2020-2021 IMPACT REPORT

ELECTRICAL and COMPUTER engineering

BOSTON UNIVERSITY

SPOTLIGHT: New Machine Learning Concentration

Machine Learning has become ubiquitous in our lives and in our field. In response, BU's College of Engineering has launched a **new undergraduate concentration** aimed at giving students all the tools they need to acquire this core competency. Coordinated by ECE Professor **Prakash Ishwar** (who has earned a Faculty Service Award from the College for his contributions), the 12-credit concentration requires students to take a foundational course on the **theory** of machine learning and two additional courses from areas covering **modeling**, **optimization** and **applications**, plus an experiential component in the form of research or an internship. According to Professor Ishwar, "Machine Learning has become central not only to research, but to our day-to-day lives as well. Our timely new concentration will provide students with the increasingly crucial skills they will need to succeed in their professional careers."

A letter from the Chair:

Fresh from one of the most unusual academic years in Boston University's history--or indeed, that of the entire world--the Department of Electrical and Computer Engineering has risen to ongoing challenges both at home and abroad, and come through it all more dynamic and determined than ever. When they're not busy growing our diverse funding portfolio with grants from federal agencies, private foundations, and more, our faculty are taking the lead with the College of Engineering's vital new Machine Learning concentration, or co-founding the Faculty of Computing and Data Sciences. And of course, we're proud to welcome four new Assistant Professors to our ranks; researchers and educators who have already begun to make their own outstanding marks on the field. As our alumni do us proud with prestigious Best Paper awards and accolades from the business world, our enrollment continues to increase with bright new young minds who will propel us into the future, and our commitment to diversity remains robust through it all. I invite you to browse some of our latest accomplishments, as we forge ahead into another productive year!

-Professor W. Clem Karl, ECE Chair
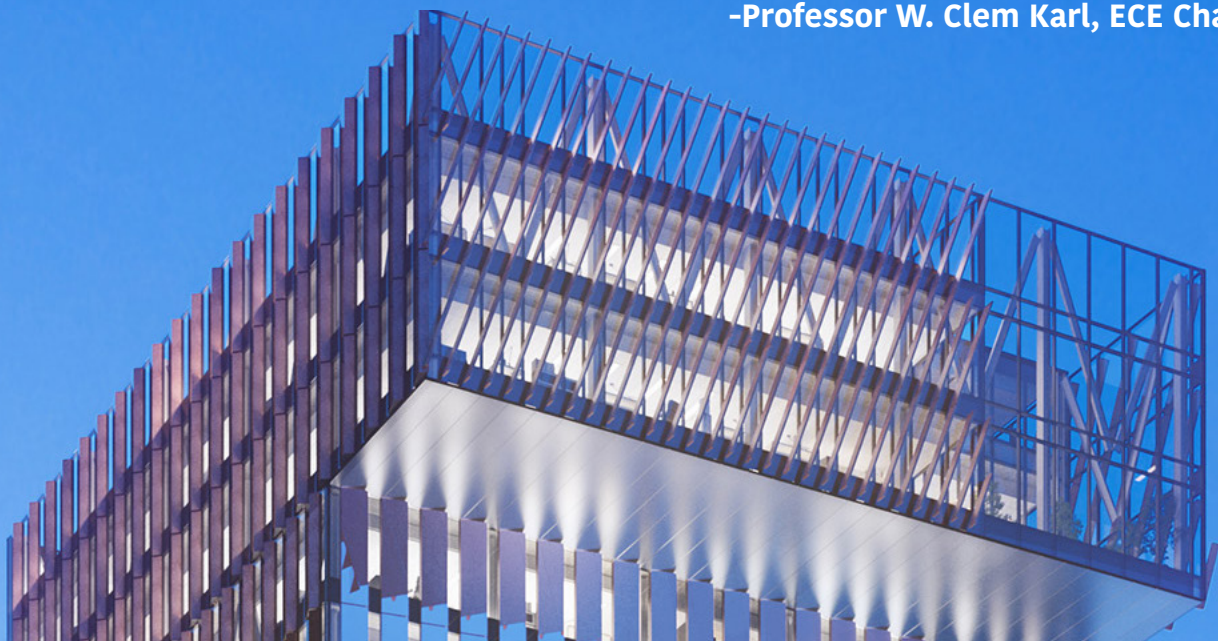
NEW FACULTY

Ashok Cutkosky - Machine Learning and Artificial Intelligence

Previously a research scientist at Google, Assistant Professor Cutkosky holds a PhD in Computer Science from Stanford University, and an AB in mathematics from Harvard. His research interests focus on artificial intelligence and, in particular, optimization algorithms for machine learning.

Abdoulaye Ndao - Photonics and Optics

With research interests in non-Hermitian Photonic Systems, metamaterials, topological phenomena, and nanoscale materials and devices, Assistant Professor Ndao joins ECE following post-doctoral fellowships at UC Berkeley and UC San Diego. He received his PhD degree at the University Franche Comte, France, and is a co-inventor of the first topological laser (recognized by Physics World as one of 2017's Top Ten Breakthroughs.)

Eshed Ohn-Bar - Autonomous Systems

Fresh from his post-doctoral fellowship at the CMU Robotics Institute and Humboldt Research Fellowship at the Max Planck Institute, Assistant Professor Ohn-Bar brings research interests in autonomous navigation, computer vision, and assistive technologies to his new role with ECE. He completed his doctoral work at UC San Diego in 2017, earning the IEEE Intelligent Transportation Systems Society's Best PhD Dissertation Award in the process.

Alan Liu - Systems & Networking

ECE welcomes Alan Liu as Assistant Professor. After receiving his PhD from Johns Hopkins University, he carried out post-doctoral research at Carnegie Mellon University, winning several awards from USENIX and the Association for Computing Machinery. His research interests include mobile and cloud computing, network security and big data.
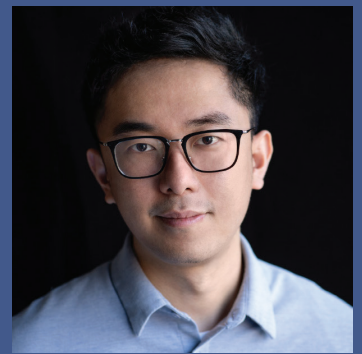

Ashok Cutkosky　　Abdoulaye Ndao　　Eshed Ohn-Bar　　Alan Liu

Junior Faculty Excellence

Striving for Algorithmic Independence

Assistant Professor **Francesco Orabona** is passionate about improving machine learning. While our digital lives are increasingly organized by algorithms, frequent human intervention and adjustment is still a universal requirement. Orabona's tireless work to rectify this functional dependence has recently been recognized with a prestigious **CAREER award** from the **National Science Foundation**.


Packing a Big Punch on a Very Small Scale

Good things can come in VERY small packages, as far as Assistant Professor **Rabia Yazicigil** is concerned--and the **Catalyst Foundation** must agree, if their 4-year, **$240K research grant** is any indication! In collaboration with researchers at MIT, Yazicigil and her team are developing a pill-sized, low-power ingestible device that could make life much easier for millions of people suffering from gastrointestinal disorders by improving diagnostics and reducing the need for uncomfortable, invasive procedures.

Illuminating the Microscopic, Inside and Out

Assistant Professor **Lei Tian**'s expertise in computational microscopy and imaging, recently recognized with an **Early Career Excellence in Research Award** from the BU College of Engineering, is having an outsized impact on the ongoing effort to better understand our bodies - inside and out. His continuing CM2 project with BU's Neurophotonics Center is developing a novel device for measuring brain function; meanwhile, his collaborative work on a fingerprint spectroscopic SR platform was recently featured in **Nature Communications**.
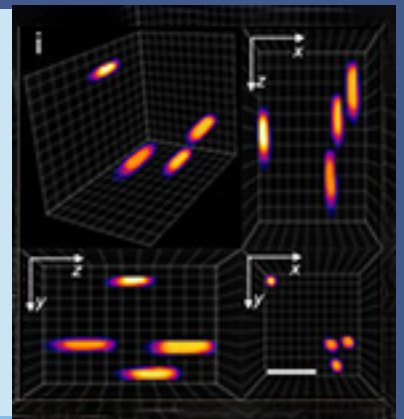
Accessible Vehicles for Autonomous People

In our push towards a more advanced future, it's important not to leave anyone behind; this emphasis on inclusion is a core philosophy for Assistant Professor **Eshed Ohn-Bar**, a recently-appointed **Hariri Institute Junior Faculty Fellow**. Ohn-Bar's OpenGuide project, a semifinalist in USDOT's Inclusive Design Challenge, aims to design accessible self-driving cars for the blind and visually impaired, with an emphasis on providing autonomy for the riders … not just the vehicles.
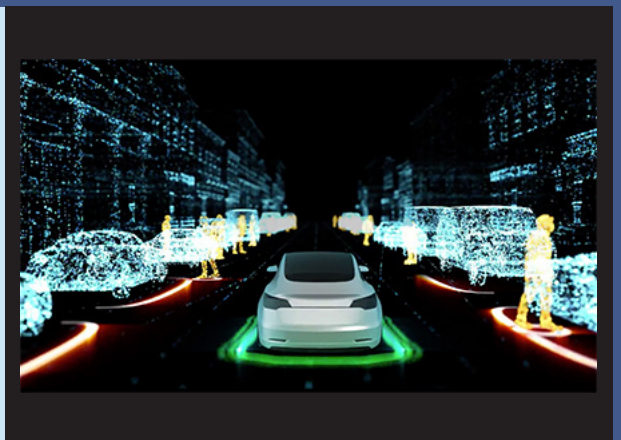
Faculty in Numbers

35 Average H-Index

7K Average Number of Citations

4 National Academy Members

3 Current/Former IEEE Society Presidents

45 Society Fellows

30 Early-Career Awards

12% FEMALE FACULTY

10% URM FACULTY

28 FULL PROFESSORS

12 ASSOCIATE PROFESSORS

11 ASSISTANT PROFESSORS

The Red Hat Collaboratory: $20 Million For Open Cloud Research
At the 2021 Red Hat Summit, BU and Red Hat announced a $20 million renewal and expansion of their partnership, originally founded in 2017. The **Red Hat Collaboratory**, housed within BU's Hariri Institute for Computing and led by **ECE Professor Orran Krieger** and Red Hat Director of Research Hugh Brock, provides funding and opportunities for research and community building, working with open-source developers from Red Hat and partners. Dozens of BU graduates have gone on to accept positions with Red Hat.

Faculty Recognition

Interdisciplinary Excellence

Associate Professor **Douglas Densmore** was elected to the **2021 American Institute for Medical and Biological Engineering (AIMBE) College of Fellows**, out of a record-breaking pool of nominees. Densmore has leveraged his background in electrical engineering with unusual disciplinary agility throughout his career, with a focus on synthetic biology to engineer living systems for bio-sensing and bio-remediation applications.

Optical Society Accolades

For BU ECE Professor Emeritus and inaugural Distinguished Professor of Photonics and Optoelectronics, **Theodore Moustakas**, his election to the **Optical Society of America** as a **Fellow Member** is the latest in a lengthy list of awards and honors over the course of an exceptional and wide-ranging career. Moustakas is the co-editor of 8 books, holder of 39 U.S. patents, an accomplished researcher and prolific lecturer on an international level.

A Half-Century of Service

In choosing to honor BU ECE Research Professor **Robert Gray** with the **2020 Aaron D. Wyner Distinguished Service Award**, the **IEEE Information Theory Society** could hardly have chosen a more suitable candidate. Gray, a Professor Emeritus at Stanford University, has shown particular dedication to service and the promotion of equity within his field during his lengthy career. His previous accolades include a U.S. Presidential Award for excellence in mentoring underrepresented students, among many others.

An International Spotlight

The **IEEE Signal Processing Society**'s annual Distinguished Lecturer Program selects five preeminent authors and educators, and provides funding for them to serve as international ambassadors, delivering lectures to Society chapters around the world. Professor **Venkatesh Saligrama**'s recent selection as a **2021-22 IEEE SPS Distinguished Lecturer** confirms his status as one of the foremost scholars in the field of signal processing.

Engineering Solutions for a Pandemic

In order to bring students back to campus for the 2020-21 school year, a team assembled by Professor **Douglas Densmore** and his co-PI, Dr. Klapperich, spent a whirlwind summer creating BU's very own **in-house, high-capacity COVID-19 testing facility** powered by carefully calibrated liquid-handling robots. The results of their efforts speak for themselves: **BU has faced no major outbreaks to date.**

Looking beyond our borders, Professors **Ioannis Paschalidis** and **Christos Cassandras** worked with Systems Engineering PhD Candidate Salomon Wollenstein-Betech and 2016 graduate Julia Lima Fleck to develop **localized, personalized predictive models** of severe COVID-19 outcomes for populations in Mexico and Brazil. Using machine learning methodology, such models can potentially be used for **risk assessment** to inform **policy and resource allocation**.
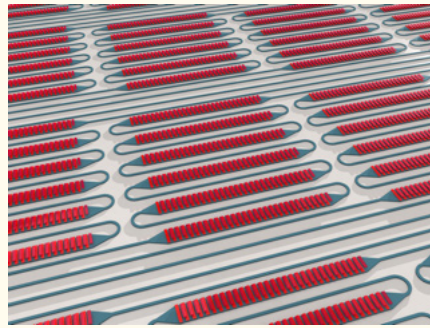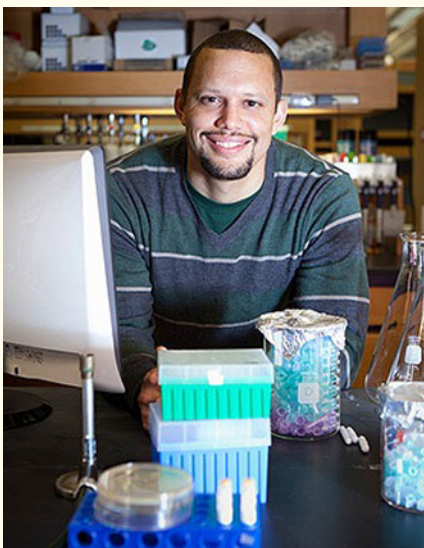

Helping Your Car See Where It's Going

Autonomous vehicles may be the key to the future of transportation, but among the challenges that stand between us and that era is the need to perfect safe steering without the use of human vision. Professors **Vivek Goyal** and **Milos Popovic** are hard at work on new optical technologies to solve this problem. Popovic and his team have developed a tiny **light-manipulating silicon chip** that uses a serpentine structure to launch and steer a laser beam without any moving parts, bulky electronic components or complicated user inputs: a big step towards streamlining the components AVs need. Meanwhile, Goyal's team has published a series of articles about their break-throughs in **"non-line-of-sight" image mapping**, improving the precision of distance estimates using a type of **subtractive dithering**, and compensating for hardware limitations such as "dead times" in high-flux single-photon LIDAR readings to reliably handle **less-than-ideal real-world conditions**.

Getting Smart about Safer Buildings

As society looks forward to a post-COVID-19 world, an increased focus on creating safe environments and preventing the spread of disease is a priority for researchers and industry alike. Professors **Janusz Konrad**, **Prakash Ishwar**, **Thomas Little** and their Mechanical Engineer-ing co-PI have developed a new technology with considerable potential to address these urgent issues: **COSSY (Computational Occupancy Sensing System)**, a scalable system for estimating and monitoring **real-time building occupancy**. An automation system can use this data to manage airflow and temperature, efficiently and at a reduced cost, while building administrators can monitor compliance with occupancy restrictions. COSSY uses fisheye cameras and thermal sensors alongside deep-learning algorithms to perform its counts and, if called for, can constrain identity information to protect privacy.
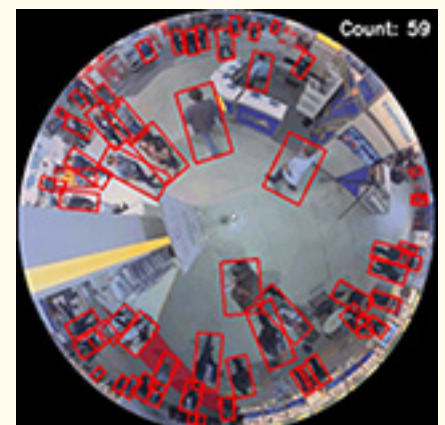
Pushing the Boundaries of the Unknown

Investigating the Physical Markers of Learning: How does learning a new skill or activity change the physical structure of the brain? Professors **Bobak Nazer**, **Venkatesh Saligrama** and their BME Co-PI are developing models and algorithms to help them investigate this question, using large-scale calcium imaging neural datasets collected from the brains of mice during association, learning and unlearning experiments. Backed by a **$1.2M NSF Award**, the team will use an approach called "network change discovery" to create a methodology which, if successful, will have wide-reaching applications.

Measuring Brain Activity in the Real World: Current technology allows us to take amazingly detailed images of brain activity - in controlled laboratory conditions. With the support of a **$5.9M grant** from the **NIH's BRAIN Initiative**, Professor **David Boas** is poised to shatter this paradigm by creating a much more flexible, portable, wearable brain imaging system. The flexible, shower-cap-esque device, which uses fNIRS (functional near-infrared spectroscopy) to measure blood flow, will be used to track brain activity in more natural, everyday conditions.

Pioneering Advances in Medical Imaging: Professor **Ji-Xin Cheng** believes in developing new medical technologies with the capacity to detect the unexpected. In recent years, his team has developed several improved forms of "label-free" diagnostic imaging, which don't rely on locating specific biomarkers. A recent **$2.9M MIRA** grant will support this continuing work. The NIH has also awarded Cheng's team an additional **$2.4M grant** to fund development of a new dual-frequency intravascular photoacoustic/ultrasound imaging catheter capable of detecting and differentiating arterial build-ups that could cause higher risk of heart disease..

Forays into Biomaterials at the Supramolecular Level: Fueled by a **$720K award** from the **National Science Foundation**, Associate Professor **Sahar Sharifzadeh** is ready to explore new territory: she and her collaborators at the University of California's Center for Complex and Active Materials plan to simulate supramolecular structures and develop new self-assembled biological materials for electronics. The NSF's funding will significantly broaden the scope of the group's research and impact as they explore this exciting new direction.

Miniaturizing Essential Optical Technology:

Spectroscopic optical technology is used for a wide-ranging assortment of critical everyday applications, including medical diagnostics, forensics, and security. Unfortunately, the existing systems are costly and complex. Professor **Luca Dal Negro** is working on a solution: with the support of a **$380K NSF award**, his team is developing a new generation of ultra-compact, multi-functional, and inexpensive spectroscopic devices based on nano-structured silicon materials, each as slender as a human hair.
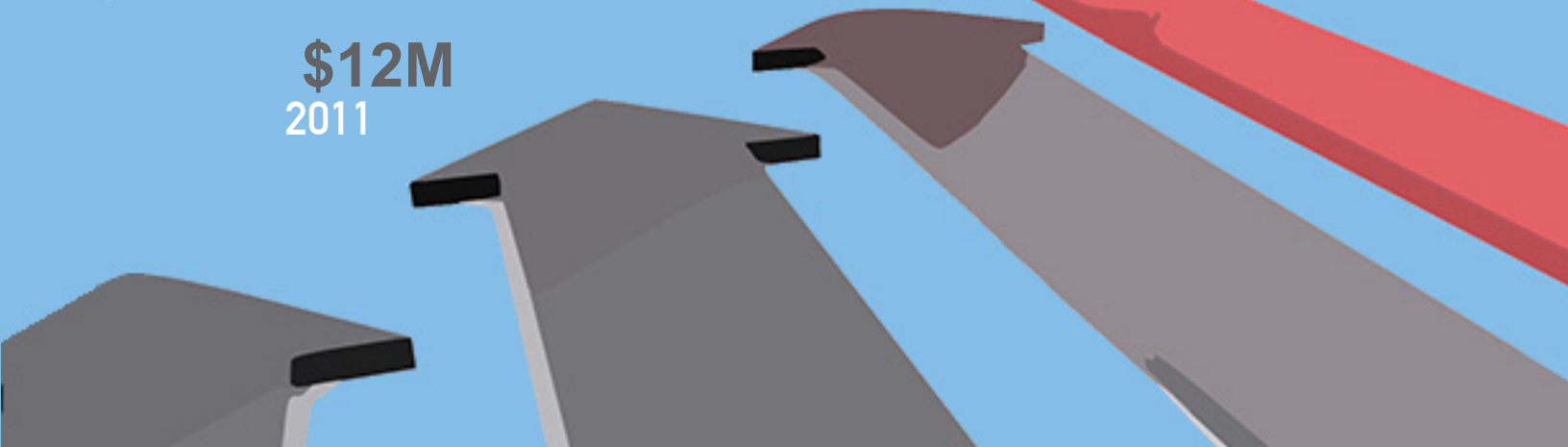
Creating Biosensors from the Memory of Living Cells:

A **$1.5M NSF grant**, awarded to Professors **Douglas Densmore**, **Rabia Yazicigil**, and their BME collaborators, will fund the development of a device that leverages the natural memory of living matter to create "swarms" of collective smart biosensors. Using artificial environments built with microfluidics, the team will generate custom biological "memories." Special semiconductor-based electronics capable of measuring biological outputs will store the results, which can be used to report on environmental conditions. Their work will all eventually be open source or otherwise publicly available.

Funding Growth

300%
Increase Over 10 Years

a Diverse Funding Profile

NSF	NIH	DoD	NASA	Other
$12M	$8M	$4M	$2M	$22M

$48M
2021

$17M
2016

$12M
2011

BACHELORS

9%*
increase

472
enrolled

MASTERS

6%*
increase

158
enrolled

PHD

16%*
increase

160
enrolled
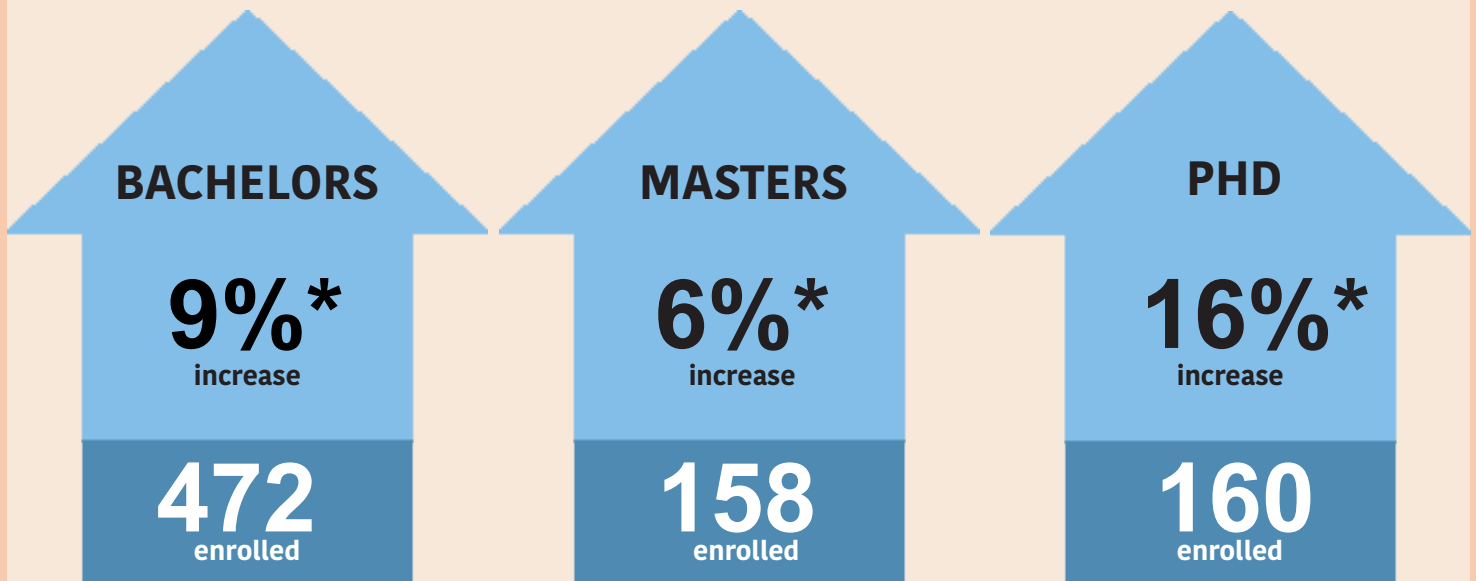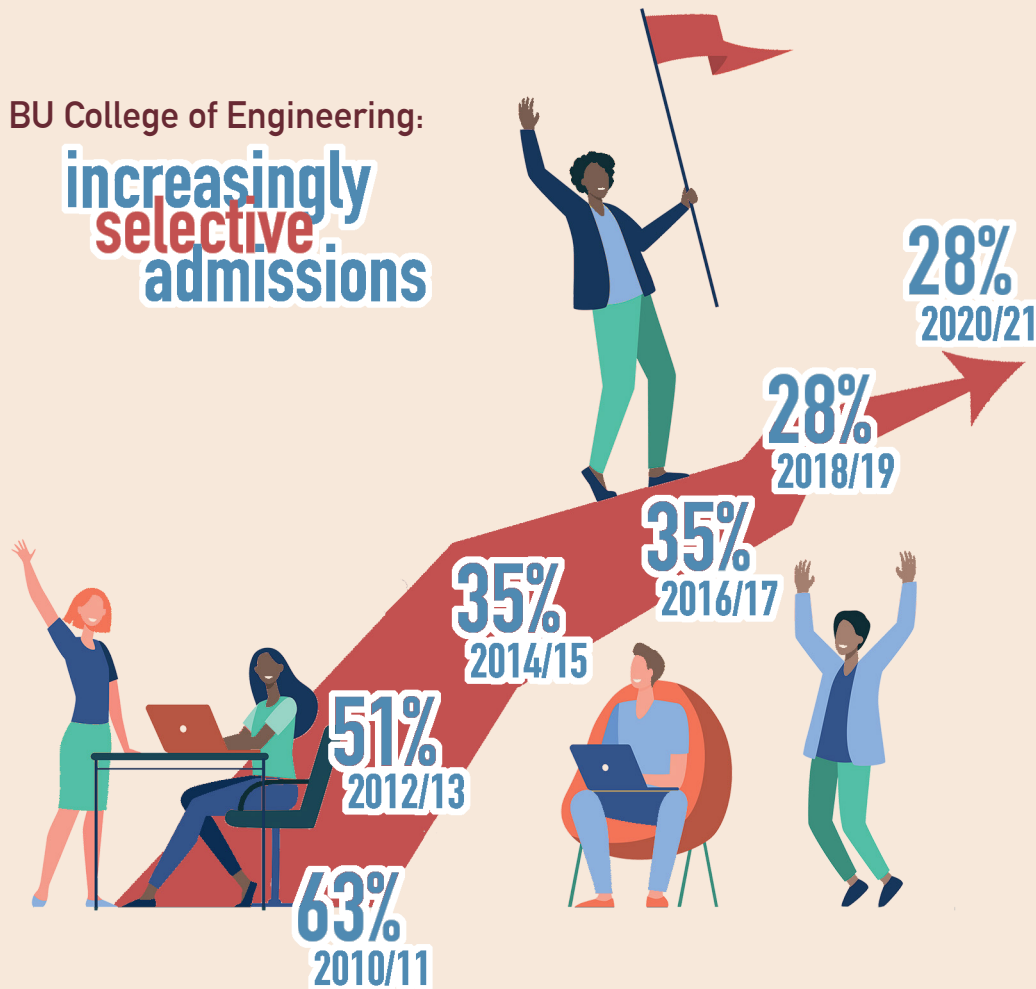
*average annual enrollment growth over 10 years

BU College of Engineering:

increasingly
selective
admissions

28%
2020/21

28%
2018/19

35%
2016/17

35%
2014/15

51%
2012/13

63%
2010/11

Average # of ECE BS degrees awarded to women:

27%

15%

national avg. *

***2019 ASEE report**

BU '21

Start-Up Stars!

The **Forbes 30 Under 30** Class of 2021 featured two enterprising BU alums, whose work with ECE faculty helped to launch them towards their achievements. **Saniya Shah** '16, whose ambition impressed her instructor, Professor **David Castañon**, is the creator of Pilota, an app that calculates risk factors for flight cancellation/delay, thereby allowing passengers to make timely alternative plans. **Eduardo Portet** '18, also a Technology Innovation Concentration (TIC) alum, took lessons learned from his Senior Design sponsor and mentor Professor **Thomas Little** to develop Index, a business-intelligence (BI) dashboard-building app for business managers looking to better utilize data.

Cassandras Advisee Wins Outstanding Student Paper Award

Systems Engineering PhD candidate **Wei Xiao** was awarded one of four **Outstanding Student Paper Awards** given at the **2020 IEEE Conference on Decisions and Control**. Selected from a pool of 64 nominees and over 1300 total conference papers, "Feasibility-Guided Learning for Constrained Optimal Control Problems" outlines methodology that could improve autonomous vehicular navigation around obstacles. According to his co-writer and advisor, Professor **Christos Cassandras**, "this paper addresses a crucial dilemma in modern engineering: how to bridge the gap between control planning and powerful motion learning techniques."

Recent Alum Recognized for Exceptional Research

2020 BU ECE **Outstanding Dissertation Award** winner, **Joshua Rapp**, also took home the prestigious 2020 **IEEE Signal Processing Society's Young Author Best Paper Award** for "A Few Photons Among Many: Unmixing Signal and Noise for Photon-Efficient Active Imaging," co-authored by his former advisor, Professor **Vivek Goyal**. Rapp's paper outlines a novel computational imaging method designed to dramatically improve image quality. His algorithm has proved wildly successful, with a 25x improvement in reducing distortion in 3D images taken in challenging environments with high ambient light. Elements of his work are already finding industry applications.

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Shaping & Improving the Digital Landscape:

Coskun Receives IBM Faculty Award

This award, given in support of Professor **Ayse Coskun**'s continued work on **AI-driven techniques** for shoring up the performance and security of new **cloud-based applications**, is only the latest in the long list of her accomplishments and innovations. Never one to rest on her laurels, Coskun's career has been extremely productive and award-winning from the beginning; the recipient of an **IEEE Ernest Kuh Early Career Award** and an **NSF CAREER Award**, just for starters, the prolific professor has published over 120 scientific papers in top-tier journals and at conferences. Along with her team, she has contributed widely to open-source repositories and to the computing community at large.