

SYSTEMS ENGINEERING

RESEARCH, ACADEMICS, COMMUNITY

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AT A GLANCE

SECTION 1



LETTER FROM THE HEAD

The 2019-2020 Division of Systems Engineering Annual Report summarizes information on new research projects, PhD dissertations completed, and the scholarly output, distinctions and honors received by our faculty and graduate students.

The Division now includes 18 appointed faculty members with home departments in Electrical and Computer Engineering and in Mechanical Engineering, along with 15 affiliated faculty members from the College of Engineering, the College of Arts and Sciences, the Questrom School of Business, and the Medical School. Our PhD student enrollment has grown to 45 students, along with 24 students in the MS and MEng programs.

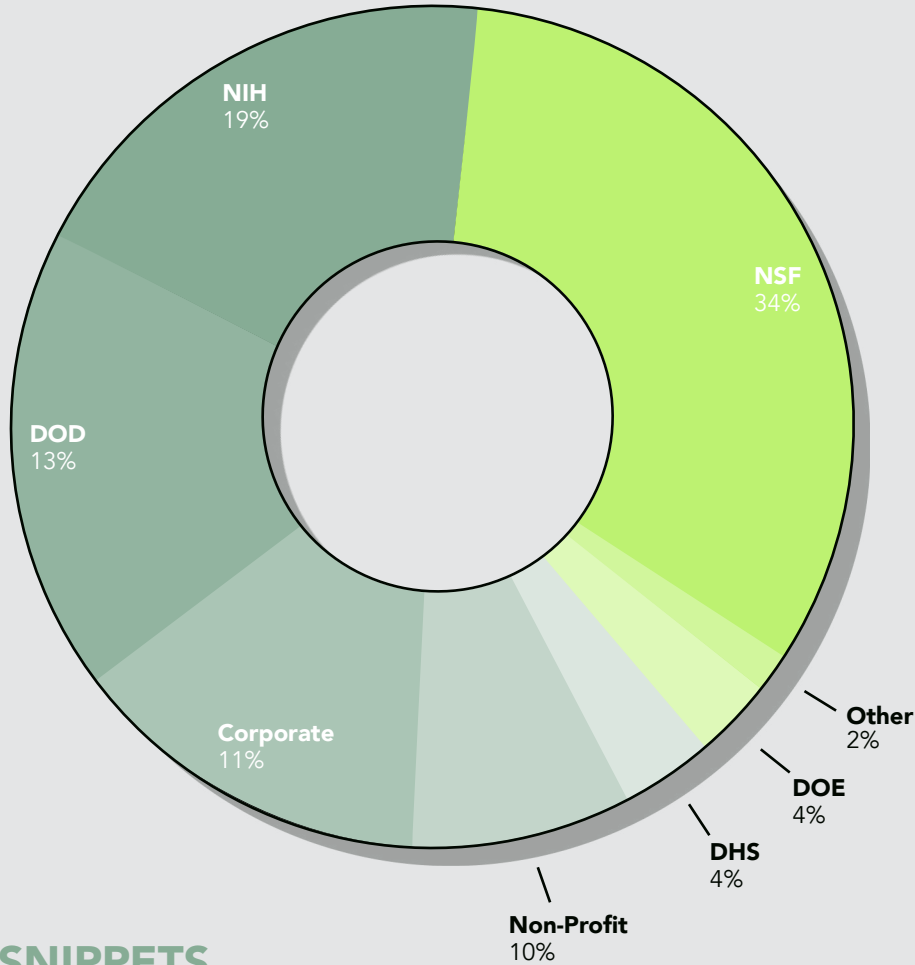
There were 10 PhD degrees awarded last year, along with 14 MS degrees and 4 MEng degrees. The Division continues to provide full financial support to all admitted PhD students through fellowships, while our continuing PhD students remain funded from research grants received by participating and affiliated faculty. This year, our total sponsor commitment for active grants reached approximately \$67M, including a number of new grants, some of which are highlighted in the report. We are also proud to list a number of honors and awards received by our faculty, as well as accomplishments by our students.

The Division remains committed to world-class interdisciplinary research activities in our primary concentration areas: Automation, Robotics and Control, Communications and Networking, Computational Biology, Information Sciences, and Production, Service and Energy Systems. In partnership with the Center for Information and Systems Engineering (CISE), we continue to look for exciting collaborative projects that involve faculty from different colleges and departments at BU. We are also expanding summer internship opportunities for our students with companies and research laboratories across the US. I would like to close by gratefully acknowledging the contributions of all Division faculty and students who, along with our outstanding staff, continue to pursue the Division’s research and educational mission.

Christos Cassandras
Distinguished Professor of Engineering
Division Head

FUNDING

ANNUAL TOTALS
\$67 MILLION IN ACTIVE FUNDS
\$52.5M Continuing Grants
\$14.6M New Grants



FUNDING AGENCY SNIPPETS

NATIONAL SCI. FOUNDATION
\$23.4M in total funding

\$2M to fight cyber attacks: David Starobinski is backed by five grants aimed at identifying and combating cybersecurity threats.

Update: Google and Apple addressed Starobinski's team discovery while developing a COVID-19 contact tracing tool (P7).

NATIONAL INST. OF HEALTH
\$12.9M in total funding

\$561K for protein docking: (New Grant) Pirooz Vakili (PI), Ioannis Paschalidis and Sandor Vajda are developing optimization methods for protein structure prediction.

Update: Backed by four grants totaling \$4M, their work was recently published in Science and the Journal of Medicinal Chemistry.

DEPT. OF DEFENSE
\$8.9M in total funding

\$300K for artificial intelligence: (New Grant) Wenchao Li aims to detect and defend against Trojans hidden in AI models.

Update: Li received press coverage in Wired for work that appeared in the 2020 Design Automation Conference.

CORPORATE
\$7.5M in total funding

\$5M for the cloud: Azer Bestavros and Orran Krieger (PI) are developing the Massachusetts Open Cloud (MOC) for free public use.

Update: MOC offers Cloud services to groups fighting COVID-19 including hospitals.

NON-PROFIT
\$6.9M in total funding

\$82K for research training: (New Grant) Rebecca Khurshid received the Clare Boothe Luce Award (CBL) to provide funding to a woman graduate student on her team.

Update: An earlier CBL awardee, Rebecca Swaszek, graduates this year as a smart-transportation expert.

DEPT. OF HOMELAND SEC.
\$2.6M in total funding

\$2.6M for first responders: David Castañón (PI), Clem Karl and Venkatesh Saligrama are improving emergency response to explosives.

Update: Saligrama extended this work into a new project and earned a patent (P5).

DEPT. OF ENERGY
\$2.6M in total funding

\$7K for energy inefficiency: Michael Gevelber is developing a system to determine internal and external building air leaks.

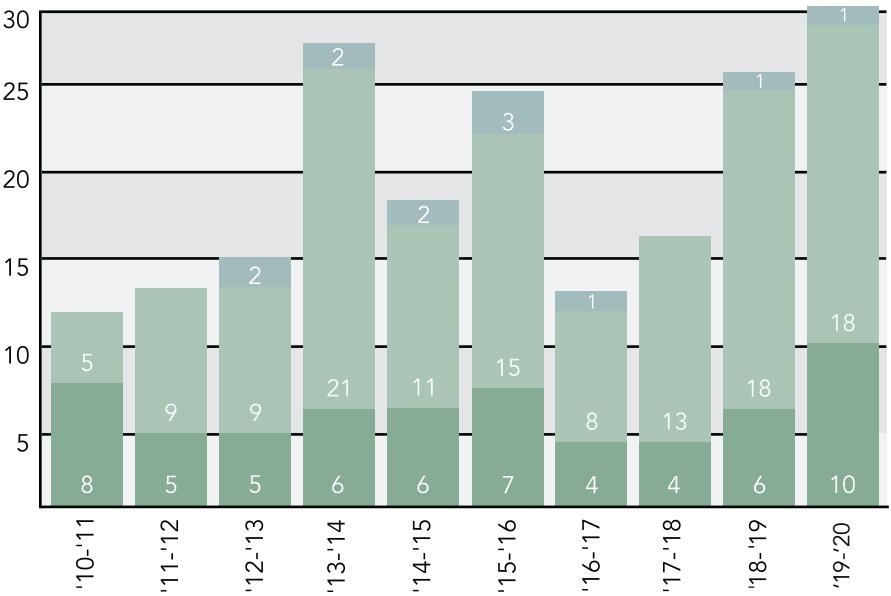
Update: Gevelber earned a patent for work related to energy and sensing this year (P5).

GIFTS FROM INDUSTRY

\$200K for road traffic: Christos Cassandra is improving traffic mobility in highways with Safe Swarms of smart vehicles.

Update: The team recently published work in Automatica and presented an optimal control framework solution for traffic intersections (P15).

DEGREES AWARDED

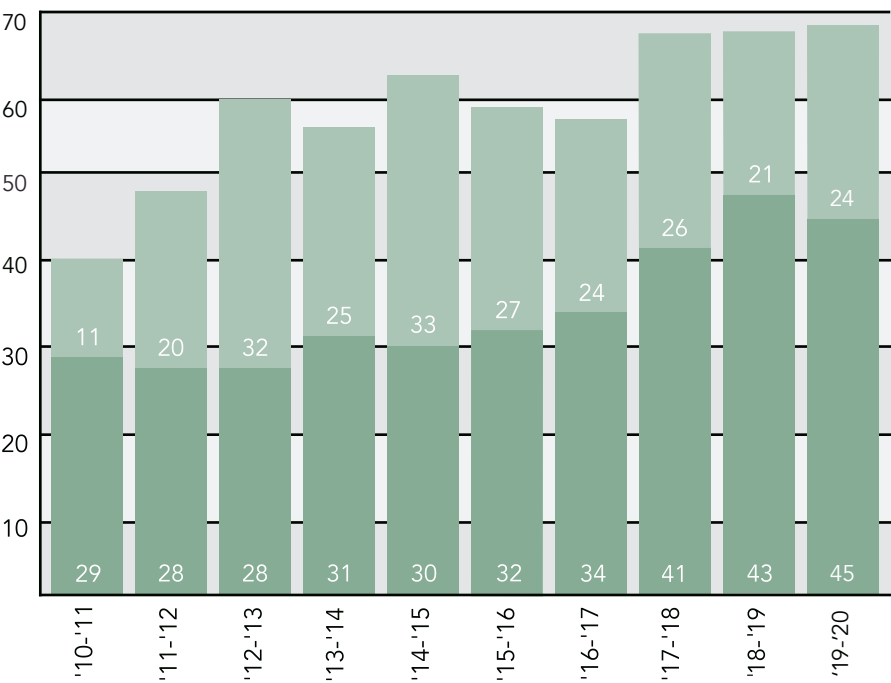


2019-2020 TOTALS
10 PhD Degrees
14 MS Degrees
4 MEng Degrees
0 MS Degrees with Practice
1 Undergrad Minor

TOTAL HISTORICALLY
91 PhD Degrees
78 MS Degrees
50 MEng Degrees
4 MS with Practice Degrees
11 Undergrad Minors

- PhD
- Masters
- UG Minor

ENROLLMENT



2019-2020 TOTAL ENROLLMENT
45 PhD Students
14 MS Students
10 MEng Students

- PhD
- Masters

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PROMOTIONS

Sean Andersson was promoted to Professor of Mechanical Engineering and Systems Engineering
Alex Olshevsky was promoted to Associate Professor of Electrical and Computer Engineering and Systems Engineering.

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APPOINTMENTS

Azer Bestavros, Boston University, Associate Provost for Computing & Data Sciences
Eric Kolaczyk, Hariri Institute, Director
Erol Peköz, Department of Operations and Technology Management, Chairperson

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UNIVERSITY AWARDS

Brian Kulis, Hariri Institute, Research Incubation Award
Bobak Nazer, College of Engineering, Distinguished Faculty Fellow
Ioannis Paschalidis, College of Engineering, Charles DeLisi Award and Lecturer
David Starobinski, Hariri Institute, Research Incubation Award; Department of Electrical and Computer Engineering, Faculty Teaching Award

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PATENTS

Prakash Ishwar, *Method and Systems using privacy-preserving analytics for aggregate data*, BU alumnus Dr. Ye Wang is among the co-authors
Thomas Little, 2 Patents: *System and method for embedding phase and amplitude into a real-valued unipolar signal* and *Ray-surface positioning systems and methods*
Venkatesh Saligrama, *Large scale video search using queries that define relationships between objects*

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PLENARY TALKS

Thomas Little, “The Changing Requirements of Indoor Short-Range Wireless Communications Motivated by 6G” at Silicon Labs
Azer Bestavros, ACM/IEEE CCGrid Symposium
Christos Cassandras, 2 Plenary talks: 1) 2019 IEEE Systems, Man, and Cybernetics Conference and 2) Kwan Chao-Chih Distinguished Lecturer at the Chinese Academy of Sciences
Calin Belta, MIT LIDS Student Conference

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SOCIETAL AWARDS

Eric Kolaczyk, ASA, Mosteller Statistician of the Year; NESS, Appointed President-Elect
Thomas Little, IEEE TAOS, Best Paper, BU PhD candidate Iman Abdalla is first author
Venkatesh Saligrama, IEEE SPS BigData SIG, Elected Chairperson
David Starobinski and **Ari Trachtenberg**, IEEE ICBC, Best Paper, BU PhD candidate Anas Imtiaz is first author

PLUS FACULTY RECENTLY PUBLISHED 192 JOURNAL PAPERS & 1 BOOK CHAPTER

RESEARCH
SECTION 2

RESEARCH AREAS

AUTOMATION, ROBOTICS AND CONTROL

Cyber-physical systems, teams of autonomous agents, networked control systems, image-guided surgery, control of material processes and nanoscale systems.

COMMUNICATIONS AND NETWORKING

Performance analysis, pricing and resource allocation, communication protocols, cybersecurity, visible light communication, and optical, wireless and sensor networks.

COMPUTATIONAL BIOLOGY

Metabolic and gene networks, systems biology and protein docking.

INFORMATION SCIENCES

Signal and image processing, multi-resolution signal modeling, multidimensional detection and estimation, geometric-based modeling and estimation, image encoding/decoding and the integration of digital signal processing with signal understanding.

PRODUCTION, SERVICE AND ENERGY SYSTEMS

Energy economics and management, smart grids, production scheduling and planning, logistics, inventory control, supply chain management and financial engineering.

TRACKING LOCATION WITH BLUETOOTH

David Starobinski proved that select Bluetooth devices allow third parties to hack the device and obtain sensitive information, such as your whereabouts and activities. Starobinski’s team revealed that cyber information becomes vulnerable to attack when different Bluetooth devices establish a connection.

According to Starobinski, the very same features that allow a device to “authenticate,” or correctly identify, its user—e.g., saved paired device information or a fingerprint pass code—can be co-opted by a third party to track the person instead.

Before a pair of Bluetooth devices can begin transmitting information, it must first establish which device will play a central role in the connection and which device will play a peripheral role. Once the pair’s hierarchy is established, the central device begins scanning for signals sent by the

peripheral device that indicate it is available for connection. These signals contain a unique address—similar to the IP address of a computer—and a payload containing data about the connection.

Most devices produce randomized addresses that automatically reconfigure periodically, instead of maintaining one permanent address in an attempt to improve privacy. It’s designed to throw nefarious observers off the scent of a given device’s location, but Starobinski’s team discovered an oversight in this process that allows a device to be tracked even as its address changes.

Since the payload information updates at a different rate than the address information, the communication blips between Bluetooth devices paint an identifiable pattern. Having discovered this vulnerability, the

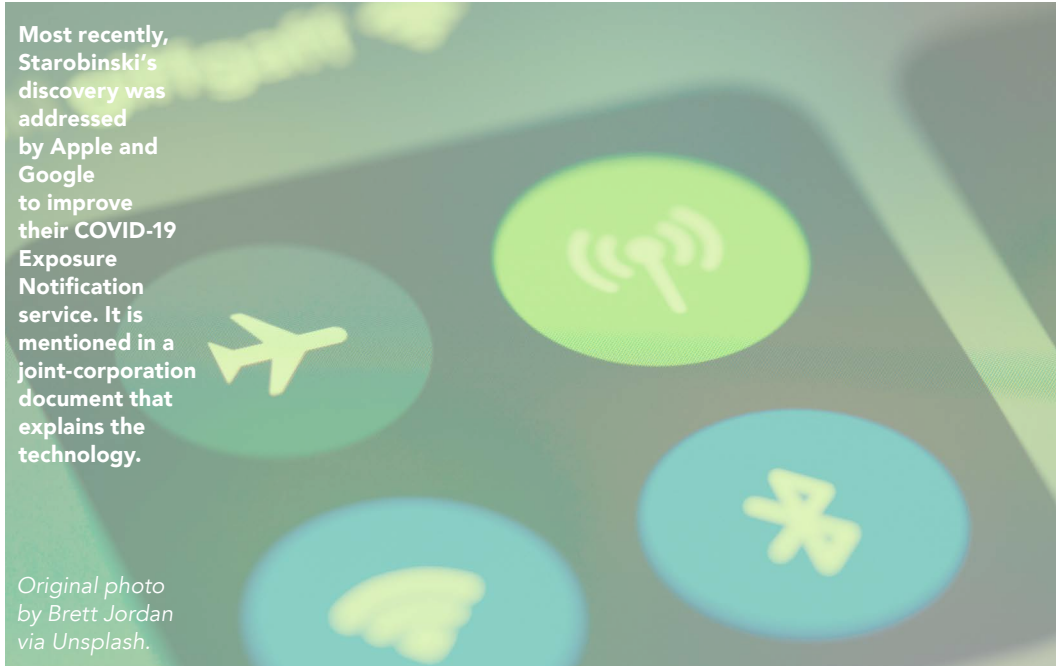
researchers tested out how well it could be used by a third party to track individual devices.

The researchers are not too worried about the security of Bluetooth devices—yet.

“There are tons of ways to track people, with or without Bluetooth,” says graduate researcher Johannes Becker.

“It’s always good to be aware of the kind of signals you’re sending out, especially in the age of IoT. I’m much more skeptical toward these devices that don’t give you control [of Bluetooth], such as smartwatches, where you can just assume they are broadcasting something all the time.”

This piece is based on an article written by Sarah Wells (COM ’18) for BU Today.



Most recently, Starobinski’s discovery was addressed by Apple and Google to improve their COVID-19 Exposure Notification service. It is mentioned in a joint-corporation document that explains the technology.

Original photo by Brett Jordan via Unsplash.



FERTILITY SERVICES

A BU-Harvard research team, led by Professors **Ioannis Paschalidis** and **Alex Olshevsky** led a project aimed at improving women’s reproductive health using AI and machine learning.

The demands of modern life, education and career choices, as well as the availability of assisted reproductive technologies, are leading many individuals and couples to delay childbearing. This has contributed to infertility and sub-fertility emerging as significant public health problems in the US, affecting about 15% of couples, and resulting in more than \$5 billion spent annually in infertility services. Such costs are often not covered by health insurance and, consequently, generate access disparities.

The BU-led project will leverage machine learning and artificial

intelligence to develop an integrative approach to enable personalized reproductive/fertility predictions and individualized prescriptions to help address fertility problems. The researchers will also focus on improving the understanding of socioeconomic disparities in the use of infertility treatment services.

“The overall goal is to enable people to optimize health before conception, identify modifiable determinants of fertility, and reduce health risks during pregnancy and beyond,” says Professor **Ioannis Paschalidis (PI)**.

“Collaboration for improving discovery and improving care for women across the life course is critically important,” says collaborator Dr. Shruthi Mahalingaiah (Harvard University).

“Merged datasets including self reporting, lifestyle, and exposures, clinical-grade data, and data collected from wearable devices will provide personalized insights so that women can be empowered to understand information on the health of their bodies and make the best choices for their health and futures.”

The research team will develop

fertility/family planning models, including predicting pregnancy, the success of an IVF cycle, the presence of specific reproductive health issues affecting fertility, and making related health care recommendations.

Predictive models will identify the most important factors associated with reduced fertility or Assisted Reproductive Technologies (ART) success rates, which could pinpoint specific lifestyle habits, environmental factors, and other key drivers of reduced positive outcomes that can inform health policy recommendations.

A key focus will be on ovulation disorders, including Polycystic Ovary Syndrome, which are the leading cause of female infertility and are associated with an increased risk of chronic diseases, such as diabetes and cardiovascular disease.

This work is backed by a \$1.2 million NSF grant.

By Maureen Stanton for the Center for Information and Systems Engineering.

Original photo by Priscilla Du Preez via Unsplash.

DRONE AUTOPILOT

Inside **Ioannis Paschalidis'** lab, moths are playing a "video game" where they travel through a virtual forest displayed on a projector screen.

The team is working to develop a self-navigating vehicle that behaves like an omniscient living animal. By studying how moths' naturally approach navigation, the team can build a bio-inspired synthetic navigation system. Fellow SE professors **John Baillieul** and **Roberto Tron** are among the team of researchers.

"Humans and animals are ideal navigators," says Paschalidis, senior author on a new study published in *PLOS Computational Biology*.

Moths primarily rely on a system called "optical flow" to navigate while flying; and while this technique is effective, it is not failsafe. Moths frequently crash and die while flying. To explore this dilemma, the team developed a test to compare two navigation approaches - optical flow vs. enhanced optical flow. The enhancement is essentially the addition of a second-tier

navigation method that maps the specific location of obstacles.

Back in the lab, the team coded a computer simulation with an obstacle course that looked like a forest, through which the drones would trek. The first done mimicked the moth's optical flow strategy, while the second drone utilized an upgraded system with optical flow and obstacle detection support.

The second drone navigated more effectively than the first, but with a big catch: the enhanced program had to be readjusted to perform optimally in each new forest simulation.

In contrast, the first drone was more adaptable to new environments. While it didn't select the absolute best path through the different forest environments, its strategy could perform better across a wide range of scenarios without needing to be adjusted by human input.

Key to this study is the methodology. It is the first experiment to establish a

framework for how scientists can observe animals and collect actionable data.

"Together with behavioral observations, we can understand what is happening in the brain," says Paschalidis. "[And ultimately, create] more autonomous, more adaptable robot systems."

This project is funded in part by a \$7.5 million Department of Defense Multidisciplinary University Research Initiative (MURI) grant.

This piece is based on an article written by Kerry Benson, The Brink

The original moth photo by Paul Biñas' via Unsplash; original drone photo by Jason Blackeye via Unsplash.



CHANGING THE ENERGY LANDSCAPE

To create a tool that measures the risk associated with energy markets, academic and industry researchers are joining forces. Lead by a BU Professor of Systems Engineering, the team is creating a tool is called New Risk Assessment and Management Paradigm or NewRAMP. It is expected to overhaul electricity markets by efficiently addressing uncertainty in the forthcoming massive renewable generation and electrification of fossil fuel reliant energy uses.

"The NewRAMP project will develop innovative approaches that quantify the risk of individual Electric-Power-Grid-interconnected assets based on

their performance and ability to deliver market cleared capacity and energy," explains project lead **Michael Caramanis**.

"By synthesizing ideas and theories from finance and insurance, operations research, power system engineering and electricity market design, NewRAMP will offer groundbreaking methodologies constituting a risk-driven paradigm to achieve higher adoption of stochastic resources and a more efficient and reliable system operation. As such, it will contribute to reducing imported energy, reducing energy-related emissions and improving energy efficiency."

Caramanis is joined by fellow Boston University Systems Engineering Professors **Christos Cassandras** and **Ioannis Paschalidis**. **Panagiotis Andrianesis** joined the team as an SE post-doc and was appointed Research Associate Professor of Systems Engineering in late Summer 2020.

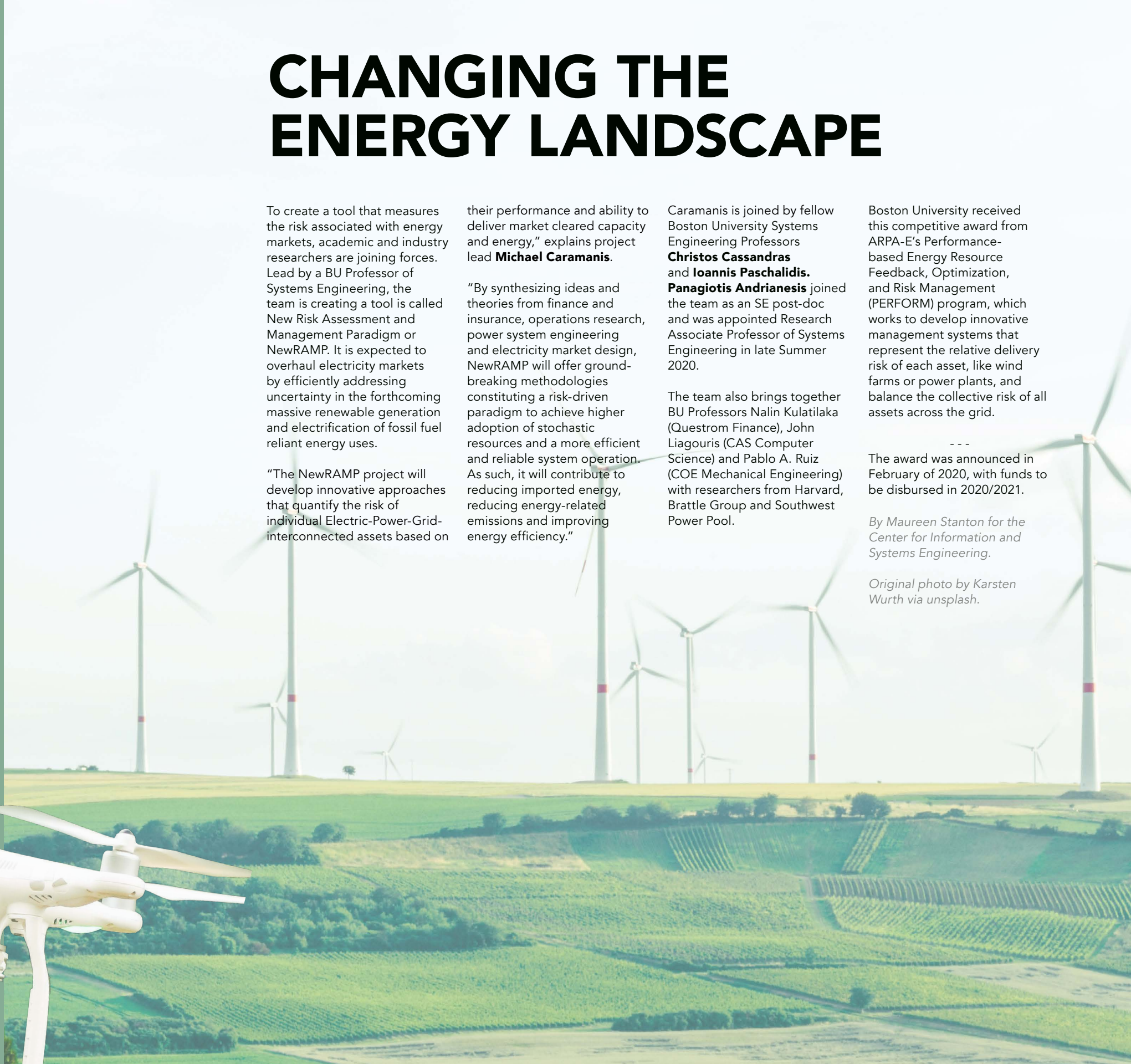
The team also brings together BU Professors Nalin Kulatilaka (Questrom Finance), John Liagouris (CAS Computer Science) and Pablo A. Ruiz (COE Mechanical Engineering) with researchers from Harvard, Brattle Group and Southwest Power Pool.

Boston University received this competitive award from ARPA-E's Performance-based Energy Resource Feedback, Optimization, and Risk Management (PERFORM) program, which works to develop innovative management systems that represent the relative delivery risk of each asset, like wind farms or power plants, and balance the collective risk of all assets across the grid.

The award was announced in February of 2020, with funds to be disbursed in 2020/2021.

By Maureen Stanton for the Center for Information and Systems Engineering.

Original photo by Karsten Wurth via unsplash.



LABORATORIES

ANDERSSON LABORATORY
Sean Andersson

bu.edu/anderssonlab
The lab explores the dynamics in nanometer-scale systems with fundamental theory, applied mathematics, and physical experiments. The work applies to nanobioscience, nanotechnology, and robotics.

ADVANCED PROCESS
CONTROL LABORATORY
Michael Gevelber

bu.edu/pcl
The lab applies a controls-based approach to integrate process modeling, sensor development, system and control design and experimentation.

CONTROL OF DISCRETE
EVENT SYSTEMS
LABORATORY (CODES)
Christos Cassandras

christosgscassandras.org/codes
The lab conducts research on modeling, design, analysis, performance evaluation, control and optimization of a variety of discrete events and hybrid systems.

DATA SCIENCE & MACHINE
LEARNING LABORATORY
Venkatesh Saligrama

sites.bu.edu/data/
Projects related to vision and learning, decision and control machine learning and structured signal processing.

DEPENDABLE COMPUTING
LABORATORY
Wenchao Li

sites.bu.edu/depend/
The research spans dependable computing, particularly the development of computational proof methods and machine learning techniques to aid the construction of safe, reliable and secure systems.

HYBRID AND NETWORKED
SYSTEMS LABORATORY
Calin Belta

sites.bu.edu/hyness
The lab is focused on integrating algorithms and machine learning to make robots smarter and more autonomous.

INFORMATION & DATA
SCIENCES LABORATORY
C. Cassandras, D. Castañón,
W. Karl, B. Kulis, W. Li,
T. Little, P. Ishwar, B. Nazer,
A. Olshevsky, I. Paschalidis,
V. Saligrama, D. Starobinski,
A. Trachtenberg

bu.edu/iss
The lab designs and synthesizes secure networked systems for optimum decision-making and control.

INTELLIGENT
MECHATRONICS
LABORATORY
J. Baillieul, S. Andersson,
H. Wang

bu.edu/iml
Projects explore limited-bandwidth control problems, cooperative systems and control, symbolic control and animal-inspired agile flight control.

LABORATORY OF
NETWORKING &
INFORMATION SYSTEMS
D. Starobinski,
A.Trachtenberg

nislab.bu.edu
The lab offers a perspective on modern networking with emphasis on scalability, heterogeneity and performance.

MULTI-DIMENSIONAL
SIGNAL PROCESSING
LABORATORY
W. Clem Karl

mdsp.bu.edu
The lab applies computational imaging to develop statistical models to extract information from diverse and vulnerable data sources.

MULTIMEDIA
COMMUNICATIONS
LABORATORY
Thomas Little

hulk.bu.edu
Projects focus on ubiquitous distributed computing, specifically in the area of distributed multimedia information systems emphasizing time-dependent and continuous media data.

NETWORKS RESEARCH
GROUP
A. Bestavros, M. Crovella,
A. Matta

bu.edu/cs/nrg/
Research encompasses network measurement, architectures and protocols. Projects span from the design and implementation to the analysis of networked applications and systems.

OPTIMIZATION AND
MACHINE LEARNING
LABORATORY
Francesco Orabona

sites.google.com/view/optimal-lab/
The lab explores the research topic at the intersection between machine learning and optimization, with emphasis on adaptive and parameter-free methods.

NETWORK OPTIMIZATION &
CONTROL LABORATORY
Ioannis Paschalidis

sites.bu.edu/paschalidis/
Research deals with fundamental problems in the fields of optimization, control, stochastic systems and data science.

RELIABLE COMPUTING
LABORATORY
Lev Levitin

bu.edu/reliable
Projects span from the design of computer chips to efficiency testing in hardware, software, signal processing and networks.

ROBOTICS LABORATORY
C. Belta & S. Andersson,
J. Baillieul, C. Cassandras,
R. Tron

sites.bu.edu/robotics
Research spans several areas of robotics, including motion planning, control, machine learning and computer vision.

SPIRA-LENBURG
LABORATORY
Avrum Spira

bumc.bu.edu/compbiomed/labs/spira-lenburg
The lab utilizes post-genomic technologies and computational tools to improve the diagnosis, treatment and prevention of lung disease.

VAJDA LABORATORY
Sandor Vajda

vajdalab.org
The lab focuses on the recognition of proteins and small molecules by protein receptors. The work applies to metabolic control, signal transduction, gene regulation, rational drug and vaccine design.

VISUAL INFORMATION
PROCESSING LABORATORY
J. Konrad, P. Ishwar

vip.bu.edu/
Projects relate to technology transfer in the broad areas of image, video and multimedia processing. This visual information processing research applies to visual surveillance, 3D video and human-computer interfaces.

ACADEMICS
SECTION 3

THE MISSION

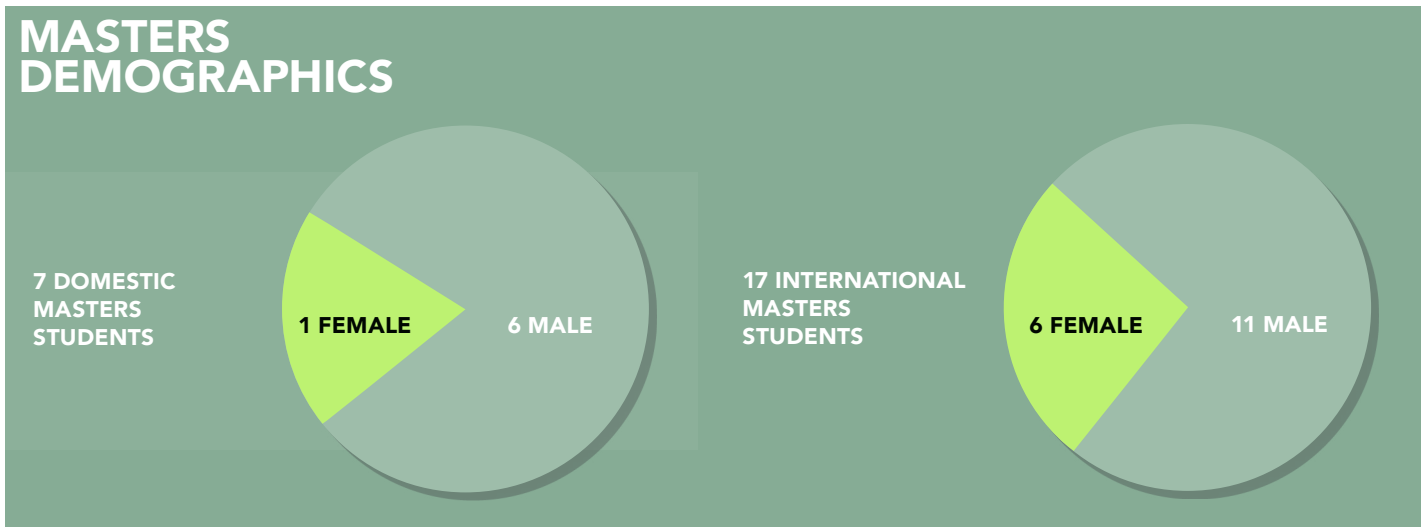
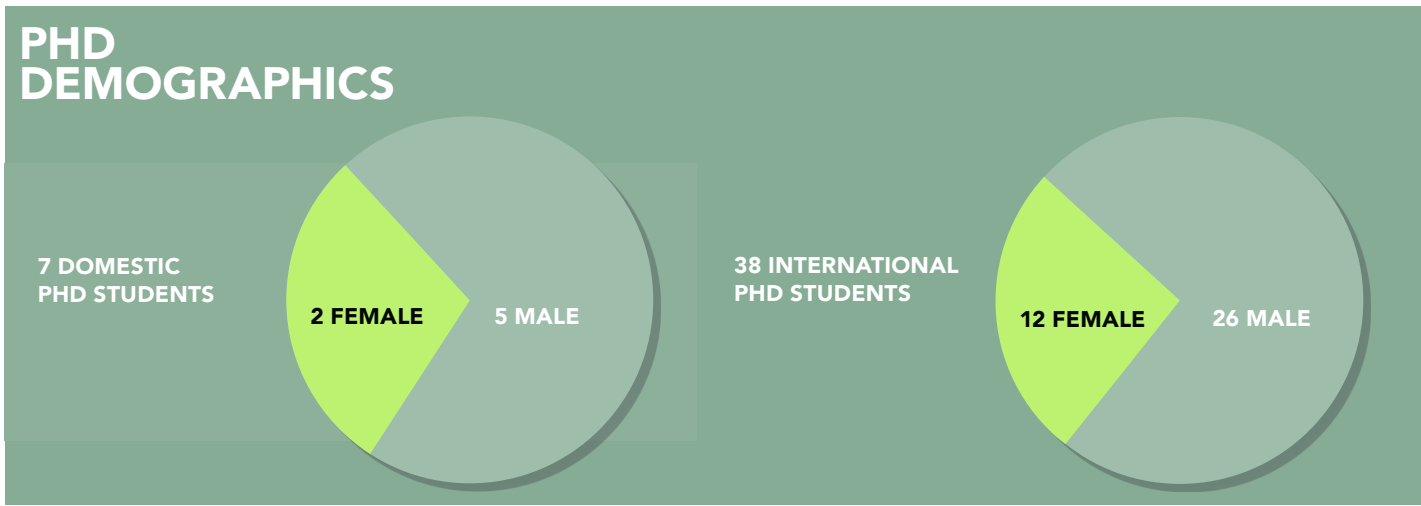
Rather than focus on specific application areas, the SE curriculum offers a holistic view of the field: a fundamental science-based education applicable to all aspects of modeling, analysis, simulation, control, optimization and management of complex systems. The Division cuts across numerous departments at BU to provide a well-rounded perspective of the environment in which a system is housed. An education in systems engineering touches on skill sets based in areas like electronics, mechanics, chemistry, biology, business management, logistics and more. Graduates are equipped with unique skills to adapt to a variety of domains.

GLOBAL DUAL DEGREE

SE partners with Tsinghua University in Beijing for a dual engineering degree program. Students are selected from the Department of Automation at Tsinghua University to enroll in BU’s courses for two semesters. Afterwards, they return to Tsinghua University to complete the program. *US News & World Report* ranks partner Tsinghua University as one of the top global engineering programs.

STUDENT FUNDING

Students are guaranteed funding for five years conditioned on satisfactory academic performance. Currently, 44 PhD students and 6 MS students receive funding:
36 PhD Doctoral Research Fellows
6 PhD Systems Fellows
2 PhD Dean’s Fellows
6 MS students with Tuition Scholarships



PHD DISSERTATIONS

RUIDI CHEN , Advised by I. Paschalidis, Distributionally Robust Learning under the Wasserstein Metric
ARIAN HOUSHMAND , Advised by C. Cassandras, Eco-routing and Scheduling of Connected and Autonomous Vehicles
FRANCISCO PENEDO ALVAREZ , Advised by C. Belta, Formal Methods for Partial Differential Equations
ADAM SONNENBERG , Advised by B. Suki, Towards Optimizing Particle Deposition in Bifurcating Structures
REBECCA SWASZEK , Advised by C. Cassandras, Data-Driven Fleet Load Balancing Strategies for Shared Mobility-On-Demand Systems
TAIYAO WANG , Advised by C. Cassandras, Data Analytics And Optimization Methods In Biomedical Systems: From Microbes To Humans
TINGTING XU , Advised by I. Paschalidis, Machine Learning for Effective Predictions and Prescriptions in Health Care
FATMA YANIKARA , Advised by M. Caramanis, Decentralized Scheduling of EV Energy and Regulation Reserve Services in Distribution Network Markets
YUE (JOYCE) ZHANG , Advised by C. Cassandras, Methods in Intelligent Transportation Systems Exploiting Vehicle Connectivity, Autonomy and Roadway Data
HENGHUI ZHU , Advised by I. Paschalidis, Making Decisions Based on Context: Models and Applications in Cognitive Sciences and Natural Language Processing

INTERNSHIPS

MAHROO BAHREINIAN , iRobot
MAJID HEIDARIFAR , Electric Power Research Institute
ARTIN SPIRIDONOFF , Radial Analytics
XIAO WANG , Amazon Web Services
SALOMON WOLLENSTEIN-BETECH , PROS Inc.
WEI XIAO , APTIV

STUDENT ACCOMPLISHMENTS

SUHAIL ALSALEHI

Advisor: C. Belta

Oral Presentation: MIT Ideathon: How the Education System in the MENA Region has been Affected by the COVID-19 Pandemic.

Oral Presentation: MIT Sloan Health Competition: Pitched a Startup Idea.

RUI CHEN

Advisor: C. Cassandras

Journal Publication: R. Chen and C. G. Cassandras. Stochastic Flow Models with Delays, Blocking and Applications to Multi-Intersection Traffic Light Control, Journal of Discrete Event Dynamic Systems.

Conference Publication: R. Chen, C. G. Cassandras, and A. Tahmasbi-Sarvestani. Time and energy-optimal lane change maneuvers for cooperating connected automated vehicles, IEEE CDC

Travel Award: Canada: Neural Information Processing Systems Foundation.

ADITYA GANGRADE

Advisor: B. Nazer

Journal Publication: Gangrade, Aditya, Praveen Venkatesh, Bobak Nazer, Venkatesh Saligrama. Efficient Near-Optimal Testing of Community Changes in Balanced Stochastic Block Models, Advances in Neural Information Processing Systems.

Conference Publication: Gangrade, Aditya, Durmus Alp Emre Acar, and Venkatesh Saligrama. Budget Learning via Bracketing, International Conference on Artificial Intelligence and Statistics.

Conference Publication: Siahamari, Ali, Aditya Gangrade, Brian Kulis, and Venkatesh Saligrama. Piecewise Linear Regression via a Difference of Convex Functions, International Conference on Machine Learning.

KASRA GHASEMI

Advisor: C. Belta

Journal Publication: Ghasemi, Kasra & Sadraddini, Sadra & Belta, Calin. Compositional Synthesis via a Convex Parameterization of Assume-Guarantee Contracts.

Journal Publication: Ghasemi, Kasra & Sadraddini, Sadra & Belta, Calin. Compositional Synthesis of Decentralized Robust Set-Invariance Controllers for Large-scale Linear Systems.

VITTORIO GIAMMARINO

Advisor: C. Cassandras

Conference Publication: V. Giammarino, M. Lv, S. Baldi, P. Frasca and M. L. Delle Monache. On a weaker notion of ring stability for mixed traffic with human-driven and autonomous vehicles, IEEE CDC.

Journal Publication: V. Giammarino, S. Baldi, P. Frasca and M. L. D. Monache, Traffic Flow on a Ring With a Single Autonomous Vehicle: An Interconnected Stability Perspective, IEEE Transactions on Intelligent Transportation Systems.

NASSER HASHEMI

Advisor: P. Vakili

Journal Publication: Houshmand, Arian, Christos G. Cassandras, Nan Zhou, Nasser Hashemi, Boqi Li, and Huei Peng. Combined Eco-Routing and Power-Train Control of Plug-In Hybrid Electric Vehicles in Transportation Networks.

MAJID HEIDARIFAR

Advisor: M. Caramanis

Travel Award: Atlanta, GA: IEEE PES General Meeting.

ARIAN HOUSHMAND

Advisor: C. Cassandras

Conference Publication: Houshmand, Arian, Salom3n Wollenstein-Betech, and Christos G. Cassandras. The

penetration rate effect of connected and automated vehicles in mixed traffic routing, IEEE Intelligent Transportation Systems Conference.

Conference Publication: Salazar, Mauro, Arian Houshmand, Christos G. Cassandras, and Marco Pavone. Optimal routing and energy management strategies for plug-in hybrid electric vehicles, IEEE Intelligent Transportation Systems Conference.

ARMAN KARIMIAN

Advisor: R. Tron

Conference Publication: Karimian, Arman, Roberto Tron. Bearing-only Consensus and Formation Control under Directed Topologies, IEEE ACC.

XIAOYU LI

Advisor: R. Orabona

Conference Publication: Li, Xiaoyu, Francesco Orabona. A High Probability Analysis of Adaptive SGD with Momentum, ICML 2020 Workshop on Beyond First Order Methods in ML Systems.

YE LIN

Advisor: S. Andersson

Conference Publication: Godoy, Boris I., Ye Lin, Sean B. Andersson. A Time-Varying Approach to Single Particle Tracking with a Nonlinear Observation Mode, 2020 ACC.

Conference Publication: Godoy, Boris I. , Nicholas A. Vicker, Ye Lin, Sean B. Andersson. Estimation of General Time-varying Single Particle Tracking Linear Models Using Local Likelihood, European Control Conference.

Conference Publication: Lin, Ye, Sean B. Andersson. Simultaneous Localization and Parameter Estimation for Single Particle Tracking via Sigma Points based EM., 58th IEEE CDC.

Oral Presentation: Grace

Hopper Conference: Simultaneous Localization and Parameter Estimation for Single Particle Tracking in Confined Environments.

Journal Publication: Lin, Ye, Sean B. Andersson. Quantitative Comparison of Single Particle Tracking Algorithms Across Different Signal and Noise Levels, Biophysical Journal.

Oral Presentation: CISE CGSW 7.0: Simultaneous Localization and Parameter Estimation for Single Particle Tracking via Sigma Points based EM.

Oral Presentation: Quantitative Bioluminescence Conference, UK: Quantitative Comparison of Single Particle Tracking Algorithms Across Different Signal and Noise Levels.

Conference Publication: Center for Autonomous and Robotic Systems Kick off: Simultaneous Localization and Parameter Estimation for Single Particle Tracking via Sigma Points based EM.

NOUSHIN MEHDIPOUR

Advisor: C. Belta

Travel Award: Phoenix, AZ: ACC Annual Meeting

Conference Publication: Mehdipour, Noushin, Cristian-Ioan Vasile, Calin Belta. Arithmetic-geometric mean robustness for control from signal temporal logic specifications, IEEE ACC.

Conference Publication: Mehdipour, Noushin, Cristian-Ioan Vasile, Calin Belta. Average-based robustness for continuous-time signal temporal logic, IEEE CDC.

Conference Publication: Haghighi, Iman, Noushin Mehdipour, Ezio Bartocci, Calin Belta. Control from signal temporal logic specifications with smooth cumulative quantitative semantics, IEEE CDC.

CONTINUED

Oral Presentation: EBICS Research Webinar on SynBio Approaches to Organoids: Automated Frameworks for Spatial and Spatiotemporal Pattern Synthesis.

Oral Presentation: Grace Hopper Celebration: Spatiotemporal Pattern Synthesis Using Machine Learning and Optimization.

Conference Publication: Arithmetic-geometric mean robustness for control from signal temporal logic specifications, IEEE ACC.

SHAHABEDDIN SOTUDIAN
Advisor: I. Paschalidis

Award: Summer fellowship from BU Institute for Health System Innovation & Policy, Digital Health Initiative.

TAIYAO WANG
Advisor: I. Paschalidis
Award: CISE CGSW 7.0, Third Place, Best Paper Award. Convergence of Parameter

Estimates for Regularized Mixed Linear Regression Models by Taiyao Wang and Ioannis Paschalidis, Presented at IEEE CDC and CISE CGSW 7.0.

Journal Publication: Wang, Taiyao, Paschalidis, Ioannis. Convergence of Parameter Estimates for Regularized Mixed Linear Regression Models.

XIAO WANG
Advisor: P. Chin

Travel Award: Macao, China: International Joint Conference on Artificial Intelligence.

YUPING WANG
Advisor: G. Stringhini

Oral Presentation: BU IHSIP Student Research Summer Seminar: Tracking COVID-19 Misinformation.

SHIRANTHA WELIKALA
Advisor: C. Cassandras

Conference Publication: Welikala, Shirantha, Christos

G. Cassandras. Distributed Non-Convex Optimization of Multi-Agent Systems Using Boosting Functions to Escape Local Optima, IEEE ACC.

Journal Publication: Sun, Chuangchuang, Shirantha Welikala, Christos G. Cassandras. Optimal Composition of Heterogeneous Multi-Agent Teams for Coverage Problems with Performance Bound Guarantees, Automatica.

Journal Publication: Sun, Chuangchuang, Shirantha Welikala, Christos G. Cassandras. Optimal Composition of Heterogeneous Multi-Agent Teams for Coverage Problems with Performance Bound Guarantees.

Conference Publication: Welikala, Shirantha, Christos G. Cassandras. Asymptotic Analysis for Greedy Initialization of Threshold-Based Distributed Optimization of Persistent Monitoring on Graphs, Proc. of

21st IFAC World Congress.

Journal Publication: Welikala, Shirantha, Christos G. Cassandras. Asymptotic Analysis for Greedy Initialization of Threshold-Based Distributed Optimization of Persistent Monitoring on Graphs.

Journal Publication: Welikala, Shirantha, Christos G. Cassandras. Event-Driven Receding Horizon Control For Distributed Persistent Monitoring in Network Systems.

Oral Presentation: CISE CGSW 7.0: Improved Performance Bound Guarantees for Submodular Maximization and Applications in Multi-Agent Coverage Control.

DISSERTATION AWARD

Ruidi Chen won the Division of Systems Engineering Best Dissertation Award, titled “Distributionally Robust Learning under the Wasserstein Metric.” Chen was advised by **Ioannis Paschalidis**.

GRACE HOPPER CELEBRATION

Three SE PhD students - **Clara Lin**, **Rui Liu** and **Xiaoyu Li** - were among seven students representing BU at this year’s Grace Hopper Celebration. The students were sponsored by the Division of SE and CISE.

SMART CITIES

In road transport engineering, an intersection is defined as at-grade junction where two or more roads or streets meet or cross. Statistically, it has been evidenced that intersections present a major hurdle in traffic control as they account for the lion’s share of accidents and of overall road congestion. Present technological innovations have led to the introduction of autonomous vehicles/ Connected Automated Vehicles (CAVs). Ideally, such innovations demand the development of an efficient traffic management method purposed to reduce congestion and increase safety with not affect the existing infrastructure. This can be achieved through tighter spacing of vehicles.

Professor **Christos Cassandras** and former PhD student Yue Zhang published a solution to the problem in *Automatica*. They presented a intersection traffic management framework for CAVs crossing a signal-free intersection.

Zhang is now a research scientist at Facebook.

Originally published in Advances in Engineering.

COMMUNITY
SECTION 4

CROSS-DISCIPLINARY FOUNDATION

The Division of Systems makes possible ground-breaking collaborations and discoveries by uniting researchers that have primary appointments in different colleges across the campus, including:

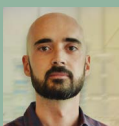
- College of Arts and Sciences**
Bioinformatics Program, Department of Computer Science, Department of Mathematics and Statistics
- College of Engineering**
Department of Biomedical Engineering, Department of Electrical and Computer Engineering, Department of Mechanical Engineering, Division of Materials Science and Engineering
- Questrom School of Business**
Operations and Technology Management
- School of Medicine**
Division of Computational Biomedicine

FACULTY PROFESSIONAL SOCIETY ENGAGEMENT

- 4 Presidents of Professional Society (past/present)
- 6 Editors-in-Chief (past/present)
- 19 Professional Society Fellows
- 14 CAREER Winners

Plus, SE faculty have served as general chair or track chair for more than 100 major conferences hosted all over the world.

APPOINTED
PROFESSORS

	SEAN ANDERSSON Professor of ME & SE <i>Robotics, control theory, scanning probe microscopy, single molecule tracking</i> PhD, University of Maryland, 2003 NSF CAREER Award, 2009		DAVID CASTAÑÓN Professor of ECE & SE <i>Stochastic control, estimation optimization, image understanding and parallel computation</i> PhD, Massachusetts Institute of Technology, 1976 IEEE Fellow, 2019 IEEE Control Systems Society Past President, 2008		FRANCESCO ORABONA Assistant Professor of ECE, SE & CS <i>Machine learning and optimization</i> PhD, University of Genoa, 2007		ROBERTO TRON Assistant Professor of ME & SE <i>Intersection of automatic control, robotics and computer vision, with a particular emphasis on applications of Riemannian geometry and on distributed problems involving teams of multiple agents</i> PhD, Johns Hopkins University, 2012
	JOHN BAILLIEUL Distinguished Professor of ME, ECE & SE <i>Robotics, control of mechanical systems, mathematical system theory, information-based control theory</i> PhD, Harvard University, 1975 IEEE, IFAC & SIAM Fellow 40th President of the IEEE Control Systems Society, 2006		PRAKASH ISHWAR Professor of ECE & SE <i>Statistical signal processing, machine learning, information theory, secure multi-party computation, visual information processing and analysis</i> PhD, University of Illinois Urbana, Champaign, 2002 IEEE Transactions on Signal Processing Associate Editor, 2012-2014 NSF CAREER Award, 2005		IOANNIS PASCHALIDIS Professor of ECE, BME & SE Director of CISE <i>Systems and control, networking, applied probability, optimization, operations research, computational biology, medical informatics, bioinformatics.</i> PhD, Massachusetts Institute of Technology, 1996 IEEE Fellow; IEEE Transactions on Control of Network Systems Founding Editor-in-Chief; NSF CAREER Award, 2000 NAE Frontiers of Engineering, 2002		PIROOZ VAKILI Research Associate Professor of ME & SE <i>Monte Carlo simulation, optimization, computational biology, computational finance</i> PhD, Harvard University, 1989
	CALIN BELTA Professor of ME, ECE, Bioinformatics & SE <i>Verification/ control of dynamical systems, hybrid systems, symbolic control, robot motion planning/ control, gene/ metabolic networks</i> PhD, University of Pennsylvania, 2003 IEEE Fellow, 2017 AFOSR Young Investigator Award, 2008 NSF CAREER Award, 2005		REBECCA KHURSHID Assistant Professor of ME & SE <i>Robotics</i> PhD, University of Pennsylvania, 2015		JAMES PERKINS Associate Professor of ME & SE <i>Real-time scheduling and control of manufacturing systems, supply chain management, resource pricing and congestion control in communications networks</i> PhD, University of Illinois, Urbana-Champaign, 1993		HUA WANG Associate Professor of ME & SE Associate Head of Division of Systems Engineering <i>Control of nonlinear phenomena, intelligent systems and control, complex networks, cooperative control, robotics, applications in biological, energy and aerospace systems</i> PhD, University of Maryland at College Park, 1993
	MICHAEL CARAMANIS Professor of ME & SE <i>Mathematical programming, control and stochastic systems</i> PhD, Harvard University, 1976		BRIAN KULIS Associate Professor of ECE & SE <i>Machine learning, statistics, large-scale data analysis</i> PhD, University of Texas at Austin, 2008 NSF CAREER Award, 2015		VENKATESH SALIGRAMA Professor of ECE & SE <i>Machine learning, computer vision, information theory, and statistical signal processing</i> PhD, Massachusetts Institute of Technology, 1997 IEEE Fellow, 2019 NSF CAREER Award, 2005 Presidential Early Career Award, 2003 ONR Young Investigator Award, 2002		
	CHRISTOS CASSANDRAS Distinguished Professor of ECE and SE Head of Division of Systems Engineering <i>Discrete event/ hybrid systems, stochastic optimization, simulation, manufacturing systems, communication/ sensor networks, multi-agent systems</i> PhD, Harvard University, 1982 IEEE & IFAC Fellow IEEE Control Systems Society President, 2012 IBM/IEEE Smarter Planet Challenge prize, 2011 & 2014		ALEX OLSHEVSKY Associate Professor of ECE & SE <i>Control and algorithms for multi-agent systems, sensor networks, distributed optimization, control of large-scale systems</i> PhD, Massachusetts Institute of Technology, 2010 AFOSR Young Investigator Award, 2015 NSF CAREER Award, 2014		DAVID STAROBINSKI Professor of ECE & SE <i>Wireless and vehicular networks; QOS and traffic engineering; network economics; cybersecurity</i> PhD, Technion, Israel Institute of Technology, 1999 DOE Early Career Award, 2004 NSF CAREER Award, 2002		

AFFILIATED
PROFESSORS



AZER BESTAVROS
Professor of CS
Associate Provost for Computing & Data Sciences
Networking, distributed systems, and trustworthy computing research
PhD, Harvard University, 1992



LEV LEVITIN
Distinguished Professor of ECE
Information theory, physics of communication and computing, complex and organized systems, quantum theory of measurement, reliable communication and computing, bioinformatics
PhD, Gorky University, 1969



EROL PEKÖZ
Professor of Operations & Technology Management (OTM)
Chairperson of OTM
Applied probability and statistics, rare events, Stein's method queuing theory and statistical methods for health care data
PhD, University of California Berkeley, 1995



MARK CROVELLA
Professor of CS
Performance evaluation, focused on parallel and networked computer systems, detecting and understanding anomalies in IP networks, efficient network monitoring, network security
PhD, University of Rochester, 1994



WENCHAO LI
Assistant Professor of ECE
AI safety, human cyber physical systems, formal methods, design automation
PhD, University of California, Berkeley, 2013



AVRUM SPIRA
Alexander Graham Bell Professor of Healthcare Entrepreneurship,
Chief of the Division of Computational Biomedicine,
Director of Translational Bioinformatics Program
Lung cancer and COPD genomics, smoking and airway gene expression, bioinformatics
MD, McGill University, 1996



MICHAEL GEVELBER
Associate Professor of ME & MSE
Development of control and sensing systems for electrosinning of nanofibers, plasma spray, ebeam deposition, crystal growth, CVD, and intelligent building HVAC systems
PhD, Massachusetts Institute of Technology, 1988



THOMAS LITTLE
Professor of ECE
Associate Dean of COE Educational Initiatives
Associate Director NSF Smart Lighting ERC
Computer networking, mobile computing, distributed systems, multimedia streaming and storage, visible light communications
PhD, Syracuse University, 1991



ARI TRACHTENBERG
Professor of ECE
Cyber security, algorithms, error-correcting codes
PhD, University of Illinois, 2000



W. CLEM KARL
Professor of ECE & BME
Chairperson of ECE
Computational imaging, detection and estimation, inverse problems, biomedical signal and image processing
PhD, Massachusetts Institute of Technology, 1991



ABRAHAM MATTA
Professor of Computer Science
Chairperson of Computer Science
Design of network protocols and architectures based on a range of computer science principles, mathematical techniques, and performance evaluation tools
PhD, University of Maryland at College Park, 1995



SANDOR VAJDA
Professor of BME & Chemistry
Director of BMERC
Scientific computing, primarily optimization, computational chemistry and biology, including protein and peptide structure determination, protein engineering, and drug design
PhD, Hungarian Academy of Science, 1983



ERIC KOLACZYK
Professor of Mathematics and Statistics
Director of Hariri Institute
Statistical modeling of instrumental data in temporal, spatial, and network-indexed contexts
PhD, Stanford University, 1994



BOBAK NAZER
Associate Professor of ECE
Information theory, communications, signal processing, and neuroscience
PhD, University of California, Berkeley, 2009

VISITING
COMMITTEE

TAMER BASAR
Director, Center for Advanced Study; Swanlund Endowed Chair, Department of Electrical and Computer Engineering; CAS Professor of Electrical and Computer Engineering, Center for Advanced Study; Research Professor, Coordinated Science Laboratory; Research Professor, Information Trust Institute, University of Illinois at Urbana-Champaign

DIMITRIS BERTSIMAS
Boeing Professor of Operations Research and Co-Director, Operations Research Center, Massachusetts Institute of Technology

YU-CHI (LARRY) HO
Professor Emeritus, Harvard University;
Chief Scientist and Chair Professor, Center for Intelligent and Networked Systems, Tsinghua University, Beijing, China

KIRK E. JORDAN
IBM Distinguished Engineer, Data Centric Systems, IBM T.J. Watson Research; Chief Science Officer, IBM Research UK; Member, IBM Academy of Technology

P. R. KUMAR
University Distinguished Professor and College of Engineering Chair in Computer Engineering, Texas A&M University

MARK T. MAYBURY
Vice President and Chief Technology Officer, The MITRE Corporation

STEFAN MIESBACH
Vice President and Director, Unify Inc., Service Practice Circuit

ROBERT R. TENNEY
Former Vice President, BAE Systems Advanced Information Technology

PRAVIN VARAIYA
Professor of Electrical Engineering and Computer Sciences, University of California, Berkeley

GRADUATE COMMITTEE

Hua Wang, Chair
Sean Andersson, Calin Belta, Alex Olshevsky, Rebecca Khurshid, Elizabeth Flagg

POST-DOCS

PANAGIOTIS ANDRIANESIS PhD, University of Michigan, 2019
Power systems economics, optimization, distributed algorithms

YIDING JI PhD, University of Michigan, 2019
Robotic path planning, autonomous vehicles, multi-agent systems

ADMINISTRATION

CHRISTOS G. CASSANDRAS
Division Head (P17)
HUA WANG
Associate Head (P18)



RUTH MASON
Division Director



ELIZABETH FLAGG, ED.M.
Graduate Programs Manager



GABRIELLA McNEVIN-MELENDEZ, MS
Communications Manager

RESEARCH PARTNER

CENTER FOR INFORMATION & SYSTEMS ENGINEERING (CISE)
is an interdepartmental research center focused on deepening and broadening interdisciplinary research in the study and design of intelligent systems. With 49 faculty affiliates across 3 colleges and 9 departments, CISE researchers advance information and data science to solve complex problems in fields such as autonomous systems, robotics, healthcare, information systems, communications, transportation, energy, and national security. Key research areas include automation, robotics and control; computational biology and medicine; cyber-physical systems; data analytics; energy systems; information sciences; networks and smart cities.

CISE manages grants, offers seed funding, hosts a resident scholar program, organizes student events and supports conferences with government agencies, industries, and engineering societies. The center strengthens relationships between faculty and their corporate partners by running weekly seminars, lectures, workshops, and round table events.

CISE 2019-2020 FUNDING
Annual expenditures were \$7.9 million.

THE TEAM
Ioannis Paschalidis, Director (P18)
Christina Polyzos, Associate Director
Maureen Stanton, Center Administrator

SE & CISE PARTNERSHIP

31 professors associated with both SE and CISE.
21 events were organized by CISE for the joint communities this year.

CISE LECTURES

Fall 2019

DR. ANANT SAHAI
UC Berkeley College of Engineering
Harmless Interpolation in Learning

DR. LORENZO ROSASCO
Massachusetts Institute of Technology
Not So Fast: Learning with Accelerated Optimization

DR. DYLAN LOSEY
Stanford University
Personalizing Robots with Physics and Intelligence

DR. SASHA RAKHLIN
Massachusetts Institute of Technology
Is Memorization Compatible with Learning?

DR. CATHY WU
Massachusetts Institute of Technology
Integrating Autonomy into Urban Systems

DR. MICHAEL CHERTKOV
University of Arizona, Tucson
Interpretable & Tractable Machine Learning for Natural and Engineering Sciences

DR. KONSTANTINOS N. PLATANIOTIS
University of Toronto
Image Processing and Machine Learning for Histopathology and Radiomics

DR. HENRY LAM
Columbia University
Efficient Uncertainty Quantification in Simulation Analysis

DAVID LINDELL
Stanford University, PhD Candidate
Computational Imaging with Single-Photon Detectors

DR. OLEG SOKOLSKY
University of Pennsylvania
Checkpoint-Based Cyber-Physical Recovery

Spring 2020

DR. MAURO SALAZA
Stanford University, Postdoctoral Scholar
Optimization for Smart Mobility Systems: From Formula 1 Racing to Urban Mobility

DR. SIDHARTH JAGGI
Chinese University of Hong Kong
A Shannon-Style Theory for Adversarial Noise Problems: When Can One Pack (Exponentially) Many Copies of a Given Pattern?

DR. STAVROS TRIPAKIS
Northeastern University
Recent Work in the Science of Software and Systems

DR. BRIAN LEVINE
UMass Amherst
The Role of Darknets in Internet based Crimes Against Children

MINI CISE SEMINAR/ WORKSHOP
IBM/Red Hat
BU Cloud Computing Workshop with IBM Research

DR. YASAMAN KHAZAENI
IBM Cambridge
Bayesian Nonparametric Fusion of Heterogeneous Models

DR. NESS SHROFF
The Ohio State University
Rescheduled for Fall 2020

DR. MERT GÜRBÜZBALABAN
Rutgers University
Rescheduled for Fall 2020

DR. CLAYTON SCOTT
University of Michigan, CISE Visiting Scholar
Rescheduled for Spring 2021

DR. RAADHAKRISHNAN POOVENDRAN
University of Washington
Rescheduled for Fall 2020

DR. MARCO PAVONE
Stanford University
Rescheduled for Fall 2020

\$5.5M

ROBOTICS & AUTONOMOUS SYSTEMS

Ioannis Paschalidis (PI), John Baillieul and Roberto Tron are developing robots that learn on-the-fly to adapt to their surroundings. Recently published student results in *PLOS Computational Biology* (P8).

New grant

\$2M

HEALTHCARE

Calin Belta and industry partners are coaxing STEM cells to form new arrangements and eventually generate personalized organs. A study in which the team revealed new ways to engineer cells was published in *Cell Systems*.

\$1M

ENERGY

Janusz Konrad (PI), Prakash Ishwar, Thomas Little and Michael Gevelber are developing next-generation people-counting sensors for HVAC systems. The team has published one patent and four papers (P3).

\$200K

SMART CITIES & TRANSPORTATION

Christos Cassandras is optimizing and securing cloud-supported automated vehicle coordination. Alum Yue Zhang co-authored a paper in *Automatica* with an optimal control framework solution. Zhang completed her PhD in 2019 and now works at Facebook as a research scientist (P15).

New grant

\$5M

INFORMATION SYSTEMS

Azer Bestavros and Orran Krieger (PI) are developing the Massachusetts Open Cloud (MOC) for free public use. MOC recently pivoted to offer Cloud service support to those fighting COVID-19 including hospitals (P3).

PIVOTING FOR COVID-19

A team of researchers analyzed Mexico and Brazil's national COVID-19 patient data, and found disproportionate patient health impacts throughout the countries. To help government officials predict the health-risk of their residents, **Christos Cassandras, Ioannis Paschalidis** and SE PhD candidate Salomón Wollenstein-Betech examined the role of preexisting health conditions and socioeconomics factors in predicting outcomes for COVID-19 patients.

The team established a method to identify patients at higher-risk of severe COVID-19 disease that may require hospitalization, ICU treatment and mechanical ventilation. The findings were published in the *International Journal of Medical Informatics* and in *PLOS ONE*.

2019-2020 Annual Report
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