nanopore Technologies that provides sequencing data in real-time. A key challenge is making it work for different sample matrices, from wastewater to drinking water, while keeping the price point low. The overall goal is to develop methods to capture target genes from extracted DNA and then concentrate them quickly so they can be sequenced on the MinION device without the need for PCR amplification.

This image-only based estimation for microbial community is likely to work on a system by system basis, but the fact that the two enabling technologies that supply the data do not require significant capital investment means that the platform can remain affordable to every water utility.

Getting state-of-the-art technology in the hands of every operator and in every water utility—irrespective of size of their customer base—will radically change how biology is managed and has the potential to bring many more water professionals into the business of innovation in the water sector.

$1.5 Million FEMA Grant to Study Health Effects of Wildland Fire Smoke to Firefighters

Wildland firefighters not only face immediate danger, but could also suffer long-term health effects from smoke inhalation. Between January and mid-October 2018, there were almost 50,000 wildfires in the United States, burning about 8.1 million acres.

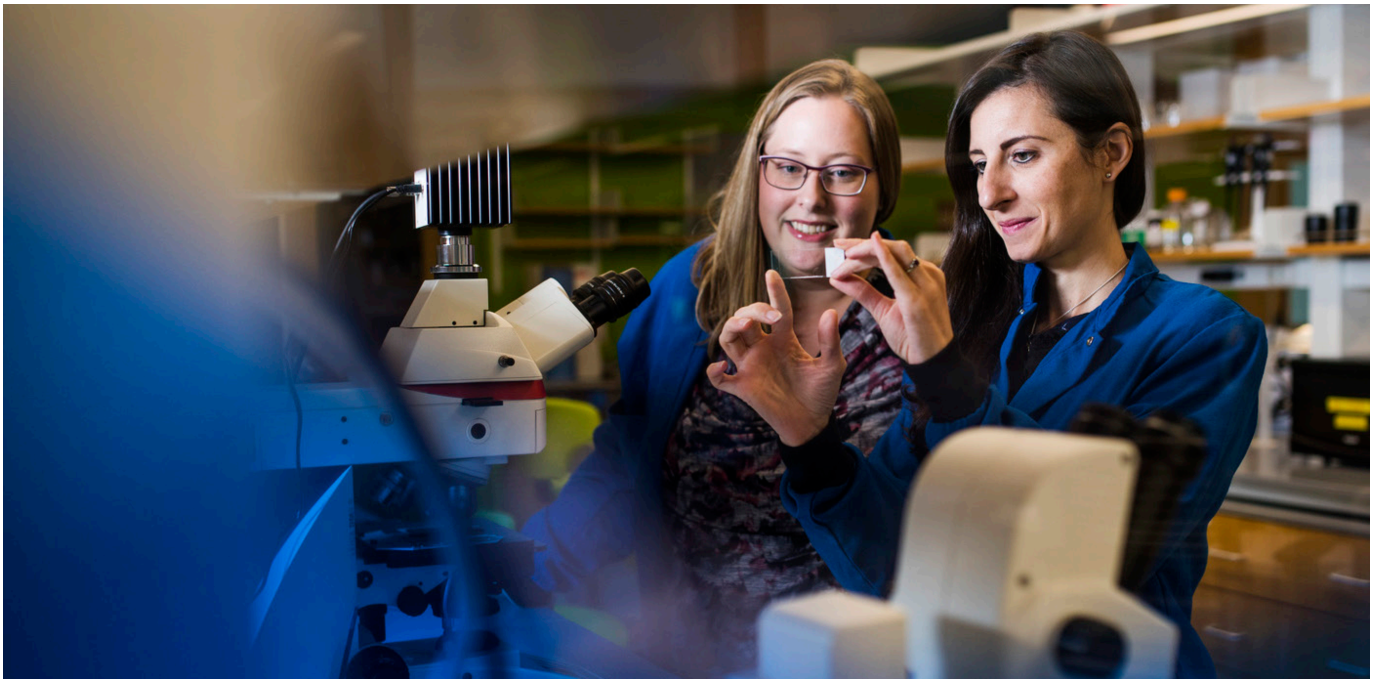
To help understand and combat negative health effects to firefighters, the U.S. Federal Emergency Management Agency (FEMA) through the Assistance to Firefighters Grant Program—part of the Department of Homeland Security—awarded $1.5 million in research funding to Bioengineering Assistant Professors Jessica Oakes and Chiara Bellini (both PIs) for “Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke.” They are supported in this research by co-PI Michael Gollner, a faculty member at the University of Maryland College Park, and Casey Grant, the executive director of the Fire Protection Research Foundation.

According to Oakes and Bellini, there’s a reason their research is unique: because long-term smoke inhalation by wildland firefighters is challenging to study scientifically. “Wildland firefighters work seasonally, and they travel from place to place,” explains Oakes. “Sometimes they are battling a raging fire, and sometimes they are mopping up, or containing smoldering remnants of a larger fire.”

“The wildland firefighters may wear bandanas or face masks, but usually personal protective equipment is just too hot and uncomfortable,” adds Bellini. “We have to understand and contend with a whole range of environmental factors because of the varying experiences these workers have.”

The team will combine their expertise to solve this challenging problem: Gollner will contribute expertise in firefighting practices and fire generation, while Oakes and Bellini will offer interdisciplinary bioengineering expertise that’s critical to understanding this complex health problem. Oakes’ research interests primarily center on respiratory health and lung mechanics, and Bellini studies diseases of the cardiovascular systems from a mechanical perspective.

By using a combination of computational modeling and animal studies, the team is creating the first study to address this problem in a controlled laboratory setting over time. The final outcome will be recommendations for best practices regarding overall duration of exposure and use of protective equipment, which FEMA can implement to minimize the negative health effects for our nation’s wildland firefighters.



left to right: Jessica Oakes and Chiara Bellini, assistant professors, bioengineering

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.

Using Industrial Engineering Principles to Combat Human Trafficking

Kayse Lee Maass, assistant professor, mechanical and industrial engineering

An estimated 24.9 million people worldwide are victims of human trafficking, and although difficult to track, the industry is thought to be worth $150 billion. Kayse Lee Maass, an assistant professor of mechanical and industrial engineering, is adapting mathematical techniques typically used in industrial engineering to model supply chains or plan media campaigns to find ways to disrupt trafficking networks or organize support services for survivors.

She is collaborating with other engineers, as well as criminologists, public health professionals, sociologists, and human trafficking experts to determine how engineering-inspired modeling can be used to support ongoing efforts to combat trafficking. Maass has formed partnerships both in the United States and abroad.

Recently, Maass received two grants. First, she is principal investigator of a $574K grant from the National Science Foundation (NSF) for “ISN2: Coordinated Interdiction for Disruption of Labor Trafficking in the Agricultural Sector.” In collaboration with Shawn Bhimani (co-PO) in Northeastern’s D’Amore-McKim School of Business’s Supply Chain and Information Management Group and Amy Farrell (co-PI), associate professor in the School of Criminology and Criminal Justice and co-director of the Violence and Justice Research Lab, the research will exploit the knowledge of operational models and methods from commercial supply chain management to guide efforts to disrupt labor trafficking in the U.S. agricultural sector, focusing particularly on infrastructure use, economic factors affecting supply and demand, and environmental factors, such as legal and regulatory frameworks. In addition, the project will study how a broad range of anti-trafficking stakeholders with limited resources can most efficiently coordinate their efforts to ensure that supply chains are free of trafficked labor. This research has the potential to transform the ways anti-trafficking policies and programs are formulated and evaluated, leading to more effective disruption of human trafficking supply chains within a limited resource environment.

Secondly, Maass is co-principal investigator on a $535K NSF grant, titled, “ISN2: Disrupting Human Trafficking via Needs Matching and Capacity Expansion.” The interdisciplinary award is in collaboration with Worcester Polytechnic Institute (lead) and John Jay College of Criminal Justice, and will study the efficient allocation of resources over time to disrupt human trafficking networks.

A key, and largely understudied, means to disrupt human trafficking is by reducing the supply of potential victims through a better understanding of the critical role that housing plays in individual vulnerability. In order to reduce the population at risk of being trafficked

continued from page 23

(or re-trafficked), the project provides a need-based prevalence estimation of homeless youth in New York City and an optimization-based approach to determine the most efficient use of scarce shelter and service resources. Shelter and associated rehabilitative services disrupt human trafficking networks by decreasing future vulnerability and recidivism for those at-risk of trafficking. The award will help guide a long-term, cost-effective intervention approach by developing an optimal policy for the deployment of marginal temporal housing and services capacity.

$1 Million NIH Grant to Predict the Onset of Epileptogenesis

Electrical and Computer Engineering Professor Deniz Erdogmus is co-PI for a $1 million grant from the National Institutes of Health in collaboration with the University of Southern California for a “Multimodal Signal Analysis and Data Fusion for Post-Traumatic Epilepsy.” The research objective is to predict the onset of epileptic seizures following traumatic brain injury (TBI), using innovative analytic tools from machine learning and applied mathematics to identify features of epileptiform activity, from a multimodal dataset collected from both an animal model and human patients.

The proposed research will accelerate the discovery of salient and robust features of epileptogenesis following TBI from a rich dataset, collected from the Epilepsy Bioinformatics Study for Antiepileptogenic Therapy (EpiBioS4Rx), as it is being acquired by investigating state-of-the-art models, methods, and algorithms from contemporary machine learning theory. This secondary use of data to support automated discovery of reliable knowledge from aggregated records of animal model and human patient data will lead to innovative models to predict post-traumatic epilepsy (PTE). This machine learning based investigation of a rich dataset complements ongoing data acquisition and classical biostatistics-based analyses ongoing in the study and can lead to rigorous outcomes for the development of antiepileptogenic therapies, which can prevent this disease.

Identifying salient features in time series and images to help design a predictor of PTE using data from two species and multiple individuals with heterogeneous TBI conditions presents significant theoretical challenges that need to be tackled. In this project, it is proposed to adopt transfer learning and domain adaptation perspectives to accomplish these goals in multimodal biomedical datasets across two populations. Specifically, techniques emerging from deep learning literature will be exploited to augment data, share parameters across model components to reduce the number of parameters that need to be optimized, and use state-of-the-art architectures to develop models for feature extraction. These will be compared against established pipelines of hand-crafted feature extraction in rigorous cross-validation analyses.

Developed techniques for transfer learning will be able to extract features that generalize across animal and human data. Moreover, these theoretical techniques with associated models and optimization methods will be applicable to other multi-species transfer learning challenges that may arise in the context of health and medicine. Multimodal feature extraction and discriminative model learning for disease onset prediction using novel classifiers also offer insights into biomarker discovery using advanced machine learning techniques through joint multimodal data analysis.

Deniz Erdogmus, professor, electrical and computer engineering

$1.2 Million Award to Improve Energy Efficiency and Performance of DNN Models for Hardware

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

Deep neural networks (DNNs) have been employed in wide application domains due to their extraordinary performance. Hardware implementations of DNNs are of critical importance for the ubiquitous embedded and Internet of Things (IoT) devices, which call for high performance in energy and resource constrained systems. Assistant Professor Xue (Shelley) Lin (PI) and Professor Miriam Leeser (co-PI), electrical and computer engineering, in collaboration with the University of Southern California, have been awarded a $1.2 million grant from the National Science Foundation for "A Unified Software/Hardware Framework of DNN Computation and Storage Reduction Using ADMM."

This project aims to address the challenges when mapping complicated DNN models into hardware for energy-efficient and performance-driven implementations. The proposed techniques will promote wider adoptions of deep learning into both high-performance and low-power computing systems. The project will also enhance economic opportunities and have significant societal benefits via solutions that support broader adoption of intelligent systems for big data analytics, weather modeling and forecasting, disease diagnosis and drug delivery, and medical image processing.

Exploring the inherent model redundancy of DNNs, the project will develop an algorithm-hardware co-optimization framework for greatly reducing DNN computation and storage requirements by leveraging ADMM (alternating direction method of multipliers), a powerful optimization technique. This project first solves the challenge in the application of ADMM due to the non-convex objective function in DNN training, and thereby lack of guarantees on solution feasibility, solution quality, and low runtime. Therefore, an integrated framework of ADMM regularization and masked mapping and retraining will be developed and further improvements on solution quality, performance-driven computation/storage reduction, and hardware feasibility will be investigated. Next, the project proposes a unified weight and intermediate result pruning and quantization technique that explores all four redundancy sources of DNN models. Due to the impact on energy efficiency of hardware implementations of DNNs, nearly all DNN models, or at least the most computationally intensive convolutional layers, can be then placed on a single chip. Finally, design-time parameterization and algorithm-hardware co-design solutions will be developed for efficient utilization of available hardware resources, achieving high performance, energy efficiency, and adaptation capability. Extensive experimentation and evaluation will be performed to validate and tune the proposed technique with prototype systems using FPGA devices.

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
- Transportation security
- Cybersecurity

NSF CAREER Award to 'Bring GPS Indoors'

Pau Closas, assistant professor, electrical and computer engineering

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

Closas's work recently earned him the prestigious National Science Foundation CAREER Award, a five-year, $500K grant for research and education, and outreach programs. The award will help Closas—who joined Northeastern in 2017—and his team address some of the most common GNSS receiver challenges, including indoor usage, signal spoofing, and disruption by malicious actors.

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

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

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

Patent Awarded for 360-degree Human Imaging

For many people, the worst part about flying is the security line at the airport. Each person takes a turn standing perfectly still in the scanner. But what if people could just keep walking? College of Engineering Distinguished Professor Carey Rappaport, electrical and computer engineering, and Associate Professor Jose Martinez-Lorenzo, mechanical and industrial engineering, jointly appointed in electrical and computer engineering, are working to build a system that could keep travelers moving and cut down on long wait times at the airport.

"The eventual goal is to have hallways with sensors on the left and right sides," says Rappaport. "You walk between them and as you walk by, the sensors will create an image of your body."

Currently, when you step into an airport scanner, place your feet on the yellow footprints, and raise your hands over your head, columns of sensors rotate around you to get an image of your body from every angle. Rappaport and Martinez-Lorenzo recently received a patent for a way to create a 360-degree image without needing a head-on view of every side of a person.

Carey Rappaport, COE Distinguished Professor, electrical and computer engineering

Jose Martinez-Lorenzo, associate professor, mechanical and industrial engineering

The sensors in an airport scanner send out millimeter waves, tiny radio signals that penetrate clothing and bounce off skin or other objects. They pick up the reflected signals and compile them into an image (which is fuzzed up by algorithms to an acceptable degree of propriety). But the sensors can only pick up signals that are reflected back at them. "Unless you have a receiver in the right direction, you won't be able to image that part of a person," says Martinez-Lorenzo.

Rappaport and Martinez-Lorenzo, along with Borja Gonzales-Valdez who is now a postdoctoral researcher at the University of Vigo in Spain, came up with a way to put linked sensors on the opposite wall to pick up these scattered reflections and form a complete picture.

"The waves bounce off your stomach or your back and end up on the other side of the hallway," Rappaport says. "So put detectors on both sides. Put a transmitter on the right, and observe right and left. Put a transmitter on the left, and observe left and right. That's it. That's the way you could get the front of a person, and you don't have to have him or her turning to face the wall or pirouetting around."

Each transmitter would be linked to multiple receivers on each wall, to successfully catch the reflected waves no matter where they bounce. This could help to cut down on false positives as well. If millimeter waves ricochet off of two parts of your body that are in close proximity, the unexpected change in direction can read as a hidden object, even when nothing is there. This is why you have to stand in that awkward, hands-over-the-head position in the current scanners; the pose is an attempt to minimize the number of valleys that could cause confusing reflections. But by transmitting signals from both sides of the hallway and receiving them wherever they end up, the system would have enough information to correctly identify these spaces. You could stand or walk normally.

There are still a few challenges to work through, including how to lower the costs of such a system. But Rappaport says the technology that could speed up waits at airports across the country isn't far off. "The wish that TSA, the Department of Homeland Security, and everybody wants is this hallway system," Rappaport says. "You want someone to just walk normally or stand on a moving walkway as they approach a gate or an airport and be scanned."

Editorial Credits, Laura Castañón

$1.5 Million Award for Decentralized Classification and Coordination Framework for Swarms of Small Unmanned Aerial Systems

There is a need for real-time systems and algorithms capable of providing decentralized multi-sensor classification and multi-agent coordination in missions subject to variable communications conditions. This is especially important in GPS-denied environments performing non-centralized surveillance with non-scheduled coordination. Jose Martinez-Lorenzo, mechanical and industrial engineering, jointly appointed in electrical and computer engineering (ECE), along with ECE faculty William Lincoln Smith Professor Tommaso Melodia, Associate Professor Kaushik Chowdhury, Professor Hanumant Singh and Affiliated Faculty Chris Amato, has been awarded a $1.5 million grant from the Air Force Research Laboratory for "Robust Decentralized Classification and Coordination Algorithms for Swarms of SUAS."

Current positioning systems operating in GPS denied environments do not fully exploit the prior-knowledge of the terrain while being robust to uncertainty, and they are neither fast nor effective when dealing with high dimensional data. Conventional systems also do not fully take into consideration the instantaneous performance of the communications network or sensing platforms in order to dynamically adapt task priorities in multi-agent missions. Additionally, Swarms of Small Unmanned Aerial Systems (SUAS) hardware platforms are severely constrained in terms of on-board processing capability as well as communication range; and state-of-the-art networks do not ensure that the data is efficiently shared among other members of the SUAS swarm, or relayed timely over multiple hops to the ground station (if used) during network operation.

The research project will address current challenges by developing a decentralized classification and coordination framework for SUAS operating under constrained communications. The framework will rely on, 1) advanced detection, classification, and identification algorithms that fuse full motion video with novel onboard radars operating in real-time by using Deep Learning and 4D (space + time) Compressive Sensing (CS); 2) multi-agent coordination using Multi-Task Reinforcement Learning (RL) in Decentralized Partially Observable Markov Decision Processes (Dec-POMDPs); and 3) a robust aerial architecture orchestrated by a Software Denied Network (SDN) control plane that jointly configures the link, network, and transport layers.

$1.2 Million NSF Grant to Protect the Security of Deep Neural Networks

Deep learning has become a foundational means for solving diverse problems ranging from computer vision, natural language processing, digital surveillance to finance and healthcare. Security of the deep neural network (DNN) inference engines and trained DNN models on various platforms has become one of the biggest challenges in deploying artificial intelligence. Confidentiality breaches of the DNN model can facilitate manipulations of the DNN inference, resulting in potentially devastating consequences.

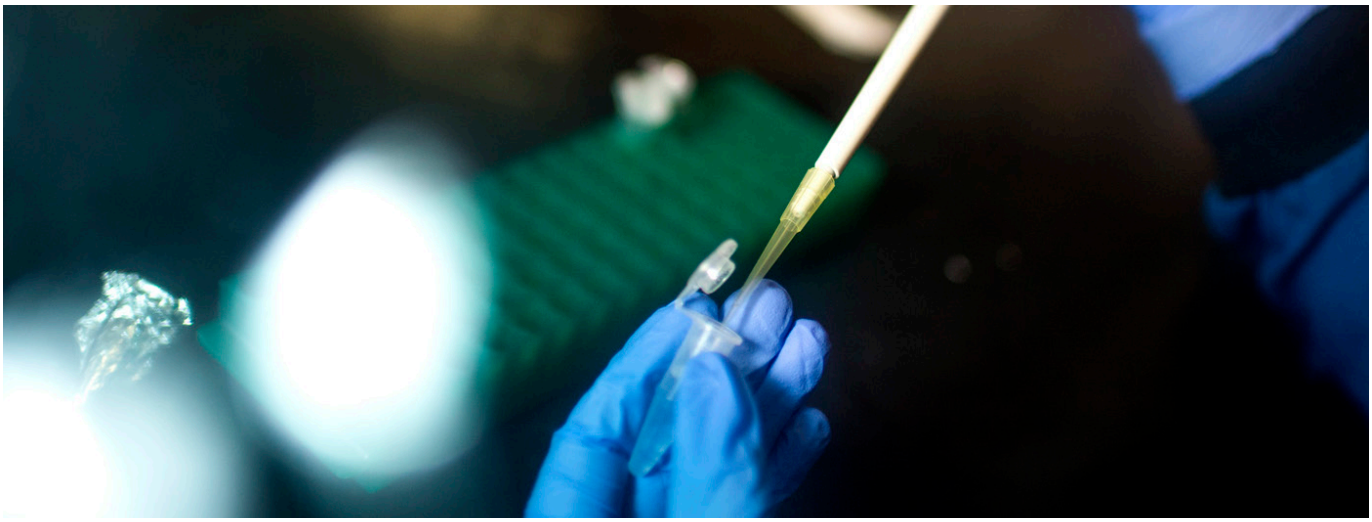
Electrical and Computer Engineering Professor Yunsi Fei, Assistant Professor Xue (Shelley) Lin, and Khoury College of Computer Sciences Associate Professor Thomas Wahl were awarded a $1.2 million National Science Foundation grant for "Protecting Confidentiality and Integrity of Deep Neural Networks against Side-Channel and Fault Attacks." The project aims to promote broader applications of DNNs in security-critical scenarios by ensuring secure execution of DNN inference engines against side-channel and fault injection attacks. It is composed of three salient and interdependent thrusts. SpyNet will study vulnerability of DNNs implemented on mainstream platforms to model reverse engineering via passive side-channel attacks. DisruptNet will investigate the feasibility of active fault injection attacks to disrupt execution of DNN inference engines, and SecureNet will explore protection, detection, and hardening mechanisms for secure execution of DNN inference engines. This project may deepen the understanding of inherent information leakage and fault tolerance of DNN models.

The unprecedented rise of deep learning technology in diverse application domains has rendered secure execution, primarily confidentiality and integrity, a top priority. The research significantly advances the state-of-the-art on deep learning implementations, computer architecture and heterogeneous systems, hardware security, and formal methods/verification.

Yunsi Fei, professor, electrical and computer engineering

CHEMICAL IMAGING OF LIVING SYSTEMS

$1.5 Million NIH Award for MRI-based Nanosensor for Brain Chemical Monitoring



The neurotransmitter acetylcholine is widely distributed in the central nervous system and brain, and is a key signaling molecule involved in neural function. Current measurements of this important signaling molecule rely on implanted electrodes or sampling techniques, which often trade temporal or spatial resolution for chemical specificity, or vice versa.

With a long-term goal to apply an MRI-based nanosensor to monitor the distribution and activity of acetylcholine in the brain, and generate a data set that enables comparison of the neural activity differences between healthy and diseased tissue, Professor Heather Clark, bioengineering and chemistry, and director of the Institute for Chemical Imaging of Living Systems, has been awarded a $1.5 million grant from the National Institute of Neurological Disorders and Stroke for "Nanosensors for Chemical Imaging of Acetylcholine Using MRI."

The objective of Clark's research project, which is the first step in achieving the long-term goal, is to develop her multidisciplinary team's Acetylcholine Magnetic Resonance Nanosensor (ACh- MRNS) that can continuously and reversibly respond to physiological release of acetylcholine in the brain of live animal models, and pair it with a novel technique for fast, quantitative imaging, namely Dual Contrast - Magnetic Resonance Fingerprinting (DC-MRF). It will also investigate a focused ultrasound technique for enabling nanosensor penetration across the blood brain barrier, to enable detection in the brain after systemic injection of the probe.

The mechanism of Clark's sensor is based on a unique pairing of a pH-sensitive MR probe with enzymatic recognition of acetylcholine in a nano-scale scaffold that will detect the local pH changes that are created by the hydrolysis of acetylcholine. When cholinesterase and pH-sensitive MR contrast agents are incorporated into one nanoparticle, the hydrolysis that is catalyzed by cholinesterase reduces the local pH, leading to a change of the T1 and T2 relaxation times of MR contrast agent. The research team will then combine this highly sensitive and specific MRI agent with their DC-MRF methodology to dynamically and simultaneously track the ACh-MRNS and control agents, enabling an in vivo assessment of acetylcholine levels in rodent brains, ultimately providing a non-invasive, high-resolution, radiation-free imaging platform to study neurotransmitters in vivo.

Institute for Chemical Imaging of Living Systems
at Northeastern University

Imaging the Chemistry of our Bodies

Doctors have a variety of tools at their disposal to peer inside our bodies. Between x-rays, CT scans, ultrasounds, and MRIs, it might seem like our every angle has been thoroughly revealed. But each of these methods has its limitations. And none of them can track the intricate chemical signaling that underlies everything our body does.

A group of 26 researchers at Northeastern is working on new technology that would allow doctors to zoom in on these minute interactions. The new Institute for the Chemical Imaging of Living Systems, led by Heather Clark, professor of bioengineering and chemistry, will focus on finding ways to image the chemistry of our bodies.

Our bodies run on chemical interactions. But modern medical imaging tends to focus more on larger-scale structures than chemistry. Take, for example, the brain. By tracking blood flow, scientists can determine which areas of the brain are most active. These areas can be linked to certain functions. But the details of this activity—the specific chemical signals being sent that dictate our memory, our thoughts, and our movements—are still beyond our grasp.

Various diseases can disrupt or change these chemical signals. But without knowing the specifics of how they're being affected, doctors have limited treatment options. Measuring those chemicals in real-time could lead to better treatment for diseases such as Alzheimer's and amyotrophic lateral sclerosis, or ALS.

In order to track chemicals in the body, scientists have to design tiny synthetic particles that will bind to a specific chemical and give off a traceable signal. That's what Clark's lab focuses on. But to develop this into technology that can be used in humans, there are many more steps.

"What an institute enables us to do is bring in people from all across campus to tackle different pieces of the problem," Clark said. Clark leads one of the teams designing the particles going into a patient. Other groups are focusing on how to deliver these particles, how to detect them, and how to see if they work before they're injected into a human.
"It's the opportunity to do science that's so much bigger than one person," said Clark. "That's what's exciting."

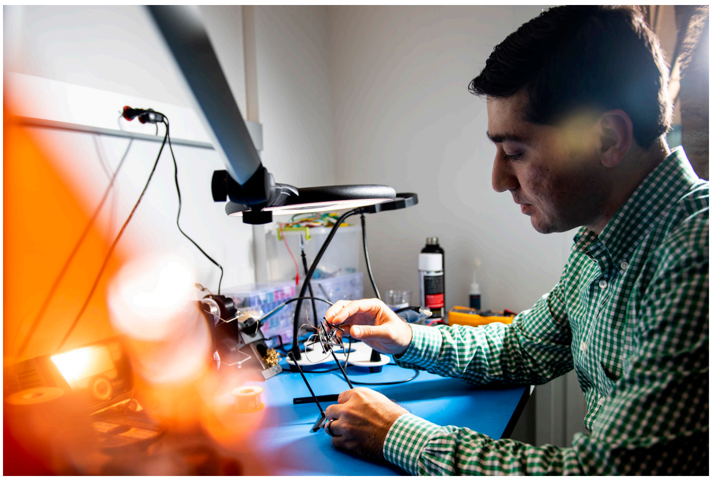
Editorial credits, Laura Castañón

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

Heather Clark, professor, bioengineering and chemistry

EXPERIENTIAL ROBOTICS

Autonomous Drone with Bat-like Capabilities


Alireza Ramezani, assistant professor, electrical and computer engineering

After three years of work, Alireza Ramezani, assistant professor of electrical and computer engineering, and his collaborators created Bat Bot, which is an autonomous drone that can flap its wings, glide, make sharp turns, and swoop down. It was unveiled in the journal *Science Robotics* in 2017, and now he and his doctoral students are expanding the capabilities.

Bats have more than 40 joints on their wings, more than birds and other flying creatures. This gives them greater agility, flexibility, and maneuverability in the air. Ramezani said these traits make bats an ideal model for designing the next generation of flying robots. These types of drones, he said, would be particularly useful for surveillance, whether inside a building or outside monitoring traffic patterns or airport security.

With a 1-foot wingspan, a Bat Bot can navigate tight spaces that larger drones can't. It also only weighs slightly over 3 ounces, and its carbon-fiber skeleton is covered by a soft, super-stretchable silicon-based membrane. Unlike today's drones, which have fast rotating blades, a bat drone would be unlikely to cause much harm if it accidentally hit a person.

Ramezani worked on Bat Bot as a postdoctoral research associate, first at the University of Illinois at Urbana-Champaign and then later at the California Institute of Technology. Now, he and his doctoral students at Northeastern will build an advanced version of the bat drone that perches and hangs upside down like a bat. He's also planning to add on-board cameras and sensors that collect all kinds of data about the environments where the drone flies.

He envisions future versions of the flying robot being integrated with the so-called internet of things. He said one or more of these drones could scan city streets or a busy airport, and the data collected and immediately shared with people on the ground who are trying to ease traffic congestion or assess potential safety threats.

"If robotic systems can hang from structures, they can harvest solar energy and once they're fully charged they can fly around again," he said. "It sounds futuristic, but we'll see how we can accomplish this."

Editorial Credits, Greg St. Martin

Institute for Experiential Robotics at Northeastern University

Designing Robots that Enrich Collective Human-Robot Experience

Northeastern launched the Institute for Experiential Robotics, a university-wide research collaboration led by Taskin Padir, associate professor of electrical and computer engineering. The institute focuses on advancing the capabilities of today's robotics and artificial intelligence technologies to address grand societal problems such as healthy aging, transportation, and advanced manufacturing.

Building on advances in collaborative robotics and autonomy, the institute develops technologies that help machines translate and adapt to the way humans behave in changing environments. There are a wide range of potential applications for experiential robotics, including manufacturing industries like seafood processing and distribution, as well as healthcare. Because of the inherent complexity of the human-robot experience, the institute collaborates with engineers, ethicists, sociologists, and economists, as well as other academic institutions, industry, and government.

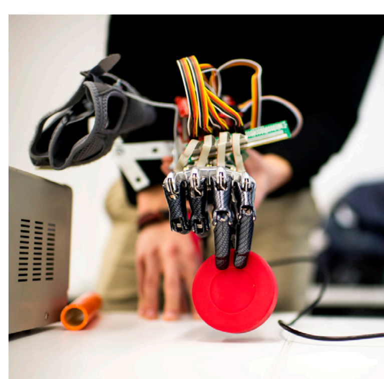
Taskin Padir, associate professor, electrical and computer engineering

Creating Gentle Robots for Home Use

While robots are found in almost every factory today, they live behind safety barriers, out of reach of people. Traditional robots are good at controlling their motion, but bad at controlling the forces they apply when touching objects; essentially, they are precise but not gentle. As such, they cannot be used as service robots in the home such as for people with disabilities or to assist the elderly with daily living tasks.

To address this, Assistant Professor John "Peter" Whitney, mechanical and industrial engineering, and Professor Robert Platt, MIE Affiliated Faculty, were awarded a $750K National Science Foundation grant for creating "A New Robotic Arm for Contact-Rich Manipulation." Robots with arms and hands that have human-like abilities could help retrieve dropped or distant objects, and help with cooking, cleaning, and grooming. This would increase people's quality of life and independence, and greatly reduce the burden on their caregivers.

This research introduces a new way to design robots that allows them to easily feel when they are in contact with people and objects. A new design allows all of the motors that move the arms to be located in the robot's base. A traditional robot has a motor mounted at each joint in the arm, making the robot very heavy. When robots are lighter and move more gently, it does not just make them safer, but it also makes it easier to program them to learn how to pick up and manipulate objects. Traditionally, robots depend only on cameras to detect objects and plan how to grab them, but in this research, robots will also adapt and learn to interact with objects through their sense of touch.



John "Peter" Whitney, assistant professor, mechanical and industrial engineering

$2.5 Million NSF Grant to Develop Collaborative Robots to Impact the Future of Work at the Human-Technology Frontier

> **If we can augment every human worker we have right now with a robotic coworker, we should be able to double the production. We should be able to process the seafood that we cannot currently process in the United States."**
>
> Taskin Padir, associate professor, electrical and computer engineering

In 2017, the U.S. imported record amounts of seafood, corresponding to a trade deficit of more than $17 billion. Due to low domestic unemployment and obstacles to employing migrant labor, the U.S. seafood processing industry has been unable to meet U.S. consumer demand.

Electrical and Computer Engineering Associate Professor Taskin Padir (PI) was recently awarded a $2.5 million National Science Foundation grant, leading a convergent team of Northeastern University researchers to create "Co-worker Robots to Impact Seafood Processing (CRISP): Designs, Tools and Methods for Enhanced Worker Experience." A follow-on award to a Department of Defense funded project, CRISP will redesign the processes in these harsh environments to provide better working conditions and enhance company productivity.

The seafood processing industry is being used as a test case to learn more about how robots could be integrated into the workforce. The project will investigate the appropriate development and deployment of collaborative robots to transform profitability, productivity, safety, sustainability, and worker quality of life in the seafood processing industry, where harsh conditions and demanding and dangerous tasks challenge the capabilities of humans and robots alike. The result will be designs, tools, methods, and datasets to facilitate seamless human-robot collaboration.

Padir explained that the process of getting a fish from the ocean to a restaurant or supermarket is cold, messy, and dangerous. The animals have to be gutted, deboned, fileted, weighed, measured, sorted and packaged—all in a frigid, slippery warehouse. He says there aren't enough U.S. workers interested in this kind of work. Much of the seafood caught by American fishermen is shipped overseas for processing, and then sold back to retailers in the United States.

"If we can augment every human worker we have right now with a robotic coworker, we should be able to double the production," says Padir, who has been working with seafood processing plants in Massachusetts for the past year. "We should be able to process the seafood that we cannot currently process in the United States."

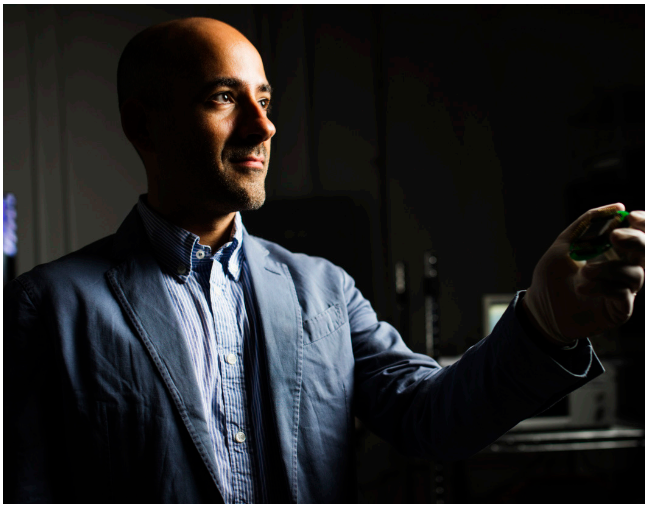
Soft robot manipulators will augment the safe and reliable handling of slippery, scaly, and flexible objects. Emerging capabilities in artificial intelligence will assist in identifying and inspecting varieties of fish and shellfish. Critical to the project is understanding how best to allocate specific tasks among robot and human workers, integrating a complex set of desired outcomes, across scales of individual workers, independent businesses, domestic and migrant labor markets, national economic sectors, and global trade, while respecting environmental and ethical constraints.

With the help of the new award, the research team is completely re-imagining the industry. Taskin Padir is the principal investigator and will be designing the robots. Kristian Kloeckl, an associate professor of art, design, and architecture is investigating the best way for humans and robots to work together; Alicia Sasser Modestino, associate professor of public policy, urban affairs, and economics, is evaluating the economic impact on workers and companies; John Basl, associate professor of philosophy, is looking at the ethics of autonomy (How do we build a robot that respects human values, such as privacy?); and Kemi Jona, assistant vice chancellor of digital innovation and enterprise learning, is designing training programs to give workers the skills they will need in the new workplace.

Editorial credits, Laura Castañón

WIRELESS INTERNET OF THINGS

$1.7 Million Award for Transformational Energy Technology



Matteo Rinaldi, associate professor, electrical and computer engineering

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

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

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

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

Rinaldi sees the result of his team's research in zero-power sensors as "a foundational technology" and an enabler for a wide variety of applications—in digital agriculture and 'smart' farms to other areas.

'Smart' fire detector

In fact, Rinaldi has invented a smart detector that wakes itself up from ultra-battery saver mode using the very flames it is engineered to detect. It is the first technology to detect fire wirelessly without frequent battery changes. Rather than wasting energy to monitor the environment when there is nothing relevant to detect, it continuously monitors in sleep mode with zero standby power consumption—extending battery life to up to 10 years or until a flame wakes it up.

There is a patent application for the infrared sensor technology and Rinaldi plans to commercialize the zero-power, wireless flame detectors for settings like construction sites, warehouses and forests through a start-up company named Zepsor Technologies.

"Nothing like this exists in the market," Rinaldi says. "It's a low-cost, coin-sized wireless flame detector that won't need new batteries for several years and can be easily retrofitted for the most complex environments."

Institute for the Wireless Internet of Things at Northeastern University

Building the Next Generation of Wireless Technologies

Imagine a future of limitless connections. Tiny devices implanted in your body relay health information to your smartphone. Young students operate high-definition microscopes at a university hundreds of miles away. Networks of underwater sensors provide real-time ocean data to scientists on shore. A group of researchers at Northeastern isn't just imagining this future—they're designing it.

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

"We're moving into a world in which everyday objects, and all the fabric of our daily lives, have intelligence," said Tommaso Melodia, the William Lincoln Smith Professor in Northeastern's Department of Electrical and Computer Engineering. "This intelligence enables interactions between the cyber world and the physical world."

Melodia is the founding director of Northeastern's new Institute for the Wireless Internet of Things, which will bring together a wide variety of expertise to build the next generation of wireless technologies for a faster, more connected world.

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

Faster wireless networks are just one part of the equation. The new institute will have groups working on designing smaller, more effective sensors for interacting with the physical environment, developing artificial intelligence and machine learning programs to make sense of the data, and creating the protections to make sure that information stays secure.

"The institute will be a liaison between the expertise in these different areas," Melodia said. "We're hoping to create a visible point of connection between academic researchers and industry and government to create new partnerships." These collaborations will help translate laboratory research into marketable products that create new ways for us to connect with our friends, our environment, and ourselves.

Several of Melodia's fellows in electrical and computer engineering will also be taking leadership roles in the new institute. Associate Professor Kaushik Chowdhury will be connecting with industry professionals in the U.S. and abroad, and Associate Professor Stefano Basagni will be designing new degree programs to prepare Northeastern students to build the wireless future.

"There's already a lot of interesting work in the wireless arena coming out of this university," Melodia said. "I would like for this institute to be a point of reference, nationwide and internationally, for the next generation of Internet of Things and smart wireless networked systems."

Editorial Credits, Laura Castañón

Northeastern is Home to the World's Most Powerful Emulator of Wireless Systems

The National Science Foundation and the Defense Advanced Research Projects Agency have selected Northeastern University to run a massive data center that will enable 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.

The testbed, named Colosseum after the iconic Roman amphitheater, is the world's most powerful emulator of wireless systems. It can process more information in a single second than is estimated to be held in the entire print collection of the Library of Congress.

Colosseum is capable of creating virtual environments that have hundreds of wireless signals hurtling through them, which will enable researchers to understand how these signals interact, develop artificial intelligence algorithms that allow more devices to share the wireless space, and design ways to protect the system from attackers.

Northeastern's College of Engineering research team, led by Tommaso Melodia, William Lincoln Smith Professor of electrical and computer engineering, together with U.S. Ignite, Inc., a nonprofit organization, directs the National Science Foundation Platforms for Advanced Wireless Networks (PAWR) Project Office, responsible for $100 million in investments and a $6M NSF grant.

Colosseum will move from the Applied Physics Lab at Johns Hopkins University to Northeastern's Innovation Campus in Burlington, Massachusetts in November, where it will join the Platforms for Advanced Wireless Research (PAWR) program, which is co-led by Northeastern and US Ignite, where William Lincoln Smith Professor Tommaso Melodia, electrical and computer engineering, is the academic lead. The program, which is supported by the National Science Foundation, provides researchers with facilities to experimentally evaluate wireless networked systems in real-life testing scenarios. The addition of Colosseum will allow researchers to virtually test their ideas before taking them to one of the program's real-world testing sites.

Colosseum will become part of Northeastern's Institute for the Wireless Internet of Things, under the leadership of Melodia and his research team including associate professors Kaushik Chowdhury and Stefano Basagni, and Abhimanyu Gosain, technical director of PAWR.

Colosseum, which cost $20 million to build, was originally designed by the Defense Advanced Research Projects Agency for a competition in which teams of researchers around the country used artificial intelligence to collaboratively decide how to share the wireless spectrum in specific scenarios.

Northeastern submitted a proposal to the Defense Advanced Research Projects Agency and the National Science Foundation to take over the management of Colosseum once the competition ends, and received $5 million in funding from the National Science Foundation to support the effort.

Editorial credits, Laura Castañón

FACULTY HONORS AND AWARDS

SELECT HIGHLIGHTS

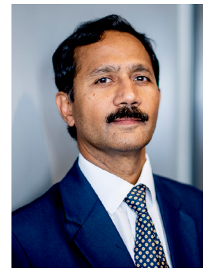
Professor Dagmar Sternad, jointly appointed in Biology and Electrical and Computer Engineering, has been promoted to the rank of University Distinguished Professor, the highest honor the university can bestow upon a faculty member, for her achievements in the field of experimental and computational motor neuroscience.

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

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

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

Associate Professor and Associate Chair for Research Matthew Eckelman, civil and environmental engineering, was selected by the journals, *Environmental Science & Technology (ES&T)* and *Environmental Science & Technology Letters (ES&T Letters)*, for inclusion in their Early Career Scientists Virtual Issue, which highlights 24 early career scientists with research of outstanding quality.



Mechanical and Industrial Engineering Professor Yingzi Lin (PI) and Professor Sagar Kamarthi, in collaboration with the University of Texas at Arlington and Brigham & Women's Hospital, were awarded a $1.2M National Science Foundation grant for "Novel Computational Methods for Continuous Objective Multimodal Pain Assessment Sensing System (COMPASS)."

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

Assistant Professor Nikolai Slavov, bioengineering, has developed a data-driven technique to detect more than 2,000 proteins in a single cell. His single cell mass spectroscopy now offers a cheaper and faster technique that allows researchers to analyze a much larger number of single cells and results in much more accurate data. To further the research, Slavov is working

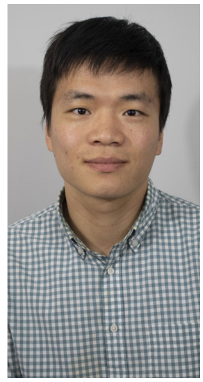
Professor Yunsi Fei, electrical and computer engineering, has been awarded a $750K five-year grant from the National Science Foundation as the Northeastern lead for a new multi-university research center, CHEST, or Center for Hardware and Embedded Systems Security and Trust. Part of the Industry-University Cooperative Research Centers Program, CHEST will coordinate university-based research with the needs of industry and government partners to advance knowledge of security, assurance, and trust for electronic hardware and embedded systems.

collectively with another 200 labs from various countries in the Human Atlas Project, an effort to identify all of the different single cells comprising the human body. His part of the project is supported by the Chan Zuckerberg Initiative.

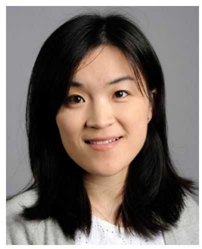
Associate Director Kaushik Chowdhury, electrical and computer engineering (ECE), is leading a $1.5 million DARPA grant, in collaboration with ECE faculty faculty Stratis Ioannidis, Tommaso Melodia, and Jennifer Dy, to identify device-specific radio signals on a massive scale using machine-learning algorithms.

Professor Hameed Metghalchi, mechanical and industrial engineering, was awarded the American Society of Mechanical Engineers 2019 George Westinghouse Gold Medal "for 40 years of scientific research and educational efforts in the field of power generation, which have contributed to improved plant operation and efficiency, and reduced pollutants; and for successfully promoting the dissemination of research as editor of ASME's *Journal of Energy Resources Technology*."

Tommaso Melodia, electrical and computer engineering, was named William Lincoln Smith Professor and was also selected as an IEEE Distinguished Lecturer.



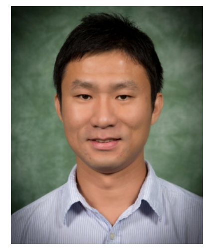
Bioengineering Assistant Professors Ambika Bajpayee (PI) and Jiahe Li (co-PI) were awarded a $628K NIH Trailblazer R21 grant for New and Early Stage Investigators from the National Institute of Biomedical Imaging and Bioengineering (NIBIB) for "Anti-Catabolic Drug Anchored Cationic Exosomes For Cartilage Targeting And Repair."



Assistant Professors Xiaoning "Sarah" Jin and Hongli Zhu, mechanical and industrial engineering, were awarded a $544K National Science Foundation grant for "Manufacturing USA: Precision Alignment of Roll-to-Roll Printing of Flexible Paper Electronics Through Modeling and Virtual Sensor-based Control."

Professor Mansoor Amiji, jointly appointed in pharmaceutical sciences and chemical engineering, received the 2019 Distinguished Alumni Award from Purdue University's College of Pharmacy.

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



Assistant Professor Chun-An "Joe" Chou, mechanical and industrial engineering, was awarded a Collaborative Research Travel Grant from Burroughs Wellcome Fund for his research project, "Data-Driven Method for Learning and Recognizing Dynamical Systems in Computational Neuroscience." The grant program supports academic scientists to begin and continue a collaboration to address biomedical questions.

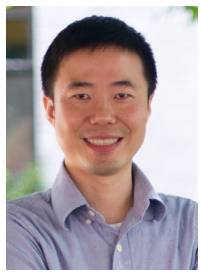
Assistant Professor Devesh Tiwari, electrical and computer engineering, was awarded a $500K grant from the National Science Foundation for "REYAZ: Reliability-Aware Job Scheduling for HPC Systems." REYAZ will enable two novel capabilities: a reliability-aware job scheduling approach and a family of techniques to reduce the input/output overhead.

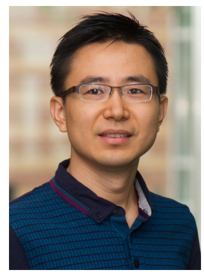
Associate Professor Eno Ebong, chemical engineering, received a National Science Foundation CAREER Award for "EMBRACE STEM (Endothelial MechanoBiology Research And multiCultural Education in STEM)."

Professor Bahram Shafai, electrical and computer engineering, received the Lifetime Achievement Award from World Automation Congress (WAC) 2018 for outstanding contributions to robust stability and control of multivariable systems and observer design for fault detection.

The article "Kinetic solvent effects in organic reactions" by Associate Professor and Associate Chair of Graduate Studies for Chemical Engineering Richard West's research group made the cover of the March 2019 Issue of the *Journal of Physical Organic Chemistry*. West is also the Northeastern lead of a $2.5M multi-university National Science Foundation grant to further develop and support the successful and popular open-source modeling software Cantera.

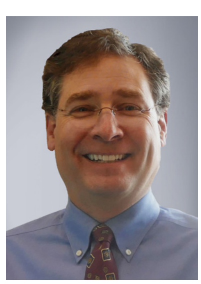
Professor Auroop Ganguly, civil and environmental engineering, has been selected as a Fellow of the American Society of Civil Engineers in recognition of his outstanding contributions to the profession.





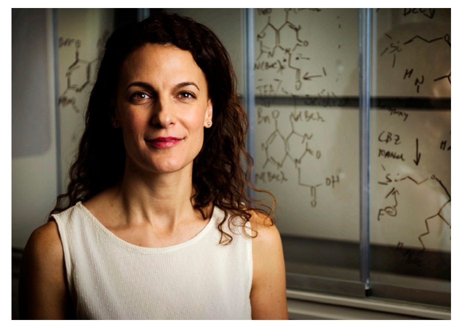
Associate Professor Yongmin Liu, mechanical and industrial engineering, and electrical and computer engineering (ECE), and ECE/Khoury College of Computer Sciences Professor Yun Raymond Fu were awarded a $530K National Science Foundation grant for "Multi-Functional Optical Meta-Systems Enabled by Deep-Learning-Aided Inverse Design."

Assistant Professors of Bioengineering Ambika Bajpayee and Nikolai Slavov were each recipients of a Sanofi iAward, created to promote scientific breakthroughs. Bajpayee's project is "Exosomes for oral delivery of siRNA for treatment of Type 1 diabetes," and Slavov's project is "Developing a technology platform for discovering biomarkers and drug targets."

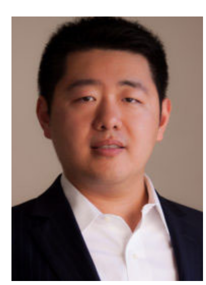


James Benneyan, professor of mechanical and industrial engineering and director of the Healthcare Systems Engineering Institute, received, in collaboration with Brigham and Women's Hospital (lead), a $1.8M R18 award from the Agency for Healthcare Research and Quality for a Patient Safety Learning Lab to develop real-time predictive/detection models of patient misdiagnoses. Benneyan also received a $450K NIH/NIDA award for "Model-Informed Understanding and Mitigation of the U.S. Opioid and Heroin Epidemic."

Professor Yun Raymond Fu, jointly appointed in electrical and computer engineering and Khoury College of Computer Sciences, has been elevated to an IEEE Fellow, named a Fellow of The Optical Society, and selected as a distinguished member of the Association for Computing Machinery.



Professor and Associate Chair for Research Rebecca Carrier, chemical engineering, was awarded a four-year $1.57M renewal National Institutes of Health grant for "Impact of Lipids and Food on Oral Compound Absorption: Mechanistic Studies and Modeling." She was also elected a Fellow of the American Institute of Medical and Biological Engineering (AIMBE) for her exceptional achievements and significant contributions within the medical and biological engineering fields.



Assistant Professor Yanzhi Wang, electrical and computer engineering, is the Northeastern lead as part of a $1.2M National Science Foundation grant that is in collaboration with the University of Southern California to create, "FASTLEAP: an FPGA-based

Compact Deep Learning Platform," to accelerate deep learning, not only inference, but also training and model compression.

COE Distinguished Professor David Kaeli, electrical and computer engineering, has received a $753K DARPA Software-Defined Hardware TA-2 grant, titled "Mitchell," as part of a three-partner team to design a state-of-the-art domain-specific language for computationally challenging applications as well as develop supporting compiler/binary-optimization technology, with the goal for Mitchell to enable Intel's reconfigurable processors to achieve ASIC-like performance.

STUDENTS

Isaac Kresse, E/S'19, who graduated with both a chemistry and computer engineering degree, was awarded a Fulbright Fellowship, which he will use to conduct research on protein aggregation at the Max-Planck Institute for Biochemistry in Munich.

Mary Elizabeth (Lizzy) Warner, PhD Interdisciplinary Engineering '20, and her team were awarded second place from the Homeland Security Advisory Council's Crisis Management Case Challenge for their innovative proposal specifying how to increase the resiliency of cities.

Assistant Professor Xiaoning "Sarah" Jin, mechanical and industrial engineering, and Anqi He, PhD'21, received the Best Paper Award at the ASME International Manufacturing Science and Engineering Conference (MSEC) 2019, which took place in Erie, PA for their paper "Failure Detection and Remaining Life Estimation for Ion Mill Etching Process Through Deep-Learning Based Multimodal Data Fusion."

Erica Wagner, E'20, bioengineering, earned the prestigious Barry Goldwater Scholarship, the United States' premier award for outstanding young researchers in STEM fields.

PhD student Pranali Buch, advised by Professor Edgar Goluch, had her review paper, titled "Treating Polymicrobial Infections in Chronic Diabetic Wounds" featured on the front page of the Clinical Microbiology Reviews journal website. CMR is ranked second out of 126 microbiology journals with an Impact Factor of 20.642.

Northeastern's student chapter of the Institute for Operations Research and the Management Sciences (INFORMS), advised by Professor Ozlem Ergun, received the 2019 Student Chapter Annual Award at the Magna cum laude level.

A group of Northeastern students, led by Associate Professor Taskin Padir, electrical and computer engineering, was selected as one of ten finalists in NASA's 2019 Revolutionary Aerospace Systems Concepts – Academic Linkage (RASC-AL) Special Edition: Moon to Mars Ice and Prospecting Challenge for their project "Northeastern University Prospecting Underground Distilling Liquid Extractor (NU-PUDLE)."

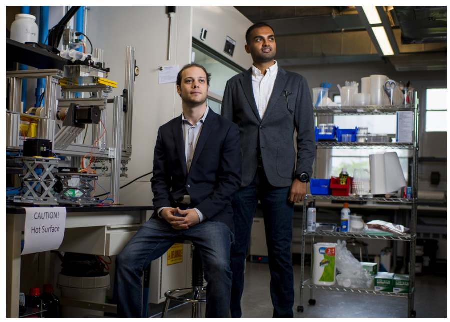
PhD student Yujie Yan was named a 2018 O.H. Ammann Research Fellow in Structural Engineering by the American Society of Civil Engineers.

Kritika Singh, E'20, bioengineering, was named a 2019 Truman Scholar, a United States' premier graduate fellowship for those who intend to devote their careers to serving the public good.

Congtin Justin Nguyen, E'19, bioengineering, received the German Academic Exchange Service (DAAD) Study Scholarship, which will support his Master of Science program in Regenerative Biology and Medicine at Germany's Technische Universität Dresden (TUD), one of that nations' finest universities in the sciences and engineering.

Mo Han, PhD'22, Yagmur Gunay, PhD'21, and Ilkay Yildiz, PhD'22, electrical and computer engineering, received the Best Student Paper Award at the PErvasive Technologies Related to Assistive Environments (PETRA) conference, which took place in Rhodes, Greece, for their paper "From Hand-perspective Visual Information to Grasp Type Probabilities: Deep Learning via Ranking Labels."

Minhal Ahmed, E'19, bioengineering, was selected as a George J. Mitchell Scholar, which sends future American leaders to the island of Ireland for a year of graduate study. He was also named the winner of the Harold D. Hodgkinson Achievement Award for 2019, one of the highest honors a senior can receive.



Two start-up companies, Boston Materials and Mobile Pixels, both founded by mechanical engineering students and alumni, each won the 2018 MassChallenge Boston, which is a global business accelerator program for companies in the early stages of development. Boston Materials, a Gold level winner, was co-founded by Michael Segal, E'16, and Anvesh Gurijala, E'16, along with Associate Professor Randall Erb. Mobile Pixels, which was co-founded by Stephen Ng, ME'19, along with MIT alumni, was selected as Diamond level winner.

Vidhan Bhaiya, E’21, chemical engineering, and Danny Jooyoung Kim, PharmD’21, won the Global Impact Award at the Schulze Entrepreneurship Challenge. Their business submission was Dr. Brinsely, a footwear manufacturer for diabetics that combines medical performance with chic style.

Jude Arbogast, E’19, civil engineering, was one of 10 students from across the nation named to the American Society of Civil Engineers “New Faces of Civil Engineering” list. According to the ASCE, “the 2019 honorees are rising stars, inspired and inspiring, many of them drawn to the profession by a desire to help others and protect the planet.”

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

Departments

Bioengineering

Chemical Engineering

Civil and Environmental Engineering

Electrical and Computer Engineering

Mechanical and Industrial Engineering

DEPARTMENT CHAIR MESSAGE

The Department of Bioengineering is the newest department in Northeastern's College of Engineering. Building on the success of its PhD program, BioE added BS and MS degree programs in the 2015 – 2016 academic year. We are now in an era of rapid growth with plans to double our faculty over the next three years and continue to increase 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 BioE 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.

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

Sincerely,

Lee Makowski, PhD
Chair of Bioengineering
l.makowski@northeastern.edu

RESEARCH AREAS

Imaging, Instrumentation, and Signal Processing

Biomechanics, Biotransport and MechanoBiology

Computational and Systems Biology

Molecular, Cell, and Tissue Engineering

616 **Students**

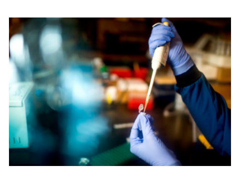
36%

BS enrollment growth
since 2017

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

National Academy Member
Herbert Levine, University Distinguished Professor

4 **Young Investigator Awards**



LEADING-EDGE RESEARCH

NEW INSTITUTE FOR THE CHEMICAL IMAGING OF LIVING SYSTEMS LED BY PROFESSOR **HEATHER CLARK.**
SEE PAGE 30.

DEPARTMENT CHAIR MESSAGE

The Department of Chemical Engineering continues to innovate and grow. Since 2012, our graduate student enrollment rose 143% and undergraduate student enrollment increased 58%. We have also hired highly accomplished tenured/tenure-track faculty, several who have been recently recognized with Young Investigator Awards and National Science Foundation CAREER Awards, as well as selected as fellows of their professional societies. Additionally, our department has received $20 million in research funding since 2016, while research expenditures increased 90%.

The *U.S. News and World Report* has recognized our success; since 2012, our graduate rankings experienced an unprecedented and significant increase. It is clear that our impact in chemical engineering education and research is poised for continual growth in the years ahead.

We offer degrees at all levels, Bachelor of Science, Master of Science and Doctor of Philosophy, and are internationally renowned for high quality classroom-based education in conjunction with professional work experience. Northeastern's top-rated (and one of the nation's largest) cooperative education (co-op) program was one of the first in the country; Chemical Engineering placed students in co-op positions in 180 companies in 2018, spanning the areas of consumer products, plastics, biotechnology, nanotechnology, alternative energy, and petrochemicals, to name a few. Our students have also been placed in international co-op locations in Germany, Chile, France, Singapore, China, United Arab Emirates, Madagascar, India, Italy, Costa Rica, Spain, and Belgium. Additionally, our graduate students have been placed in top companies such as Glaxosmithkline, CONTINUUS Pharmaceuticals, Kaleido Biosciences, Inc., and NBD Nanotechnologies.

Our graduate program is very interdisciplinary and offers students opportunities to work with outstanding faculty to attain research experience and achieve their career goals in a variety of subfields of chemical engineering. In 2018 alone, our faculty gave over 300 presentations (including invited talks at conferences, professional societies, workshops, and more) and we now have international research centers in China and other countries around the world, demonstrating our leadership across the chemical engineering community.

I invite you to explore all of the many aspects of our Department of Chemical Engineering in our Scholarship Report, and visit or contact us for more information.

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

Sincerely,

Ronald J. Willey, PhD, P.E.,
Professor and Interim
Department Chair
Chemical Engineering
r.willey@northeastern edu

RESEARCH AREAS

Advanced Materials Research

Biological Engineering

145 **Graduate Students** enrolled

90% **Increase in research expenditures** since 2016

36 **Visiting Scholars** (2017-2019)

21 Young Investigator Awards, including **10** National Science Foundation CAREER Awards

National Academy of Engineering Member, Arthur Coury, University Distinguished Professor

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

17 **Professional** Society Fellows

DEPARTMENT CHAIR MESSAGE

The coming decades will represent a crucial time, as climate change, urbanization, and technological progress profoundly reshape the ways in which we live and work. From the opportunities of renewable energy and artificial intelligence to the threats of rising sea levels and vulnerable urban infrastructure, Northeastern University's Department of Civil and Environmental Engineering is educating students to serve as leaders in an evolving and complex world.

Our department is strategically focused on urban engineering, preparing students for the great challenges of our time by exploring the unique ways in which the built and natural environment interact. Utilizing the latest advances in simulation, smart sensing, data and network science, and urban informatics, our faculty are conducting critical research in civil infrastructure security, environmental health, and sustainable resource engineering.

Faculty research efforts are broad and interdisciplinary. Among these efforts, we are leveraging artificial intelligence to fight climate change, spearheading a regional effort to make the US a leader in wind energy, harnessing big data to understand population dynamics and urban mobility, and leading a multi-institutional center studying the relationship between environmental contamination and preterm births.

This year sees continued growth in the breadth of our program offerings, with the addition of BS degrees in Civil Engineering and Architectural Studies, Environmental Engineering and Landscape Architecture, and Environmental Engineering and Health Science. We are pleased to augment our expertise in engineered water systems, smart infrastructure, and atmospheric and coastal systems with the hiring of new faculty members.

Our scholars are engineering a resilient and sustainable future through leading-edge research. The department's sixth annual scholarship report details the exceptional academic and professional accomplishments of our faculty and PhD candidates for the 2018-2019 year. For the latest highlights, please visit us at cee.northeastern.edu. We look forward to building a better world together.

Sincerely,

Jerome F. Hajjar, PhD, 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

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

194 **Masters Students**

Doctoral Students **68**

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

10 **Professional** Society Fellows

11 **Young Investigator** Awards

8 **National Science Foundation** CAREER Awards

2018 NSF CAREER WINNER Ameet Pinto for "Developing a Spatial-Temporal Predictive Framework for the Drinking Water Microbiome."

DEPARTMENT CHAIR MESSAGE

The Department of Electrical and Computer Engineering (ECE) at Northeastern University has had many faculty and research accomplishments over the past year. Our 2018-2019 Scholarship Report serves as a reminder of the transformative and impactful research being done in ECE at Northeastern.

Two new tenure-track faculty joined our department, including Associate Professor Josep Jornet in the area of Networking and IoT and Assistant Professor Milad Siami in the area of Controls and Robotics. The year also saw the appointment of four new Research Professors namely: Dana Brooks, Emrecan Demirors, Sumientra Rampersad, and Zhenyun Qian. Additionally, we welcome two new Teaching Professors: Elena Bernal-Mor and Iman Salama.

In the last year, we formed three new research institutes and centers, including the Institute for the Wireless Internet of Things led by Professor Tommaso Melodia, the Institute for Experiential Robotics led by Associate Professor Taskin Padir, and the Northeastern SMART Center led by Associate Professor Matteo Rinaldi. In addition, the year saw several new projects being funded, such as continued funding at more than $4M for the Awareness and Localization of Explosives-Related Threats (ALERT) Center from the Department of Homeland Security led by COE Distinguished Professors Michael Silevitch and Carey Rappaport; a $4.3M grant by the National Science Foundation, entitled PAWR Platform POWDER-RENEW: A Platform for Open Wireless Data-driven Experimental Research with Massive MIMO Capabilities awarded to Professor Tommaso Melodia; and a $3.5M grant awarded to a team of faculty led by Associate Professor Kaushik Chowdhury for Advancing Warfighter Technologies by the US Navy, to name just a few.

Several of our faculty have also received prestigious recognitions. Professor Tommaso Melodia was named the William Lincoln Smith Professor in ECE; Prof. Dagmar Sternad was named a University Distinguished Professor; Professor Bahram Shafai received the Lifetime Achievement Award from the World Automation Congress (WAC); Professors Mario Sznaier and Raymond Fu were named as Fellows of the IEEE; Professor Fu was also named Fellow of the Optical Society (OSA); and Assistant Professors Hui Fang and Pau Closas received CAREER Awards from the National Science Foundation. In addition, ECE faculty were granted 11 U.S. Patents in the last year.

These are just a few of the many research efforts and accomplishments in ECE. I invite you to view our Scholarship Report for many more, as well as visit us to see all the exciting work being done in our wonderful department and college.

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

Sincerely,

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

RESEARCH AREAS

Computer Networks and Security

Communications, Control and Signal Processing

Computer Systems and Software

Computer Vision, Machine Learning, and Algorithms

Electromagnetics, Plasma, and Optics

Microsystems, Materials and Devices

Power Electronics, Systems and Controls

Robotics

The department offers **8** research concentrations and is either the lead or partner of **10** federally-funded research centers and institutes.

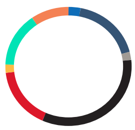
New Research Institutes and Centers:

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

$30M

Annual Faculty Research Expenditures

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



Masters Students

298

20% female

Doctoral Students

271

24% female

24 **Professional Society Fellows** Including 12 IEEE Fellows

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

58

TENURED/ TENURE-TRACK Faculty

DEPARTMENT CHAIR MESSAGE

The Department of Mechanical and Industrial Engineering is the largest disciplinary department at Northeastern University's College of Engineering, with a total student enrollment of nearly 3,000 in 2018. We offer 20 degree programs at the BS, MS, and PhD level in mechanical and industrial engineering as well as interdisciplinary and even multidisciplinary programs, including innovative degrees such as a BS in Mechanical Engineering/JD in Law 3+3 program, and BS in Mechanical Engineering and Physics, and MS degrees in Data Analytics Engineering, Energy Systems, Human Factors, Robotics, and Operations Research, to name a few.

Our department has over 70 tenured/tenure-track and teaching faculty. Since 2011, we hired 32 tenured/tenure-track faculty, propelling multiple research clusters in the department toward excellence, while our increase in teaching faculty enable educational excellence to advance even further. Our faculty are accomplished in their field, such as University Distinguished Professor Ahmed Busnaina who was named a Fellow of the National Academy of Inventors this past year, and Professor Hameed Metghalchi who was awarded the American Society of Mechanical Engineers George Westinghouse Medal.

Collaboration with government, academia and industry is part of our focus. As such we have established large-scale collaborations with major industrial companies including General Electric, Raytheon, and Northrop. The industrial collaborations augment multiple governmental supports secured by our faculty, such as the $20M contract order from the US Army Research Office and $125M contract order from the US Veterans Health Administration.

According to the *US News and World Report*, our mechanical engineering graduate program moved up 14 places to No. 43 in five years, while our industrial engineering graduate program has moved up three places to No. 33 during the same period. This momentum will continue through strategic growth. I invite alumni and other stakeholders to join us in propelling this department even further, and also invite all to consider this department for your education and for research and development projects.

We thank you for your interest and if you have any further questions or information needs, please don't hesitate to reach out to us.

Sincerely,

Emanuel Melachrinoudis, PhD
Professor and Interim
Department Chair
Mechanical and
Industrial Engineering
e.melachrinoudis@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

2 **federally funded** research centers

NSF/DHHS Healthcare Systems Engineering Institute

NSF CENTER for High-rate Nanomanufacturing

$145M

Contract Vehicle

$125M: five years from the Veterans Health Administration

$20M: three years from Army Research Labs

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

1584 **Graduate Students** Enrolled

28 **Professional** Society Fellows

56 **TENURED/ TENURE-TRACK** Faculty

National Academy Member
Vinod Sahney, University Distinguished Professor

NORTHEASTERN • UNIVERSITY • 1898

LVX VERITAS VIRTVS

Northeastern University
College of Engineering

coe.northeastern.edu

COLLEGE OF ENGINEERING

230 Snell Engineering Center
Northeastern University
360 Huntington Avenue
Boston, MA 02115

coe.northeastern.edu

COVER IMAGE

More than 30 million adults in the United States suffer from debilitating pain, stiffness, and swelling in their joints caused by osteoarthritis, which results from the breakdown of cartilage, the connective and cushioning tissue between our bones. Ambika Bajpayee, assistant professor of bioengineering, recently received the National Institutes of Health Trailblazer New/Early Stage Investigator Award from the National Institute of Biomedical Imaging and Bioengineering to use her charge-based delivery platform to transport cell-derived extra-cellular vesicles into negatively charged cartilage for applications in delivery of disease-modifying osteoarthritis drugs immediately after a traumatic injury to help prevent osteoarthritis.