GW | Engineering

DEPARTMENT OF COMPUTER SCIENCE

Revolutionizing the Way We Live, Work and Learn

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

LETTER FROM THE DEPARTMENT CHAIR

Computer Science is more than just an academic discipline – it is a driving force behind the profound technological shifts that are revolutionizing how we live, work, and learn. At GW's Computer Science Department, we are deeply committed to leading this transformation.

Our world relies on reliable distributed systems to power emerging technologies like the Internet of Things (IoT) and Cyber Physical Systems (CPS). These systems, from smartphones to autonomous vehicles, shape our digital interactions, serving as the architects of our modern lives. Simultaneously, Artificial Intelligence (AI) and Machine Learning (ML) infiltrate every facet of society, from information gathering and data analysis to knowledge presentation, challenging the next generation of computer scientists with technical and societal complexities, including bias, security, and ethics.

At GW, we embrace this transformative role. Our professors are dedicated to student success, and excel in teaching and cutting-edge research supported by funding from NSF, NIH, and DoD. Some of their accomplishments in AI, ML, cybersecurity, and autonomous systems, as well as a note on our new NSF-funded Designing Trustworthy AI Systems research traineeship, are described in the rest of this brochure. Beyond academics, we foster a strong sense of community, with students actively participating in internships, research collaborations, and cultural experiences, all set against the backdrop of the nation's capital.

Our students and alumni are reshaping academia, industry, and entrepreneurship, serving as living proof of our mission. GW's Computer Science Department leads transformative change, driven by innovation, knowledge, and community. Together, we're forging a future where technology fuels progress.

Rebecca Hwa, Ph.D.
Chair, Department of Computer Science

UNCOVERING HOW USERS UNDERSTAND AND INTERACT WITH SECURITY AND PRIVACY TOOLS

Since joining GW Engineering in 2019, Professor Adam J. Aviv has been building an active research program in the Computer Science Department. The GW Usable and Security and Privacy Lab (GWUSEC) focuses on human factors in security and privacy, asking and answering research questions about the impact of users on systems and how users understand them. This work builds on cybersecurity, human-computer interaction, and sociology/psychology to uncover how users understand and interact with security and privacy tools, then design and build better solutions. Current projects examine various topics in privacy and security, including authentication, password managers, security advice and behavior, privacy label communication, and more, demonstrating how the lab's research connects engineering/computing and social science, law, and policy.

Members of GWUSEC gather for a weekly meeting to provide updates on their research.

Some recent highlights include publications focusing on how users manage their privacy online, particularly in the face of automated, intelligent tracking mechanisms that use their data to learn about their behaviors and interests. This research aims to design better dashboards for users so they can understand how advertising systems use their data and make more informed decisions. Prof. Aviv's lab is also investigating privacy concerns around remote exam proctoring software, which became more prevalent during the pandemic. These tools use advanced and unexplainable artificial intelligence software to perform cheat detection. The team is studying how students and educators understand these tools, circumvent them, and what monitoring they believe is appropriate in addition to the process institutions use to evaluate them.

At GWUSEC, the researchers strive to conduct high-quality academic research that is inclusive, diverse, and impactful. Ph.D. student Collins Muyendo exemplified this value statement by expanding the lab's research beyond a Western context in a project alongside Prof. Aviv and Prof. Yasemin Acar. They researched security and privacy challenges at cybercafes in Kenya and found most customers struggle with the general use of computers and password selection and management. After identifying these challenges, the team provided several suggestions, including computer training and security awareness provided by the Kenyan government and alternative methods of authentication. They won a Distinguished Paper Award at the 2023 IEEE Symposium on Security and Privacy.

CREATING TRUSTWORTHY AI SYSTEMS TO ENSURE EQUITY IN THE REAL WORLD

Artificial Intelligence (AI) is becoming more deeply integrated within all parts of modern society, driving advances in science, engineering, the workforce, transportation, and social interaction. This integration creates a tension between the opportunities for ubiquitous AI to transform our world and the emergent risks around bias, security and privacy that arise. GW Engineering will play a leading role in developing the next generation of AI algorithms and systems and build an understanding of how those systems can be best integrated within society. Ph.D. fellows from GW's Designing Trustworthy AI Systems (DTAIS) program are gaining firsthand knowledge about convergent problems in artificial intelligence and machine learning.

DTAIS is an NSF Research Traineeship (NRT) administered by the GW departments of Computer Science and Engineering Management and Systems Engineering. Our NSF funding allows us to support full-time PhD students pursuing critical research that lies outside the bounds of traditional disciplines. At the same time, DTAIS remains committed to innovative modes of instruction, interdisciplinary education and broadening STEM education to communities typically excluded from participation. DTAIS also offers a graduate certificate on Trustworthy AI for Decision Making Systems for students and professionals to gain the competency needed to address questions in this space and lead initiatives at their organizations.

The DTAIS community brings together dedicated students, faculty and professionals to shape our relationship to AI and the workplace of tomorrow. Our students receive mentorship from professors across campus and experts in industry, and our academic and professional partners gain access to passionate early researchers eager to make a difference.

Ph.D. fellows from GW's Designing Trustworthy AI Systems program spoke to experts to learn about search and rescue, and to consider potential opportunities for AI to support their operations.

PROTECTING AUTONOMOUS CYBER-PHYSICAL SYSTEMS IN REAL-TIME

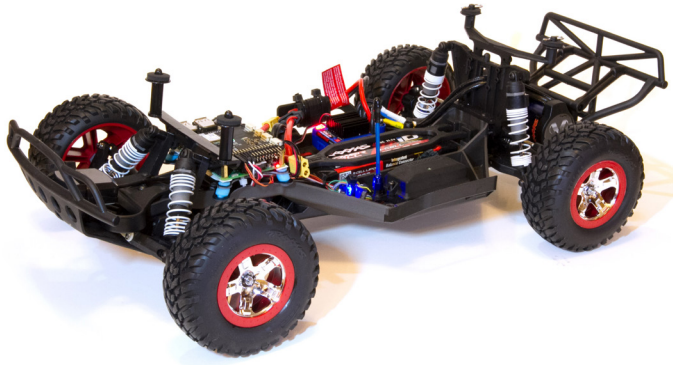
Professors Sibin Mohan, Timothy Wood, and Gabriel Parmer lead pioneering research teams dedicated to addressing critical challenges in autonomous systems and cyber-physical systems (CPS). As the world increasingly relies on autonomous technologies, the demand for security, resiliency, and efficiency in these systems has reached unprecedented levels. Their collaborative endeavors are centered on fortifying autonomous systems against vulnerabilities, achieved through enhancing the underlying operating systems and networks to better cater to their stringent requirements.

The emergence of autonomous systems, ranging from IoT-style devices to UAV swarms, has ushered in a new era of technological progress. However, security remains a vital yet often underestimated challenge within this wave of innovation. Professor Sibin Mohan's research endeavors to reinforce the resilience and security of Cyber-Physical Systems, while also paving the way for innovative approaches to secure cloud computing. His recent NSF CAREER award supports the development of secure safety-critical systems, preventing real-time information leakage. His work ultimately seeks to simultaneously improve real-time guarantees and security for autonomous systems.

Meanwhile, Professor Gabriel Parmer's research is concentrated on advancing component-based operating systems and efficient serverless platforms. These systems empower fine-grained control and predictability in cloud-scale and embedded systems. Prof. Parmer and his students were honored with the Best Student Paper Award at RTSS 2023 for their contributions to OS support in multi-tenant edge environments. Their work pushes the boundaries of real-time systems, offering robust performance guarantees without compromising resource efficiency.

Professor Timothy Wood's contributions span operating systems and networking, with a particular focus on edge computing. As the shift toward 5G-based edge clouds gains momentum, his research addresses the challenge of efficiently accommodating diverse applications while ensuring isolation and consolidation at the edge. In their recent projects funded by the NSF CPS program, the Semiconductor Research Corporation, and the Office of Naval Research, Professors Wood and Parmer have designed innovative edge computing platforms optimized for low latency and robust isolation, achieving up to a 10,000x reduction in cold start delays compared to container-based systems.

Together, the systems research team at George Washington University is working at one of the most challenging frontiers of computer science. Their work in security, resiliency, and efficiency is laying the foundation for safer and more reliable autonomous technologies, while meeting the stringent requirements of cyber-physical systems and working within the tight resource constraints of edge environments.

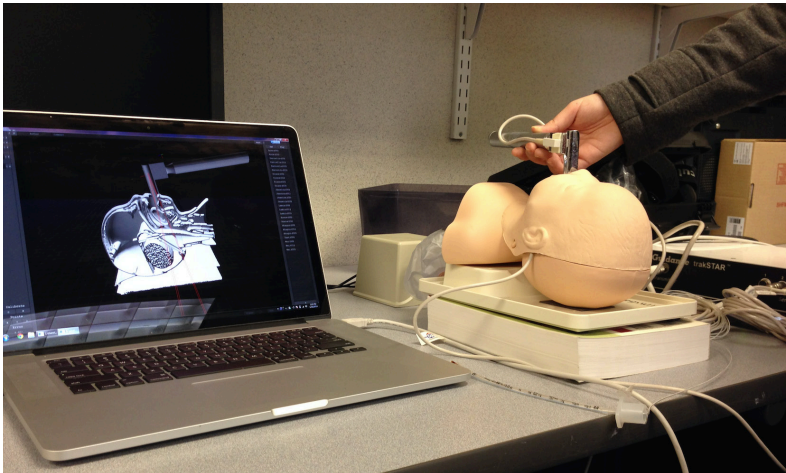


REACHING ACROSS DISCIPLINES TO SOLVE PROBLEMS IN HEALTHCARE WITH DIGITAL SOLUTIONS

Barriers between disciplines prevent the creation of novel solutions for real-world problems. The Institute for Computer Graphics (ICG), led by Professor James Hahn, reaches across disciplines to overcome these barriers and solve challenging problems in healthcare using innovative digital solutions. Thus, ICG represents the diverse research interests of its members, who come from the Mechanical and Aerospace Engineering and Computer Science fields and a wide range of medical areas such as Radiology, Psychology, Surgery, etc. The interdisciplinarity of the Institute enables researchers from the problem-rich field of medicine to interact with solution-rich disciplines in engineering and computer science.

Prof. Hahn and his team have two active R01 grants from the National Institutes of Health. The first combines 3D body surface scanning technology and machine learning to develop an inexpensive and noninvasive way to assess the health of highly obese individuals, explicitly focusing on fat build-up in the liver. They recruited 250 patients undergoing weight-loss surgery to participate in this study and found that body shapes from optical scanners do provide valuable information about the medical condition of the subject. The second addresses the low success rates for early-career physicians in performing the difficult and time-sensitive neonatal endotracheal intubation procedure. To reverse this trend, they designed an augmented reality mannequin simulator based on CT scans of an infant mannequin so students can watch their movements on a computer in real-time using a visualization algorithm. A machine learning algorithm was created to automatically analyze and assess the subjects' performance. Such features benefit medical training using simulators where realism, situational awareness, and qualified mentor resources are insufficient.

These projects build upon more than a decade of digital health research Prof. Hahn has conducted. One of the primary roles of ICG is to run the Motion Capture and Analysis Laboratory, which develops and houses motion and surface capture technology such as the Vicon optical motion capture system and a novel instrument they developed with the help of a National Science Foundation Major Research Instrumentation Grant. These technologies enable researchers to accurately record the movement of objects through space and time in various applications that are also highly interdisciplinary.

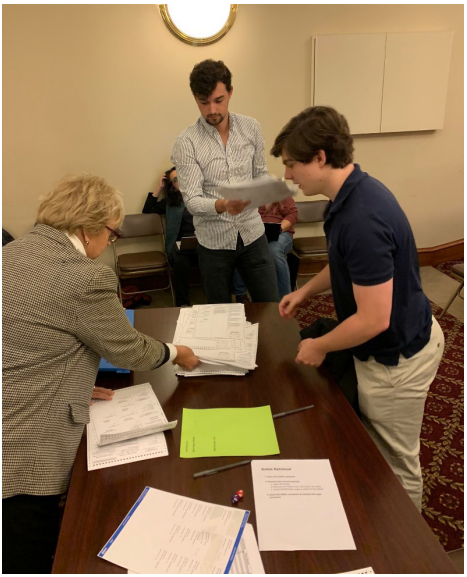


Prof. Hahn's team created an augmented reality simulator to help students track their success performing neonatal endotracheal intubation on an infant mannequin.

IMPROVING ELECTION SECURITY THROUGH BETTER AUDITING PROCESSES

No matter how well-tested and designed a computerized voting system is, it is impossible to be completely certain that it will always provide the correct tally. An area of active research is the design of systems and processes that would help detect incorrectly announced outcomes.

Professor Poorvi Vora's research group – in collaboration with Filip Zagórski, Assistant Professor of Computer Science at the University of Wroclaw – has been working on rigorous statistical election audits known as ballot polling audits. Securely stored ballots are chosen at random and manually examined to determine if the announced election outcome is correct. The group has developed new approaches that are more efficient than existing ones, requiring as few as half as many ballots. The audit procedure Minerva was used for a statutory audit of the 2020 US primaries in Montgomery County, Ohio, and the procedure Providence by Rhode Island to audit its 2022 elections, the name being in acknowledgment of its first use. The code for both audits has been integrated into Arlo, the most popular election audit software used by election officials across the US. GW students developed R2B2, an audit software library upon which *Providence* was built.



GW Computer Science undergraduate students Grant McClearn and Seamus Malley help out with a pilot Risk Limiting Audit carried out by Mercer County, Pennsylvania, in November 2019.

Previously, her group had participated in the design, development and deployment of end-to-end independently verifiable (E2E-V) voting system Scantegrity in the 2009 and 2011 elections of the City of Takoma Park. 2009 marked the first time anywhere in the world that voters and observers could determine whether an election outcome was correct without being required to trust election officials or voting system software.

The research group's work has been published in the top computer security and secure voting conferences and funded primarily by the National Science Foundation. Both undergraduate and graduate students have had the opportunity to develop ideas, prove their properties, receive author publications, write the code, deploy it and be present while it is used by voters and election officials. In the process, Prof. Vora has formed collaborative relationships with policy organizations such as the Brennan Center for Justice and Common Cause. She serves on the Board of Directors of Verified Voting, the leading non-partisan organization in the election integrity space.