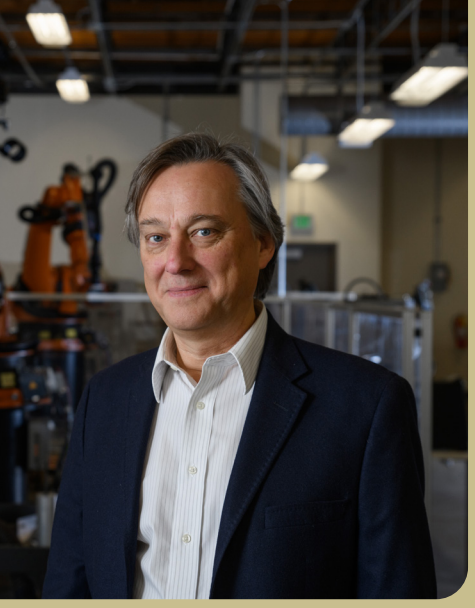
Georgia Tech
Institute for Robotics
and Intelligent Machines

Impact Report
2022 - 2023



A Message From The Director

Robotics has the potential to mitigate future labor shortages and drive economic growth, to supplement the efforts of caregivers for an aging population, to provide physical assistance to those with disabilities, and to actively engage those with cognitive to enhance learning, reasoning, and performing typical activities of daily living. In The Institute for Robotics and Intelligent Machines (IRIM) at the Georgia Institute of Technology we perform the fundamental research that will enable all of this and more.

Since its creation in 2013, IRIM has been the focal point of robotics research on the Georgia Tech campus. With more than forty core faculty members and more than two hundred graduate students, IRIM's research portfolio ranges from the theoretical to the applied, from actuation to intelligence, with application areas such as human-robot interaction, medical robotics, human augmentation and prosthetics, autonomous vehicles, locomotion, and factory automation. IRIM is recognized as one of the world's leading interdisciplinary robotics institutes, and its faculty are among the world leaders in the robotics research community.

In this year's annual report, you will find updates about our research activities, including major research centers and facilities, our seed grant program, and the newest members of our faculty. In addition, the report includes an overview of our educational programs, and information about our newly launched Industry Partners Program.

It has been a good year for GT Robotics, and I hope you enjoy reading about what we've been up to.

Sincerely,

Seth Hutchinson
Executive Director, Institute for Robotics and Intelligent Machines
Professor and KUKA Chair for Robotics, School of Interactive Computing
Georgia Institute of Technology

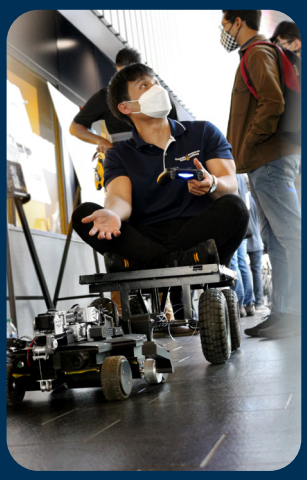
Meet the Leadership Team

Gary McMurray
Division Chief | Robotics, Modeling, & Sensing for Agriculture; Georgia Tech Research Institute

Nader Sadegh
Professor; School of Mechanical Engineering

Supporting Robotics Education

Georgia Tech offers a fully integrated, multidisciplinary experience in robotics education. The M.S. & Ph.D. programs include both coursework and research with faculty members in various units across campus. IRIM serves as the flagship for Tech's robotics efforts and has an integral relationship with many faculty members serving as course instructors and research advisors to students pursuing degrees within these programs.



Supporting Education Via Community Building Events

Fall Robotics Research Symposium
ICRA Writer's Workshop
Robotics Seminar Series | ~12 annually
Spring Research Showcase
Ph.D. Applicant Recruiting Week
Annual GT @ ICRA Robotics Party

Supporting Education Via Funding

This year, IRIM received funding for four two-year GRA appointments. The purpose of these fellowships is to recruit students who were invited to the PhD recruiting day (and are therefore top students), but who do not yet have funding. This fellowship allows up to two years for students to find an advisor with financial support. After our annual Ph.D. recruiting events, IRIM solicited nominations for candidates from participating faculty.

Robotics Students by the Numbers

Robotics Ph.D Program Year-over-Year Enrollment

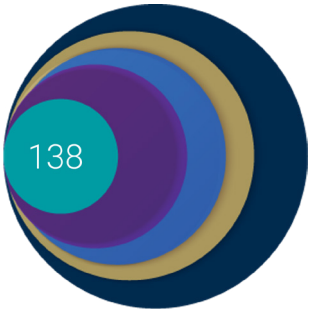
AY 2008-2009 | 11
AY 2015 - 2016 | 64
AY 2020 - 2021 | 116
AY 2021 - 2022 | 130

Robotics M.S.Program Year-over-Year Enrollment

AY 2021 - 2022 (Launch of Program) | 35

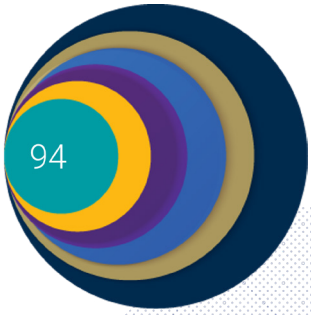
Ph.D. Robotics Students AY 2022-2023

Mechanical Engineering | 68
Electrical and Computer Engineering | 27
Aerospace Engineering | 24
College of Computing/Interactive Computing | 16
Biomedical Engineering | 3

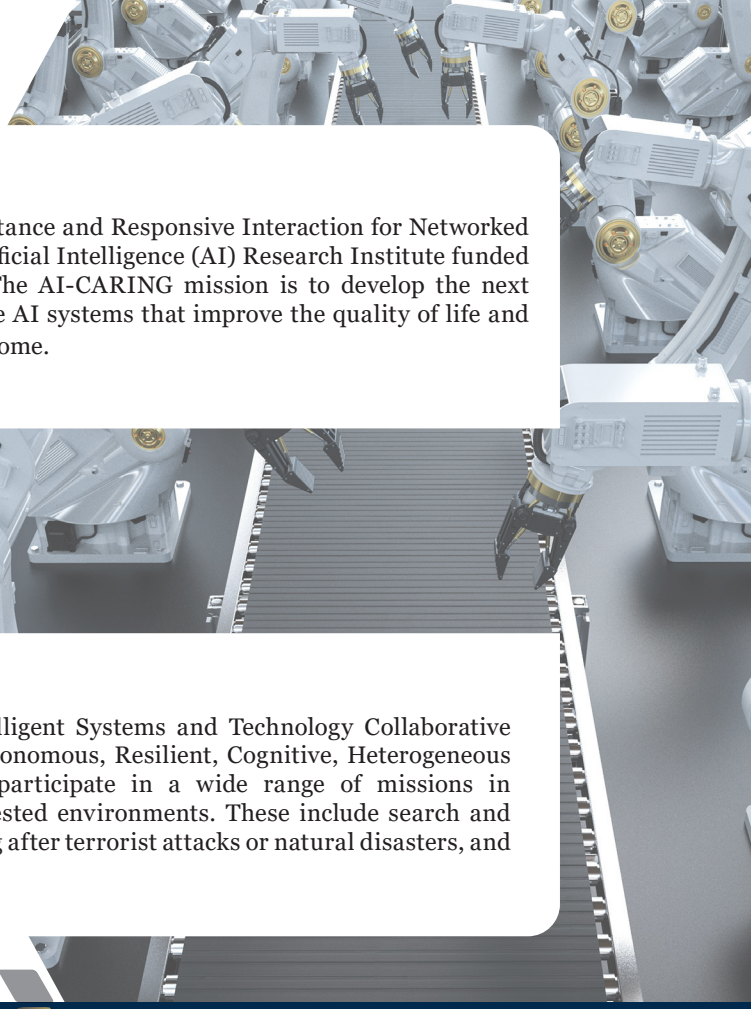


M.S. Robotics Students AY 2022-2023

Electrical and Computer Engineering | 41
Mechanical Engineering | 20
College of Computing/Interactive Computing | 13
Aerospace Engineering | 9
Biomedical Engineering | 6
Physics | 5



Project Portfolio



AI CARING
ai-caring.org

The AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING) is a National Artificial Intelligence (AI) Research Institute funded by the National Science Foundation. The AI-CARING mission is to develop the next generation of personalized collaborative AI systems that improve the quality of life and independence of aging adults living at home.

dcist
dcist-cra.org

The Distributed and Collaborative Intelligent Systems and Technology Collaborative Research Alliance (CRA) will create Autonomous, Resilient, Cognitive, Heterogeneous Swarms that can enable humans to participate in a wide range of missions in dynamically changing, harsh, and contested environments. These include search and rescue of hostages, information gathering after terrorist attacks or natural disasters, and humanitarian missions.

GTRI | Aerospace, Transportation & Advanced Systems Laboratory

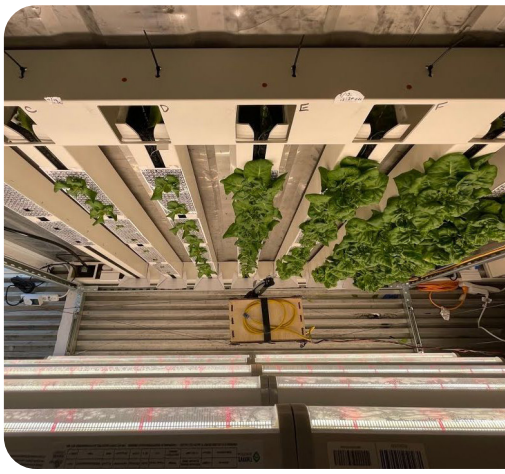
The Georgia Tech Research Institute's (GTRI) Aerospace, Transportation and Advanced Systems (ATAS) Laboratory conducts robotics and systems design research for Department of Defense (DOD) and manufacturing/agriculture domains. ATAS's DOD-focused mission is a preeminent leader in innovative and advanced research for fielded unmanned systems, providing both single and multi-agent solutions, spanning from basic research to advanced prototypes and test and evaluation. The laboratory's work specializes in applying concepts well established in the robotics domain to address applications unique to the DOD. For manufacturing/agriculture domains, ATAS performs cutting-edge research to make robotic systems (articulated arms to mobile platforms) more agile, flexible, and adaptable to allow them to work in unstructured environments. Sample projects include automating harvesting of specialty crops, automating deboning of poultry, and using large language models (LLMs) for task planning in assembly operations. In both domains, IRIM fosters collaboration by bringing together Georgia Tech faculty members and GTRI researchers to integrate the latest research advances into systems that are field tested for our sponsors.

gtri.gatech.edu

Seeded Projects

IRIM's Seed Grant Program supports high-risk, high-reward research. Seed grants provide ground-level funding for multi-faculty teams to pursue next-generation robotics research with strong market translation possibilities and the promise to provide rapid impacts on local, regional, and global issues. The following projects have received IRIM Seed Grant funding in the past year:

- Co-adaptive Human-Humanoid Collaboration through Multi-modal Wearable Sensing and Human Collaborative Dynamics Reasoning
- FarmHand: a Robotic Manipulator for Indoor Farming
- Large Language Model Based Planning for Autonomous Assembly and Repair
- Continuum Robotics for Autonomous Space Servicing
- Human Animal-Robot Interaction System (HARIS) for Autistic Children
- Development and Evaluation of a Virtual Reality Environment for Robot Learning from Human Demonstration
- Integration of Haptic Feedback in Virtual Reality Environments Using a WAM Robot Arm (VRWAM)
- Teaching Robots New Concepts through Conversation
- Diffusion Models for Interpretable Robot Task Planning



Research Facilities

Human Augmentation Facility

The Human Augmentation Core Facility is a ~ 3000 square foot space in the Callaway Building with two main human subject research bays: The Motek CAREN system bay and the Gait Lab bay. Additionally, a private patient changing room is equipped with a hi-lo plinth and sink for preparation of subjects prior to and following experiments. Wearable robotic devices intended to augment the hip, knee and ankle are available in portable or tethered capabilities.

Additional physiological measurement systems available for use during human subject experiments include metabolic consumption analysis tools(Parvo/COSMED), EMG/IMU systems (Delsys/ Biometrics) and Ultrasound (Telemed/SonixTouch). These tools allow for improved understanding of the physiological processes occurring during ambulation and other functional tasks.

For questions about training & access or general inquiries regarding the Human Augmentation Core Facility please contact:

service@robotics.gatech.edu

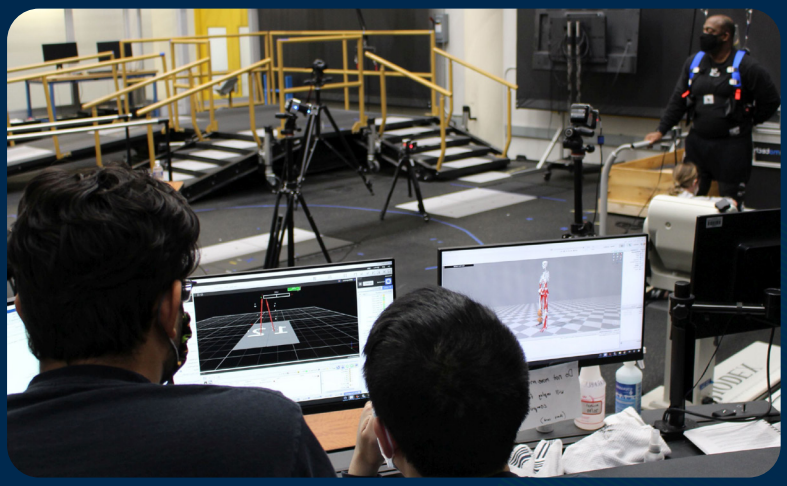
Human Augmentation Facility - Labs

Motek CAREN System

The Motek CAREN system bay, a facility that supports research in exoskeletons, prosthetics, and human augmentation, incorporates an instrumented treadmill mounted on a six degree-of-freedom motion system, immersed in a virtual reality space, equipped with a high-precision motion capture system.

Gait Lab Bay

The Gait Lab bay includes multiple instrumented terrain instances, including treadmills, stairs, and ramps, all within a workspace that is covered by a high-precision motion capture system.



Robotarium

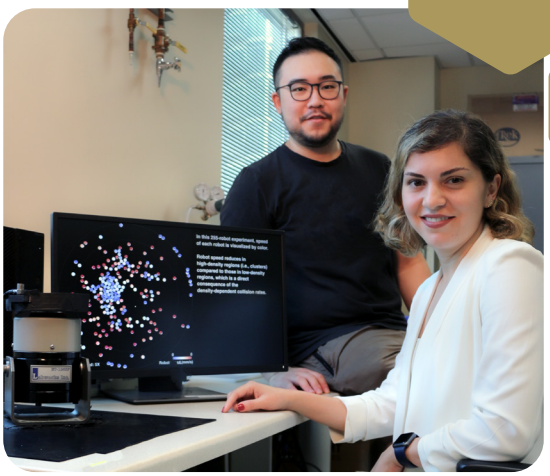
The Robotarium project provides a remotely accessible swarm robotics research platform that is freely accessible to anyone. Robotics research requires significant investments in terms of manpower and resources to competitively participate. We believe that anyone with new, amazing ideas should be able to see their algorithms deployed on real robots, rather than purely simulated. In order to make this vision a reality, we have created a remote-access, robotics lab where anyone can upload and test their ideas on real robotic hardware.

Aware Home

The Aware Home Research Initiative (AHRI) at the Georgia Institute of Technology is an interdisciplinary research endeavor spearheaded by the Institute for People and Technology (IPaT) Living Labs aimed at addressing the fundamental technical, design, and social challenges for people in a home setting. The Aware Home is a 3-story, 5040 square foot facility designed to facilitate interdisciplinary research, while providing an authentic home environment.

IRIM Research Highlights

Microrobots Controlled by Vibrations Could Be a Boon for Research



Regardless of their potential, the size of the microrobots mostly means they have restricted sensing, motility, communication, and computation abilities, but a new study from the Georgia Institute of Technology improves their ability to cooperate in an efficient manner.

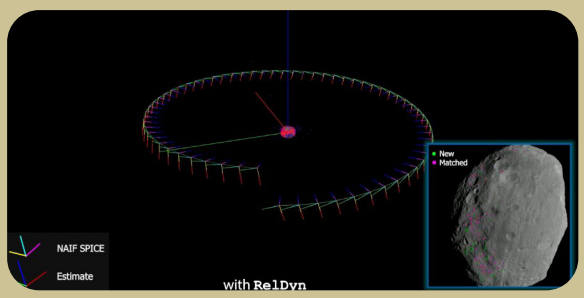
The study provides a new system to regulate the ability of swarms of 300 3-mm microbristle robots (microbots) to combine and scatter controllably without the need for onboard sensing.

The innovation is exclusive to Georgia Tech's capability in electric and computer engineering (ECE) and robotics and its zeal for interdisciplinary partnerships.

While larger robots can regulate movement by sensing the surroundings and wirelessly transmitting this data to each other, microbots do not have the capacity and cannot carry the same power units, sensors, or communications. In this research, the team instead employed inter-robot physical interactions to prompt robots to swarm.

These behaviors, or motility features, establish how microbots travel linearly and the unpredictability of their rotation. The team could regulate these motility features by employing vibration and conducting motility-induced phase separation (MIPS).

The scientists took inspiration for the concept from thermodynamics, where an agitated material can alter phases from solid to liquid to gas. The scientists exploited the vibration level to impact the microbots to develop clusters or scatter to form good spatial coverage.



A Model to Enable the Autonomous Navigation of Spacecraft During Deep-Space Missions

Simultaneous localization and mapping (SLAM) is a promising technology that can be used to improve the navigation of autonomous systems, helping them to map their surrounding environment and track other objects within it. So far, it has primarily been applied to terrestrial vehicles and mobile robots, yet it could also potentially be expanded to spacecraft.

Researchers at Georgia Institute of Technology (Georgia Tech) and the NASA Goddard Space Flight Center recently created AstroSLAM, a SLAM-based algorithm that could allow spacecraft to navigate more autonomously. The new solution, introduced in a paper pre-published on arXiv, could be particularly useful in instances where space systems are navigating around a small celestial body, such as an asteroid.

"Our recent work is part of a NASA-funded ESI (Early-Stage Innovations) program whose objective was to make future spacecraft destined for deep-space missions (e.g., visiting and surveying asteroids) more autonomous," Panagiotis Tsiotras, one of the researchers who carried out the study, told TechXplore.

Faster-than-reflexes robo-boots boost balance

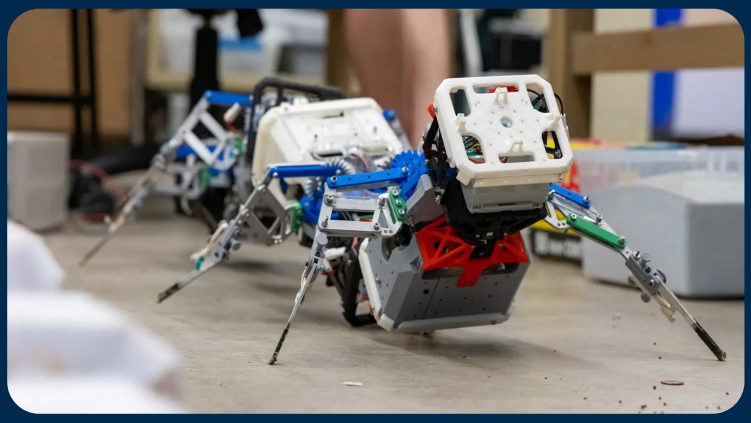
Robotic boots providing superhuman reflexes can help your balance. Our new study shows that the key to augmenting balance is to have boots that can act faster than human reaction times.

When people slip or trip, their reactions to regain balance are far slower than some machines can act. For humans, and other animals with legs, it takes time for biological sensors to send signals to the nervous system and then turn on muscles. Robots can act much faster, using wires instead of nerves to send their signals.

But robots are still notoriously bad at balancing, because they can't yet mimic how humans respond when their balance is challenged. We are biomechanical engineers and rehabilitation physiology researchers who study the neurophysiology of movement. In our study, we sought to answer the question of whether wearable robots – like powered lower-limb exoskeletons or prostheses – can improve balance above and beyond a normal baseline.

To build a better crawly robot, add legs—lots of legs

When traveling on rough and unpredictable roads, the more legs the better—at least for robots. Balancing on two legs is somewhat hard; on four legs, it's slightly easier. But what if you had many many legs, like a centipede? Researchers at Georgia Institute of Technology have found that by giving a robot multiple, connected legs, it allows the machine to easily clamber over landscapes with cracks, hills, and uneven surfaces without the need for extensive sensor systems that would otherwise have helped it navigate its environment. Their results are published in a study this week in the journal Science.



Robotics Professor Seeks to Revolutionize Heart Surgery

Gombolay received the prestigious National Institutes of Health RO1 grant, which will fund a three-year study of how robotics can improve and minimize the risks of open-heart surgery. Gombolay has partnered with Roger Dias, assistant professor of emergency medicine at Harvard Medical School, and Marco Zenati, professor of surgery at Harvard Medical School and chief of cardiothoracic surgery for the U.S. Department of Veterans Affairs to conduct the study.

Researchers use novel approach to teach robot to navigate over obstacles

When it comes to robotic locomotion and navigation, Naoki Yokoyama says most four-legged robots are trained to regain their footing if an obstacle causes them to stumble. Working toward a larger effort to develop a housekeeping robot, Yokoyama and his collaborators—Simar Kareer and Joanne Truong—set out to train their robot to walk over clutter it might encounter in a home.

"The main motivation of the project is getting low-level control over the legs of the robot that also incorporates visual input," said Yokoyama, a Ph.D. student within the School of Electrical and Computer Engineering. "We envisioned a controller that could be deployed in an indoor setting with a lot of clutter, such as shoes or toys on the ground of a messy home. Whereas blind locomotive controllers tend to be more reactive—if they step on something, they'll make sure they don't fall over—we wanted ours to use visual input to avoid stepping on the obstacle altogether."

To achieve their goal, the researchers took a novel training approach of fusing a high-level visual navigation policy with a visual locomotion policy.

To read the full text of these news items, scan the QR Code

IRIM Faculty Updates

Gregory Sawicki Honored for Human-Centered Robotics Research

Gregory S. Sawicki, Associate Professor in the School of Mechanical Engineering and the School of Biological Sciences, was named the Recipient of the 2023 American Society of Biomechanics Founders' Award for his biomechanics-based robotics research. The Founders' Award was established in 2017 to recognize scientific accomplishment in biomechanics and excellence in mentoring and is open to investigators of all disciplines within ASB.

Yue Chen Receives NIH Grant to Research Robotic Platform for Treating Atrial Fibrillation

To address issues in AF treatment Yue Chen, Assistant Professor at the Department of Biomedical Engineering at Georgia Tech & Emory and team will use this new award to develop an MR-tracked catheterization toolset with an MR-enabled intraoperative navigation feedback framework and robotic hardware system. Their innovative approach is the first to integrate accurate catheter manipulation and CTCF feedback with MRI-based monitoring and lesion assessment to provide a unified system for AF ablation planning, treatment, and assessment.

Ye Zhao Wins NSF CAREER Award for "Interactive Decision-making and Resilient Planning for Safe Legged Locomotion and Navigation"

Dr. Ye Zhao, Assistant Professor at the George Woodruff School of Mechanical Engineering, Director of the Laboratory for Intelligent Decision and Autonomous Robots (LIDAR) and member of the Institute for Robotics and Intelligent Machines, has been granted an NSF CAREER Award of ~$595,000.00 over a period of 5 years. Ye and his team will use the funding to develop a novel task and motion planning framework for bipedal robotic locomotion interacting with complex environments. Prof. Zhao's goal is to achieve safe and autonomous robot locomotion that will move legged robotic systems from the confines of research labs into real-world application domains such as disaster relief, first responder assistance, surveillance for civil and mechanical infrastructures, and use in agricultural environments.

Alex Abramson
Assistant Professor, School of Chemical and Biomolecular Engineering

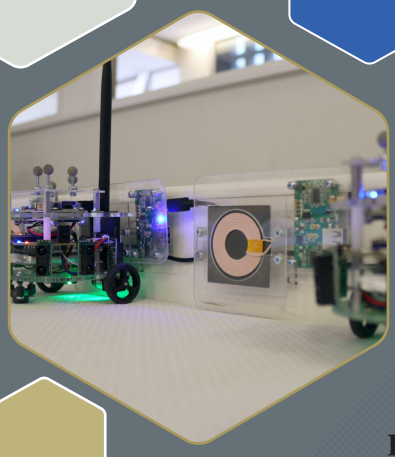
Alexander Adams
Assistant Professor, College of Computing

Shreyas Kousik
Assistant Professor, George W. Woodruff School of Mechanical Engineering

Alexis Noel
Research Engineer II; Aerospace, Transportation & Advanced Systems Laboratory @ GTRI

Omobolanle Ogunseiju
Assistant Professor, School of Building Construction

Lonnie Parker
Collaborative Autonomy Branch Chief, ATAS Lab @ GTRI



Industry Partners Program

Our Industry Partners Program allows members to explore opportunities for research collaborations, testing services, consulting relationships, student hiring, and other valuable interactions.

IRIM's industry partners are well positioned to take advantage of new technologies as they are developed, and the collaborative research environment provides companies with unprecedented access to some of the world's best computer scientists and engineers. Through Georgia Tech's redesigned research contracting, members enjoy industry-friendly intellectual property arrangements.

We invite you to join our Industrial Partners Program (IP2), a partnership that offers your company exclusive benefits tailored to meet your needs through three different membership tiers. Whether you join us as a strategic partner, an industry affiliate, or as a member of one of our customized industry consortia, your company will be invigorated and supported through our ongoing work as a consolidated group of robotics leaders.

Automation & Logistics

Human Centered Robotics

Manufacturing & Agricultural

Medical & Assistive

Membership Levels

Member: $10,000

- Southeast Robotics Symposium – two free registrations
- Invitation to IRIM Research Showcase during the spring semester
- Early access to students in the Robotics Master's program for required internship
- Ability post job openings on the IRIM website
- Recognition of your membership on the IRIM website
- Branding opportunities with the Georgia Tech Robotics community Variable cost structure based on size of company
-

Partner: $25,000

- All benefits of being a Member
- Free Partner Status for companies that fund in excess of $200,000 research in the field of robotics in a given academic year.
- Seminar and classroom presentation opportunities
- Invitation to serve on the IRIM Industry Advisory Board
- Recognition as a sponsor of select IRIM

For More Information Contact:
Gary McMurray - Associate Director, IRIM | (404) 407-8844 (Office) | (770) 355-3934 (Mobile)

Regularly Scheduled IRIM Events

- Fall Robotics Research Symposium
- ICRA Writer's Workshop
- Robotics Seminar Series | ~12 annually
- IRIM + Industry Robotics Meet-Up Nights
- IRIM Robotics Days for Industry (RD4I)
- National Robotics Week | Education Outreach
- The Atlanta Science Festival | Educational Outreach
- Spring Research Showcase
- Ph.D. Applicant Recruiting Week
- Annual GT @ ICRA Robotics Party

2022 - 2023 Outreach Highlights

HAC and LIDAR Lab host a visit from State Congressional Representatives

EPIC and PoWeR Labs host APS Biomechanics Day

2022 Atlanta Science Festival Georgia Tech Science and Engineering Day

IRIM & Robotics in Atlanta

2023 Conference on Robot Learning (CoRL)

International Symposium on Medical Robotics

Graffiti Bot
@ AVANT South

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