

2019-2020



IMPACT REPORT



ELECTRICAL AND COMPUTER ENGINEERING



**BOSTON
UNIVERSITY**

DEPARTMENT HIGHLIGHTS

FACULTY EXCELLENCE

NATIONAL ACADEMY

4

MEMBERS

FELLOWS

44

SOCIETY FELLOWS

GRADUATE PROGRAM

RANK

↑16 SPOTS

2021 USNWR
RANKINGS

ENROLLMENT

↑10%

AVERAGE ANNUAL GROWTH
RATE OVER 10 YEARS

RESEARCH

FUNDING GROWTH

↑233%

GROWTH OVER 10 YEARS

GRANT FUNDING

\$40M

FISCAL YEAR 2020

UNDERGRADUATE PROGRAM

SELECTIVITY

28%

UNDERGRADUATE
SELECTIVITY

ENROLLMENT

↑11%

AVERAGE ANNUAL GROWTH
RATE OVER 10 YEARS

ECE CHAIR, PROFESSOR W. CLEM KARL

While 2020 has shaped up to be anything but “just another year,” the Department of Electrical and Computer Engineering at Boston University certainly isn’t slowing down. The Department is in the midst of an extended period of sustained growth, both deepening our existing areas of strength as well as branching into exciting new areas. Our College is developing an impactful new strategic plan focusing on convergent societal research thrusts. We have separately reached a milestone of \$40M in funding and hired a group of outstanding new faculty members. Our faculty continue to reach new heights of achievement, from 4 new Fellow recognitions to prestigious NSF CAREER awards and board memberships. Our enrollment continues to increase across the board, and our students are busily making their mark on the world, from building small satellites to challenging racist terminology within their own textbooks. As we collectively face the enormous challenge of the COVID-19 pandemic, ECE faculty are taking prominent roles in the fight;

Professor Densmore and his team have developed the efficient new testing facilities that are central to our ongoing return to campus, Professor Krieger is helping to provide medical professionals and community groups with targeted technical assistance, and Professor Trachtenberg has published research considering the possibilities and implications of app-based contact tracking aimed at fighting the virus that has made such an impact on all our lives. Read on for a taste of this past year’s achievements, and of BU ECE’s ingenuity and resilience as we move forward as a vibrant academic and research community.



JUNIOR FACULTY EXCELLENCE



STRINGHINI: PROTECTING THE INTERNET FROM HATE

Cyberbullying has become an ever-increasing problem for internet users, especially on social media. Professor Gianluca Stringhini's NSF CAREER Award-winning project, "Towards Data-Driven Methods to Counter Online Aggression," utilizes signal processing and machine learning techniques to battle these unprecedented levels of online aggression. Stringhini and his team aim to develop techniques and models to pinpoint and mitigate the activities of hateful user accounts, and ultimately to prevent attacks on content identified as high-risk.



EGELE: DE-BUGGING OUR DEVICES

The Internet of Things (IoT) collectively describes day-to-day devices such as cell phones, wireless routers, and self-driving cars; however, for all their ubiquitousness, these devices are typically not manufactured with much concern for security, which can lead to large-scale breaches. Professor Manuel Egele's investigative work, aimed at analyzing device code to locate bugs and vulnerabilities, has earned him the support of an NSF CAREER Award towards his continuing efforts to protect the devices which are central to modern life.



SHARIFZADEH: LEADING MATERIALS RESEARCH INTO THE FUTURE

Professor Sahar Sharifzadeh was appointed to the early career advisory board of *ACS Material Letters* to help strengthen the relationship between the journal and evolving research areas and trends in the materials community. Sharifzadeh's research focuses on understanding atomic-scale physical phenomena and predicting how they will affect the functionality of novel materials based on first-principles theory.



SANDER: A NEW VISION FOR PHOTONICS

Professor Michelle Sander was elected for a three-year term on the Board of Governors for the IEEE Photonics Society; a striking achievement for an early-career scholar. The Society focuses on various optical technologies ranging from quantum physics to fiber optics and solar energy. Sander, whose research focuses on fiber optics, ultrafast lasers and photothermal material interactions for biomedical imaging and infrared nerve modulation, aims to create a new vision for the society and tackle the most critical issues in the field.

FACULTY RECOGNITION



GOYAL DISTINGUISHED BY OSA AND IEEE

Professor Vivek Goyal's innovative work in computational imaging and sensing received recognition from more than one quarter this past year. He was elected Fellow of The Optical Society of America (OSA) "for outstanding inventions" in his field. This inventiveness also won him a 2019 IEEE Signal Processing Society Best Paper award. In "Photon-Efficient Computational 3-D and Reflectivity Imaging With Single-Photon Detectors," Goyal describes models and methodology which can provide up to a 20-fold depth error reduction over state-of-the-art techniques.



ÜNLÜ ELECTED AIMBE FELLOW

Professor Selim Ünlü was elected to the American Institute for Medical and Biological Engineering (AIMBE) College of Fellows for his pioneering work on optical interference in biological imaging and sensing. Ünlü has applied the concept of light interference to enhance the light collecting efficiency of photodetectors and to develop novel biological sensing and imaging techniques, allowing him to quickly identify viruses in blood samples. He hopes to pivot this technique towards crucial COVID-19 research.



GILES RECOGNIZED FOR DEDICATION TO DIVERSITY

Throughout his entire career, Professor Roscoe Giles has been dedicated to expanding multiracial representation and equity in the fields of scientific research and scholarship. Giles is active in several diversity-driven organizations, and was recently elected Fellow of the American Association for Advancement of Science (AAAS) for leading contributions towards the increased participation of underrepresented populations in computing.



RAMACHANDRAN: ANOTHER FELLOW RECOGNITION

Professor Siddharth Ramachandran was elected Fellow of the International Society for Optics and Photonics (SPIE) for his work on structured and singular light beams and their many applications. Ramachandran expressed enthusiasm for SPIE's pioneering support of the link between academic research and industrial applications, and confidence that his own election could serve as confirmation that higher-order fiber mode technologies, to which he has dedicated years of research, have reached a threshold of industrial viability.



CHENG INVENTION CELEBRATED FOR GLOBAL IMPACT

Professor Ji-Xin Cheng was honored with a 2020 Pittsburgh Spectroscopy Award for his unique impact and ground-breaking discoveries in the field. In the 1990s, Cheng developed a patented microscope that is used in labs across the world. Today, Cheng is developing less invasive techniques for diagnosing patients, with the ultimate goal of creating a method to determine the difference between

FACULTY IN NUMBERS



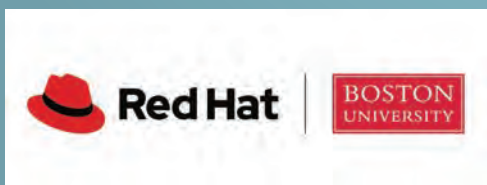
30
FULL
PROFESSORS

12
ASSOCIATE
PROFESSORS

9
ASSISTANT
PROFESSORS

12%
FEMALE
FACULTY

10%
URM
FACULTY



The Red Hat Collaboratory at Boston University provides funding and opportunities for research and community building. Working with open-source developers from Red Hat and partners, ECE faculty integrate innovative ideas into practical software artifacts, impact products, and evaluate their research in a realistic environment. These efforts drive a multiplier effect, attracting research funding from other sources. The Collaboratory has also created a successful mechanism for BU students to gain experience working in industry. In the summer of 2020, 37 BU students interned at Red Hat and dozens of BU alumni have accepted positions with Red Hat after graduating.

CUTTING-EDGE RESEARCH: SECURITY AND PRIVACY



FIGHTING COVID-19 WITH COMPUTING

BU's ECE department has joined the battle against the coronavirus on multiple fronts. Professor Ari Trachtenberg has published articles considering both the potential benefits of voluntary app-based virus tracking, and the likely implications various tracking methods may have for privacy, especially in an employment context. Professor Orran Krieger leads Mass Open Cloud in collaboration with Massachusetts Green High Performance Computing Center on the *Computing Against COVID* website, to connect groups developing and deploying COVID-related applications with expert developers, architects, and operators in the fight to end the pandemic.



BLUETOOTH COMMUNICATION: NOT AS PRIVATE AS YOU THINK

Professor David Starobinski and his team uncovered vulnerabilities in the Bluetooth LE's security protocols, which are supposed to prevent third parties from tracking users and eavesdropping on their conversations. The problem lies with the process of randomizing a device's MAC address, which is not currently synchronized with the automatic refreshing of its unique payload. Starobinski and his team proposed such synchronization, as a potential solution, at the 19th Privacy Enhancing Technologies Symposium in Stockholm.



CRYPTIC PRIVACY– UNCOVERING THREATS TO BITCOIN

Professors Ari Trachtenberg and David Starobinski, with the help of PhD students, won the Best Paper Award at the Second IEEE International Conference on Blockchain and Cryptocurrency (ICBC'20) for their research on Bitcoin's security performance. The lab team discovered potential threats to the Bitcoin network, due to "churn" – when the network connections are intermittent, not continuous.

CUTTING-EDGE RESEARCH: LIGHT AND IMAGING



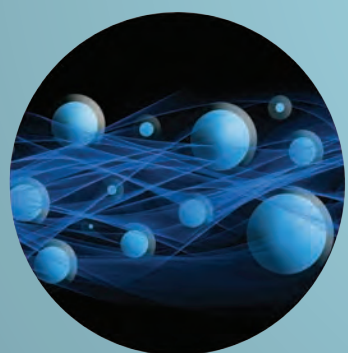
A BUG'S-EYE VIEW

Taking inspiration from the natural world, Professors Roberto Paiella and Lei Tian are tackling a long-standing problem with camera technology: as advanced as our increasingly miniaturized cameras are, their field-of-view and image quality are sacrificed in proportion to size. Using standard materials and fabrication processes, easily reproducible in the commercial sphere, Paiella's and Tian's new camera design mimics the compound eye structure found in insects, but within a flat geometry rather than a rounded one. They accomplish this by using novel metasurfaces, developed specifically for the project, which allow to algorithmically reconstruct a high-quality composite image.



RANDOM LASERS IN A CLASS OF THEIR OWN

Professor Luca Dal Negro and his international team of collaborators are developing a new, highly efficient type of laser that leverages structural correlations in random media to improve performance. By applying fractional calculus to photonics, they were able to rigorously obtain simple closed-form expressions for the critical amplification volumes required to initiate laser action. Their work also establishes the benefits of anomalous sub-diffusive photon transport for the engineering of novel random lasers; reducing footprint and amplification volumes. They anticipate innovative applications of the new device to miniaturized smart lighting systems, on-chip spectroscopy, and optical sensing.



MOLECULAR FOCUS, GLOBAL IMPACT

The accurate analysis of symptoms at a molecular level is of prime importance to effective medical treatment. Phase-contrast microscopy, while a superior method of cellular analysis in many respects, does not currently allow precise identification of affected molecules. Professor Ji-Xin Cheng and his research partners have developed a new technique, utilizing infrared light to incite molecular vibration, which can create a contrast precise enough to allow for diagnosis at a molecular level. Once perfected, this "bond-selective transient phase imaging" could have a large impact on the research and treatment of diseases such as Alzheimer's.



A FASTER WAY FORWARD FOR FIBER OPTICS

Fiber optics technology has already revolutionized communication far beyond what was possible with electrical wire. Professor Siddharth Ramachandran and his team, however, have discovered a new method that can speed up data transmission even more. In a publication for Nature Communications, Ramachandran explained that not only can their new fiber transmit 24 times the amount of data per second than any pre-existing form of optical fiber, but also that this design can scale much further. This is great news, given the exponentially growing demands of high-performance data centers, supercomputers and telecommunications networks.

FUNDING THE FUTURE



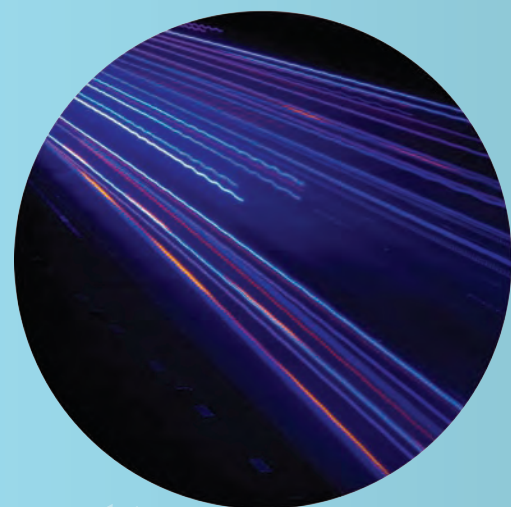
NSF FUNDS NEW TESTBED TO “DEMOCRATIZE” CLOUD COMPUTING

ECE Professors Orran Krieger and Martin Herbordt lead the BU contingent of a multi-institutional research team focused on developing a new cloud-based testbed for collecting and processing large amounts of data; one which will be more broadly accessible to diverse communities than ever before, and will enable increased collaboration between research and open-source communities. The project was awarded a grant of up to **\$5M by the National Science Foundation**; with BU's portion expected to total \$2M over 5 years.



RESEARCHERS WIN NSF GRANT TO IMPROVE REPRODUCTIVE HEALTH

A joint BU-Harvard multidisciplinary project, led by a team of PIs including ECE Professors Yannis Paschalidis and Alex Olshevsky, is working to leverage machine learning and artificial intelligence to improve reproductive/fertility options on a personalized basis. Backed by a **\$1.2 M, four-year grant funded by the NSF through its Smart and Connected Health (SCH) program**, researchers will develop a new, integrative approach to produce highly accurate personalized predictions and recommendations, while prioritizing user privacy and incorporating research into socioeconomic disparities in the use of infertility-treatment services.

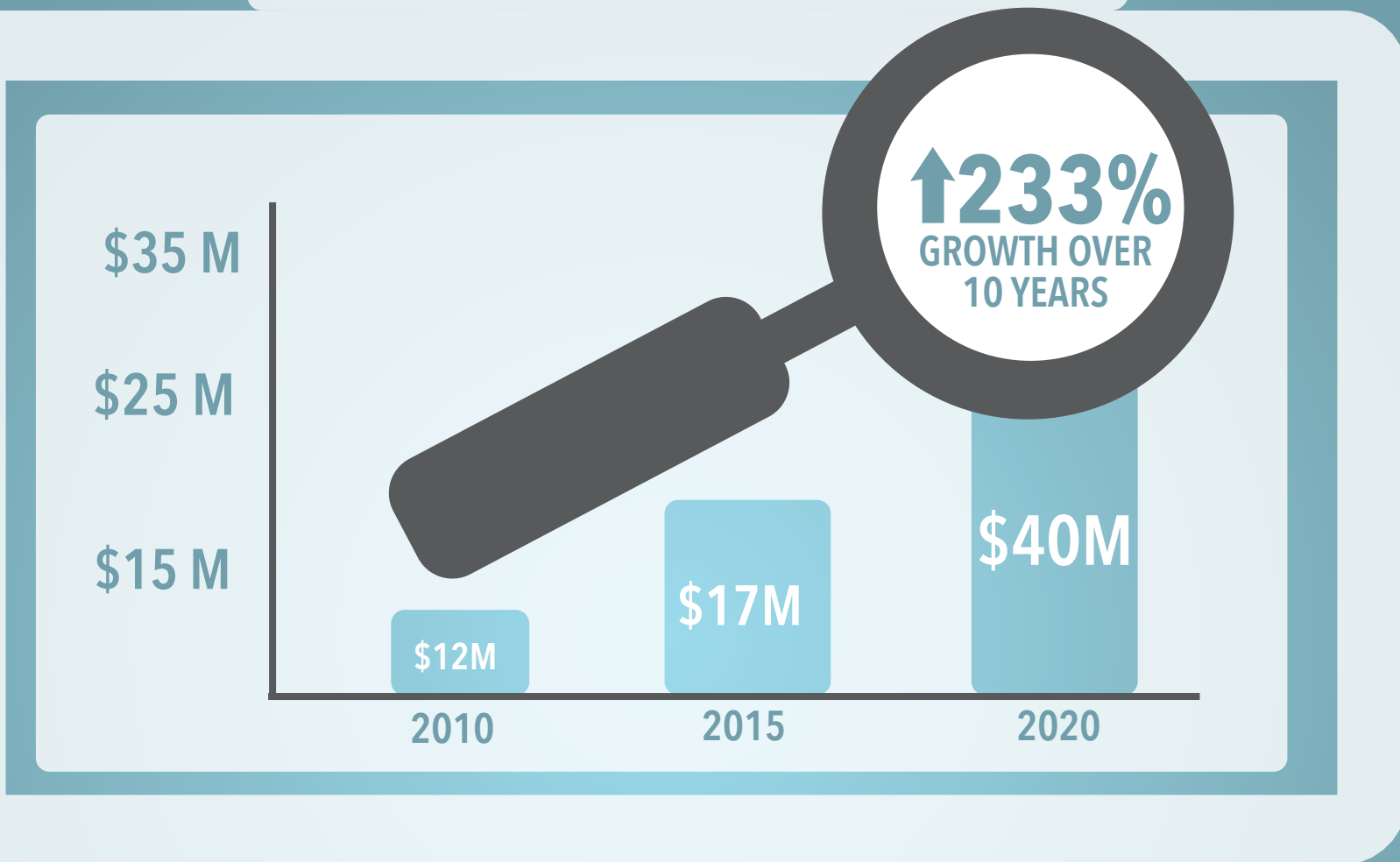


MURI SUPPORT FOR SPIN-ORBIT INVESTIGATION

Professor Siddarth Ramachandran, in collaboration with co-PIs at Harvard and Stanford, has been awarded a **\$3M Multi University Research Initiative (MURI) grant from the Office of Naval Research** in support of their investigations into the science and application of singular light beams in the presence of spin-orbit interactions. The project will focus on three interrelated topics: pairing topologically complex light with acoustic and optical photons, studying topologically complex metasurfaces and artificial structures, and researching topological invariants that will inform the design of spin-orbit coupled optical fibers and metasurfaces.

FUNDING GROWTH

RESEARCH FUNDING



DIVERSE FUNDING PROFILE

| | | | | | |
|--------------|-------------|--------------|-------------|-------------|-------------|
| \$14M | \$7M | \$12M | \$3M | \$1M | \$3M |
| NSF | NIH | DoD | NASA | DoE | OTHER |

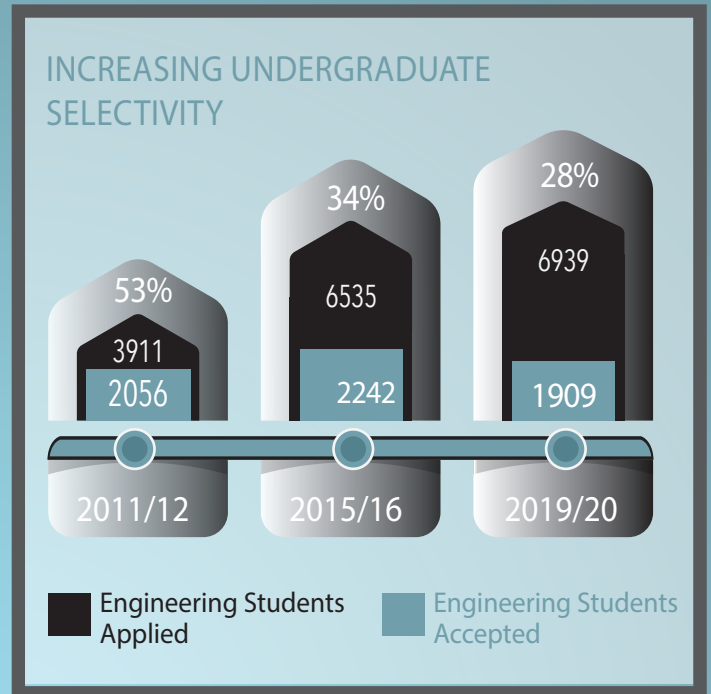
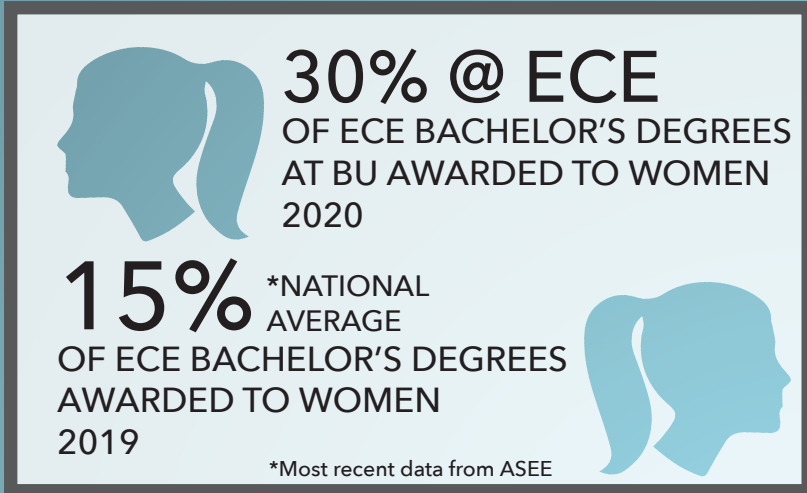
NOTABLE RESEARCH FUNDING IN THE LAST 3 YEARS:

\$7.5M MURI grant to develop neuro-inspired autonomous robots (Department of Defense)

\$20M Engineering Research Center in Cellular Metamaterials (National Science Foundation)

\$2M Center for Semiconductor Materials and Devices Modeling (Army Research Laboratory)

ACADEMIC EXCELLENCE



TOTAL STUDENTS ENROLLED



ENROLLMENT GROWTH



Average annual enrollment growth over 10 years

STUDENT ACHIEVEMENTS



ECE JUNIOR WINS HACKHARVARD WITH SOCIALLY-CONSCIOUS APP

ECE student Austin Negrón collaborated with peers from BU and Northeastern to develop an app that could assist non-native English speakers, like Negrón's grandmother, with filling out important English-language forms. Phillinda.space, which translates such forms into the user's native language, and then retranslates the completed forms back into English, took home the top prize at the 2019 HackHarvard Hackathon. Negrón and his partners are continuing to develop the app as part of their start-up, Toku, which is focused on leveraging technology for the general social good.



STUDENT SATELLITE BLASTS OFF!

After three years of work, the Boston University SATellite program (BUSAT) launched a network of mini-sensors, ANDESITE, into space on a private rocket from New Zealand's Mahia Peninsula. The sensors, which can completely orbit Earth in 90 minutes, are collecting data on the different currents in the magnetic field surrounding Earth that can stifle communication and power on the ground. Recent ECE graduate Phillip Teng, who worked on the satellites extensively in collaboration with a team co-led by ECE Professor Josh Semeter, commented: "to say that I felt ecstatic and proud...would be an understatement."



CRA RECOGNITION FOR SOLUTIONS TO ISSUES OF THE MODERN WORLD

The Computing Research Association (CRA) recognized ECE students Sadie Allen and John Mikulskis for their work on monitoring and security in the age of IoT and cloud computing. Allen's work with BU's Performance and Energy Aware Computing Lab (PEACLab) contributed to the development of Praxi, an efficient monitoring system which uses a machine learning algorithm to identify recurring patterns in software installations and alert cloud administrators to any vulnerabilities. Mikulskis, alongside ECE PhD student Johannes Becker, developed a software-defined, radio-based networking tool for IoT networks called Snout, which will detect vulnerabilities in devices ranging from headphones to pacemakers.

LEADING ANTI-RACISM IN ENGINEERING

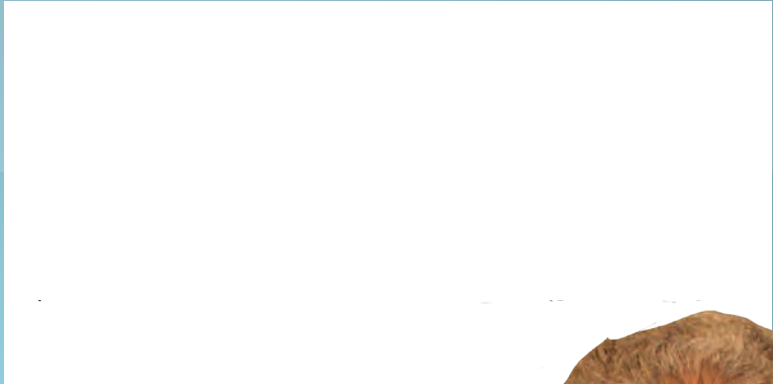


The use of "slave" and "master" terminology to describe the relationship between computing devices has been an accepted practice in engineering for decades. However, when computer engineering graduate student Santiago Gomez came across this metaphor in his textbook, he found it unsettling and outdated. With the support and assistance of ECE Professor Roscoe Giles, Gomez contacted lead academic publisher Pearson, and successfully urged them to make long overdue changes. In response, Pearson pledged that they would pull the textbook in question, update the language in not only that volume, but in their general catalog, and conduct a broad review of policy regarding racially-charged metaphorical language in general.

8 Saint Mary's Street
Boston, Massachusetts 02215
Tel: (617) 353-2811
Fax: (617) 353-7337
Web: ece.bu.edu



@BU_ece BUece ECE Communications



IRVING BIGIO WINS JOSEPH W. GOODMAN BOOK WRITING AWARD

Professor Irving Bigio received the prestigious Joseph W. Goodman Book Writing Award for "Quantitative Biomedical Optics: Theory, Methods, and Applications" (Cambridge University Press, 2016). The Optical Society of America (OSA) and the International Society for Optics and Photonics (SPIE) jointly present this award to the authors whose books are influential in the teaching, business, industry, or research of optics and photonics. Bigio's textbook can be used as a core teaching tool, and as a reference guide for various topics in biomedical optics.

