Spotlight

RECONNECTING WITH OUR ALUMNI

NC STATE UNIVERSITY

In this Spotlight

Managing and Creative Director: Charles Hall • *Editors:* Daniel Stancil, Greg Byrd, Daniel Green, Trudi Brown, Elizabeth New
Writers: Maimoona Almontaser, Stefani Ashkinazy, Charles Hall, Danielle Herman, Tim Peeler, Matt Shipman, Matt Simpson, NC State Engineering Communications, NC State University Communications.

2000 copies of this public document were printed at a cost of $4,945.53 (G.S. 143-170.1).

Department Head's Note

My wife and I are crazy about a little boy that lives across the street from us. He often comes over to see my wife and spends the afternoon playing. Once when he was eating dinner with us a couple of years ago, the conversation steered to what he was doing in school. He announced proudly that he was a grade ahead in math. "Not only can I do subtraction," he stated, "but I can subtract a bigger number from a smaller number!"

Now being a professor, I recognized that this might be a "teachable moment." So I replied, "Aha! So you must know about negative numbers." He nodded confidently. "And if you know about negative numbers, you must also know about the number line." He nodded again.

I pointed to a seam in the table where two leaves came together: "Suppose this is the number line with zero here. To the right I have positive numbers, and to the left I have negative numbers, right?" He agreed. "So what happens if I start at zero and go straight up?" I asked. He looked at me with a puzzled expression on his face, so after a moment I declared with some excitement and enthusiasm: "If I go straight up from zero, I get imaginary numbers!"

At this, he studied my face carefully, not entirely sure if I was serious or just pulling his leg. After a moment, he turned to my wife and asked, "Ms Kathy, are imaginary numbers real?" Since my wife was caught a bit off-guard by this question, I chimed in to further clarify: "Of course they're not real—they're imaginary!"

Now it's not clear whether this conversation had the effect of encouraging his interest in math or not. However, it is a reminder that most of us who ended up as engineers, had conversations with parents, teachers, or role models somewhere along the line that encouraged our interests.

I know that many of you have already started to look for opportunities to give back and encourage others who are at earlier stages of their adventure, and I encourage all of you to look for such opportunities.

Someone who spent a career teaching and mentoring was Dr. Bob Trew, a distinguished professor in our department. Shortly after retiring in December, Professor Trew passed away earlier this year after a brief illness. Among many significant accomplishments over his career, he served as the Electrical and Computer Engineering Department Head at three major universities, including NC State. During this time he taught and mentored a number of students and colleagues, many of whom attended his celebration of life and shared their memories and his impact on their paths.

Hearing about what is going on in the lives and careers of our former students is one of the most enjoyable aspects of being at a university. This is why we are endeavoring to reconnect with alumni around the world and share their stories to inspire the next generation of engineers and thought-leaders. In this spirit, I hope you enjoy some of the exciting accomplishments of our alumni as well as our students and faculty highlighted in this issue of the Spotlight.

Dr. Daniel D. Stancil
ECE Department Head

#6

Best Value among Public Universities Nationally

according to US News & World Report 2019

23

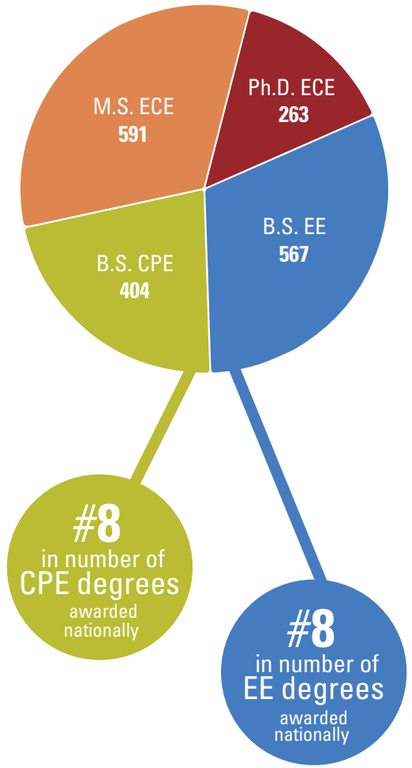
National Science Foundation CAREER Award Recipients

61

Tenured and Tenure-Track Faculty

Total ECE Enrollment by Degree for 2018

According to ASEE 2019



#8

University in the U.S. to study Electrical Engineering

according to ShanghaiRanking's Global Ranking 2019

Centennial Celebration Events

As the department's 100th anniversary came to a close, two landmark events were held, looking forward to the future of the department, as well as the future of electrical and computer engineering itself.

Forum on Broadening Participating in Engineering

Experts from all corners of engineering education came together at NC State University on September 6, 2018 to discuss the challenges and solutions for finding ways to broaden participation in engineering to underrepresented groups.

"This forum addresses a continuing challenge for ECE: the demographics of our Department are very different from those of the State that we serve," explained **Daniel Stancil**, department head of ECE at NC State. "As an example, although African Americans make up almost ¼ of the population of North Carolina, less than 5% of our undergraduate students identify themselves as African American. Consequently, broadening the participation in our Department will help us better serve the citizens of the state, and will also bring fresh perspectives to ECE—enhancing our success."

Following a welcome by Chancellor Woodson of NC State, an opening keynote by Dr. Harold Martin, the Chancellor of North Carolina A&T State University, dove into the long history of historically black colleges and universities (HBCUs) in North Carolina, and followed the journey that NC A&T has taken since its founding, tracking the challenges they have overcome.

"There is so much to do, and so much opportunity," summed up Martin. "Conversations like these are always inspiring to me, so I think we have to be clear about what we're trying to accomplish, how we're trying to ensure that all have an opportunity to be included in the conversations, to benefit from the educational opportunities, and then the opportunities that will be able to be afforded to them following graduation."

The Forum continued with an enlightening panel discussion featuring Dr. Clay Gloster, Jr, the Interim Vice Provost for Research, Graduate Programs and Extended Learning at North Carolina A&T State University; Dr. Elebeoba E. May, Program Director, Molecular & Cellular Biosciences (BIO/MCB) at the National Science Foundation; Dr. Manuel Pérez-Quiñones, Associate Dean of the College of Computing and Informatics at the University of North Carolina, Charlotte; Dr. Renetta Tull, Special Assistant to the Sr. Vice Chancellor for Academic Affairs at the University System of Maryland; and Dr. Iris R. Wagstaff, STEM Program Director for the American Association for the Advancement of Science.

Moderated by Dr. Christine Grant, the associate dean for faculty advancement in the College of Engineering at NC State, the panel tackled questions ranging from the impact of research faculty's engagement of underrepresented students to the impacts of culture in engineering.

Future of ECE Symposium

The Future of ECE symposium was held at James B. Hunt, Jr. Library on November 9, 2018, and was a day full of special guests discussing the future of electrical and computer engineering and the evolution of future groundbreaking technologies.

The symposium kicked off with Dr. Ted Rappaport, director, NYU WIRELESS and David Lee/Ernest Weber Professor of Electrical Engineering, Tandon School of Engineering, New York University, speaking on wireless communications: past, present, and future, specifically taking a look at the future of ECE in wireless communications 50-100 years from now.

Following the symposium was a panel with special guests Dr. Ali Khatibzadeh, President & CEO of LUMEOVA, Mr. Gregg Lowe, President and CEO of Cree, Inc., Mr. Scott Moody, Co-Founder, CEO and Chief Member Advocate of K4Connect, and Ms. Lisa Smith, Engineering Manager for Spreedly, and founding Director of Women Who Code Raleigh-Durham.

Each spoke about future innovations, and then took questions and debated amongst themselves over what the future holds for electrical and computer engineers.

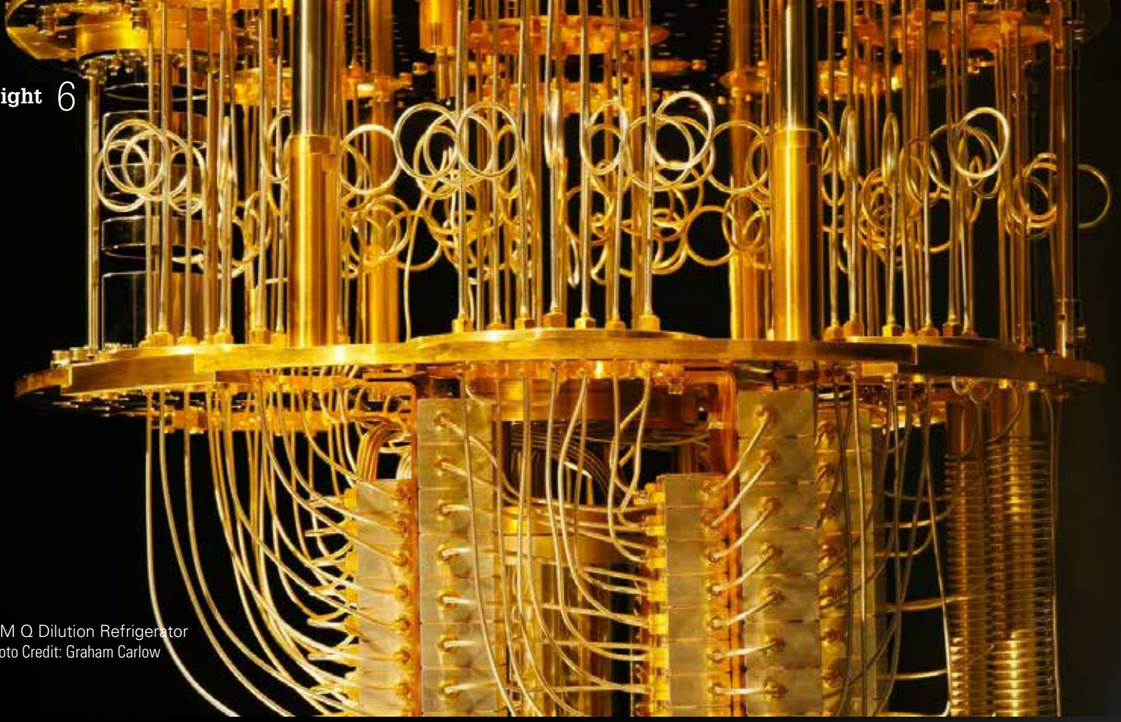
Next, Dr. Marija Ilic, Professor Emeritus at Carnegie Mellon University, spoke about the future of electric power grids and their challenges.

Dr. Dario Gil, Vice President of AI at IBM, discussed what AI and quantum computing is, what it went through in the past, and where it's going in the future.

The Future of ECE symposium ended on a high note with Dean Kamen, inventor, entrepreneur and founder of FIRST, who spoke about the future of engineering and technology. With over two hundred FIRST robotics students from high schools around the state in attendance, Kamen provided experienced inspiration for the future engineers who might one day grace the halls of Engineering Building II.

In addition to the audience in the room, the entire symposium was broadcast live to an audience around the world.

Take a look at **go.ncsu.edu/future-of-ece**



IBM Q Dilution Refrigerator
Photo Credit: Graham Carlow

NC State Queues up to Advance Quantum Computing

Essential as they are, traditional computers — the laptops and desktops most of us use — rely on a language that doesn't always translate to the real-world problems they help us solve.

That realization, reached by famed physicist Richard Feynman in the 1980s, launched a quantum computing movement that has made its way to NC State. In May 2018, IBM announced that NC State would be the first North American university to host one of its Q Hubs for quantum computing.

The IBM Q Network provides early access to IBM's quantum computing systems, with the goal of exploring practical applications important to business and science. Starting last fall, NC State gained access to IBM Q commercial quantum computing devices, including the most advanced and scalable universal systems available. The Network provides access to 20 and 53 qubit IBM Q systems.

Daniel Stancil, Alcoa Distinguished Professor and head of NC State's Department of Electrical and Computer Engineering, was appointed executive director of the hub, and Patrick Dreher, research professor in the Department of Computer Science and associate faculty member in the Department of Physics, is the hub's chief scientist.

As executive director, Stancil oversees the hub's strategic operations, including partnerships with industry, government and other universities. Dreher is identifying strategic research opportunities for quantum computing at NC State and guiding the development of curriculum and education programs. Stancil and Dreher also work closely with the hub's steering and research and education advisory committees.

"Dr. Stancil has vast experience leading complex interdisciplinary initiatives within research universities," said Dennis Kekas, associate vice chancellor for partnerships and economic development, and Q Hub steering committee member. "He is a great fit to oversee the development of the IBM Q Hub at NC State."

> "Quantum computing is a subject that's not going to go away," said Dreher. "And we believe this is a game changer in terms of putting NC State in a leadership position in the interdisciplinary development of it."

Binary code is the common language of the digital world. Modern computers (and their predecessors dating to the 1940s) speak that common language. Developers write in a range of programming languages, but compiling software translates all of them back into 1s and 0s

But the interactions that shape the real world — such as bonding among chemical molecules — are governed by the rules of quantum mechanics. Quantum computing emerged, Dreher said, from the idea that machines designed and built with quantum mechanical principles would more effectively solve such problems.

"The laws of quantum mechanics operate very differently from the everyday world you and I live in," Dreher said. "In the atomic and subatomic world governed by quantum mechanics, one sees some behaviors that are not normally observed in our everyday. Some of these behaviors are incorporated as part of the operation of a quantum computer."

With the IBM Q Network, the company is bringing together partners from the corporate world, academia, and national labs around the world. Their aim is to develop a universal quantum computing system and put it in the hands of people who can find ways to apply it to practical problems.

"Academic collaborations are essential to growing the quantum computing community as we look to discover practical quantum applications and drive business and scientific breakthroughs," said Bob Sutor, vice president of IBM Q Strategy and Ecosystem, IBM Research. "Building on a 30-year research and education partnership, NC State will play a key role in helping IBM continue to extend our quantum computing ecosystem."

Hub status gives the university access to advances developing across that wide ecosystem. While NC State is home to the only academic Q Hub in North America, the network includes nodes at the universities of Melbourne (Australia) and Oxford (Great Britain), Bundeswehr University (Germany), and Keio University in Tokyo. And those universities are part of a larger, global web that includes Fortune 500 companies and national research labs.

"We're already putting together and teaming up to combine the powers of the hubs to tackle some of the most difficult problems in quantum computing that we know today," Dreher said.

IBM and NC State announced the Q Hub in spring 2018. Since then, more than 50 faculty and students have become a part of it. There's also been a flurry of activity focused on developing an interdisciplinary academic program around quantum computing. Three special topics courses launched in the Department of Electrical and Computer Engineering last year, and a council composed of math, physics, chemistry, ECE, computer science, and business faculty is exploring other research and education applications.

Recruitment for other corporate partners is also underway. Stancil's goal over the next few years is to have a "really active, vibrant" community of industrial partners and scholars finding ways to apply quantum computing to their fields. Finance, chemistry, physics, and information technology are all ripe for quantum computing approaches.

> "Interest in industries and startups is growing, and we anticipate there will be a significant talent shortage," Stancil said. "That's one reason that we think it's important for us to be out in front."

That robust community will be a boon to the NC State students who will develop the next generation of quantum computing.

Distinguished Chair in Quantum Computing

We are pleased to announce an endowed Distinguished Chair in Quantum Computing, a faculty position that will hold tenure in the Department of Electrical and Computer Engineering, and will be a key leader in the growing quantum computing community at the university.

NC State researchers have already begun investigating how quantum systems can greatly speed machine learning techniques for training artificial intelligence systems and performing highly complex molecular modeling, which is crucial to the discovery of new chemical compounds and, eventually, new types of materials, medicines, and other breakthroughs.

For more information, visit **quantum.ncsu.edu** or contact **quantumcomputing@ncsu.edu**.

NSF Activates AERPAW Platform for Advanced Wireless

Fifth generation (5G) wireless networks hold the promise to be as much as 10 times more efficient than current 4G networks, with faster speeds and higher capacity to support many more data connections than previously possible.

To ensure the nation's leadership in 5G, the National Science Foundation (NSF) and an industry consortium have invested $100 million over the next seven years to build specialized wireless networks for U.S. researchers to test new ways of increasing wireless speed and capacity.

Last year, New York City and Salt Lake City were the first cities to receive funding under the NSF Platforms for Advanced Wireless Research (PAWR) initiative.

North Carolina's Research Triangle region has been selected to host the third of these wireless platforms.

"The platform will enable significant research into the wireless communications capabilities necessary for autonomous drone and mobility systems," says Erwin Gianchandani, NSF acting assistant director for computer and information science and engineering. "By enabling experiments that consider three-dimensional, highly mobile and diverse scenarios, AERPAW will be critically important for enhancing wireless networking capabilities in our communities, and for furthering the development of innovative new applications that will improve civic services and citizen safety."

> The $24 million grant over five years is called Aerial Experimentation Research Platform for Advanced Wireless, or AERPAW.

North Carolina State University will lead research for the newest regional research platform. **Ismail Guvenc**, associate professor of electrical and computer engineering, is the primary investigator (PI) on the project. Co-PIs on the project are: Rudra Dutta, professor and interim associate head of computer science; **Brian Floyd**, professor of electrical and computer engineering; **Mihail Sichitiu**, professor of electrical and computer engineering; and Thomas Zajkowski, flight operations manager, Institute for Transportation and Research Education.

NC State will work closely with the Wireless Research Center in Wake Forest, researchers at Mississippi State University, the Renaissance Computing Institute (RENCI) at the University of North Carolina at Chapel Hill, Purdue University and the University of South Carolina, as well as local partners including the Town of Cary, City of Raleigh and N.C. Department of Transportation to deploy the technology.

It should be noted that Robert Moorhead (M.S. 1982; Ph.D. 1985), the Billie J. Ball Professor of electrical and computer engineering at Mississippi State—and one of the key team members of AERPAW—was inducted into the NC State ECE Alumni Hall of Fame in 2018.

"NC State is committed to groundbreaking research that benefits our communities," says Chancellor Randy Woodson. "We're excited to work with our public and private partners to advance wireless communications and drone interaction."

The platforms are designed to accelerate the development and commercialization of promising technologies, ensuring continued U.S. leadership in wireless communications, while also preparing the next-generation workforce for new job opportunities.

"On the AERPAW platform, drones and 5G are integrated to be mutually beneficial," says NC State Vice Chancellor for Information Technology Marc Hoit. "Drones are supporting 5G by providing increased coverage and connectivity; and 5G is supporting drones by providing improved signals and location data."

On today's networks, fixed nodes enable 4G signals to connect to wireless devices. On the AERPAW platform, nodes will be mobile, with the ability to transmit and receive radio waves from user devices while moving on demand. For example, in the aftermath of a natural disaster such as a hurricane, existing cellular networks may be damaged. As a result, aerial base stations can position themselves to provide the best wireless coverage to victims and first responders who would otherwise have no cellular connectivity.

> "Drones are not the only mobile nodes," adds Guvenc, "NC State researchers will also be putting 5G equipment on cars, buses, golf carts and rovers for vehicle-to-vehicle communications, which will support autonomous driving and accident reduction."

The platform also has the potential to help pilots fly drones beyond line of sight, allowing for improved air traffic control under FAA regulations.

Other potential impacts to citizens include:

- Safe package delivery for healthcare (like defibrillators and blood), as well as commercial products;
- Smart agriculture applications where drones can collect data from a variety of smart sensors on a farm.

"This announcement builds on the existing engineering and information technology sectors, reflecting the strength of our workforce, and creating truly unique opportunities for Raleigh and NC State," says Raleigh Mayor Nancy McFarlane.

> "As Mayor, I am both proud and humbled that our City will participate in the first of this kind of research, working together to develop the technologies of the future at NC State."

"Cary is proud to partner with so many innovation leaders in this effort," says Cary Mayor Harold Weinbrecht. "5G technology has amazing potential to help Cary improve services and public safety for our citizens. As a smart and connected community, we also understand the impact this technology will have beyond our region, and we're honored to have a role in its development."

The Wireless Research Center (WRC), based in Wake Forest, N.C., will help manage the deployment of AERPAW's wireless testbed, including supporting operation and maintenance. The center advances communications technology for companies worldwide with unique capabilities for applied research, engineering and certified testing. The WRC's Regional Internet of Things (RIoT) initiative will provide AERPAW users with access to one of the nation's largest communities of IoT technology solution providers and entrepreneurs.

The economic impact of 5G is expected to be significant, too. As a result of leadership in 4G, the U.S. increased GDP in 2016 by $100 billion, creating more jobs and lowering consumer costs. 5G promises an even larger impact, as the technology is predicted to enable more than $12 trillion in global economic output by 2035, based on data from IHS Markit.

AERPAW is expected to be operational in fall 2020.

For more information, visit **aerpaw.org**

Overcoming Key Obstacles to Scaling DNA Data Storage

Researchers from NC State have developed new techniques for labeling and retrieving data files in DNA-based information storage systems, addressing two of the key obstacles to widespread adoption of DNA data storage technologies.

"DNA systems are attractive because of their potential information storage density; they could theoretically store a billion times the amount of data stored in a conventional electronic device of comparable size," says **James Tuck**, co-corresponding author of a paper on the work and professor of electrical and computer engineering at NC State.

> "But two of the big challenges here are, how do you identify the strands of DNA that contain the file you are looking for? And once you identify those strands, how do you remove them so that they can be read – and do so without destroying the strands?"

"Previous work had come up with a system that appends short, 20-monomer long sequences of DNA called primer-binding sequences to the ends of DNA strands that are storing information," says Albert Keung, co-corresponding author of the paper and an assistant professor of chemical and biomolecular engineering at NC State. "You could use a small DNA primer that matches the corresponding primer-binding sequence to identify the appropriate strands that comprise your desired file. However, there are only an estimated 30,000 of these binding sequences available, which is insufficient for practical use."

To address these problems, the researchers developed two techniques that, taken together, they call DNA Enrichment and Nested Separation, or DENSe.

The researchers tackled the file identification challenge by using two, nested primer-binding sequences. The system first identifies all of the strands containing the initial binder sequence. It then conducts a second "search" of that subset of strands to single out those strands that contain the second binder sequence.

> "This increases the number of estimated file names from approximately 30,000 to approximately 900 million," Tuck says.

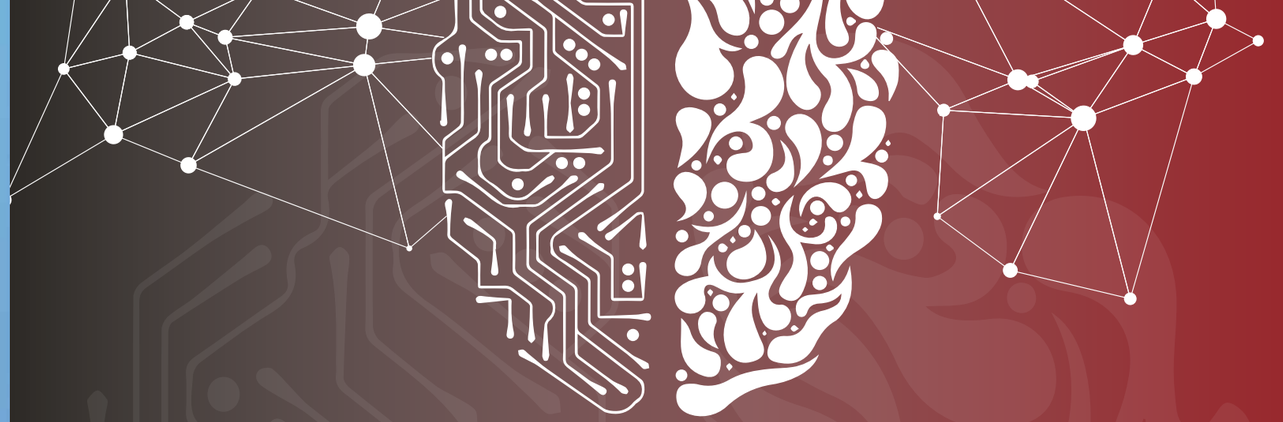
Once identified, the file still needs to be extracted. Existing techniques use polymerase chain reaction (PCR) to make lots (and lots) of copies of the relevant DNA strands, then sequence the entire sample. Because there are so many copies of the targeted DNA strands, their signal overwhelms the rest of the strands in the sample, making it possible to identify the targeted DNA sequence and read the file.

However, that technique lacks efficiency and fails in a high-capacity database due to sheer quantities of DNA.

So the researchers took a different approach to data retrieval, attaching any of several small molecular tags to the primers being used to identify targeted DNA strands. When the primer finds the targeted DNA, it uses PCR to make a copy of the relevant DNA – and the copy is attached to the molecular tag.

"We've implemented the DENSe system experimentally using sample files, and have demonstrated that it can be used to store and retrieve text and image files," Keung adds.

"Next steps include scaling this up and testing the DENSe approach with larger databases," Tuck says. "A big challenge there is cost."



Framework Improves Performance of Deep Neural Networks

NC State researchers have developed a new framework for building deep neural networks via grammar-guided network generators. In experimental testing, the new networks – called AOGNets – have outperformed existing state-of-the-art frameworks, including the widely-used ResNet and DenseNet systems, in visual recognition tasks.

"AOGNets have better prediction accuracy than any of the networks we've compared it to," says **Tianfu Wu**, an assistant professor of electrical and computer engineering at NC State and corresponding author of a paper on the work. "AOGNets are also more interpretable, meaning users can see how the system reaches its conclusions."

The new framework uses a compositional grammar approach to system architecture that draws on best practices from previous network systems to more effectively extract useful information from raw data.

> "We found that hierarchical and compositional grammar gave us a simple, elegant way to unify the approaches taken by previous system architectures, and to our best knowledge, it is the first work that makes use of grammar for network generation," Wu says.

To test their new framework, the researchers developed AOGNets and tested them against three image classification benchmarks: CIFAR-10, CIFAR-100 and ImageNet-1K.

"AOGNets obtained significantly better performance than all of the state-of-the-art networks under fair comparisons, including ResNets, DenseNets, ResNeXts and DualPathNets," Wu says. "AOGNets also obtained the best model interpretability score using the network dissection metric in ImageNet. AOGNets further show great potential in adversarial defense and platform-agnostic deployment (mobile vs cloud)."

The researchers also tested the performance of AOGNets in object detection and instance semantic segmentation, on the Microsoft COCO benchmark, using the vanilla Mask R-CNN system.

"AOGNets obtained better results than the ResNet and ResNeXt backbones with smaller model sizes and similar or slightly better inference time," Wu says. "The results show the effectiveness of AOGNets learning better features in object detection and segmentation tasks.

These tests are relevant because image classification is one of the core basic tasks in visual recognition, and ImageNet is the standard large-scale classification benchmark. Similarly, object detection and segmentation are two core high-level vision tasks, and MS-COCO is one of the most widely used benchmarks.

> "To evaluate new network architectures for deep learning in visual recognition, they are the golden testbeds," Wu says.

"AOGNets are developed under a principled grammar framework and obtain significant improvement in both ImageNet and MS-COCO, thus showing potentially broad and deep impacts for representation learning in numerous practical applications."

"We're excited about the grammar-guided AOGNet framework, and are exploring its performance in other deep learning applications, such as deep natural language understanding, deep generative learning and deep reinforcement learning," Wu says.

FREEDM Researchers Work on Grid Resilience Tools

Researchers in the FREEDM Systems Center led by NC State have received a $3.1 million research award from the U.S. Department of Energy Solar Energy Technologies Office (SETO) to advance solar energy's role in strengthening the resilience of the U.S. electricity grid.

The project will develop a Photovoltaic (PV) Analysis and Response Support (PARS) platform to provide real-time situational awareness and optimal response plan selection for electric utilities.

Grid management is becoming more complex with the addition of distributed renewable energy resources, and electric utilities require new tools to optimize a more complex system. In addition, extreme weather events and malicious cyber attacks are becoming more frequent. PARS will allow hybrid PV systems to operate similarly to conventional generation resources in terms of visibility, dispatchability, security, and reliability.

A team of researchers and faculty members from FREEDM will partner with the NC Cleantech Center, Pacific Northwest Laboratory, OPAL-RT Corporation, Strata Solar, New York Power Authority, ElectriCities of North Carolina, and Wilson Energy and Roanoke Electric Cooperative to develop grid management tools to enhance power system resilience.

"PARS can be used to develop optimal response plans for hybrid PV systems located at the transmission or distribution levels," says **Ning Lu**, principal investigator for the project and professor of electrical and computer engineering at NC State. "And when running off-line using historical data, it will be a planning tool to design and test PV-based grid support functions and perform cost-benefit studies."

PARS will use a new approach to complex grid management by linking steady state and dynamic elements together and performing real-time simulations and faster-than-real-time simulations in the same environment. The platform will also incorporate PV systems at any level of the grid in both normal and emergency operating scenarios.

The team will develop and deploy several tools on the PARS platform, including:

- An operations modeling tool that will incorporate new grid support functions;
- A model parameterization tool to update power grid operation models;
- A real-time situational awareness tool;
- An optimal response tool that incorporates distributed energy resources like PV and customer storage; and
- A cost-benefit tool for addressing the value proposition of the newly developed grid support functions.

Linking these tools creates a seamless interface for users with multiple benefits.

> The real-time situational awareness that includes prediction of future operation allows for early detection of anomalous behavior like that seen during a cyber attack.

Optimal response selection allows utilities to include distributed resources to participate in grid restoration.

"The goal here is to give utility operators better insight into grid operations and optimize performance under normal and abnormal conditions," says Lu.

> "We're excited to get started and believe our unique approach will address multiple problems utilities are facing today and lead to more PV systems connected to the grid."

Lu's research interests include load modeling and control, wide-area energy storage, renewable integration, predictive defense modeling of the smart grid and climate change impacts on power grids. She previously worked at Pacific Northwest National Lab and Shenyang Electric Power Survey and Design Institute. She currently supervises ECE's GridWrx Lab, housed within the FREEDM Center.

Additional project team members include **Mesut Baran**, **David Lubkeman** and **Wenyuan Tang**—professor, research professor, and assistant professor of electrical and computer engineering respectively.

The Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Engineering Research Center at NC State University was created in 2008 through a grant from the National Science Foundation. FREEDM partners with universities and industry to develop technologies that build a more secure, sustainable and intelligent electric grid.

Using Power Anomalies to ID Malware

Researchers from NC State and the University of Texas at Austin have developed a technique for detecting types of malware that use a system's architecture to thwart traditional security measures. The new detection approach works by tracking power fluctuations in embedded systems.

"Embedded systems are basically any computer that doesn't have a physical keyboard – from smartphones to Internet of Things devices," says **Aydin Aysu**, co-author of a paper on the work and an assistant professor of electrical and computer engineering at NC State.

> "Embedded systems are used in everything from the voice-activated virtual assistants in our homes to industrial control systems like those used in power plants. And malware that targets those systems can be used to seize control of these systems or to steal information."

At issue are so-called micro-architectural attacks. This form of malware makes use of a system's architectural design, effectively hijacking the hardware in a way that gives outside users control of the system and access to its data. Spectre and Meltdown are high-profile examples of micro-architectural malware.

"The nature of micro-architectural attacks makes them very difficult to detect – but we have found a way to detect them," Aysu says. "We have a good idea of what power consumption looks like when embedded systems are operating normally. By looking for anomalies in power consumption, we can tell that there is malware in a system – even if we can't identify the malware directly."

The power-monitoring solution can be incorporated into smart batteries for use with new embedded systems technologies. New "plug and play" hardware would be needed to apply the detection tool with existing embedded systems.

There is one other limitation: the new detection technique relies on an embedded system's power reporting. In lab testing, researchers found that – in some instances – the power monitoring detection tool could be fooled if the malware modifies its activity to mimic "normal" power usage patterns.

"However, even in these instances our technique provides an advantage," Aysu says. "We found that the effort required to mimic normal power consumption and evade detection forced malware to slow down its data transfer rate by between 86 and 97 percent. In short, our approach can still reduce the effects of malware, even in those few instances where the malware is not detected.

Leveraging Strengths to Improve Asthma Care

Edgar Lobaton, associate professor and **Alper Bozkurt,** professor in the Department of Electrical and Computer Engineering, are working to improve wearable health-monitoring devices, on a research project that could lead to people being able to detect an asthma attack sooner. Lobaton, along with two UNC researchers, will receive $1 million from the National Science Foundation for their collaborative project, "A Data-Driven Approach to Enhancing Wearable Device Performance – An Early Asthma Exacerbation Detection Study."

> "What makes this project unique is that we're focusing specifically on trying to identify when we have good signals from these types of wearable devices," Lobaton says.

Using data collected from the devices, the team will employ machine learning "to automatically learn when we can rely on these signals" to make an accurate prediction about an asthma exacerbation (commonly known as an asthma attack).

Lobaton, who won an NSF CAREER award in 2016, says the greatest value he brings to the project is his expertise and prior research in signal processing — using signals (data from a device) to create algorithms for making predictions.

Lobaton and Bozkurt met Michelle Hernandez, an associate professor in the UNC School of Medicine and Delesha Carpenter, an associate professor in the UNC Eshelman School of Pharmacy through an earlier collaboration between NC State's Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) and UNC, which evolved into this current project. It was during the earlier project that Bozkurt, who is also a 2016 recipient of the CAREER award, used equipment at ASSIST to develop the devices that will be used for this project.

"Our goal was to design a wearable system that could track the wellness of the subjects and in particular provide the infrastructure to predict asthma attacks, so that the users could take steps to prevent them by changing their activities or environment," described Bozkurt.

However, the roots for this project can be further traced back to 2012, when Hernandez worked with ASSIST through an NC TraCS grant that aimed to develop technology and tools for helping people manage their asthma care better and have fewer asthma attacks.

According to the American College of Allergy, Asthma and Immunology, asthma attacks — inflammation and obstruction of the bronchial tubes, which make it extremely difficult to breathe — can be caused by a variety of often invisible triggers wafting through the air, from pollen to perfume. Certain illnesses and strenuous exercise can also be triggers.

Edgar Lobaton, associate professor of electrical and computer engineering at NC State.
Photo Credit: Charles Hall

The ability to quickly identify an asthma attack is crucial to effective treatment for the quarter-billion Americans with asthma. And each day, asthma is responsible for roughly 10 deaths in the U.S. — most of which could be avoided with proper treatment and care.

Wearable technology has the potential to transform human healthcare, allowing people to constantly monitor their bodies to degrees once unimaginable. And it's become common for young adults to use mobile, wearable devices — such as an Apple Watch or FitBit — to monitor their health. But for wearable devices to one day be able to accurately predict an event such as an asthma attack, the data they use must first be proven to be reliable. If someone is relying on a device to anticipate an asthma attack, inaccuracy could have serious consequences.

Lobaton says that, as it stands, these kinds of wearable devices generally do well under ideal conditions, like when they're firmly secured and the wearer is sitting down. But when, for instance, someone starts running and sweat loosens this firm grip, "then all of a sudden, you start getting very erroneous measurements."

> "The quality of the signal from the device depends not only on the device itself, but also how you're using it, where you're using it, and under what conditions," Lobaton says.

That's why Lobaton hopes this research will also lead to the ability to "give feedback to the actual device itself." For example, if a device is not getting good signals due to reduced power consumption, the device could then recognize that and temporarily increase power consumption.

"And that's where having access to the prototype, where we can actually change some of those parameters, will be very useful," Lobaton says. "So we can automatically, for the next generation of sensors, learn from this data without having to rely too much on long cycles of observation."

For this project, the research team will collect and analyze both physiological and behavioral data. To collect this data, Lobaton says they'll likely use a small device placed on someone's wrist or chest as well as a slightly larger device worn on the hip.

> The device on the wrist or chest will monitor things such as heart rate and motion, while the one on the hip will collect data about environmental factors such as air pollution.

Taking all these different types of factors into account, the team will determine whether it's possible to create an algorithm that accurately predicts an impending asthma attack. Hernandez and Carpenter will also use the data to assess young adults' preferences for using wearable devices to monitor their asthma in the long term.

Alper Bozkurt, professor of electrical and computer engineering at NC State.
Photo Credit: Marc Hall

Through an ecosystem of multidisciplinary researchers, practitioners, students, and industry partners, we are advancing tomorrow's leading-edge technologies and are bringing highly-skilled talent into the marketplace.

Through our signature Translational Engineering Skills Program (TESP), **ASSIST** holds workshops to ensure that their graduates go beyond the traditional curriculum. They study important skills, like patent mining, systems thinking, market research, and scientific public speaking and presentation skills.

For more information, visit **assistcenter.org**

Researchers Create Multi-Junction Solar Cells from Off-the-Shelf Components

Multi-junction solar cells are both the most efficient type of solar cell on the market today and the most expensive type of solar cell to produce. In a proof-of-concept paper, researchers from NC State ECE detail a new approach for creating multi-junction solar cells using off-the-shelf components, resulting in lower cost, high-efficiency solar cells for use in multiple applications.

Multi-junction, or stacked, solar cells are currently the most efficient cells on the market, converting up to 45% of the solar energy they absorb into electricity. The cells are constructed by stacking semiconductors with varying bandgaps on top of one another, thereby allowing the cell to absorb differing wavelengths of solar radiation. However, these cells are much more expensive to produce than less efficient thin solar films.

"We want to create high efficiency solar cells at a reasonable cost," says **Salah Bedair**, Distinguished Professor of Electrical and Computer Engineering at NC State and lead author of the research.

> "Silicon-based thin solar cells are very popular because the material has around 20% efficiency and the cells cost about 1/10th what a multi-junction solar cell costs."

"And other low cost, lower efficiency materials are gaining popularity as well. If we could create stacked solar cells using this existing technology we would be well on our way to reaching our goal."

However, you cannot merely stack different solar cells on top of each other – the different materials are structurally incompatible, and so charges cannot pass through them to be collected. To solve that problem in current multi-junction solar cells, heavily doped metals are used to create a tunnel junction between the various layers – adding significant expense and complexity to the multi-junction solar cell's creation.

Bedair and his team developed a simpler approach, utilizing intermetallic bonding to bond solar cells made of different materials. In a proof-of-concept, the team stacked an off-the-shelf gallium arsenide solar cell on top of a silicon solar cell.

"In multi-junction solar cells, the tunnel junction enables electric connectivity by acting as a metal-to-metal connection," Bedair says. "In our system, indium serves as a shortcut to that. The existing metal contacts of the individual cells are covered with indium films. The indium films bond to themselves easily at room temperature under low pressure. The result is a solar cell made of two different materials that is mechanically stacked and electrically connected.

"With this technique we are able to take advantage of inexpensive, off-the-shelf solutions without having to develop all new technology. Manufacturers could simply tweak their existing products slightly to increase their efficiency in multi-junction solar cells, rather than having to create new products."

Intelligent Framework Aims To Optimize Data Transfer in 5G Networks

An NC State researcher has developed technology designed to allow cellular communication nodes in 5G systems to partition bandwidth more efficiently in order to improve end-to-end data transmission rates. In simulations, the tech is capable of meeting the international goal of 10 gigabits per second in peak performance areas.

"End-to-end transfer means that the technology accounts for all of the connections between a data source and the end user," says **Shih-Chun Lin**, an assistant professor of electrical and computer engineering at NC State and author of a paper on the work.

"My technology, incorporating both hardware and software, is a framework that takes into account data transfer rates, wired and wireless bandwidth availability, and the power of base stations – or eNodeBs – in a 5G network," Lin says. "It then uses stochastic optimization modeling to determine the most efficient means of transferring and retrieving data – and it does this very quickly, without using a lot of computing power."

Lin says that simulation testing of the framework is promising, and he and his research team are in the process of building a fully functional prototype.

"The prototype will allow us to conduct tests on a 5G testbed platform, since full-scale 5G networks are not yet online," Lin says.

> "Simulation results suggest that we'll be able to meet the 3GPP goal of 10 gigabits per second data transfer in peak coverage areas."

"We are currently seeking industry partners to work with us on developing, testing and deploying the framework to better characterize its performance prior to widespread adoption of 5G networks," Lin says.

New Study Demonstrates Radio Signal Benefits From Decades-Old Theory

Engineering researchers have demonstrated that a longstanding theoretical method called direct antenna modulation (DAM) has real-world utility for boosting the quality of radio signals when transmitting at high data rates. The finding has applications in fields such as military communications.

"You can always improve signal quality by using a larger antenna, but that's simply not practical for many wavelengths," says **Jacob Adams**, an assistant professor of electrical engineering at NC State and senior author of a paper on the work. "For example, antennas operating in the high-frequency range – 3 to 30 megahertz (MHz) – would be 5 meters long or longer. We've shown that DAM can improve signal quality dramatically when using much smaller antennas."

> "How much smaller can vary, but we've demonstrated the concept using antennas one-third the size of a conventional antenna for a given wavelength."

The DAM concept has been around for more than 50 years, and is essentially the idea that storing and releasing energy from the antenna at the right moments can reduce the amount of distortion in the resulting signal. However, researchers had not previously done a thorough comparison of conventional antennas to DAM antennas when transmitting at high frequencies.

Adams and his team used antennas that were just under 1 meter long to transmit at 27 MHz, and found stark differences in performance between the DAM transmitter and a conventional one.

"We focused on frequencies that are practical for communications technologies that operate beyond the line of sight but that are also typically limited by large antennas," Adams says. "And we found the DAM signal was still viable at data transmission rates where transmissions from the conventional antenna were simply indecipherable.

"We think this demonstrates the viability of DAM for use in practical technologies," Adams says. "We are currently working on ways to further improve the power handling of DAM devices and to offer more flexibility in terms of the types of modulations that can be generated with DAM."

Finding Out Why From Our Alumni

This year, the Department of Electrical and Computer Engineering invested in creating an Alumni Relations Position. As of early October, **Stefani Ashkinazy** was hired and is now leading the way in our goal of keeping alumni engaged in ways that we have not done before.

"Keeping alumni engaged and interested is an important factor for the success of the Electrical and Computer Engineering Program. Bringing alumni back to campus, having them engage with us on social media, attending socials are just a few ways I plan on helping to build ECE's Alumni Network. We want current students and even prospective students to know these alumni, not just to see the direct success of the program but to use as a resource. Networking is such an important aspect of life as many things come from who you know, not always what you know. Connecting with people in the same field as you is just as important to the success one will have after graduating."

Along with helping to coordinate events for engagement, Ashkinazy will be looking to create an Ambassador and Mentoring Program.

"The goal is to get more alumni engaged as early as possible. The earlier that they participate, the longer that they will stay engaged," explained Ashkinazy.

The Department has also been actively connecting with alumni at our key employers, showcasing these impressive graduates in an ongoing series of videos—Find Out Why From Our Alumni.

"We're talking to our alumni in industry and capturing their story," described Charles Hall, the Digital Communications Manager in the department.

"Why they got interested in electrical or computer engineering, why they chose NC State, why they came to their employer, and why they love what they do."

If you haven't already, connect with us on social media! We are in the process of revamping the LinkedIn NC State ECE Alumni & Students Group (**ece.ncsu.edu/linkedin**). We will be posting updates, invites and providing ways to stay connected.

Interested in being featured within our monthly newsletter or know someone that has a story to tell? Have an idea or want to see us somewhere specific, reach out to us at **ece-alumnus@ncsu.edu**.

Reasons to Stay Engaged

Stay updated on program information, growth and find out about ways you can connect!

NC State, the College of Engineering, ECE, and Raleigh are constantly going through changes. As our program grows and excels, we want you to know about it! Our successes are ultimately your successes and we want you to be the first to know.

Want to share your experiences? Talk to students about what to expect when they graduate? Share advice that you wish you were given when you were a student? By staying engaged with the program, you will be given opportunities to mentor and connect with current students or even other alums.

Networking opportunities abound!

Looking for a job? Looking to fill a position? What better place to start your search than through NC State connections. Stay engaged and connect with others to expand your network.

Networking opportunities may include both on and off-campus socials, corporate-sponsored events, on campus activities and sporting events, end-of-year celebrations, and speaker series.

"ECE provided applicable and marketable skills required in the field. ECE teaches the critical thinking and processes required to solve difficult problems across multiple disciplines.

Every night when we say our prayers, my daughters go through the list of who they love, and they always finish with "*Wolfpack OWWWW*". That pretty well sums up the pride I have in the Pack!"

Christopher Edge (B.S. EE 2012)
Project Leader, M.C. Dean, Inc.

NAVAIR FRC-East

We spent some time this summer talking to some of our amazing alumni working for NAVAIR Fleet Readiness Center East on Marine Corps Air Station Cherry Point in North Carolina. This diverse group of graduates are working outside typical ECE fields on helicopters and fixed wing aircraft, keeping America's warfighters safe and operational.

Take a look at **go.ncsu.edu/why-navair**

M.C. Dean, Inc.

We joined M.C. Dean in Virginia for their 70th Anniversary Tech Expo and got a chance to sit down with alumni who graduated everything from 5 months ago to over 30 years ago to find out what their lives are like as support engineers or as CEO.

Take a look at **go.ncsu.edu/why-mcdean**

Alumnus Named Ambassador to Botswana

NC State ECE alumnus Craig Lewis Cloud, who has had a decades-long career in foreign affairs, was named the U.S. ambassador to the Republic of Botswana.

Cloud earned his B.S. in electrical engineering from NC State in 1986. He credits his engineering degree in helping him get his start at the Foreign Service and calls himself "the ultimate accidental diplomat." In March, he presented his credentials to Botswana President Mokgweetski Masisi to complete the ambassador process.

Growing up in North Carolina, Cloud had an early interest in learning how things worked, often taking apart appliances and putting them back together. So for him, attending NC State for its engineering program was the best choice. With a desire to live abroad and work in foreign affairs, he applied for a security engineering officer (SEO) position at the State Department's Bureau of Diplomatic Security.

"I didn't even know what the Foreign Service was until I saw (the) job vacancy announcement," he said.

> "The analytical and troubleshooting skills I learned as a student at NC State can be applied to nearly any situation"

"Breaking down a complex system into its simplest constituent parts and testing whether the controlled inputs yield the expected output — and I utilize those same skills when I approach any problem," he said.

During his career, Cloud has served in senior leadership positions in Afghanistan, India, The Kingdom of eSwatini (formerly known as Swaziland) and the Democratic Republic of the Congo. He has also worked in Malawi, Zimbabwe, Russia, Argentina and Cote d'Ivoire, and speaks French and Spanish.

In his new position as ambassador, Cloud's primary role is to implement the United States' foreign policy and development goals in Botswana.

Irwin R. Holmes, Jr. and Chancellor Randy Woodson
Photo Credit: Matt Spivey

Holmes Hall Honors Groundbreaking ECE Alumnus

At a ceremony hosted by Chancellor Woodson and Dean of Engineering, Louis Martin-Vega, one of the Department of Electrical and Computer Engineering's distinguished alumni was honored with the dedication of Holmes Hall. Irwin R. Holmes, Jr. (B.S. EE 1960), who would go on to be involved in landmark pioneering computer projects before eventually retiring from IBM, was also notably the first African-American to receive an undergraduate degree from NC State.

"Irwin Holmes not only fulfilled his dreams at NC State; he boldly broke barriers that would forever change this university and the Atlantic Coast Conference," Woodson says. "He was, and will always remain, a role model that helped drive needed social and cultural change at NC State, in North Carolina and far beyond.

"We are proud to honor Irwin Holmes in perpetuity with this naming."

The three-story, 21,500-square-foot building was built in 2007. It is home to the Exploratory Studies program, Study Abroad, four classrooms and University Housing offices for Tucker, Owen, Turlington and Alexander residence halls.

As one of a handful of African-American students who took those first bold steps to desegregate universities in the South, Holmes helped to open the doors to generations of students in the years to follow. Leading by example, he graduated with his Bachelor of Science degree in four years—certainly not always a common occurrence at the time—while pursuing athletics and becoming the first athlete to integrate the Atlantic Coast Conference (ACC) in his senior year as co-captain of the tennis team.

> But as he expressed at the dedication ceremony on November 1, 2018, the questions of race and the pioneering steps of desegregation were not, to him, the main features of his time at NC State. Rather, the education he received and the support of his peers and faculty members that would set him onto his future careers were what stayed with him the most.

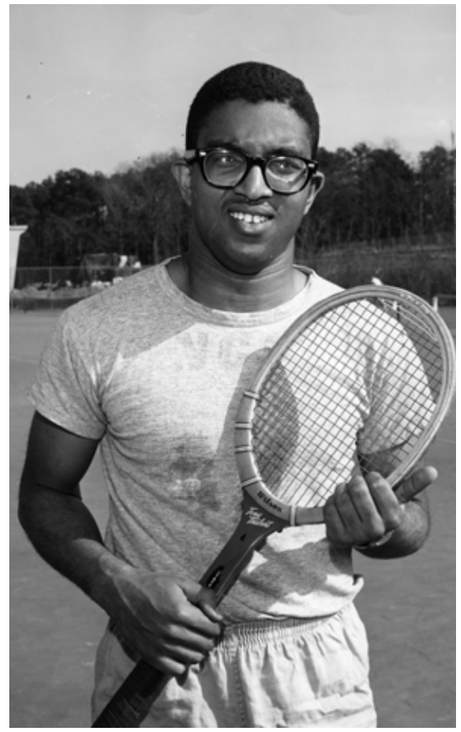
"The best person, as far as I'm concerned was a professor named William Stevenson," recalled Holmes, speaking of ECE Professor William D. Stevenson, Jr. who was on the faculty from 1944 to 1977. "He did two things: He encouraged me to interview with RCA when they came on campus for interviews. When I went to the interview, the guy said, "are you Irwin Holmes?" I said, "yes," and he said, "well, we're giving you a job." They sent me to Camden, New Jersey [and] Camden, New Jersey is where I found my wife. So I owed him double!"

> Holmes went on, "But the kinds of jobs I got with my N.C. State degree were just magical." He would go on to work with teams designing the first color television, a computer to provide vehicle and weapon guidance in a military tank, the airline reservation system for Trans World Airlines, and computer guidance systems that would put the first American in space.

"But the most interesting one was a computer that was used to develop something called—maybe you heard of it—Internet, I think it is. They didn't have any idea when we were doing that work, what the Internet was going to become," Holmes chuckled. "All it was supposed to be was a system that tied together some of the largest government computers, so they could communicate and use each other. Nobody ever expected that all of you guys out here would be using the Internet for things nobody had ever heard of."

"But through all of that, I can say none of that would have ever happened if we hadn't had an NC State professor that decided in my senior year to put in place a class to teach someone how to build and design a computer," Holmes described. "Until he did that, I had never heard of a computer, and I wasn't interested in a computer. But out of that, followed the rest of my career."

> "So you can see that I may have contributed something to NC State, but NC State contributed a whole lot to me and made me feel so honored today. It's almost icing on a cake for a special life that was put together by all these people whom we tend to forget about, that make NC State the special place it is."



Holmes, a nationally recognized junior tennis player while at Hillside High School, joined the NC State tennis team in 1957.

Christina H. Koch preparing for her second spacewalk.
Photo Credit: NASA

Making History Above Us

Christina Hammock Koch—a three-time graduate of NC State—blasted off for the International Space Station on March 14, 2019.

Koch, who grew up in Jacksonville, North Carolina, earned bachelor's degrees in electrical engineering and physics (2001), and a master's degree in electrical engineering (2002) from North Carolina State University.

Koch started her career as an electrical engineer focusing on space science instrument design at NASA's Goddard Space Flight Center in Greenbelt, Maryland. She went on to work as a research associate with the United States Antarctic Program, completing several deployments including spending the winter at the South Pole. She returned to space science instrument design at the Johns Hopkins University's Applied Physics Laboratory, contributing to such missions as the Juno probe to Jupiter. She then returned to her work at remote scientific research stations, including sessions as a field engineer in the Arctic and as station chief with the National Oceanic and Atmospheric Administration in American Samoa.

As a child, Koch dreamed of becoming an astronaut. A summer at Space Camp in Huntsville, Ala., reshaped her plan to get there. During an appearance at Talley Student Union in 2016, Koch recalled being shown a checklist of essential skills and experiences for a future astronaut.

"I thought that living your life according to a checklist wouldn't be worthy of someone who could have the responsibility to actually become an astronaut," she explained.

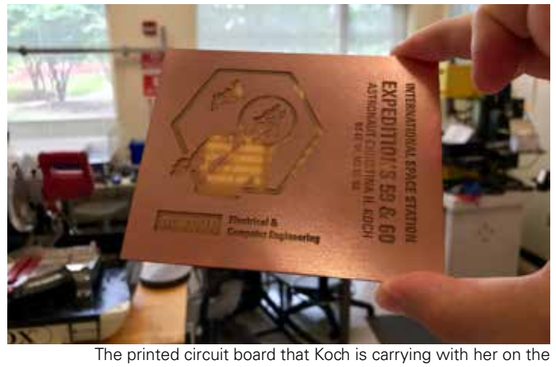
> "So I decided then and there to live my life according to my interests and passions. Down the road, if I looked at the experiences that I had gathered, and I thought that I really could contribute to the human spaceflight program as an astronaut, I would apply."

That philosophy led her to NC State and a diverse set of experiences. Some, like double-majoring in physics and electrical engineering or interning for a summer at NASA, checked the traditional boxes for future astronauts. Others, like being a staff photographer for the student newspaper or volunteering with social justice organizations, strayed outside those boxes. Through them all, Koch focused on the moment in front of her but kept a future in space travel in mind, and that dream is now about to become reality.

She took a few trinkets for the two state institutions where she received the bulk of her education before she entered the space program, the North Carolina School of Science and Math and NC State. From ECE, Koch carried a custom designed printed circuit board made in the ECE MakerSpace featuring an astronaut version of the "Circuit Wolf" icon. This will go on display outside the MakerSpace on her return to Earth.

> In a surprise appearance at the May 10, 2019 ECE Graduation Ceremony, Koch welcomed the 377 graduating students and their guests to the graduation ceremony via video from the space station, and urged the graduating students to follow their dreams.

Then, when NASA approved NC State's request to host a live downlink from the International Space Station with Koch on August 30, 2019, the university had just a few months to pull together an event that highlighted the science and wonder of space exploration — as well as the strengths in STEM education that helped one of its alums reach for the stars.



The printed circuit board that Koch is carrying with her on the International Space Station.
Photo Credit: Charles Hall

Teams from across NC State and the North Carolina School of Science and Mathematics came together to design an engaging and educational program around the 20-minute Q&A with Koch from the International Space Station.

The result was a cosmic success. Koch answered questions from students from both schools. Astrophysicist and science communication superstar Katie Mack spoke about her path to a successful career in science. A panel of engineers and physicists fielded questions about outer space. And clubs and organizations from both host schools shared interactive activities and demonstrations in the lobby of the Talley Student Union.

Watch at **go.ncsu.edu/nasa-downlink**

Welcome to Graduates

May 10, 2019

Hi everyone, and welcome to the NC State electrical and computer engineering graduation ceremony! My name is Christina Koch, a double alum from NC State ECE, and I'm greeting you from the International Space Station, flying 258 miles above Reynolds Coliseum.

First off, congratulations! This is an exciting moment to be sharing with you as you embark on the next phase of your journey. You'll be going on to pursue your dreams, break boundaries, take risks, and do the extraordinary. You're going on to a phase where, every time you tell someone that you majored in electrical engineering, their eyes get big, and you can tell that a part of them is in awe. And every time you tell them that you majored in computer engineering, their eyes get big and then they ask you if you can fix their laptop. But this is just the beginning. Now the world gets much bigger and much more open-ended—you get to start your own path.

My journey towards fulfilling my dream of being an astronaut was not an easy one, but following my passion, pushing the limits of my personal boundaries, and having the determination to do what scares me has paid off more than I could have hoped. I got to contribute to the program that I love so much by stepping out into the vastness of space on my first spacewalk, and by working on some of the coolest science experiments that test the limits of what is possible.

If I can share a single message with you, it's one that has propelled me on my dream of reaching space: don't think that there's just one way to accomplish your dreams, or a set of blocks you have to check through life. Live your life according to your interests and passions. Pursue what makes you happy and let that be the driving force which gives your life meaning. You'll be proud of achieving the things that scare you. You'll be proud of becoming the person you imagined yourself to be. You'll be proud of the people around you. And most importantly, you'll be proud to be a graduate of the Department of Electrical and Computer Engineering at NC State. Congratulations on reaching this point in your journey, and I can't wait to see what you accomplish.

Christina H. Koch

Watch at **go.ncsu.edu/christina-message**

2019 HALL OF FAME

The Department of Electrical and Computer Engineering at NC State University is proud to announce the 2019 inductees to the **ECE Alumni Hall of Fame**. The purpose of this extraordinary honor is to celebrate the accomplishments of our outstanding graduates who have used their education to excel in a profession, career, or service. Additionally, this recognition will serve as an inspiration for current students.

Our alumni are at the core of the Department, representing the agents and ambassadors that have made groundbreaking contributions in the study of electrical and computer engineering and beyond.

Learn more at **ece.ncsu.edu/HallOfFame**

Dr. Morris Chang
Professor
University of South Florida
M.S. EE 1986; Ph.D. CPE 1993

Dr. Clay Gloster, Jr.
Interim Dean, The Graduate College
North Carolina Agricultural and Technical State University
Ph.D. CPE 1993

Dr. William Gosney
Professor Emeritus
Southern Methodist University
B.S. EE 1964

Dr. Steven Hunter
Fellow (ret.)
IBM Corporation
M.S. EE 1988

Dr. William Joines
Professor
Duke University
B.S. EE 1959

Dr. Lloyd Massengill
Professor
Vanderbilt University
B.S. EE 1982; M.S. EE 1984; Ph.D. EE 1987

Dr. Ben Sloan
Executive Vice President and COO
FSI International
B.S. EE 1962; M.S. EE 1964; Ph.D. EE 1968

Mr. E. C. Sykes
General Partner
Aslan Ventures
B.S. EE 1985

Dr. Eric Vogel
Professor
Georgia Institute of Technology
M.S. EE 1996; Ph.D. EE 1998

Daniele receives NSF CAREER Award

Michael Daniele, assistant professor of electrical and computer engineering at NC State and the Joint Department of Biomedical Engineering at UNC-Chapel Hill and NC State, has received a Faculty Early Career Development award, also known as the CAREER Award, from the National Science Foundation (NSF). The award is one of the highest honors given by NSF to young faculty members in science and engineering.

The NSF will provide $500,000 in funding over five years to support his project, "Reconfigurable Microfluidic-Microbalance Sensors to Monitor and Optimize the Performance of Microphysiological Models."

Daniele will work to investigate and engineer a new generation of reconfigurable biosensor platforms that can be used to measure multiple circulating biomarkers and inform the development and analysis of microphysiological models. Because microphysiological models replicate human organ function, they are promising technologies for fundamental biological research and discovery of translatable biomarkers, pharmaceuticals and regenerative therapies.

His research will help to illuminate a path for future research into innovative means of making sensors to monitor multiple biochemical analytes simultaneously, to be reconfigured for use in microphysiological models of different organs, and to generate data streams for the future development of machine learning methods to analyze and discover novel correlations between biomarkers.

Aysu Receives NSF CRII Award

Aydin Aysu, an assistant professor of electrical and computer engineering at NC State has received the National Science Foundation CISE Research Initiation Initiative (NSF CRII) to support his ongoing work on cybersecurity.

The NSF CRII Award encourages research independence, and the Directorate for Computer and Information Science and Engineering (CISE) awards grants to initiate the course of one's independent research. Understanding the critical role of establishing that independence early in one's career, it is expected that funds will be used to support faculty or research scientists (or equivalent) in their first three years in a primary academic position after the Ph.D.

At NC State since 2018, he has been working on cybersecurity and hardware design for over a decade now. The focus of his research is on designing secure hardware for next generation cryptography systems in order to prevent advanced cyber attacks from targeting hardware vulnerabilities.

The cryptographic systems that we use today are vulnerable to quantum computer attacks. For example, when using the web to send an email, all of a person's encryptions are hidden underneath a mathematical problem that is very hard and takes a long time to solve using a classical computer. But, when using a quantum computer, it becomes extremely easy to solve this problem. Quantum computing enables exponential jumps in computing, but there aren't many that can do that yet. We don't know when we will achieve such a quantum computer, but some research is predicting within the next 5-10 years.

"If we use an encryption system, we not only want to make sure it's secure now, but also 5-10 years from now as well," explains Aysu. Being the crypto engineer that he is, his research doesn't just look at the design of the mathematics, but instead takes the algorithm once it is there, and implements it in hardware in the most efficient and secure way. This project will develop secure and efficient hardware designs for the next-generation, quantum-secure cryptographic algorithms thanks to Aysu and his team in the Hardware and Embedded Cyber Threat Research (HECTOR) lab at NC State.

Chakrabortty Named a Faculty Scholar

NC State's 2018-19 class of University Faculty Scholars include **Aranya Chakrabortty**, an associate professor of electrical and computer engineering. These 20 early- and mid-career faculty receive this designation due to their significant academic achievements and contributions to NC State through their teaching, research and community engagement.

Nearly 150 faculty have been named University Faculty Scholars since the program's founding in 2012. Faculty members selected as University Faculty Scholars carry the title for the duration of their faculty appointment at NC State and receive an increase to their base salary.

Chakrabortty's research interests span all branches of control system theory with applications to large-scale electric power systems. His current research with the NSF FREEDM Systems Center includes system and control-theoretic problems for the U.S. power grid using Phasor Measurement Unit (PMU) data for Wide Area Monitoring Systems. FREEDM Research Center is sponsored by the National Science Foundation which provides funding for basic research and engineering and science. In the center, he figures out ways to prevent blackouts from happening in the grid.

Escuti and Guvenc named Senior Members of National Academy of Inventors

Michael Escuti, professor of electrical and computer engineering at NC State and **Ismail Guvenc,** associate professor, have been elected to the inaugural class of Senior Members of the National Academy of Inventors (NAI).

The inaugural class is comprised of 66 accomplished academic inventors representing 37 research universities and governmental and non-profit research institutes worldwide. They are named inventors on over 1,100 issued U.S. patents.

Escuti is a leading photonics and electro-optic materials expert pioneering the development of polarization-independent devices and transformational diffractive optics. He currently directs applied and fundamental research for applications including ultra-efficient/portable liquid crystal displays, opto-fluidics, ultra-efficient beam steering for high energy applications and laser communications, IR/MIR polarimetry imaging, and novel diffractive lenses.

Guvenc is a multidisciplinary researcher working at the intersection of wireless communications and wireless networking. He has been leading three large-scale proposal efforts for the following National Science Foundation solicitations: NSF Platforms for Advanced Wireless Research (AERPAW), NSF BWAC I/UCRC, and NSF Expeditions in Computing.

"NAI Senior Members are active faculty, scientists and administrators at NAI member institutions with success in patents, licensing and commercialization," the organization said. "They have produced technologies that have brought, or aspire to bring, real impact on the welfare of society. Senior members also foster a spirit of innovation within their communities through enhancing an inventive atmosphere at their institutions, while educating and mentoring the next generation of inventors."

Hall Wins University Award for Excellence

Charles Hall, the ECE Digital Communications Manager was named one of the twelve winners of the 2019 NC State University Award for Excellence. Hall, along with three other nominees from the College of Engineering (who also won Engineering Awards for Excellence) and 51 nominees from across the University, was honored in a ceremony hosted by Chancellor Woodson in the Hunt Auditorium on June 11, 2019.

He is the second ECE employee to have won the University Award in its history. **Richard Hodson**, the ECE Senior Web Developer also won the award in 2014. This is the most prestigious award that an NC State non-faculty member can receive.

The Awards for Excellence program recognizes the accomplishments and achievements of permanent NC State employees at both the unit and University levels who do not hold faculty rank. Winners of the University's Award are also then nominated for the Governor's Awards for Excellence, the highest state employee award.

Hall joined the ECE department in 2016 and has brought all communications services in-house, including a complete redesign and growth of this annual magazine, Spotlight, and took the lead recognizing the 100th anniversary of the department in 2017, including researching and writing a new history document, "From Electric to Computer." Over his years with the department, he has been responsible for new internal and external websites, all print and electronic promotional material, social media, photography, and an increasing emphasis on video production and storytelling.

"The Department has never looked so good nor been marketed and promoted as well," described **Dan Green**, the ECE Director of IT and Operations. "Charles overhauled pretty much anything and everything involved with making the department visually appealing to visitors, students, and alumni both online and here."

ECE Pride of the Wolfpack Awards

NC State recognizes individual staff employees for a special or unique contribution beyond the ordinary to their college, department, or the university.

Jan Brock

Human Resources and Executive Manager
2019 Pride of the Wolfpack

Trudi Brown

Director of External Relations
2019 Pride of the Wolfpack

Demonica Hicks

Director of Finance and Administration
2019 Pride of the Wolfpack

Welcoming Our New Faculty Members

Fred Kish

Fred Kish, M.C. Dean Distinguished Professor in electrical and computer engineering, has been named the director of the NC State Nanofabrication Facility (NNF).

Prior to joining NC State and the ECE faculty in August 2019, Kish was at Hewlett-Packard from 1992-1999, where he co-invented and led the commercialization of the highest performance (efficiency) red-orange-yellow visible LEDs produced at the time (wafer-bonded transparent-substrate AlGaInP LEDs). These devices were the first LED devices to surpass the efficiency of unfiltered incandescent and halogen lamps. From 1999-2001, Kish was with Agilent Technologies as the III-V Department Manager.

In 2001, Kish joined Infinera Corporation where he co-invented and led the effort to research, develop, and commercialize the first practical (commercially deployed) fully integrated system-on-chip (SOC) photonic ICs (PICs) for optical communications. Additionally, he served as senior vice president of the Optical Integrated Circuit Group at Infinera.

Kish is a Fellow of the OSA and IEEE and is a member of the National Academy of Engineering (NAE) – bringing the total number of NAE members in the College to 19. His awards include the IEEE David Sarnoff Award, the IEEE LEOS Engineering Achievement Award, the OSA Adolph Lomb Award and the International Symposium on Compound Semiconductors Young Scientist Award. He has co-authored over 125 U.S. patents, over 150 peer-reviewed journal and conference publications and 4 book chapters on optoelectronic devices and materials.

He received his B.S., M.S. and Ph.D. degrees in electrical engineering from the University of Illinois at Urbana-Champaign in 1988, 1989 and 1992, respectively.

Yaoyao Jia

Yaoyao Jia, assistant professor of electrical and computer engineering joined the department in August 2019.

Jia's research interests lie at analog/mixed-signal integrated circuit (IC) design, system-on-a-chip (SoC) design, wireless power/data transmission, and embedded hardware/firmware design for implantable microelectronic devices, neural interfacing/neuroprostheses, and assistive/rehabilitation technologies.

She received her Ph.D. in Electrical and Computer Engineering from Georgia Institute of Technology in 2019. During her Ph.D. studies, she has built bi-directional neural interface devices for closed-loop neuromodulation, distributed mm-sized opto-electro stimulation implants, inductive power transmission systems for omnidirectional wireless power delivery, and smart data acquisition systems for enabling large wireless coverage and eliminating RF blind spots.

She also worked on power management IC design during her M.S. in Microelectronics and Solid-State Electronics from University of Electronic Science and Technology of China, Chengdu, China.

Zeljko Pantic

Zeljko Pantic received his B.S. and M.S. from the University of Belgrade, Serbia, and his Ph.D. from NC State—all in Electrical Engineering

In 2009, he joined the FREEDM Research Center at NC State as a Research Assistant, to which he returned in August 2019 as an assistant professor.

In 2013, he joined the Electrical and Computer Engineering Department, Utah State University, as an Assistant Professor, where he was an Associate Director with the Electrified Vehicles and Roadways Research Facility and a Subthrust Leader of the Dynamic Wireless Charging Group, SELECT Research Center.

His current research interests include systems for wireless inductive and capacitive power transfer, magnetic circuit design, control of power converters, and electromagnetic energy conversion applied in transportation electrification and charging system.

Pantic is a member of IAS Transportation System Committee. He serves as an Associate Editor for the IEEE Transactions on Transportation Electrification.

Remembering Former Department Head, Dr. Robert Trew

Robert James Trew, Alton and Mildred Lancaster Distinguished Professor (Emeritus) and former head of the Department of Electrical and Computer Engineering in NC State's College of Engineering, passed away on Feb. 24, 2019.

Born on December 8, 1944, Trew was the son of Robert and Phyllis. He is survived by his wife, Diane, and daughters Heather and Robin.

He received his Bachelor of Electrical Engineering from Kettering University in Flint, Michigan, in 1968, followed by his master's and Ph.D. degrees in electrical engineering from the University of Michigan in 1969 and 1975.

> Trew made important contributions to research on semiconductor devices and microwave computer-aided design, and he was a highly regarded mentor and leader. He started at NC State as an assistant professor in 1978. Throughout his distinguished career, he held high-level positions at universities and in the government.

He was a department head for a collective 11 years at three major research universities: Case Western Reserve University, Virginia Polytechnic Institute and State University and NC State. From 1989 to 1997, while working at NC State and then Case Western, Trew was also the program manager for the U.S. Army Research Office at Research Triangle Park. He served as vice-chair of the inter-agency committee that planned and implemented the U.S. Nanotechnology Initiative, which began in 2000. For four years, from 1997 to 2001, Trew was the director of research for the Office of the Secretary of Defense at the U.S. Department of Defense, where he oversaw a $1.3 billion annual budget for basic research programs.

In 2003, Trew became the ECE department head at NC State for five years. He remained at the College as a professor while also working as the director of the National Science Foundation's Division of Electrical, Communications and Cyber Systems from 2009 to 2013. He retired from NC State in December 2018.

Trew received many awards and honors throughout his career, including the 2017 Institute of Electrical and Electronics Engineers (IEEE) Microwave Theory and Techniques Society Career Award; the 2016 IEEE Rudolph E. Henning Distinguished Mentor Award; and the 2014 IEEE Microwave Theory and Techniques Society Pioneer Award. He was also a Life Fellow of the IEEE and an elected Fellow of the American Association for the Advancement of Science. Trew served as editor-in-chief of multiple journals and publications. He has 12 patents and is the author of the book "Get Funded: An Insider's Guide to Building an Academic Research Program."

ECE CONNECTIONS PARTNERS

The ECE Connections corporate program is designed to develop and sustain strong collaborations between industry and the Department, offering meaningful engagement and recruiting events and activities.

CATERPILLAR · CIRRUS LOGIC · CREE Wolfspeed · DUKE ENERGY · EASTMAN · FLUOR · HUGHES An EchoStar Company · IBM · intel · JOHN DEERE · key tech · M.C. DEAN BUILDING INTELLIGENCE · NAVAIR · NORFOLK SOUTHERN · PENTAIR · qorvo · SYNOPSYS · Texas Instruments

WANT TO GET **INVOLVED?** ece.ncsu.edu/corporate

NC STATE UNIVERSITY

Electrical and Computer Engineering

NC State University
Department of Electrical and Computer Engineering
Campus Box 7911
Raleigh, NC 27695-7911

ece.ncsu.edu

@NCStateECE

facebook.com/NCStateECE

instagram.com/NCStateECE

ece.ncsu.edu/LinkedIn

youtube.com/NCStateECE

Support ECE

A gift to the Department of Electrical and Computer Engineering is an investment in the future.

Through generous alumni, corporate partners and friends, the Department has been able to create new education opportunities, develop new research and technologies and attract the brightest faculty and students.

"When I was a student in the early-70s, I was very frustrated, because I wanted to build things, but I didn't have the tools, I didn't have the space, I didn't have the parts. When I heard that the department wanted to make MakerSpaces, that's what led me to make this donation because I don't want our students to be as frustrated as I was."

Robert M. Kolbas
Professor, Electrical and Computer Engineering

To learn more about supporting the Department, contact the NC State Engineering Foundation.

ece.ncsu.edu/**donate**