

2023 Impact Report

Electrical & Computer Engineering

“Few programs have retooled their undergraduate curricula for the digital economy as dramatically as Boston University’s College of Engineering.”

*-Mary Lord, ASEE
PRISM Magazine,
Summer 2022*

**BOSTON
UNIVERSITY**



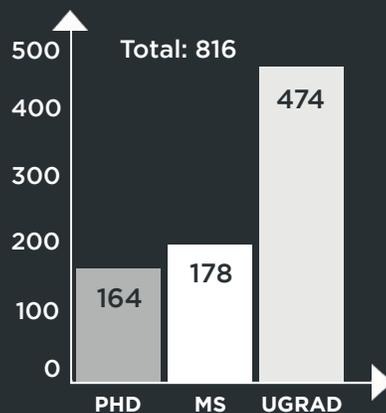
A LETTER FROM THE CHAIR

Welcome to another dynamic year of growth and impact from BU ECE, as reflected in this latest portfolio of accomplishments and advancements! Our esteemed faculty added a pair of rising stars whose work stems from the convergence of machine learning and medical science. Our researchers made strides in areas as diverse as quantum photonic sensing, synthetic biology, fiber-optic communications, chemical imaging for healthcare, and the study of unidentified aerial phenomena, and our portfolio of support for their explorations continued to grow. Our students continued to make us proud as well, winning recognition at conferences and competitions at home and abroad. As we embark on our next chapter, read on for a glimpse of the promising future we're working hard to build right now, in the present.

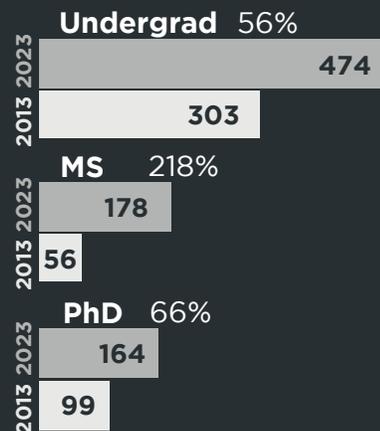
2 Professor W. Clem Karl
ECE Chair

ECE AT A GLANCE

ENROLLMENT

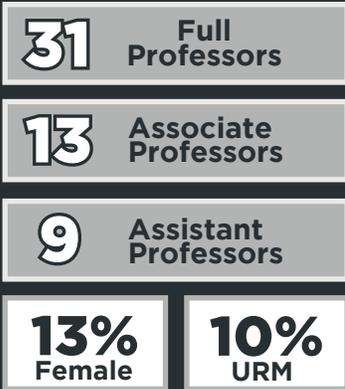


ACADEMIC GROWTH



Professor Archana Venkataraman joins BU ECE from the Johns Hopkins Whiting School of Engineering faculty. She earned her PhD from MIT in 2012, followed by postdoctoral work at MIT and the Yale School of Medicine. Supported by grants from the NIH and NSF, her Neural Systems Analysis Laboratory (NSA Lab) is dedicated to building a comprehensive, system-level understanding of the brain; an essential foundation for improving patient care and, in particular, the treatment of debilitating neurological disorders.

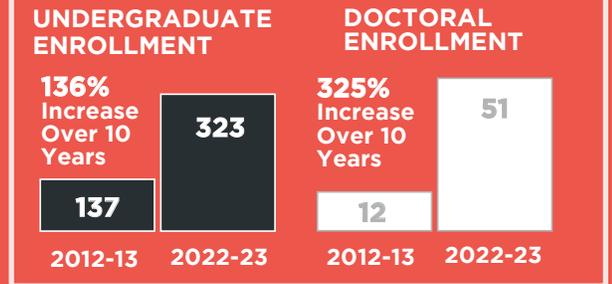
FACULTY



RESEARCH SUPPORT



SPOTLIGHT: COMPUTER ENGINEERING PROGRAM



CONVERGENCE IN ACTION:

AI & BIOMEDICAL RESEARCH



+ Kayhan Batmanghelich

Joint modeling of medical images and clinical health records for neurodegenerative and lung diseases

+ Christos Cassandras & Ioannis Paschalidis

Predictive models for health outcomes: COVID-19, Alzheimer's, hypertension, fertility, and more

+ Prakash Ishwar

"Digital Health" research thrust lead, "Novel data science and AI approaches for Brain Health and Brain Disease" Focused Research Program, Hariri Institute

+ Lei Tian

Deep learning to analyze cellular-level reflectance images; data-driven imaging cytometry technique

+ Archana Venkataraman

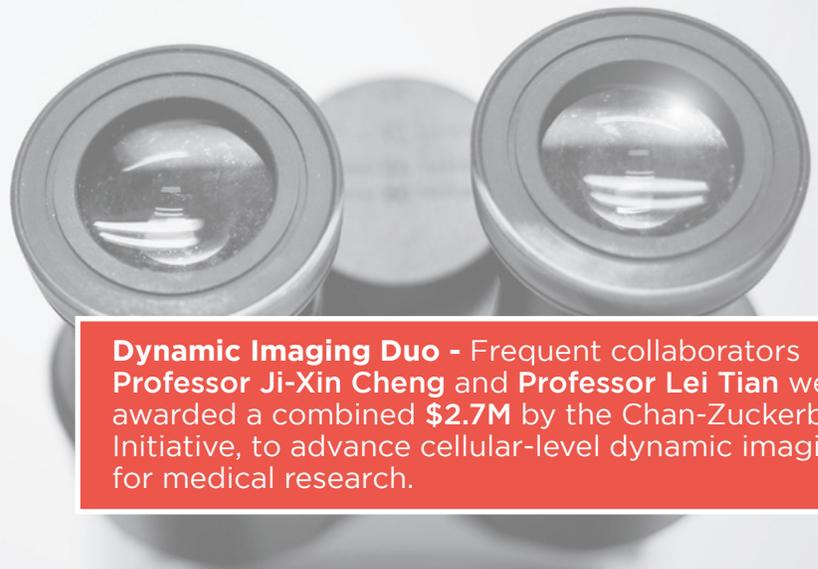
Addressing brain disorders and dysfunction via deep-generative hybrid models, biologically-informed models, and robust and adaptable optimization

★ New Faculty ★

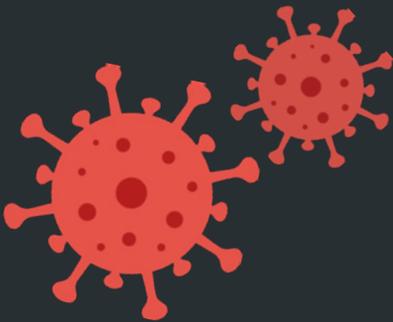
Professor Kayhan Batmanghelich's research, which encompasses AI/ML, bioinformatics, and medical image analysis, has earned broad support from the NIH, NSF, and sponsors in industry. He is the co-founder of READE.ai, a start-up focused on ML-based real-time evaluation of adverse events during surgery, and a multi-institutional virtual seminar series on ML in healthcare (MLxMed). Professor Batmanghelich joins BU ECE from the University of Pittsburgh. He earned his PhD at UPenn in 2012, followed by postdoctoral work at MIT.



OPTICS & IMAGING
MACHINE LEARNING
Funding
SYNTHETIC BIOLOGY
NANOPHOTONICS
METAMATERIALS
QUANTUM COMPUTING
MICROELECTRONICS



Dynamic Imaging Duo - Frequent collaborators **Professor Ji-Xin Cheng** and **Professor Lei Tian** were awarded a combined **\$2.7M** by the Chan-Zuckerberg Initiative, to advance cellular-level dynamic imaging for medical research.

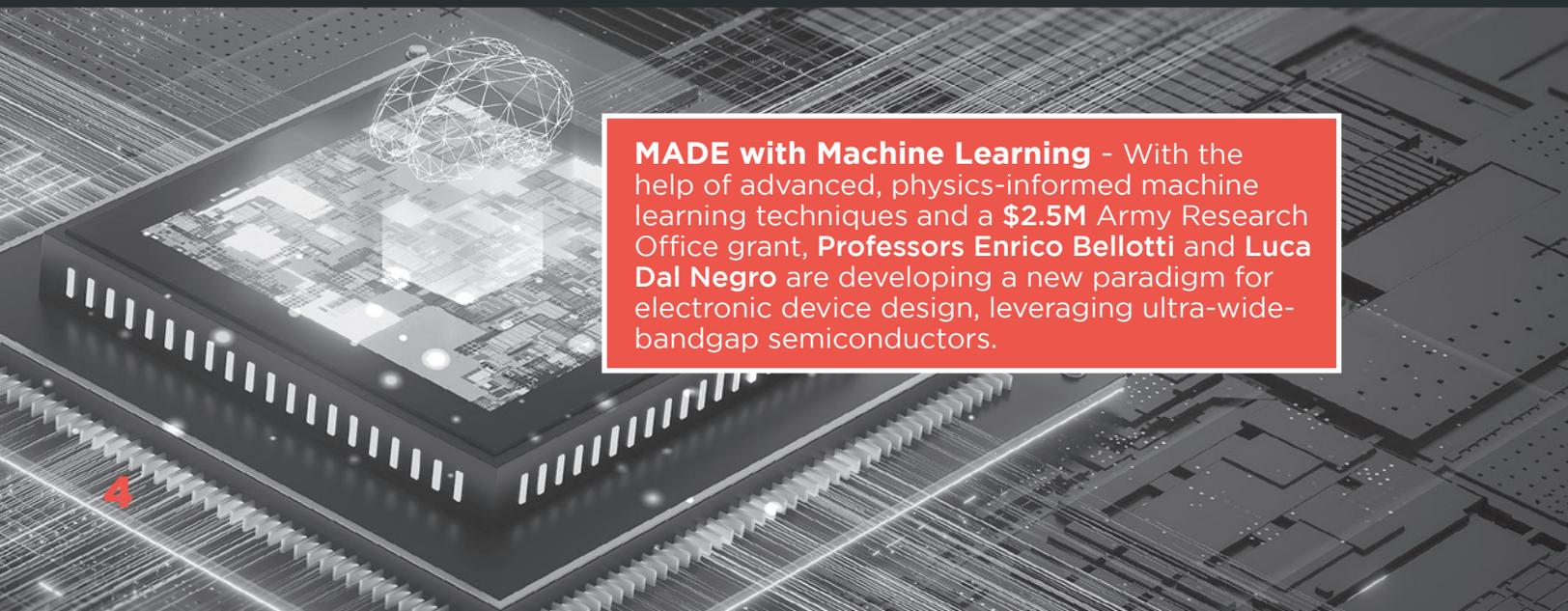


Pandemic Prevention - Supported by a **\$1M** grant from the NSF, **Professor Ioannis Paschalidis** and a multidisciplinary team of faculty are creating statistical models which can help prevent future pandemics via prediction, fast detection of local epidemics, control strategies, and driving the development of global infrastructure and public health policy.

Building the BioComputing Future - With **\$1.4M** in NSF support, **Professor Douglas Densmore**, and colleagues at UMass Amherst are teaming up to program bacterial colonies into “living circuits,” leveraging the automation of high-throughput microfluidic devices through Densmore’s DAMP Lab.



MADE with Machine Learning - With the help of advanced, physics-informed machine learning techniques and a **\$2.5M** Army Research Office grant, **Professors Enrico Bellotti** and **Luca Dal Negro** are developing a new paradigm for electronic device design, leveraging ultra-wide-bandgap semiconductors.



Pushing Quantum Boundaries - Professor Luca Dal Negro has received a **\$450K** grant from the Army Research Office to pursue improvements in quantum photonic sensing & detection technology driven by an approach called "quantum non-demolition detection."

Garbage to (Bio) Gold - Supported by **\$3M** from industry, the multi-disciplinary, multi-sector BioMADE consortium of researchers are pooling their specialties to develop smarter, more efficient bioreactors to convert waste to useful products. **Professor Rabia Yazicigil** will adapt her miniature bio-electronic sensor technology to create energy-efficient, wireless sensors to monitor the biofilm manufacturing process in real time, while **Professor Douglas Densmore** brings his expertise and DAMP Lab infrastructure to the task of automating, scaling up, and ultimately democratizing the use of this vital technology.



FUNDING SNAPSHOT

NSF

\$15M

NIH

\$10M

NASA

\$2.5M

DoD

\$7M

DoE

\$1M

OTHER

\$8M

175%

**Increase
in Support
Over 10 Years**

2023

2018

2013

\$44M

\$27M

\$16M

COMPLEX PHOTONICS
ARTIFICIAL INTELLIGENCE

Research

DEEP LEARNING
CYBERSECURITY
CHEMICAL IMAGING
REMOTE SENSING

The Sky's the Limit

In a paper published in *Science*, Zelin Ma (Ph.D.'23), **Professor Siddharth Ramachandran**, and collaborators demonstrate a ground-breaking solution to the growing problem of capacity crunch in fiber-optic communications: "topological confinement," a method which takes its inspiration from the rotation of binary stars.



AI to Ease High Blood Pressure

"Our data-driven model is not just predicting an outcome, it is suggesting the most appropriate medication to use for each patient." Working with physicians and fellow data scientists, **Professor Ioannis Paschalidis** has developed an AI/ML algorithm which can provide individually personalized treatment recommendations for patients with hypertension ... and perhaps boost trust in AI via its transparent approach.

Social Media's Identity Crisis

When it comes to using identity to help curb online misbehavior, **Professor Gianluca Stringhini** noted both the logistical difficulty of universal account verification, and the socio-political importance of pseudonymous or anonymous communication for some users. Prior to changes implemented by Elon Musk, X (Twitter)'s check system was a model of functional compromise between providing that access, and discouraging impersonation of public figures.



Building a(n Even Better) Microscope

Professors Ji-Xin Cheng and **Lei Tian** have developed a new mid-infrared photothermal device which uses "Bond-Selective Intensity Diffraction Tomography" to extract high-fidelity imaging data which can differentiate between chemical compounds within a sample. The device was designed and built as an add-on to a simple, inexpensive off-the-shelf microscope.



If the Truth is Out There ...

UFOs, officially rebranded as UAPs (Unidentified Anomalous Phenomena), have long excited the public's imagination, but up until now they have been difficult to study scientifically. A NASA project bringing together a variety of experts, including **Professor Joshua Semeter**, aims to address the problem by assessing the best available tools and techniques for future research. Professor Semeter brings his extensive experience in radar and optical remote sensing and space plasma phenomena to this effort.



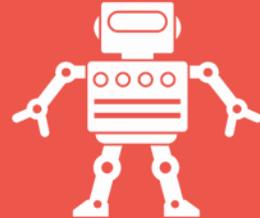
AI + ROBOTICS =

Building the Workforce of Tomorrow



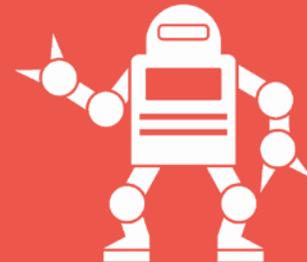
Robotics at BU: **AMONG THE NATION'S BEST**

Rated #6 in the U.S. by Analytics Insight



MASTER OF SCIENCE *in* *Robotics & Autonomous Systems*

+ Full-Time, Paid Internship at a **Top Robotics Company** Right Here In Boston
Amazon Robotics, Boston Scientific, DEKA, iRobot, Dragon, and more!

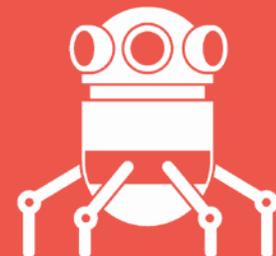


BRAND-NEW R&D CENTER

*Robotics and Autonomous Systems Center - **RASTIC***

- State-Funded, State-of-the-Art
- Local Industry Collaboration
- Emphasis on AI in Robotics
- Soft Robotics for Medical Apps

Opening By the End of 2023!



INNOVATOR OF THE YEAR
SOCIETY FELLOWS

Faculty Recognition

RISING STAR
COLLEGE HONORS



Professor Ji-Xin Cheng, Moustakas Chair in Photonics and Optoelectronics, was honored as BU's 2022 **Innovator of the Year**. With more than 30 patents and multiple companies to his name, Professor Cheng's trailblazing achievements include inventing a way to use blue light and hydrogen peroxide to treat drug-resistant MRSA, finding the molecular signatures associated with aggressive cancers, and creating novel imaging techniques using infrared light to see molecules inside living cells.

NEW SOCIETY FELLOWS

Professor Chen Yang was inducted into the American Institute for Medical and Biological Engineering (**AIMBE**)'s College of Fellows, placing her among the top 2% of medical and biological engineers who have made "outstanding contributions."



Professor Siddharth Ramachandran was named a 2022 Fellow of the American Physical Society (**APS**) for foundational contributions to the study of structured and singular light and their applications.



Going the Distance in Microelectronics

In hardware and microelectronics circles, the International Solid-State Circuits Conference is the most competitive game in town, nicknamed the "**Chip Olympics**." In those terms, it could be said that **Professor Rabia Yazicigil** and her WISE-Circuits Lab brought home a pile of medals.

As a rising star in her field, Professor Yazicigil was tapped to deliver two talks for special conference events: a tutorial covering security issues, research directions, and challenges centered on the physical layer of advanced wireless systems, and a lecture titled "The Basics of Low Noise Amplifiers" at the ISSCC Circuits Insights event, attended remotely by thousands of students around the globe. Her lab presented a paper and demonstration, several of her students won awards, and she even co-organized the Women in Circuits event for the conference.



Professor Vivek Goyal was appointed a 2022 Fellow of the American Association for the Advancement of Science (AAAS) in recognition of his significant work in computational imaging and signal processing.



Professor Ioannis Paschalidis was elected a Fellow of the International Federation of Automatic Control (IFAC), honoring his impact in network systems control, optimization, and robust learning.



It was a banner year for **optical pioneer** Professor David Boas; following his appointment to BU's prestigious Arthur G.B. Metcalf Chair, which recognizes an internationally known scholar in mathematics, science, or engineering, Professor Boas was honored with the College of Engineering's 2023 Charles DeLisi Award and Lecture, speaking on his ground-breaking research into the role of blood flow in the actively functioning brain.



FACULTY IN NUMBERS



Average h-index

Avg # of Citations



Society Fellows

Early Career Awards



National Academy Members

Current/Former IEEE Society Presidents



13%
Female Faculty

10%
URM Faculty

31
Full Professors

13
Associate Professors

9
Assistant Professors

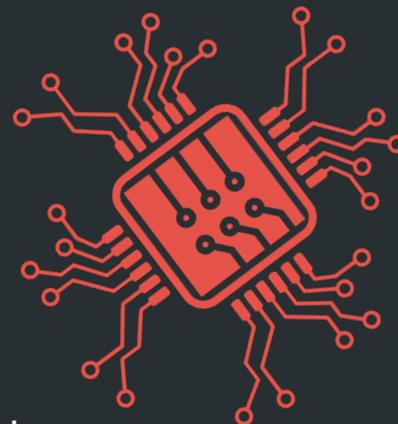
CONFERENCE AWARDS

BENCHMARK RECORD

Students & Alumni

ACADEMY HONOR

INDUSTRIAL IMPACT



A “Fuzzy” Method, Clarified.

Sadullah Canakci (PhD’22) and co-authors, including former ECE advisors Professors Ajay Joshi and Manuel Egele, received a Best Paper Award at IEEE HOST 2023 for their work on hardware fuzzing. With several novel features, their ProcessorFuzz improved both speed and coverage, in addition to exposing nine new bugs across three open-source processor test subjects.



A Promising Career, Recognized.

IEEE’s Solid-State Circuits Society, the flagship society for the microelectronics field, selected Ph.D. student **Qijun (“Mandy”) Liu** for their highest student honor: the Solid-State Circuits Predoctoral Achievement Award. Liu’s work designing hybrid bio-electronic systems, published by top journals and conferences, has already received significant recognition in the form of awards and sponsorships.



Supercomputing Savants

Composed primarily of BU students, the inter-collegiate **Massachusetts Green Team** set a new HPL benchmark record at SuperComputing 2022’s Student Cluster Competition, in addition to winning the interview portion outright. The team was advised by Professor Martin Herboldt and faculty from MIT and Northeastern, and supported by industry partners.



One Drop at a Time

BU’s 2022 **student team**, sponsored by Professor Douglas Densmore and STEM Pathways, earned a gold medal and a nomination for the Best Environmental Project at the International Genetically Engineered Machine (iGEM) competition with the development of a novel technology combining custom software and modular hardware to streamline the water testing process.





Count Her In (to the NAE)

Karen Panetta (ENG'85) was elected to the National Academy of Engineering "for leadership empowering females in STEM, and for contributions to computer vision and simulation algorithms." Panetta, now a Professor of ECE and Dean of Graduate Education at the Tufts University School of Engineering, has dedicated her professional life to engineering for positive impact, and advancing opportunities for women in STEM. Her advocacy work includes the mentorship program Nerd Girls and the *Count Girls In* guide for parents.

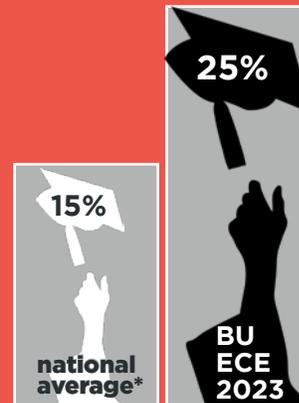
BU-Based Research Acquired by Industry

When alum **George Daaboul** (ENG'09, '13) began developing Single Particle Interferometric Reflectance Imaging Sensor (SP-IRIS) technology in his BU mentor Professor Selim Ünlü's lab, he couldn't have predicted how it would evolve. The novel sensor, which can detect specific nano-particles while tuning out sample noise (like bacteria) was initially designed as a point-of-care multi-pathogen testing method, but has broad potential applications. Daaboul's startup, NanoView, was recently acquired by biotech firm Unchained Labs, which plans to use SP-IRIS to characterize viral vectors for the purpose of delivering gene therapies.



STUDENT STATS

AVERAGE # OF ECE B.S. DEGREES AWARDED TO WOMEN



*2021 ASEE report

ECE PHD APPLICATIONS

77% INCREASE OVER 5 YEARS



SELECTIVE ADMISSIONS

2022-2023

25%

2017-2018

28%

2012-2013

51%

% engineering undergraduate applications accepted

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Micro Vision, Macro Impact.

Professor Lei Tian's star is on the rise. A self-described "instrument builder *slash* data science developer," Tian has been steadily climbing along a trajectory through computational imaging breakthroughs and novel device development over the last few years. Supported by an NSF CAREER Award and by the NIH BRAIN Initiative in 2019, the National Institute of Neurological Disorders and Stroke in 2021, and most recently, the Chan Zuckerberg Initiative, Tian's work is characterized by an innovative combination of deep learning savvy and practical applications of optical technology. His research has resulted in fast, accurate, and affordable advances in medical imaging for a variety of groundbreaking applications, including the investigation of how certain drug-resistant cancers alter metabolic behavior, or tracking cerebral blood flow in order to study damaging changes in neuronal circuitry. His grand vision is to illuminate the tiniest hidden biological operations that govern our health - and to do so in collaboration with experts across disciplines, bringing together photonics, synthetic biology, medicine and data science in a meteoric ascent towards a better future for all.

