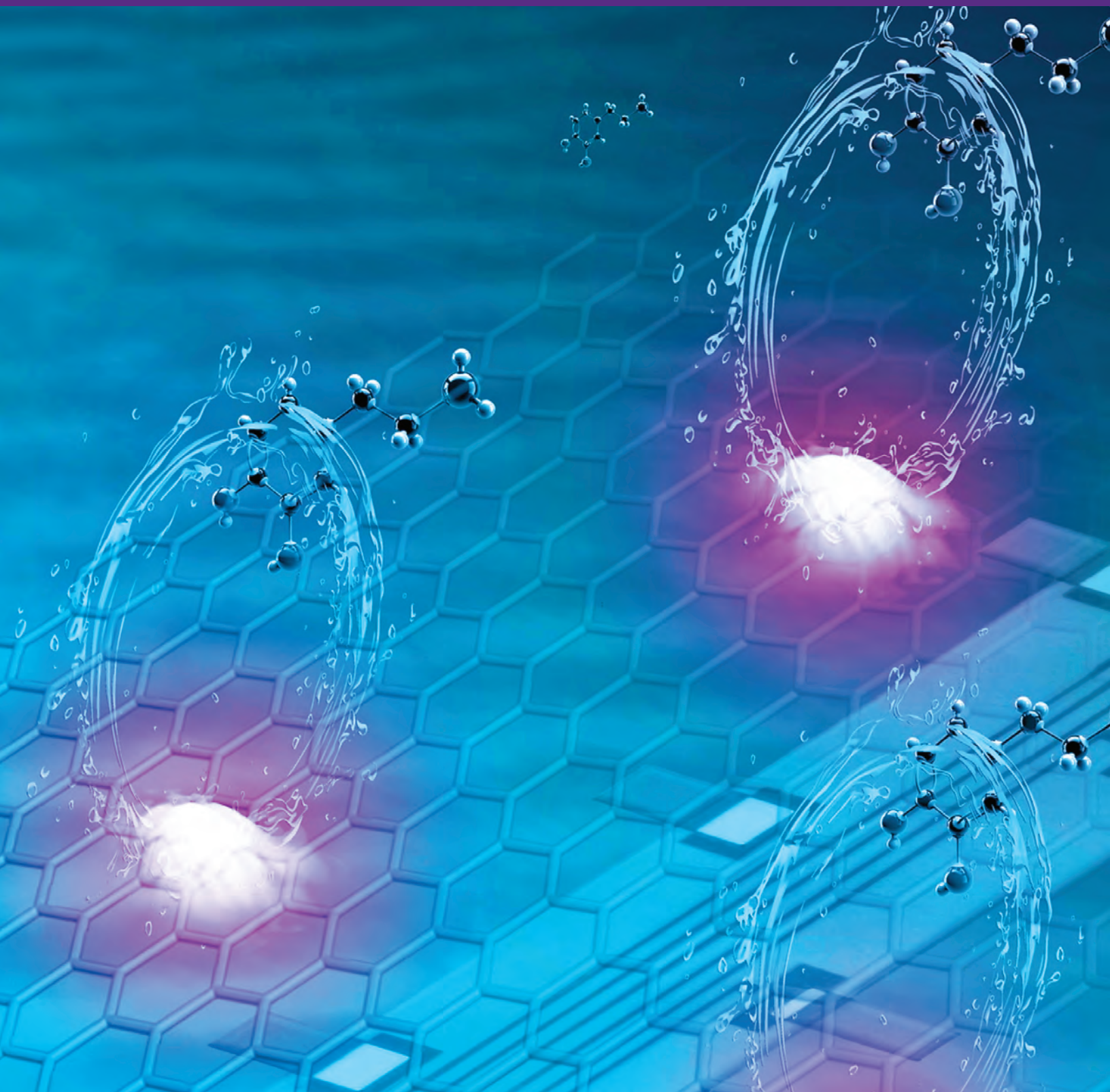
NYU WIRELESS

Pulse

FALL 2021 • VOL. 8, NO. 1 • NYUWIRELESS.COM



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About the cover:
Planar micro-sensors using a carbon nanomaterial called nano-graphitic carbon, developed by NYU WIRELESS researcher Davood Shahrjerdi, became more sensitive in response to dopamine molecules when operation voltage was reduced, a surprising discovery. Please see article on page 7 for more information.

NYU WIRELESS is a vibrant academic research center pushing the boundaries of wireless communications, sensing, networking, and devices.

Centered at NYU Tandon School of Engineering and involving leaders from industry, faculty, and students throughout the entire NYU community, NYU WIRELESS offers its Industrial Affiliate Members, students, and faculty members a world-class research environment that is creating fundamental knowledge, theories, and techniques for future mass-deployable wireless devices in a wide range of applications and markets.

Every January, NYU WIRELESS hosts an annual Open House for all of its students and Industrial Affiliate Members, followed in April by the prestigious invitation-only Brooklyn 6G summit (B6GS.com), in cooperation with Nokia Bell Laboratories, for the center's Industrial Affiliates and thought leaders throughout the global telecommunications industry (for 2021 only, the B6GS will be live and virtual on Oct. 18-19).

NYU WIRELESS, info@nyuwireless.com

Leadership Founding Director Ted Rappaport, Director Thomas L. Marzetta, and Associate Directors Sundeep Rangan, John-Ross Rizzo, and Dennis Shasha manage NYU WIRELESS across Brooklyn and Manhattan campuses of NYU. Prof. Rappaport has powered the 5G millimeter wave era and is a leading educator in the wireless arena, having authored many books and started two companies and three major academic wireless research centers. Prof. Rangan is an Electrical Engineering Professor at NYU Tandon and was a co-founder of Flarion Technologies, which developed Flash-OFDM, one of the first cellular OFDM data systems. Prof. Marzetta originated the concept of Massive MIMO and seeks ten-fold improvements over Massive MIMO through a closer union of wave propagation physics and communication theory. Prof. Rizzo is an Assistant Professor in the Departments of Rehabilitation Medicine and Neurology at NYU Langone Health. His research is focused on wearable technology and blindness and visual impairment. Prof. Shasha of Courant's Computer Science Department is widely known for his expertise in data-intensive algorithms and streaming data and is a highly acclaimed inventor of mathematical puzzles.

The Industrial Affiliates Program NYU WIRELESS invites global companies to join our Industrial Affiliates program. The NYU WIRELESS Industrial Affiliates program offers instant access to cutting-edge research results and talented students in a mutually beneficial relationship among NYU WIRELESS researchers, students, facilities, and leading industry partners. NYU WIRELESS would like to thank our Industrial Affiliate Partners as well as NSF, NIH, and DOD for their continued support. Learn more about our Industrial Affiliates program by visiting nyuwireless.com/industrial-affiliates.

NYU WIRELESS Newsletter

Download and read copies of our previous newsletters online
by visiting **nyuwireless.com/nyu-wireless-newsletter**

The Human Connection

Welcome back! All of us here at NYU WIRELESS are cautiously optimistic about returning to normal life, post pandemic. We are excited that NYU Tandon School of Engineering will once again offer in-person classes this fall, with everyone vaccinated. I am sure you join me in the sincere hope that everyone around the world will soon have access to the vaccine and proper medical care, should they need it.

During these past months, we have adapted to previously unimagined circumstances, successfully carrying out our work in the classroom and in business and personal discussions. Innovative as always, students and faculty developed their own work-arounds to overcome the changes and challenges we have faced. We met virtually with our Industrial Affiliates during our Open House/Recruiting Day, conducted the annual Board Meeting, presented Mini-Lectures, and facilitated numerous technical discussions. We were fortunate to welcome new Industrial Affiliates this year (see page 4). Throughout it all, we have been supported by our community of Industrial Affiliates and NYU colleagues, and for this we are very grateful. Thank you!

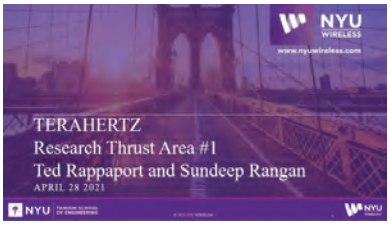
Thomas L. Marzetta
Director, NYU WIRELESS

Our six research thrust areas still serve to focus our current and future research: terahertz communications and sensing; mobile edge and low latency networking; quantum devices and circuits; 5G and 6G applications; communication foundations and machine learning; and testbeds and prototyping. You can learn more about exciting developments in several of these areas in this issue of *Pulse*.

Having witnessed the challenges of the past year and a half, I can say with conviction that there is no better time to be involved in the field of wireless communications. We have overcome tremendous obstacles during the pandemic. Our field has enabled hundreds of millions of people to work productively out of their homes. At the same time, the pandemic has revealed the limitations of Zoom-like platforms. The world is now ready for the next level of human-to-human communications, which I believe will be ubiquitous augmented/virtual reality.

I look forward to seeing you all soon back on campus!

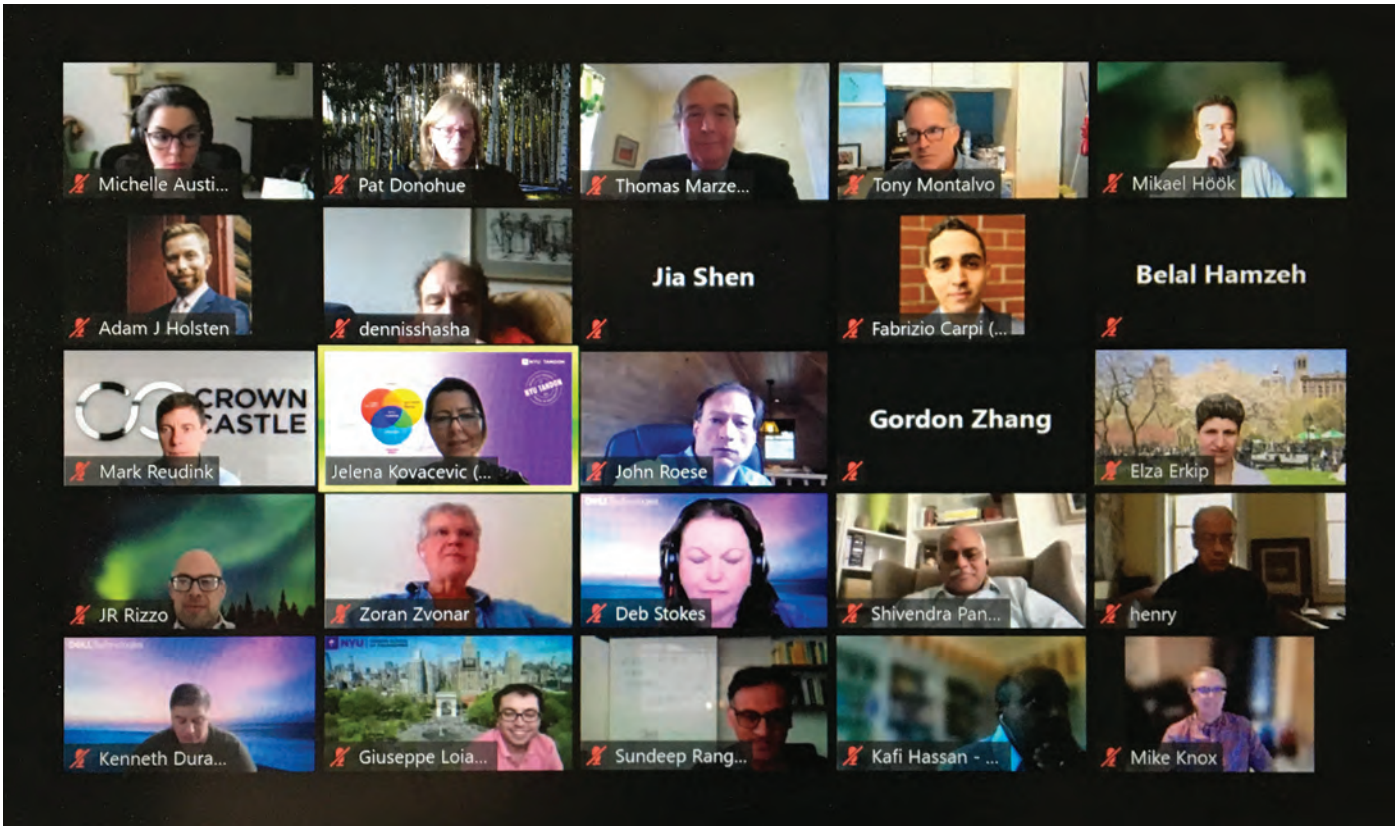
Open House & Board Meeting Draw a Virtual Crowd



We were pleased to welcome our NYU WIRELESS Industrial Affiliates to our Open House and Recruiting Day on January 22, 2021, and to our Board Meeting Part 1 on April 28, 2021. Because of the virtual nature of the events, we were able to accommodate larger audiences, which this year included company colleagues of our Board Members, making for lively discussions.

Open House/Recruiting Day is designed to connect NYU WIRELESS students with our Industrial Affiliate members, who are seeking top talent to fill summer internships and full-time positions. Following introductions during the virtual session, a video montage of each NYU WIRELESS student was shown together with their poster, along with a brief explanation of their current research. Networking sessions for Industrial Affiliates, faculty, and students followed, and interviews were scheduled. We're pleased that many students received offers for summer internships with our Industrial Affiliates (please see page 9 for a list).

At the virtual Board Meeting Part 1 on April 28, 2021, NYU WIRELESS faculty shared updates from the six thrust areas that are the focus of the center. (More information can be found at NYUWIRELESS.com.) During a spirited discussion/feedback session, faculty members and Industrial Affiliates shared their views on future directions in wireless communications and industry priorities. There was so much interest that the session was extended to give participants additional time to share their thoughts. Discussions will continue on October 20, 2021, at the second Board Meeting, which follows the Brooklyn 6G Summit.



NYUSIM Version 3.0 Now Available

Driven by the now-ubiquitous use of smart phones and the emergence of massive Internet of Things (IoT), 6G wireless systems will need to offer unprecedented reliability and system throughput—NYU WIRELESS provides free tools to make 6G happen!

6G will be achieved, in part, by deploying systems transmitting and receiving in millimeter-wave (mmWave) and Terahertz (THz) frequencies (i.e., 30 GHz–3 THz). These regions of the electromagnetic spectrum are capable of massive data throughput at near-zero latency, key to future data traffic demand created by such wireless applications as augmented/virtual reality (AR/VR) and ultra-high definition (UHD) content.

The key to successful deployment of mmWave and THz systems for 6G wireless will be their performance in indoor scenarios. Therefore, accurate THz channel characterization for indoor applications is essential to realizing the designs of transceivers, air interface, and protocols for 6G and beyond. To this end, NYU WIRELESS researchers have introduced NYUSIM 3.0, a new free public-domain software tool that provides life-like indoor statistical channel simulations, following the same mathematical framework of the NYUSIM outdoor channel modeling approach. NYUSIM 3.0 provides a full suite of outdoor models but now includes the abillty to recreate indoor channel impulse responses from 500 MHz to 150 GHz with 0 Hz to 800 MHz RF bandwidth, and a wide range of antenna beamwidths. Work on this new version of NYUSIM was led by Ph.D. student Shihao Ju together with Yunchou Xing and Ojas Kanhere, under the direction of NYU WIRELESS Founding Director Ted Rappaport. NYUSIM 3.0 may be downloaded at NYUWIRELESS.com.

The NYU WIRELESS team developed the indoor three-dimensional (3D) statistical channel models for mmWave and sub-THz frequencies from extensive channel propagation measurements conducted in the NYU WIRELESS office building at 28 GHz and 140 GHz in 2014 and 2019—in both line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios. The team analyzed more than 15,000 power delay profiles to study channel statistics such as the number of time clusters, cluster delays, and cluster powers as a function of beamwidth and carrier frequency for a wideband (800 MHz-1 GHz) signal.

The protocols for the indoor channel models incorporated in NYUSIM 3.0 were published in the June 2021 special issue of IEEE's *Journal on Selected Areas in Communications* devoted to Terahertz communications and networking. The article, "Millimeter Wave and Sub-Terahertz Spatial Statistical Channel Model for an Indoor Office Building," was authored by the NYU WIRELESS student team under Ted's guidance. Besides proposing a unified indoor channel model across mmWave and sub-THz bands based on the team's indoor channel measurements, the work is valuable for future standards development above 100 GHz.

NYUSIM 3.0 is publicly available on NYUWIRELESS.com along with free statistical channel modeling software with a simple MIT-style open-source acknowledgment license. To date, NYUSIM has been downloaded more than 80,000 times.

For more information about moving above 100 GHz, watch Ted's mini-lecture, "Spectrum Frontiers: Terahertz," on NYU WIRELESS's YouTube channel. The lecture was presented live on February 17, 2021, to the NYU WIRELESS Industrial Affiliate member companies.

Welcome New Affiliates!

NYU WIRELESS is pleased to welcome two new Industrial Affiliates in 2021: Dell Technologies and NEC Laboratories America. In addition, we are thrilled to welcome back NI, which rejoined after a short absence. We are excited to have these esteemed companies on board and look forward to providing them with brilliant students and insights into the future while benefitting from the expertise they bring to help guide and inform our research activities.

NYU WIRELESS Industrial Affiliates enjoy numerous benefits by participating in the program. From mini-lectures on current topics, to one-on-one discussions about specific areas of interest, to access to highly qualified students for internships and full-time positions, the Industrial Affiliates program is a valuable resource that helps keep our corporate members at the forefront of their industry.

Dell Technologies is focused on the power of technology to drive human progress. The company has evolved from its beginning in 1984 in Michael Dell's University of Texas dorm room, where he started selling computers because he believed that everyone should have easy and affordable access to technology. Today a multi-faceted company, Dell develops innovative products and initiatives ranging from hybrid cloud solutions to high-performance computing, all of which impact the world in meaningful ways.

NEC Laboratories America is part of NEC Corporation's global network of research laboratories. Its mission is to generate significant new knowledge and create innovative solutions for society in collaboration with industry, academia, and governments in the areas of IT integration and network solutions. NEC brings more than 100 years of expertise in technological innovation to empower people, businesses, and society.

NI, formerly National Instruments, develops tailored, software-connected systems for engineers and companies that are focused on cutting-edge technology, including 6G, digital transformation, and autonomous systems.

Robotics Researchers Make an Impact at IEEE Conference

NYU WIRELESS researchers made their presence known at the 2021 IEEE International Conference on Robotics and Automation (ICRA), the largest and most important international conference of its kind.

The conference, held May 30 to June 5, 2021, in Xi'an, China, brought together experts from around the world for both in-person and remote sessions to discuss cutting-edge research in the field. Researchers from NYU WIRELESS and NYU Tandon School of Engineering presented eighteen papers and spoke at several workshops. Highlights are presented here.

Assistant Professor S. Farokh Atashzar and his lab shared their research on the advancements in human-robot interfaces through peripheral multichannel electromyography (EMG) recordings and deep learning. This new paradigm would reduce the need for machines to be recalibrated for users, increasing efficiencies. Farokh's team has also developed the theoretical foundation of a new family of intelligent robot control algorithms, named Discrete Windowed-Energy Variable Structure Passivity Signature Control, which optimizes physical human-(tele) robot interaction, with potential application in neurorehabilitation robotics.

Farokh organized two workshops. The first, "Impact of COVID-19 on Medical Robotics and Wearables Research," examined how the use of medical technology was disrupted by the pandemic and how it can be used in the future to help provide the healthcare needed for subsequent waves and future pandemics. His second workshop, "Holistic Integration (HI) of Intelligence in Dexterous Robotic Systems," discussed how robotics research has been hampered by issues such as limited sensory perception, safety concerns, and the trade-off between power and dexterity in devices. The workshop brought together leading researchers, clinicians, and industrial engineers of differing backgrounds to discuss the applications and needs for the holistic integration of design, sensing, and intelligence in DMRS systems. Farokh also received an award for Outstanding Associate Editor for the IEEE Robotics and Automation Letters.

Farokh Atashzar
Assistant Professor

Associate Professor Ludovic Righetti and his lab showed off their continued excellence in the field of legged locomotion and robotics manipulation with seven published papers. Findings included a new framework based on Risk-Sensitive Control to rigorously take into account the uncertainty about unknown contact locations and modulate how compliant or stiff the legs should be. The new algorithm drastically improves how legged machines interact with their environment, rendering them more robust and enabling safer interactions.

Ludovic organized the workshop "Recent Advances in MPC and RL for Legged Robots," which discussed recent developments in employing Model Predictive Control (MPC) and Reinforcement Learning (RL) to control

Ludovic Righetti
Associate Professor

The 2021 International Conference on Robotics and Automation (ICRA 2021)

Giuseppe Loianno
Assistant Professor

Chen Feng
Assistant Professor

legged robots, increasing their abilities through the use of AI programing. He also spoke at several panels throughout the conference.

Assistant Professor Giuseppe Loianno and his team in the Agile Robotics and Perception Lab (ARPL) showed their leadership in the area of autonomy of aerial robots. Their papers covered a wide range of topics, including a new predictive perception-control framework for aerial vehicles equipped with a cable-suspended load, known as PCMPC, which was featured in *IEEE Spectrum*'s March 11, 2021 issue. They also discussed a newly discovered approach for coordinated perception and control of multiple drones for cooperative transportation and delivery that employs monocular vision and inertial sensing. This allows multiple machines to carry packages that would be difficult or impossible for a single drone. The team also showed results on multi-target visual tracking for swarm coordination and human-swarm interaction, as well as a construction and assembly approach with mobile manipulators.

"Resilient and Long-Term Autonomy for Aerial Robotic Systems," the workshop organized by Giuseppe, analyzed two main challenges related to aerial robotics: their resilience and the ability to perform long-term missions. The workshop put a special emphasis on field research and mass deployment of drones and other aerial robots. In addition to the workshop, Giuseppe participated in various conference panels.

Aerial robots in Assistant Professor Giuseppe Loianno's lab.

Assistant Professor Chen Feng and his lab, AI4CE (Automation and Intelligence for Civil Engineering), from NYU Tandon School of Engineering, have achieved millimeter-level mobile robot navigation and control for fused deposition modeling that could create faster, more efficient fabrications at a larger scale than gantry-based 3D printers. The AI-based system requires almost no manual calibration of the system parameters, which will make it especially useful for projects beyond the capabilities of traditional 3D printers. The team's work may offer ramifications for the world of additive manufacturing.

In addition to the colleagues mentioned above, two other NYU professors had their research published at ICRA: Electrical and Computer Engineering Department Professor Zhong-Ping Jiang and NYU WIRELESS Professor Yong Liu.

The 39th ICRA conference will be held in Philadelphia May 23–27, 2022. For more information and paper submission, visit ICRA2022.org.

SAVE THE DATES

Brooklyn 6G Summit
Virtual event: October 18 & 19, 2021/In-person event: April 12–14, 2022
For more information, visit http://b6gs.com.

NYU WIRELESS Board Meetings
Virtual meeting Part 2: October 20, 2021/In-person meeting: April 12, 2022

Open House/Recruiting Day
In-person event: January 21, 2022
nyuwireless.com/nyu-wireless-newsletter

Enhanced Micro-Sensors Super Sensitive to Biomolecules

A new way of enhancing the performance of electrochemical micro-sensors has been uncovered by researchers from NYU WIRELESS, together with partners from other NYU departments and external collaborators. This important discovery could lead to the detection of biomolecules, such as dopamine, at lower concentrations than is possible today.

Davood Shahrjerdi
Associate Professor

The findings were published in April 2021 in *Biosensors and Bioelectronics* in the article "Anomalous sensitivity enhancement of nano-graphitic electrochemical micro-sensors with reducing the operating voltage."

Dopamine molecule activity in the brain is associated with important functions, including motivation, motor control, reinforcement, and reward. Researchers and clinicians commonly monitor neurotransmitter activity in the brain through electrochemical micro-sensors made of carbon. However, due to their limited sensitivity, existing micro-sensors can detect only large changes in dopamine levels. In addition, they can record from only one site in the brain at a time.

To support the multi-site mapping of dopamine activities in the brain, the research team developed planar micro-sensors using a carbon nanomaterial called nano-graphitic carbon.

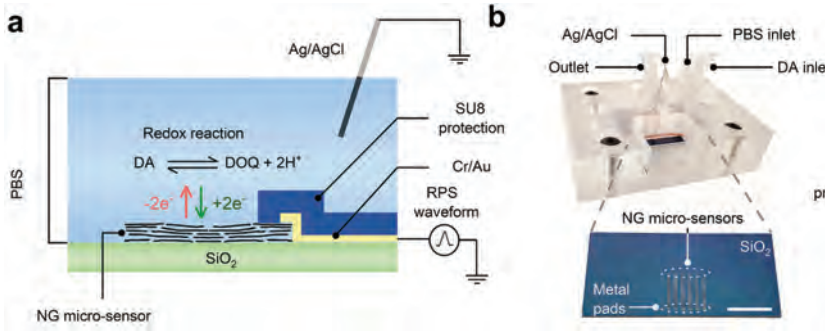
"We used nanofabrication techniques, similar to those used for building chips in consumer electronics, to create an array of many planar electrochemical micro-sensors," said Davood Shahrjerdi, Associate Professor of NYU WIRELESS and principal investigator of the study. "Our sensors are small—comparable to a neuron cell body—and can be packed close to each other for recordings with higher spatial resolution."

The team discovered that the sensor performance can be adjusted by engineering the material structure of the nano-graphitic carbon. The details of the sensor development were described last year in a paper that appeared in *Scientific Reports*.

"Our study described in *Scientific Reports* suggests that the sensor performance should remain unchanged if we reduce the operating voltage, since the sensor performance is controlled by the material structure," explained Davood.

The team made a surprising observation that the amplitude of the sensor output in response to dopamine molecules was increased by reducing the operation voltage.

"We initially thought that perhaps there was something wrong with the measurements," said Edoardo Cuniberto, a Ph.D. student at NYU WIRELESS, who is the lead author of both studies. "With over a year of significant additional experimentations and theoretical simulations, we not only confirmed our initial observation,



a) Cross-sectional schematic of the experimental set-up used for the RPS measurements of dopamine. b) Picture of the custom-made micro-fluidic chamber used in the experiment, together with a representative optical image of a sensor sample consisting of multiple planar NG micro-sensors. The scale bar is 1 cm.

but we were also able to explain the physics behind our surprising observation."

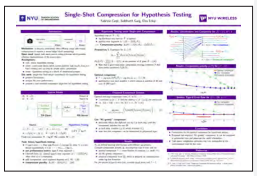
The investigators demonstrated sensors with record performance by combining the new voltage-dependent phenomenon with their approach of engineering the material structure. "We are excited about exploring the prospects of our new sensor technology for future brain studies," said Davood.

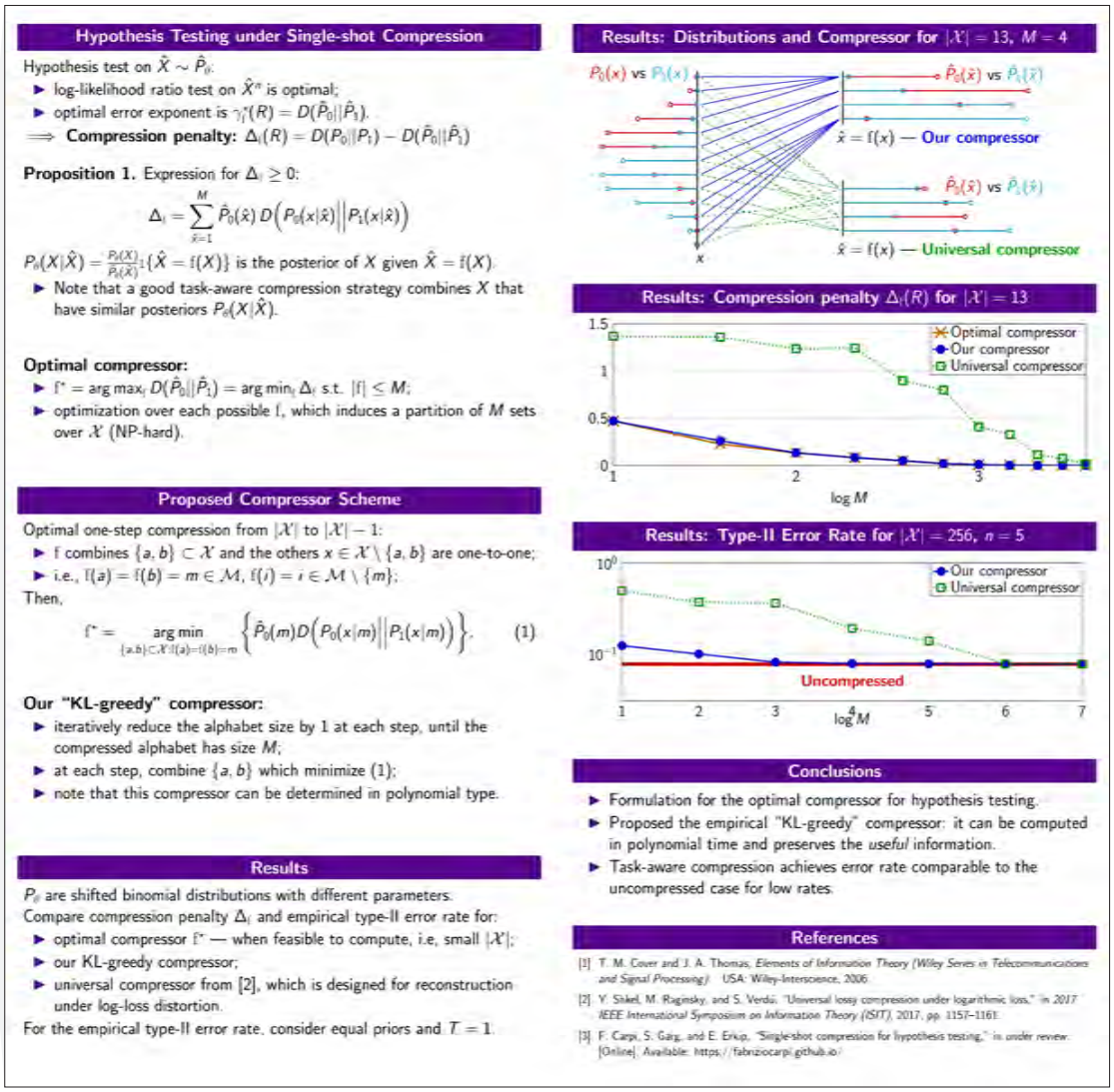
In addition to Edoardo, the team includes Zhujun Huang, a Ph.D. student at NYU WIRELESS; Abdullah Alharbi, formerly of NYU WIRELESS and the King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia; and Ting Wu and Roozbeh Kiani, both of the NYU Center for Neural Science. The research was supported, in part, by a grant from the National Science Foundation.

Best Poster Award

Fabrizio Carpi

NYU WIRELESS Ph.D. student Fabrizio Carpi received the Best Poster Award at the 2021 IEEE Communication Theory Workshop in June. His winning poster, "Single-Shot Compression for Hypothesis Testing," can be viewed in its entirety at NYUWIRELESS.com. Fabrizio's advisors are Professors Elza Erkip and Siddharth Garg. Fabrizio also received this year's Chang Education Award from NYU Tandon School of Engineering for his work as a teaching assistant.





Summer Internships

As in past years, NYU WIRELESS students took advantage of the summer to participate in enriching internships with our Industrial Affiliates, all leaders in the telecommunications and wireless fields, as well as other high-profile companies. Students connect with potential employers every January at our Open House/Recruiting Day, where they can learn more about the companies and employment opportunities. Attracting top talent for internships and full-time positions at the annual Open House/Recruiting Day is just one of the many benefits of becoming an NYU WIRELESS Industrial Affiliate.

Fabrizio Carpi
Intel

Junbo Chen
TuSimple

Yaqi Hu
AT&T

Shihao Ju
Amazon Lab 126

Chen Li
Ancestry.com Operations

Mustafa Özkoç
InterDigital

Ziming Qiu
Facebook

Ojas Kanhere
InterDigital

Syed Hashim Ali Shah
Qualcomm

Dipankar Shakya
Nokia Bell Labs

Panagiotis Skrimponis
Qualcomm

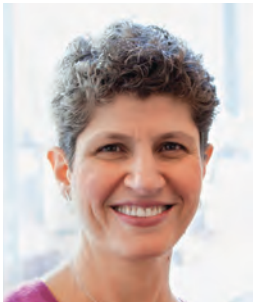
Yunchou Xing
Nokia Bell Labs

Mingsheng Yin
AT&T

Faculty News

Sundeep Rangan
Associate Director,
NYU WIRELESS

Thomas L. Marzetta
Director, NYU WIRELESS



Elza Erkip
Institute Professor

Beth Noveck
Professor and Director,
The GovLab

Distinguished Teacher Award

Associate Director of NYU WIRELESS and Professor of Electrical and Computer Engineering Sundeep Rangan received the 2021 Distinguished Teacher Award from NYU Tandon School of Engineering. This award is bestowed upon someone who has demonstrated sustained excellence in teaching over the past five years. It is considered the premier teaching award at NYU Tandon. Sundeep, a Fellow of IEEE, has helped make NYU WIRELESS one of the foremost academic centers of wireless research—and NYU Tandon a major hub for 5G technology and the pursuit of 6G. His students are well prepared to contribute to this ever-evolving field, thanks to his knowledge of industry requirements and active updates of the curriculum. His students consistently praise his ability to break down difficult problems and explain complicated material to individuals with varied backgrounds, and many have directly attributed their successes to his patience, effective teaching methods, and combination of practical and theoretical insight.

NSF Invited Lecture by Tom Marzetta

NYU WIRELESS Director Tom Marzetta presented an invited talk in May as part of the Distinguished Lecture Series of the National Science Foundation. His lecture, "Wireless Power Transfer: Principles and Prospects," along with slides, can be accessed on the NSF's website at https://bit.ly/2RdBIN6 by scrolling to the bottom of the page.

Ted Rappaport Featured in New Tech Podcast

NYU WIRELESS Founding Director Ted Rappaport was a featured guest on the first episode of *Tech2030*, a podcast launched in May that highlights the technologies and developments that will change our lives in the next decade. Ted, together with Renuka Racha from 6GWorld, discussed what lies beyond 5G. Listen to the podcast on Spotify.

Ted was also featured in *Microwave Journal*'s July 13 RF Industry Icons podcast, where he was interviewed by Editorial Director Pat Hindle. They discussed how Ted got interested in radio technology, launching wireless centers of excellence at three universities, his groundbreaking work with mmWave channel modeling, and his view on the future of wireless in 6G and beyond. The podcast is available at https://podcasts.microwavejournal.com.

Highly Cited Researchers

Once again NYU WIRELESS Founding Director Ted Rappaport and Director Tom Marzetta were listed among the Web of Science Group's Highly Cited Researchers for 2020. Scientists and social scientists from around the world who are selected for this honor have published multiple papers that consistently rank in the top one percent by citations in their field over the past decade. Experts from the Institute for Scientific Information at the Web of Science Group, which is part of Clarivate Analytics, determine who is included in this influential group.

Marconi Society Symposium and Gala

Professor Elza Erkip from NYU WIRELESS and Beth Noveck, Professor and Director of The GovLab at NYU Tandon School of Engineering, have been named to the Marconi Society's program committee for its 2021 symposium and gala, "Decade of Digital Inclusion." The program committee is comprised of a distinguished group of visionary leaders in policy, technology, academia, and digital inclusion advocacy. This year's events will be held on Friday, October 22, in Washington, D.C., at the Ronald Reagan Building and International Trade Center. More information can be found at MarconiSociety.org.

Ted Rappaport Elected to National Academy of Engineering

Ted Rappaport, Founding Director of NYU WIRELESS and a telecommunications pioneer, was elected to the National Academy of Engineering (NAE) on February 9.

Election to the NAE—part of the 158-year-old National Academies of Science, Engineering, and Medicine—is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to engineering research, practice, or education, including contributing significantly to the engineering literature and to the pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing and implementing innovative approaches to engineering education.

The NAE cited Ted's contribution to the characterization of radio frequency propagation in millimeter wave (mmWave) bands for cellular communications networks. This marks the second consecutive year in which someone from NYU WIRELESS has been elected to NAE. Tom Marzetta, Director of NYU WIRELESS, was elected to the Academy in 2020.

In addition to being the David Lee/Ernst Weber Professor of Electrical and Computer Engineering at NYU Tandon School of Engineering, Ted is also a professor of computer science at NYU Courant Institute of Mathematical Sciences and a professor of radiology at the NYU School of Medicine. He is recognized worldwide as a pioneer in radio wave propagation and wireless communications, circuits, and systems, and for the wireless research centers he created. Over the course of his distinguished career, he and his students launched two start-ups that were sold to publicly traded companies for their pioneering technologies of over-the-air cellular interception and indoor/microcell network modeling and deployment. While never leaving academia, he also founded three highly regarded wireless academic centers: at NYU, the University of Texas at Austin, and Virginia Tech. His award-winning 2013 paper, "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work," articulated the virtues of spectrum between 30 to 300 gigahertz for 5G radio and beyond and has been cited well over 5,000 times. In 2019, he co-authored a vision paper for the future of wireless, "Wireless Communications and Applications Above 100 GHz: Opportunities and Challenges for 6G and Beyond."

Ted holds more than 100 U.S. and international patents (issued or pending) and has co-authored or co-edited some 200 papers and 20 books in the wireless field, including the world's best-selling books on wireless communications, mmWave communications, and smart antennas.

Under his leadership, NYU WIRELESS researchers have conducted groundbreaking work on mmWave propagation, radio channel modeling, system simulation, and antenna technology—demonstrating that even the most challenging characteristics of mmWave radio can be overcome in both urban settings and rural markets, presaging the viability of the mmWave regime for 5G, 6G, and beyond. Together with other NYU WIRELESS researchers, he is exploring THz for ultra-fast, high-capacity data transmission and revolutionary applications for communications, medical imaging, precise position location, semiconductor testing, and new kinds of spectroscopy.

"I am deeply honored and humbled to receive this distinction and am thankful to have had such wonderful students, colleagues, sponsors, and supporters of my research and teaching efforts throughout my career," Ted said. "I am gratified that our hard work has opened up spectrum that had long been considered fallow ground for consumer telecommunications."

Ted, along with 126 other new members, will be inducted during a ceremony at the NAE's annual meeting on October 2.

Theodore Rappaport
Founding Director,
NYU WIRELESS

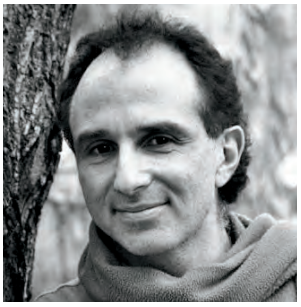
NYU WIRELESS Faculty, Post-Docs, and Research Engineers

Theodore Rappaport
Founding Director,
ECE, CS, Medicine

Thomas L. Marzetta
Director, ECE

Sundeep Rangan
Associate Director, ECE

John-Ross Rizzo
Associate Director,
NYU Langone Health



Dennis Shasha
Associate Director, CS

Sundar Aditya
Post-Doctoral Associate

Farokh Atashzar
Assistant Professor

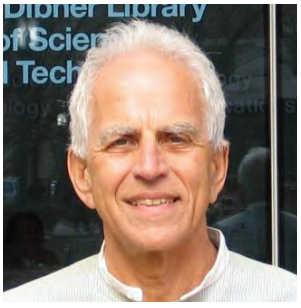
Henry Bertoni
Professor Emeritus, ECE

Aditya Dhananjay
Post-Doctoral Associate, ECE

Elza Erkip
Institute Professor, ECE

Fraida Fund
Post-Doctoral Associate

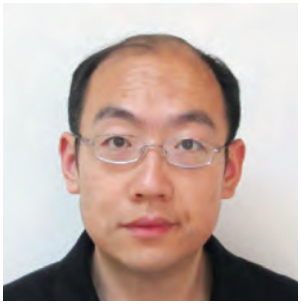
Siddharth Garg
Associate Professor, ECE



David Goodman
Professor Emeritus, ECE

Ramesh Karri
Professor, ECE

Michael Knox
Industry Professor, ECE



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