ECE News

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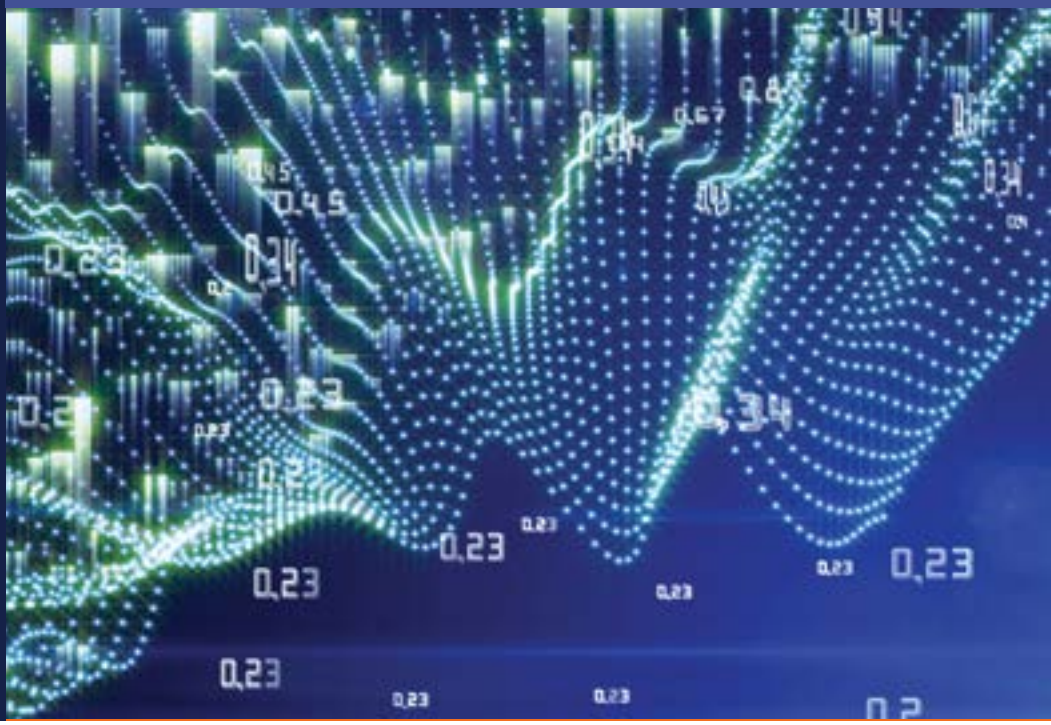
Newsletter of the Department of Electrical and Computer Engineering

GEORGE MASON UNIVERSITY | VOLGENAU SCHOOL OF ENGINEERING | SPRING 2020

Developing proficiency in big data technologies and machine learning application brings engineering skills to a higher level.



RESEARCH CORNER

An Inside View to Big Data Technologies

Ever wondered what goes on behind the scenes and what it takes to enable a big data processing environment using the latest open-source tools and applications? Or how engaging it would be to have the ability to process, analyze, and interactively visualize close to 1 billion data points using a standard engineering laptop? Here's your chance to get an insider's look at big data and advanced open-source technologies designed to leverage big data.

Big data is a group of complex and large data sets. These data sets might reach extreme volumes that most standard data processing software applications find very difficult to manage. Big data engineers are tasked with constructing extensive data storage systems that are fault-tolerant and can hold and manage these large quantities of data. Recently, data centers are flourishing in Northern Virginia, which is another indicator that data engineers, scientists, and analysts will be in high demand.

Big data have three distinct characteristics: volume, velocity, and variety. The volume describes the amount of data that can be found in many organizations. Some organizations have terabytes of data or even petabytes. The velocity defines the speed at which the data are collected from the sources (e.g., the speed at which different types of electronic sensors generate data). In many systems, data sets are streamed and processed in real time. Finally, the variety pertains to different data types. However, while many regular forms of data are very well organized, big data often appear in unorganized forms.

As mentioned before, standard data processing software is not built to leverage vast quantities of data. The development of many open-software big data applications, such as Apache Spark, enables the processing of vast amounts of data in a relatively short time by parallelizing the computation and taking advantage of the computer's memory speed. Learning how to install and use Apache Spark in concert with other big data applications is one of the main objectives of the new class being offered in spring 2020 to engineering students, Introduction to Big Data Technologies.

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Dear Alumni and Friends,

For the past 18 months, Mason's International Enrollment Partnership Office and faculty in the Electrical and Computer Engineering Department have been working diligently on establishing 3+1+1 programs with universities in China and Taiwan and have signed a number of memoranda of understanding. I am very happy to report that, as a result of their hard work and many trips to Asia, the ECE Department welcomed its first cohort of students into the program this spring semester. The 3+1+1 Program allows students to come to Mason in their fourth year of undergraduate study to complete their home institution's degree requirements, which typically includes a senior year design project. In addition to satisfying their own degree requirements, they also take 6 credits of graduate course work that can be applied to their Mason master of science in electrical or computer engineering degree via an arrangement similar to the bachelor's/accelerated master's degree program. In their second year, they complete the remaining credit hours required to earn their master's degree from Mason.

An entry-level graduate course in machine learning, DAEN/ECE 527 Learning from Data, has been taught within the department for the past four years, and beginning this spring, we have added two more courses that focus specifically on machine learning to the curriculum. The first is ECE 590 Introduction to Big Data Technologies, which will dive into the concepts and rigors of machine learning and its implementation using big data technologies. The second course, ECE 699 Deep Learning, will build on the concepts and tools that students have mastered in Learning from Data. Note that we offer many other courses that bring machine learning into practice in areas such as hardware security and the internet of things.

The ECE Department kicked off the fall semester with the third annual Recruitment Mixer, which brought a record number of ECE students, company representatives, alumni, advisory board members, administrators, faculty, and staff together. This spring semester we will host the second annual Student Alumni Mixer, a company networking event that focuses on graduate students.

Finally, the ECE Department, in collaboration with the Department of Systems Engineering and Operations Research, offers a graduate certificate in small satellite engineering with a focus on CubeSats. This certificate provides a broad understanding of small satellite missions, operations, and technologies for spacecraft design and engineering, including the satellite bus, hardware and software systems, and communications. The certificate includes a two-semester hands-on project course to transition theory into engineering practice in satellite and ground station engineering. Course work for the graduate certificate can be used for credit toward the master of science degrees in electrical engineering, computer engineering, or systems engineering. Applications are now being accepted.

Monson H. Hayes
Chair, Department of Electrical and Computer Engineering

INSIDE

Khaled Khasawneh, assistant professor

FACULTY CORNER

New Faculty Profiles

The rewards from teaching, working on research and grants, and advising students are what drive **Khaled Khasawneh** in his academic career. And as a new faculty member in the ECE Department, he hopes to grow that passion as a part of the Mason Engineering community.

"In industry you can see your product and that's the reward, but in academia you have diverse places you can get rewards," says Khasawneh. Seeing students succeed is the main motivation that drives him. "I like to see them grow in their professional life, and I like to help people succeed."

Getting students to where they want to go is Khasawneh's main goal—that, and teaching them about his research in computer architecture support.

"While I was doing my master's at Binghamton University I got really interested in security," Khasawneh says. "Now I want to bring security awareness to students and people in general."

Khasawneh hopes to get students involved in his research, which looks at security vulnerabilities in hardware that can be exploited by software.

"These are dangerous attacks because issues in the hardware can't be protected by software security defenses, since they are built into the architecture," says Khasawneh. Given this fairly new field of research, Khasawneh wants to make sure his students are aware of these new problems and can be a part of finding the solution.

Sai Manoj, assistant professor

When new faculty member **Sai Manoj Pudukotai Dinakarrao** isn't hiking the Swiss Alps or the Shenandoah hiking paths, he spends his time researching how to properly secure hardware systems.

Manoj was a research assistant at Mason before joining the ECE Department's faculty. As a research assistant, he looked at adversarial machine learning and how to protect computer hardware from side-channel attacks, malware, and hardware Trojans. He is excited to continue this research as a faculty member and to get students involved.

"I was always more interested in teaching and research," Manoj says about his decision to go into academia. "I chose Mason specifically [because] I saw how many Mason faculty worked on hardware security when I was at a conference one time, and I wanted to be a part of it."

Manoj hopes to add to Mason's research and its connections with industry and other institutions long-term to expand the field of knowledge related to hardware security.

"Recently new threats in computer hardware have been found, and there's a lot to be researched," says Manoj. He hopes to get students involved in finding those solutions.

Manoj believes that electrical and computer engineering students should know the basics of hardware security, and if he could design and teach one course, he says it would be on these basics and the research on how to fix these new hardware problems.

FACULTY NEWS

Alexander Levis Retires

Alexander Levis will be retiring at the end of this academic year after having served as a faculty member for 30 years, with most of that time spent as University Professor of Electrical, Computer, and Systems Engineering.

He was educated at Massachusetts Institute of Technology (MIT), where he received four degrees. Upon graduation, he taught control theory at the Polytechnic Institute of Brooklyn (now New York University's Tandon School of Engineering).

In 1973, he joined an engineering consulting company in Palo Alto, California. His research focused on the modeling and simulation of socio-technical systems. There, he learned the business side of research. "I worked in Silicon Valley before it was called Silicon Valley," he says. "I was losing my staff to Steve Jobs. I was telling them, 'Are you crazy? You are going to a start-up called Apple and leaving a good job?'"

In 1979, he returned to MIT as a senior research scientist in the Laboratory for Information and Decision Systems and joined in a groundbreaking effort to establish the science of military command and control. This led to his move to Mason in 1990 at the invitation of then-Dean Andrew Sage and Harry Van Trees, who had started the C3I Center.

It was an exciting time. The new School of Information Technology and Engineering was growing rapidly. Dean Sage tasked Levis to develop the curricula for the undergraduate and masters' programs for the newly created Department of Systems Engineering, where he also served two different times as chair before the unit was merged to create the Department of Systems Engineering and Operations Research (SEOR).

"The premise that Andy Sage had was to be innovative, different, flexible—to be great in a different way than other engineering schools define great," Levis says. "It frustrates me when people say, 'We tried that before, and it didn't work.' No one has ever told me that here [at Mason]. Instead, the leadership said, 'Try different things. Go for it.'"

In 1995, a great opportunity arose. The newly created Defense Information Systems Agency (DISA) came to Mason and asked for an in-house program in architecture-based systems engineering. Four hundred DISA engineers signed up for it.

A five-course graduate certificate program was created and was taught with parallel sections at DISA facilities. That program became the model for offering certificate programs, with specialized versions of the Mason courses offered in-house or through distance learning. The Naval Surface Systems Center in Dahlgren, Lockheed Martin, the CIA, and Raytheon supported multiyear programs.

Levis led the System Architectures Laboratory, first as part of the C3I Center and then as a lab of the ECE Department until 2017. The research focused on

- the design and evaluation of information architectures, with an emphasis on command and control;
- discrete event systems with an emphasis on organization design; and
- strategic planning with an emphasis on course of action development.

Mason's proximity to Washington, D.C., enabled him to serve for 25 years on scientific advisory boards for a variety of government organizations such as the U.S. Air Force, NASA, the U.S. Department of Homeland Security, and the intelligence community.

> "Joining Mason was the best professional decision of my life. The freedom that it offered and the opportunity to participate actively in building a school of engineering from the ground up with a group of similarly minded colleagues have left indelible happy memories."
>
> ***— Alexander Levis***

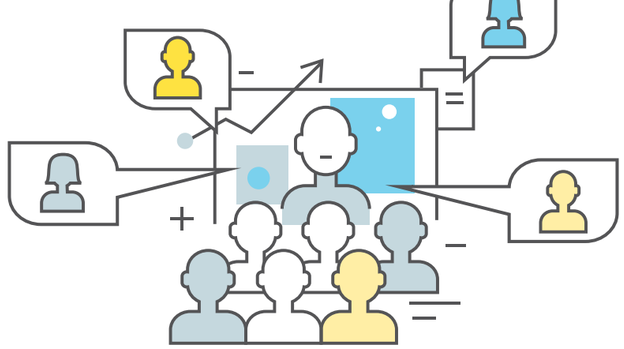
From 2001 to 2004, he served as the chief scientist of the U.S. Air Force. He remembers his first air staff meeting, which occurred on 9/11 and was interrupted by the aircraft hitting the Pentagon. His office was quarantined because of fumes from the fire, so the next morning he set up his office in one of the cafeterias. Another memory of that experience was when Levis realized a childhood dream by flying in a fighter jet (an F16—with a real pilot, of course).

Since his return to Mason in 2004, Levis has been teaching graduate courses in architecture-based systems engineering design in both the ECE and SEOR departments. He notes that one of his joys is when a student "gets it," and his or her eyes light up.

Levis believes that systems engineering is a team effort, and a good team requires two types of participants: visionaries who conceive what has not been done, and engineers who focus on accuracy and detail that can realize the vision.

U.S. Air Force Captain Booth (left), and Alexander Levis after a flight on an F-16D. Photo provided

Online Education



George Mason University has been offering remote-access education for more than 20 years. As technology improved and more options for delivering online education became available, faculty in the ECE Department began teaching online courses and developing degree programs, such as the MS in telecommunications and the MS in computer forensics, as well as certificate programs.

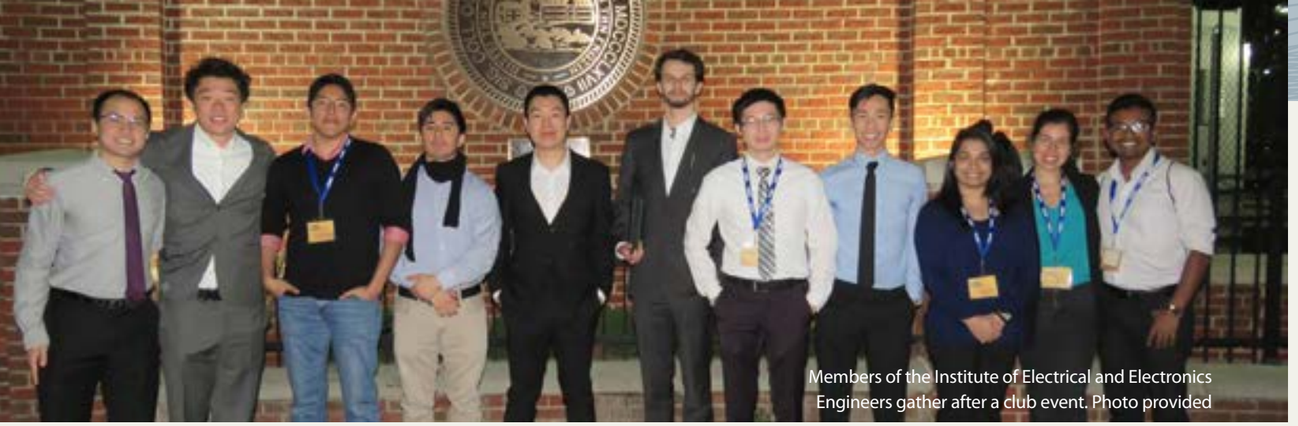
In January, the department launched a new graduate certificate program in small satellite engineering.

Online courses are usually offered in two modes: synchronous (or hybrid) and asynchronous form. In the first case, a course offered with an in-person section is made accessible synchronously to distance-learning students via Blackboard. Students access the class through the internet and listen to the lecture, see the instructor and the visuals presented, and can participate via voice or the chat application.

The key capability is that all aspects of the lecture are recorded and can be accessed immediately after the class session. This enables students who cannot attend the class synchronously due to work constraints or time differences to access everything when it is convenient for them. Students attending in person can also access the recordings to help them study. The department offers selected classes in the synchronous mode.

In the asynchronous mode, the whole course is prerecorded in a set of modules that correspond to the class syllabus and is made available through Blackboard. Students can take the course at their own pace but must complete it within the semester in which it is offered. Students interact individually with the instructor and the teaching assistant regarding homework assignments and projects.

The two modes of distance learning serve different purposes. Synchronous classes are very similar to the in-person experience, while asynchronous classes are well suited for mature professionals whose work and travel constraints prevent them from regularly attending class meetings.



Members of the Institute of Electrical and Electronics Engineers gather after a club event. Photo provided

ECE NEWS

Institute of Electrical and Electronics Engineers Student Chapter

Preparing for a career can be difficult without a support system, but Mason Engineering's chapter for the Institute of Electrical and Electronics Engineers (IEEE) is a network of students who are there to help each other build their portfolios, network, and learn about opportunities in the field of electrical and computer engineering.

"We try to provide opportunities that students wouldn't normally get in the classroom, like engineering projects, socials where you can talk with fellow students, and networking events," says Mason's IEEE chapter president Michael Nguyen.

Nguyen says simply being able to talk to fellow students can make the undergraduate experience easier and that he and the other officers of IEEE try to be there as a resource to students to provide help and share their experiences.

"The issue with a lot of new grads is that they don't have the experience to start a job, and they require experience to start their career," says Nguyen.

To help students gain experience, IEEE works on engineering projects to benefit Mason and the world as a whole. One project they are working on is a sun-tracking solar panel that moves with the sun. Additionally, they are working on a project to help with the parking issues on Mason's Fairfax Campus.

They hope to develop a program or app that helps students see which parking lots around campus are full or have spots available to prevent people from driving around looking for spots. It's similar to the ParkMobile app that is used in some cities like Washington, D.C., to pay for parking, but this will take it a step further, says the chapter's treasurer Baseerat Chaudhry.

"We want to show members the value of experience," says Nguyen.

Members can also attend the IEEE Student Activities Committee Conference, where they can meet other IEEE club members in the region.

Nguyen says the chapter hopes to develop a career fair in collaboration with the IEEE regional chapter this coming spring to provide even more networking opportunities for their members. Additionally, they hope to get students in other disciplines involved in the club, since electrical and computer engineering works with many different fields.

Kathleen Wage

Professor Signals New Way to Transmit Knowledge

When **Kathleen Wage** teaches signal processing, she doesn't stand in front of her students and lecture for the entire period.

"That's what a 'pop-star' prof would do," says Wage, an associate professor in the ECE Department. "I consider myself more of a 'DJ' prof—mixing different modes of instruction to design the best learning experience."

She has a formula for an active-learning classroom: Intersperse short lecture segments with collaborative problem-solving sessions. While students work on exercises with their classmates, she moves around the room, guiding their efforts. She also augments in-class instruction with tutorial videos posted on YouTube. Her most popular video has more than 200,000 views.

Her innovative classroom strategies and dedication earned her Mason's 2019 John Toups Presidential Medal for Faculty Excellence in Teaching, one of several teaching awards she's received during her career.

For almost 20 years, Wage has focused on improving signal processing instruction. Her interest in interactive teaching strategies began with a project aimed at designing assessment tools for engineering educators.

A year after joining Mason in 1999, she and a friend from graduate school began a decade-long project funded by the National Science Foundation. They developed the Signals and Systems Concept Inventory (SSCI), an assessment tool that has been administered to thousands of students at universities in the United States and around the world.

Concept inventories are typically administered at the beginning and end of a course to measure a student's gains in comprehension. The questions examine conceptual understanding, rather than rote computational skills.

In physics, a concept inventory study prompted reforms when it showed that students in active-learning courses gained approximately twice as much knowledge as students in traditional lecture courses. The SSCI study convinced Wage that switching to an interactive format was the right method.

She is working with colleagues at Mason and elsewhere to develop active-learning materials for undergraduate signal processing and acoustics classes.

Her main area of research is a synthesis of signal processing and ocean acoustics, which is funded by the Office of Naval Research. "I'm currently applying new results from mathematics to analyze and improve algorithms for processing data from larger and larger arrays of sensors," she says.

Sometimes, she's able to weave that research into classroom discussions.

"I love using experimental data from deep-water arrays to illustrate applications of abstract signal-processing concepts," she says.

Wage notes that signal processing is mathematical, and students don't always see the connection to engineering. "The challenge of it is convincing them that these are tools that will be helpful if they put some effort into learning them."

What she likes most about teaching is getting students excited about the material and helping them develop critical-thinking skills that apply to her course and beyond.

"At Mason, I am grateful to have found a community of other DJ profs who are devoted to improving their pedagogical playlists and engaging students in learning," Wage says.

An Inside View to Big Data Technologies,
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Apache Spark is one of the most popular and general-purpose data science platforms today. It can be accessed by its native language, Scala; however, it provides full API access via R, Python (a prerequisite for this class), and SQL. Generally, Apache Spark is a faster and simpler substitute for intricate structures like MapReduce, a Hadoop-based application. Many companies and organizations are now looking for engineers with experience in Apache Spark and related big data technologies. There is a noticeable scarcity of data engineers and data scientists and analysts, particularly in engineering organizations.

Additionally, students in the class will dive into the concepts and rigors of machine learning and its implementation using big data technologies, which will help electrical, mechanical, and computer engineering students solve problems in their domain of expertise. Developing proficiency in big data technologies and machine learning application brings engineering skills to a higher level. The future engineers that possess such big data proficiency, while crucial to businesses like Google, Netflix, Amazon, Facebook, and Instagram, will become transformational to engineering companies focused on wireless communications and power, computer, mechanical, aviation, aerospace, and other engineering fields.

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Pelin Kurtay

Liz White

Faculty Consult on Computing at Forum

The Women-in-Computing forum was held at the annual ACM/IEEE Symposium on Edge Computing in Washington, D.C., on November 8.

The forum brought together a number of academic and industry representatives to discuss important challenges that women face in science, technology, engineering, and mathematics (STEM) careers. Keynote talks centered around how to achieve a fulfilling career in the tech sector, as well as how to attain success as a female in academia.

The ECE Department's associate chair **Pelin Kurtay**, as well as **Liz White**, associate chair of the Department of Computer Science, were invited as panelists to discuss their initiatives and ideas related to increasing women participation in engineering and computing within a forum panel, "Industry and Academic Careers: Challenges, Prospects, and Recipes."

The panel was moderated by Lei Ding of Accenture Technology Labs. Kurtay shared her personal experiences that influenced her thinking about gender diversity in technology and what motivated her to get involved in being an advocate for change. She also shared some pointers on resources showing how to identify and work with male advocates.

The panel attracted not only a number of female symposium participants, but also male participants, and brought attention to the important and challenging issue of the need for greater gender diversity in STEM fields. The audience posed various questions to the panelists, who shared unique perspectives around the issue.