GW | Engineering

DEPARTMENT OF **ELECTRICAL AND COMPUTER ENGINEERING**

Technology-oriented solutions for real-world challenges

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

LETTER FROM THE DEPARTMENT CHAIR

ECE has had a fantastic year moving from one strength to another, continuing to build its research prominence and enhancing its progressive educational programs in critical areas for advancing humanity and our nation. On the research side, the department has achieved unprecedented levels of research expenditure, and our faculty has given a stellar performance that will have a lasting impact. Professor Gina Adam, among many other successes and university awards, has received the AFOSR Young Investigator Program (YIP), the NSF CAREER, and a DoD DEPSCoR capacity-building grant. Meanwhile, Professor Ahmed Louri was recently awarded three NSF grants totaling $3.8 million to develop next-generation computing architectures. Professor Can Korman was a pivotal leader in establishing the PREP agreement with NIST which has the potential of growing to $29 million in research collaboration.

Our student population has also been rapidly growing again after the pandemic years. Our programs at the undergraduate and graduate levels now embody new exciting concentrations and areas of focus that underscore security, AI/ML, Chip Design, High-Performance Computing, High-Performance Data Analytics, and Robotics, to name a few.

The department has been growing and asserting its strengths in timely areas such as Next Generation AI Hardware. I take this opportunity to welcome our newest brilliant additions to our faculty body, Profs. Nan Wu and Weidong Cao. They both joined us as assistant professors in Fall 2023 from the University of Santa Barbara and TSMC, respectively. Dr. Wu uses graph learning and deep reinforcement learning to automate the hardware development flow. Dr. Cao works on VLSI design, emerging computer architectures, and security and robustness for machine learning.

Prof. Nan Wu

Prof. Weidong Cao

We also continue to partner with industry and provide interested students with real-world experience and training, such as our recent partnership with Qualcomm, which will allow our students to receive training and certification in 5G.

Dr. Tarek El-Ghazawi, IEEE Fellow
ECE Professor and Chair

CULTIVATING HUMAN-AI SYNERGY WITH NOVEL AI/ML CAPABILITIES

Prof. Tian Lan

Technological advancements are creating new opportunities for teams of AI agents/robots to be deployed alongside humans to support and augment labor-intensive and/or dangerous manual work. The vision is for robots to not just free up humans so they can focus on the tasks they are skilled at but also work collaboratively with them to solve problems that would be difficult, dangerous, or impossible otherwise. Some version of this vision is being realized across many sectors, such as warehouse management, mission planning, and disaster response. However, AI agents/robots exhibit brittle autonomy and poor adaptability to changing human behaviors and strategies, which are commonly undefined/unknown to AI agents and can also be altered substantially by the presence of AI agents.

To tackle this challenging problem, ECE Professor Tian Lan is leading a $1.5 million grant from the Office of Naval Research under its Science of AI program, awarded recently for their project, "CHASE: Cultivating Human-AI Synergy via Decentralized Elicitation and Learning." Together with two co-PIs, Prof. Lan will investigate novel AI/ML capabilities of decentralized preference elicitation and learning to make AI agents better understand human behaviors/strategies in shared environments, thus supporting teams of human and AI agents working together to solve complex problems.

The research is expected to have a profound impact on many real-world scenarios, such as assistive autonomy, crisis response, search and rescue, and mission planning, where the collaborative team of human and AI agents, e.g., robots and unmanned ground/aerial vehicles, take advance planning and immediate actions to address natural and man-made disasters, crises, urgent incidents, and critical events in ways not possible today.

AWARD-WINNING ECE FACULTY AND STUDENTS ILLUMINATE PATHWAYS IN EDUCATION AND RESEARCH

Countless faculty from the ECE Department have been recognized through various university and school awards for their research and education efforts and achievements. For example, Assistant Professor Gina Adam received the School of Engineering & Applied Science's (GW Engineering) Outstanding Early Career Teaching Award and GW's Morton A. Bender Teaching Award to recognize her educational contributions, prototyping work, and outreach to local high school and community college students. Dr. Milos Doroslovacki also received the Silver Anniversary Faculty Award for completing 25 years of continuous full-time service at GW.

Within GW Engineering, Associate Prof. Payman Dehghanian received the Outstanding Early Career Researcher Award for his significant contributions to our understanding of smart power grids and the development of technological solutions for weather- and cyber-resilient electricity grids of the future. Prof. Shahrokh Ahmadi received the Outstanding Service Award due to his exceptional contributions that have advanced the school.

The brilliance of ECE graduate students has also been recognized. Doctoral student Samuel Farid received the university-wide accolade the Phillip J. Amsterdam Graduate Teaching Assistant Award for his contributions to shaping the minds of future engineers. It was a moment of pride not only for Farid but for the entire ECE department, which previously acknowledged his teaching prowess with the Best Graduate Teaching Assistant Award. Dr. Mostafa Nazemi, a Ph.D. graduate and GW Smart Grid Laboratory alumnus, was also recognized with the GW ECE Best Dissertation Award for his dissertation.

DESIGNING AI HARDWARE CHIPS FOR THE NEXT GENERATION

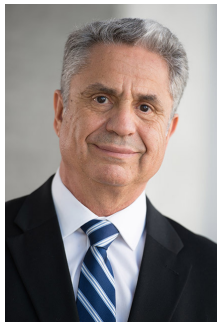
Chips are embedded in every aspect of our modern society, from defense to entertainment. Thus, research in efficient chip solutions has far-reaching implications. Several faculty tackle different aspects of designing better next-generation hardware computing architectures and systems for AI, such as Prof. Tarek El-Ghazawi, Prof. Ahmed Louri, Prof. Howie Huang, Prof. Guru Ventakaramani, Prof. Gina Adam, Prof. Nan Wu, and Prof. Weidong Cao.

The recent successes of Dr. Ahmed Louri, IEEE Fellow and Karlgaard Endowed Chair, best exemplify our recent achievements in this area. Prof. Louri was recently awarded three NSF grants totaling $3.8 million to develop next-generation computing architectures. In his $2 million grant, "Multi-function cross-layer electro-optic fabrics for reliable and sustainable computing systems," Prof. Louri and his team will work to improve the environmental sustainability of computing systems via three tenets, namely reuse the same hardware architecture, reduce the operational energy, and recycle the hardware via self-healing techniques. Another barrier includes power dissipation. In his $1.2 million project, "Exploiting photonic interconnects for resilient data communication and acceleration in energy-efficient chiplet-based architectures," Prof. Louri plans on designing a novel, dual-purpose photonic fabric to enable power-efficient and scalable on-chip communications for heterogeneous multicores and function as a neural network accelerator. However, designing suitable on-chip interconnects is a critical challenge for multicore chips. In the $600,000, three-year project, "Cross-layer Learning-based Energy-efficient and Resilient NoC Design for Multicore Systems," he proposes a machine-learning-enabled, cross-layer approach for designing these systems to be resilient and energy-efficient.

Dr. Tarek El-Ghazawi focuses on AI high-performance computing and AI hardware with FPGAs and exotic processor technologies. Dr. Howie Huang develops high-performance computing and machine-learning techniques tailored for large-scale graph datasets. Dr. Guru Venkataramani and his research group made pioneering contributions in investigating secure hardware and timing channels on multicore processors. Prof. Gina Adam works on memristive technologies for neuro-inspired computing. Dr. Nan Wu uses graph learning and deep reinforcement learning to automate the hardware development flow, while Dr. Weidong Cao works on VLSI design, emerging computer architectures, and security and robustness for machine learning.

"Our Department is becoming a true powerhouse for AI Hardware and AI HPC. Together, faculty research in this area has been funded by several millions of dollars and produced scores of patents and publications," Professor and Department Chair Dr. Tarek El-Ghazawi says.

These efforts span work in emerging electronics and photonics to advance the science of designing next-generation computing systems and integrate discovery with teaching and training in the field of advanced computing architectures and AI hardware.



Prof. Ahmed Louri

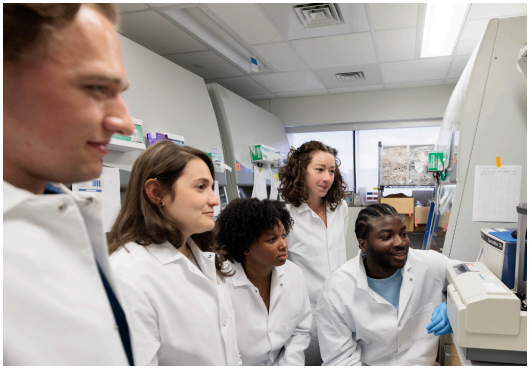
LARGE-SCALE PARTNERSHIP WITH NIST TO CULTIVATE DIVERSE SCIENTIFIC WORKFORCE

The George Washington University is now part of the Professional Research Experience Program (PREP) at the National Institute of Standards and Technology (NIST). This five-year cooperative agreement will strengthen the scientific workforce and provide cooperation opportunities for GW and its partners with scientists at NIST. For this effort, GW has partnered with the Southeastern Universities Research Association and will facilitate the recruitment and retention of researchers from historically marginalized groups such as women, minorities, and persons with disabilities. NIST will provide financial assistance to eligible students, postdoctoral researchers, and faculty of up to $29.9 million in federal funds.

"My role is to make sure that both the NIST goals and GW programmatic goals are being met. I will coordinate with other GW schools, colleges, and departments to review a number of outcomes and program priorities, and I will work with undergraduate and graduate students, postdocs, and faculty to help them effectively engage in the program."

Prof. Can Korman
Professor and Associate Department Chair for Graudate Studies
Program Manager for GWU-PREP

Prof. Korman will work alongside Prof. David Broniatowski, associate professor in the EMSE department, who serves as the principal investigator and PREP program coordinator. They both emphasize the cooperative nature of the GWU-PREP agreement. NIST may have specific openings for which GW will then put forward resumes, but it is also possible for a GW faculty member to propose a project.



Prof. Korman supports the GWU-PREP program, which will train a diverse pool of researchers.

Both GW and NIST scientists make vital contributions to fields such as information technology, artificial intelligence, cybersecurity, nanotechnology, and many others. Dr. Gina Adam, assistant professor, works on memristive materials and devices for neuro-inspired computing and has ongoing collaborations with groups across three labs at NIST. Prof. Mona Zaghloul has collaborated with NIST since 1984 on projects ranging from testing electronic circuits and electronic materials to MEMS and devices based on 2D materials. Dr. Tarek El-Ghazawi, professor and chair, and his students have a history of working with NIST in cloud-computing technologies. Based on the common interests and a clear track record of joint work, such a collaboration between the institutions is an excellent match and will support future success.

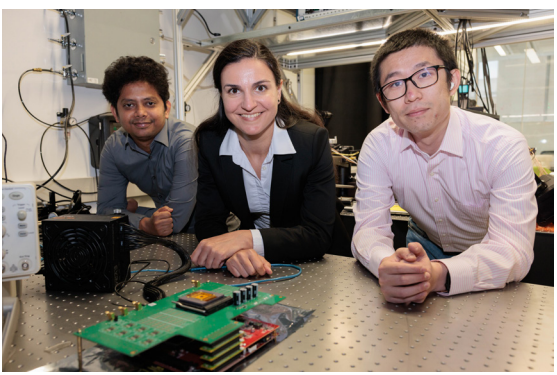
BUILDING RELIABLE, BRAIN-INSPIRED MEMRISTIVE TECHNOLOGIES

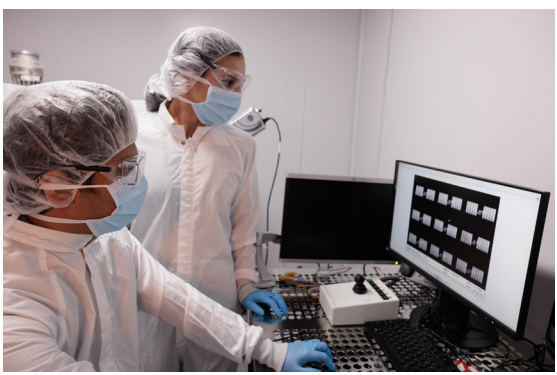
Assistant Professor Gina Adam works extensively on novel memristor chips for neuromorphic computing. The innovations she proposes are greatly needed because existing memristive technologies suffer from imperfections, which negatively affect the accuracy performance of artificial intelligence hardware acceleration. In 2023, Prof. Adam received several grants totaling about $2 million to overcome the challenge that no two devices are alike.

Prof. Adam tackles this variability issue through both top-down and bottom-up approaches. The top-down approach is developing algorithms robust to device imperfections. This work is funded by the AFOSR Young Investigator Program Award she received to investigate realistic dynamic neural networks inspired by hippocampal architecture and its specific neurogenesis capabilities. The bottom-up approach to improving the performance of neuromorphic systems is developing ultra-low variability memristors using new classes of complex oxides as part of the NSF CAREER Award she received.

“I am excited to develop the next generation of memristors and to incorporate our research results into educational efforts thanks to this prestigious CAREER award,” said Prof. Adam.

Prof. Adam also received a two-year $1 million DoD DEPSCoR capacity-building grant to develop neuromorphic devices and sensors using materials driven by short-range order and to strengthen the District of Columbia’s research position in energy-efficient neuromorphic systems. Vice-Provost for Research, Prof. Pamela Norris, will support the project as team lead while Prof. Adam will serve as the technical lead. They will work in partnership with Profs. Tianshu Li and Mona Zaghloul, technical co-leads, and four DC universities are sub-awards. A state-of-the-art sputtering chamber for depositing complex materials will be acquired for the GW Nanofabrication facility.





(left) Prof. Adam and two of her doctoral students (Imtiaz Hossen and Lei Zhang) showcasing their memristive prototype.
(right) Prof. Adam and her doctoral student, Imtiaz Hossen, work in the GW Nanofabrication facility.

NAVIGATING THE FUTURE: ECE UNVEILS NEW UNDERGRADUATE STUDY TRACKS

In a world constantly evolving with technology, staying ahead of the curve is crucial for success. In the ECE department, a pioneering initiative is being put in place that will empower our undergraduate students to not only thrive in the dynamic landscape of technology but also shape the future. The ECE department has been working hard to introduce several cutting-edge specialized tracks for undergraduate students majoring in electrical engineering and computer engineering, who will be required to select a specialized Track from the provided options. By utilizing technical elective courses, students can fulfill the necessary coursework for their chosen Track.

- **Electronics, Nanotechnology, and Chip Design:** Students dive into the microcosm of electronic wonders and explore the intricate world of nanotechnology and chip design. From supercharged smartphones to life-saving medical devices, this track unveils the magic behind modern electronics.
- **Artificial Intelligence and Robotics:** Students learn the fundamentals of AI and the robotics revolution, where machines learn, adapt, and collaborate with humans. From autonomous cars to smart homes, AI and robotics are at the forefront of creating a smarter, more connected world.
- **Computer Design and Cybersecurity:** Students learn the art of creating robust computer systems and how to defend them against cyber threats. As digital dependence grows, computer design and cybersecurity are vital for safeguarding our interconnected lives.
- **Telecommunication and Network Security:** Students dive into the realm of telecommunication and network security, where they can master the technology that keeps the world connected while ensuring data privacy and integrity.
- **Sustainable Energy and Power Systems:** Students will explore renewable energy sources, smart grids, and technologies that are reshaping the world's energy landscape, preparing them to be a part of the solution to climate change.
- **General:** It is essential to recognize that the decision to specialize in a track or take courses in multiple areas depends on individual career goals and interests. Some students may prefer a broader knowledge base, especially if they are uncertain about their long-term career goals, while others may thrive in a specialized area. Ultimately, both approaches have their merits, and the choice should align with the individual's aspirations and objectives.

Our new tracks are not just about knowledge but about shaping students' careers and impact. Whether they're aiming to join the workforce right after graduation or considering graduate school, these tracks offer unparalleled opportunities. With specialized expertise, our undergraduate students gain in-depth knowledge and a solid foundation in their chosen field. Our tracks are designed in consultation with industry leaders, ensuring that the students are job-ready upon graduation. If students aspire to continue their education, these tracks provide a strong foundation for pursuing advanced degrees. We will soon be inviting our students to join us in this exciting journey of innovation, discovery, and transformation as we equip the engineers of tomorrow to create a brighter and smarter world.