Carnegie Mellon University

the LINK

THE MAGAZINE OF CMU'S SCHOOL OF COMPUTER SCIENCE

SUMMER 2022
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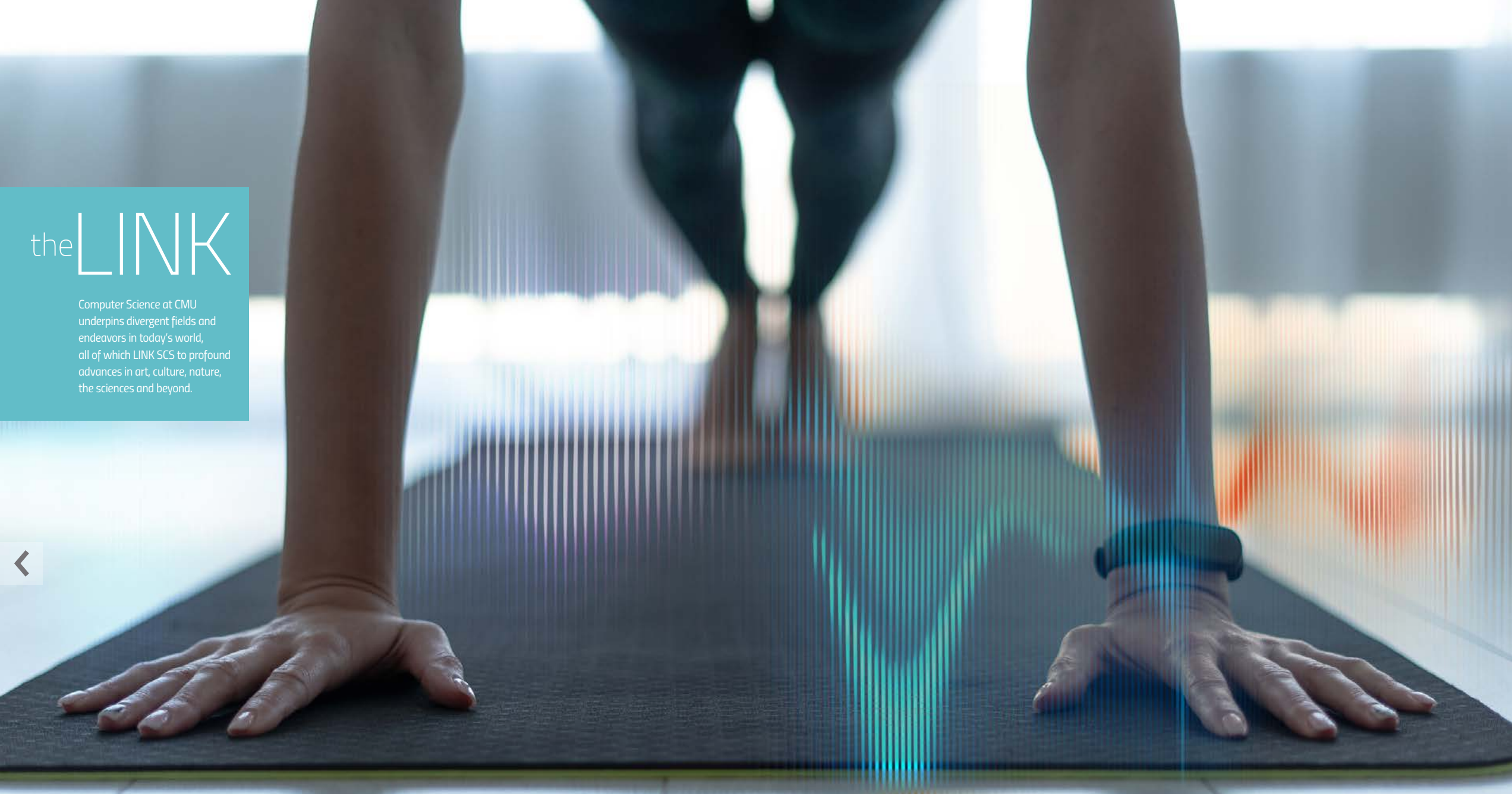
Building Accessibility

SCS Research and Outreach Target a More Diverse and Accessible Future



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Computer Science at CMU underpins divergent fields and endeavors in today's world, all of which LINK SCS to profound advances in art, culture, nature, the sciences and beyond.

Sensors That Increase Privacy?

Wearables Train New Privacy-Preserving Sensors

AARON AUPPERLEE

Data about home sales likely won't help someone looking for a car, just like basketball statistics won't help someone understand baseball.

But inside the Smart Sensing for Humans (SMASH) Lab, researchers in the Human-Computer Interaction Institute are using data collected from one type of sensor to train another. Their work, called IMU2Doppler, has shown that data collected from inertial measurement unit (IMU) sensors in smartwatches can quickly train a millimeter wave doppler to recognize human movements and behaviors.

Doppler sensors use millimeter waves and the doppler effect to determine the velocity and direction of a moving object. The ambient sensor can be installed in a smart house, where it can recognize and track daily activities such as eating, drinking, brushing teeth and folding clothes. It is a privacy-preserving alternative to popular smart devices with speakers and cameras that have raised concerns about privacy.

While large, labeled data sets exist for training sensors that depend on IMU or video, they do not exist for doppler sensors. Collecting and labeling the data takes time and resources — expenditures researchers could avoid through the work of the SMASH Lab team.

"Wearables like Fitbit and Apple Watch have been commonplace for so many years now. People have already put so much time into labeling IMU data sets for everyday activities, and we can just piggyback on that to label new sensors such as a doppler," said Rushil Khurana, a member of SMASH Lab and Ph.D. student in human-computer interaction.

The team used a neural network trained on existing IMU and video data to facilitate training a doppler sensor model and found that it was 75% accurate out of the gate with only a few seconds of its own training data.

Besides tracking daily activities in a house, researchers in the SMASH Lab eventually want to track and monitor the movements of people in their homes to help doctors, counselors, clinicians and other medical professionals spot illnesses or the signs of potential problems. Doppler sensors installed in homes could make this possible.

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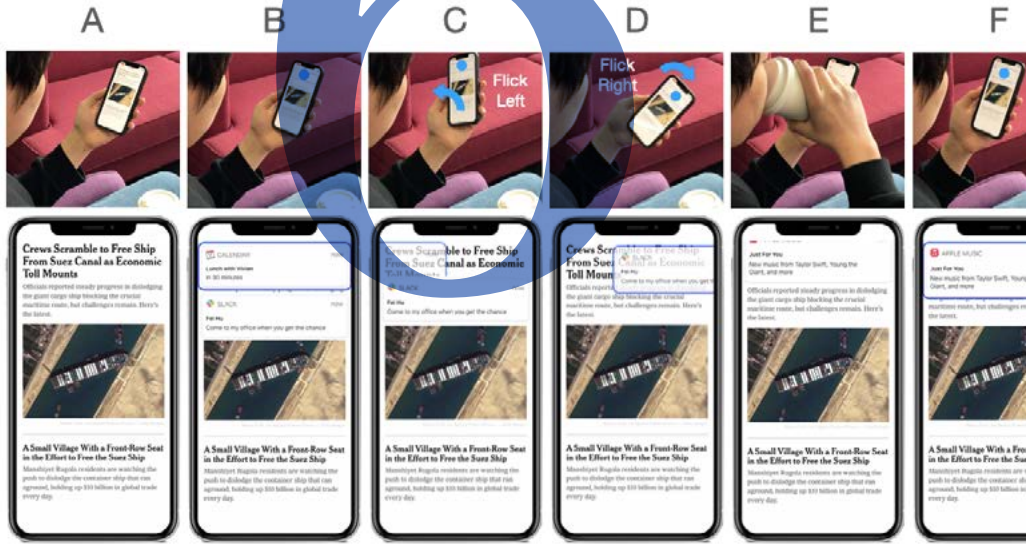

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Working in the Best Interests of All

SCS remains committed to diversifying and building inroads to our college and community of scholarship and research. We do this not only because it is the right thing to do, but because when we make use of diverse ways of thinking we create better research, better science and better technologies. We consider how to build technologies that work for as many different people as possible. At every level of the process of innovation, we look to collaborate with those who think differently than we do. It is the SCS way.

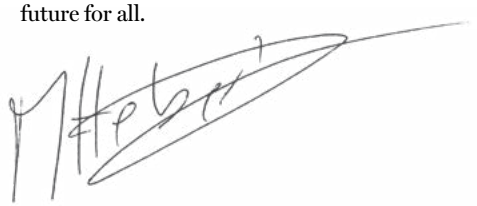
However, it is also important to recognize that SCS remains committed to addressing the gap in access to technology known as the "Digital Divide." This line of division between people must be narrowed, for those without access to careers in tech will be left out of the opportunity and prosperity they offer.

While we have put forth considerable effort into the SCS initiatives centered on making access to computer science, our curricula and SCS itself attainable to more people from varying backgrounds, it is important to remember that more work remains to be done. We invite you to be a part of this effort as it gains momentum across our school and campus. The Ph.D. students who created the JEDI course (Justice, Equity, Diversity and Inclusion) are an excellent example. The course, taught to other Ph.D. students, helps make our campus more welcoming and inclusive.

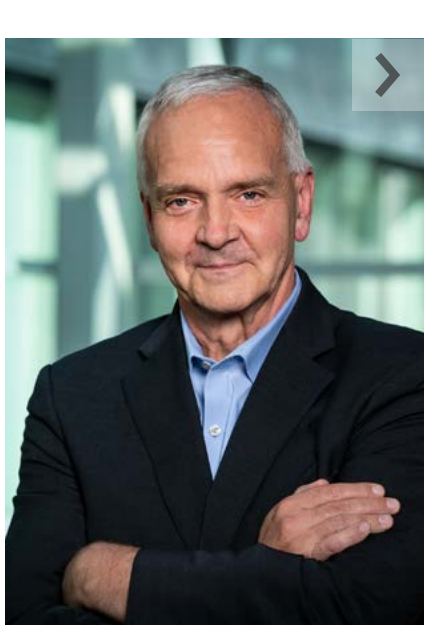
Among the articles in this issue, you'll find a common thread of diverse and accessible education and outreach as pillars of our mission in SCS. Papers submitted to the recent ACM CHI Conference on computer and human interaction lead the field in making smartphone screens and online interactions more accessible than ever before. We continue to grow our outreach programs like CS Pathways, CS Academy and the Robotics Academy which place access to computer science curriculum and opportunities in tech within the grasp of more communities, as well as degrees and careers in computer science. A profile of SCS faculty member Hoda Heidari's work to make AI more socially responsible has far-reaching applications in these areas. And I hope you enjoy the wonderful article that tracks the Girls of Steel team and their competing in the FIRST World Robotics Championship. Good work, all.

These efforts beyond our own immediate use represent two sides of the same coin: the building of diverse, collaborative and accessible teams equipped to create technologies that work better and are more accessible to more people, who then go on to make greater contributions from which we all benefit. It is a journey worth our effort and leadership, and one that we must continue to keep at the top of our minds.

The fact is, we need all of our young people to consider careers in tech and feel capable to attend institutions that teach computer science, even if they do not attend CMU. As an institution we firmly believe that our efforts will mutually benefit SCS, the Pittsburgh region and our nation, as we do our part to build a better future for all.



Martial Hebert
Dean, School of Computer Science



Accessibility Enables Equality

CHRIS QUIRK

The Drive Toward Accessible Devices and Research Leads SCS to Improvements for All

If a technological device or application failed one out of four times, most reviewers would deem it a flop. But if a quarter of the population couldn't use a device or application, would the verdict be the same?

According to the Centers for Disease Control and Prevention, 61 million adults in the U.S. live with some disability, around one in four, and too often technological products fail them. And while no single product causes headaches for everyone living with a disability, the widespread lack of accessible features on apps, devices and webpages means that people with disabilities face disproportionate barriers to technology and the needs it can fulfill.

Researchers at Carnegie Mellon University's Human-Computer Interaction Institute (HCII) want to change that.

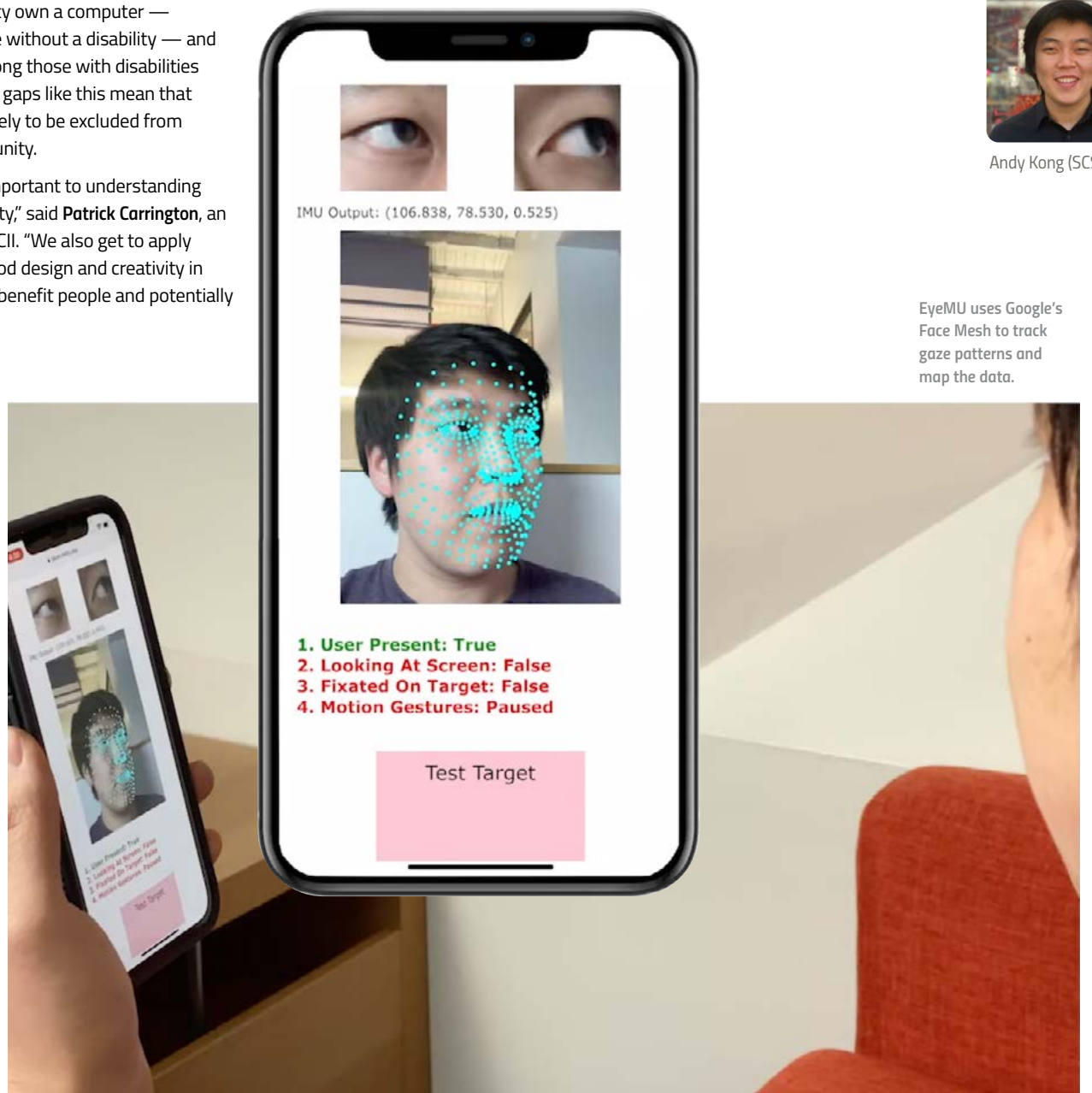
> " Accessibility is squarely at the intersection of computer science with people. The HCII was founded on the belief that we need a place with people who are comfortable working at that intersection. That's why accessibility is a core part of human-computer interaction and the HCII."

Jeffrey Bigham, Associate Professor in HCII

"If we care about human-computer interaction, accessibility is a fundamental part of that. More than 20% of people have some sort of disability, and we'll all have a disability if we live long enough," said **Jeffrey Bigham**, an associate professor in the HCII. "Accessibility is squarely at the intersection of computer science with people. The HCII was founded on the belief that we need a place with people who are comfortable working at that intersection. That's why accessibility is a core part of human-computer interaction and the HCII."

Last year, Pew Research Center analysis found that people with disabilities are less likely to use a computer or smartphone. Only 62% of adults with a disability own a computer — compared with 81% of those without a disability — and smartphone ownership among those with disabilities similarly lagged. Technology gaps like this mean that disabled people are more likely to be excluded from economic and social opportunity.

"Accessibility is incredibly important to understanding human ability and its diversity," said **Patrick Carrington**, an assistant professor in the HCII. "We also get to apply many of the principles of good design and creativity in situations that will critically benefit people and potentially change lives."



EyeMU uses Google's Face Mesh to track gaze patterns and map the data.

Using the Eyes with EyeMU

Chris Harrison, Associate Professor in HCII

Andy Kong (SCS 2022)

One group of HCII researchers has built a tool called EyeMU, which allows users to execute operations on a smartphone through gaze control. The tool could help users with limited agility control apps on their phones without ever touching the screen.

Gaze analysis and prediction aren't new, but achieving an acceptable level of functionality on a smartphone would be a noteworthy advance.

"The eyes have what you would call the Midas touch problem," said **Chris Harrison**, an associate professor in the HCII. "You can't have a situation in which everywhere you look something happens on the phone. Too many applications would open."

Software that tracks the eyes with precision can solve this problem. **Andy Kong** (SCS 2022) has been interested in eye-tracking technologies since he first came to CMU. He found commercial versions pricey, so he wrote a program that used the built-in camera on a laptop to track the user's eyes, which in turn moved the cursor around the screen — an important early step toward EyeMU.

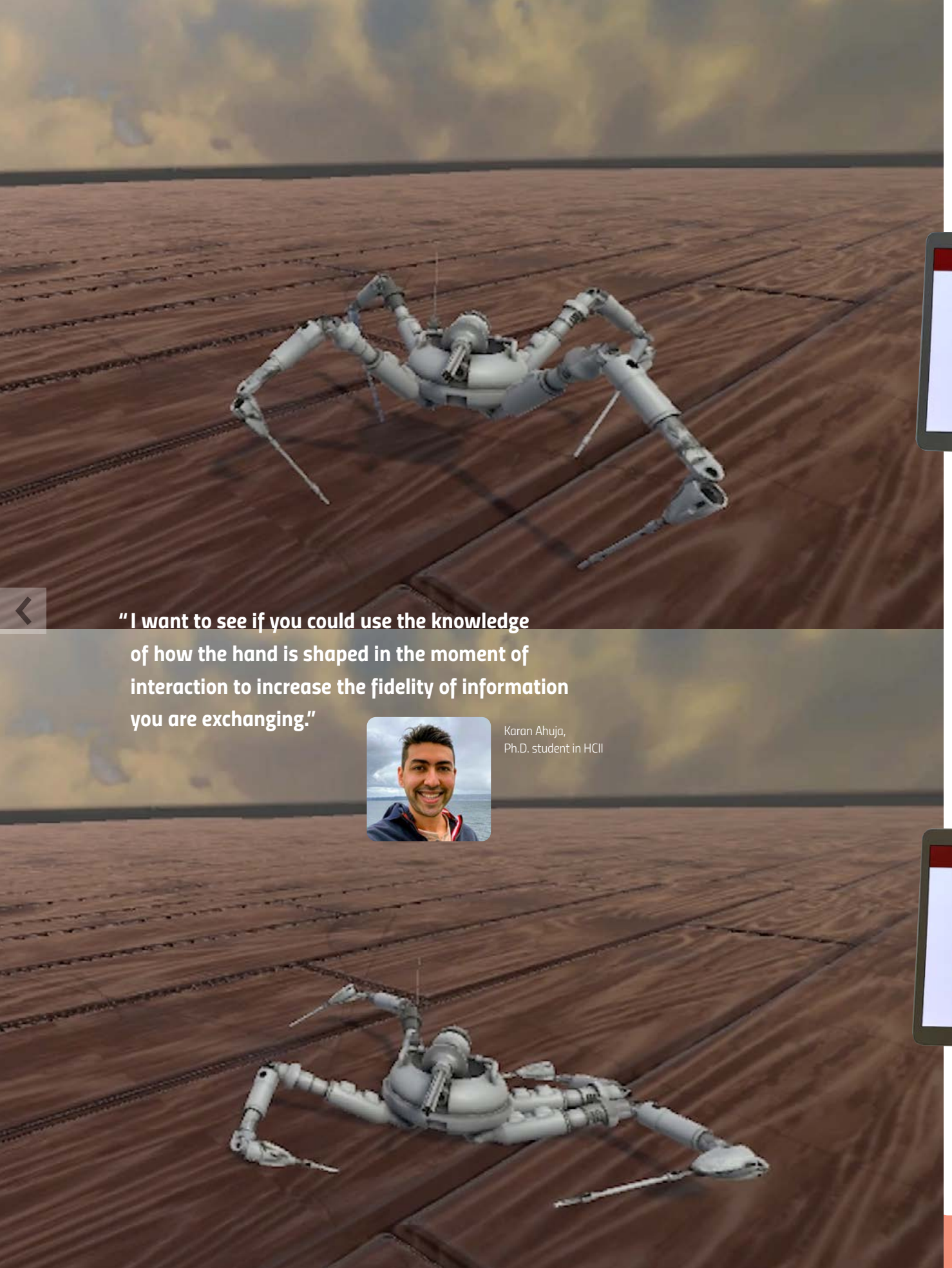
"Current phones only respond when we ask them for things, whether by speech, taps or button clicks," Kong said. "If the phone is widely used now, imagine how much more useful it would be if we could predict what the user wanted by analyzing gaze or other biometrics."

Kong and HCII Ph.D. student **Karan Ahuja** advanced that early prototype by utilizing Google's Face Mesh tool to both study the gaze patterns of users looking at different areas of the screen and render the mapping data. Next, the team developed a gaze predictor that uses the smartphone's front-facing camera to lock in what the viewer is looking at and register it as the target.

The team made the tool more productive by combining the gaze predictor with the smartphone's built-in motion sensors to enable commands. For example, a user could look at a notification long enough to secure it as a target and flick the phone to the left to dismiss it or to the right to respond to it. Similarly, a user might pull the phone closer to enlarge an image or move the phone away to disengage gaze control.

To deal with varying facial geometries, EyeMU calibrates itself to the face of the individual user via the smartphone camera. EyeMU could be expanded and combined with other sensing modalities and could share the gaze-tracking information with other apps.

"I believe future applications on devices will use built-in eye tracking to read our intentions before we even have to lift a finger. EyeMU is a step toward that goal," said Kong.



"I want to see if you could use the knowledge of how the hand is shaped in the moment of interaction to increase the fidelity of information you are exchanging."

Karan Ahuja,
Ph.D. student in HCII

Using the Hands with TouchPose

Touchscreens miss a lot of information. Improving how they work could result in better accessibility for users. Ahuja worked with **Paul Streli** and **Christian Holz** while in residency at the Department of Computer Science at ETH Zürich to build TouchPose, a neural network estimator that calculates hand postures based on the geometry of finger touch points on smartphone and tablet screens. The team believes it is the first tool of its kind.

"All interactions with the screen are two-dimensional, but your hands have very complex 3D geometries," Ahuja said. "I want to see if you could use the knowledge of how the hand is shaped in the moment of interaction to increase the fidelity of information you are exchanging."

Research in robotics, virtual reality and other fields has provided a strong vocabulary of human hand forms and motion dynamics. Ahuja's tool determines if the posture of a hand could be reverse engineered based on finger information from the screen. For example, if you move your hand back and forth while keeping the tip of your index finger on a touchscreen, nothing happens. But if a smartphone tool could process the changing shape of the fingertip on the screen to infer if your hand was moving to the left, right, forward or back, your finger could be used like a joystick. A tool like this could also help eliminate false touch mistakes and ambiguities, which cause frustration and slow down users.

The final data set to train the model contained more than 65,000 images. To build it, Ahuja and his colleagues spent a year recording 10 participants interacting with a flat screen using 14 unique hand positions. For the model, the team developed a new machine learning architecture to handle the novel nature of the research.

"We can't know for sure what a user's hand is going to look like, so there's always a probability associated with priors from the data set we captured naturally," said Ahuja. "If you have a situation where there's a single touch point, and the model can't resolve whether it's the index finger or the middle finger, it will use probabilistic understanding to figure it out."

TouchPose could be used on its own or it could form a foundation for accessibility features on other apps and devices. To encourage those efforts, Ahuja and his colleagues have made all their training data, code and the model itself public.

Research to Improve
Future Accessibility Studies

To build a stronger foundation for accessibility, a team of HCII researchers is assembling a knowledge base and assessing current needs and resources. Sometimes their findings are counterintuitive.

"Building empathy to improve the lives of people with disabilities is necessary, but maybe not in the way most people would expect," Carrington said. "One of the biggest challenges I see regarding accessibility is ableism. People make assumptions about what people can do, what they should be able to do, and how they can or should do it."

"One of the biggest challenges I see regarding accessibility is ableism. People make assumptions about what people can do, what they should be able to do, and how they can or should do it."

Patrick Carrington, Assistant Professor in HCII

Carrington and CMU colleagues Franklin Mingzhe Li, Franchesca Spektor, Peter Cederberg and Yuqi Gong joined colleagues from the Rochester Institute of Technology and the KAIST School of Computing in the Republic of Korea to present a study on the use of cosmetics by the visually impaired at the ACM CHI Conference on Human Factors in Computing Systems (CHI 2022) this past May in New Orleans.

More than 40% of people in the U.S. use cosmetics regularly, but few of them are visually impaired. The paper shares testimonials from visually impaired people — who number 2.2 billion globally — on the importance of having agency over their own self-care, which using makeup can help provide. "When I first lost my eyesight, I was quite sad that I couldn't look in the mirror," said Lucy Edward, CoverGirl's first blind beauty ambassador. "Applying makeup is a way that I can control my appearance again."

Carrington and the team analyzed YouTube videos that help visually impaired people use makeup, cataloging the challenges they face and noting what users found helpful. The team also interviewed visually impaired people about their experiences and the effectiveness of some of the videos as a core part of the study.

To gather the source material for their analysis, Carrington and his fellow researchers executed an algorithmic search for relevant videos using targeted keywords for both visual disability and makeup practices, and strategically filtered the results. They then analyzed the 145 collected videos to generate a knowledge base of makeup practices used by visually impaired persons. The researchers documented that people with visual disabilities prefer to learn about makeup practices from individuals with a similar complexion or who were from their own demographic. Additionally the data showed that people with visual impairments want to be able to easily know the quantity of the cosmetics they are using and that they utilized sound and smell of the products to help them differentiate one product from another. In addition to the wealth of their findings, Carrington's team hopes their research will result in avenues for future projects and a richer understanding of best practices.

How research happens also presents accessibility challenges, which HCII researchers Bigham, Emma McDonnell and Jailyn Zabala set out to tackle with colleagues from the University of Washington and Vanderbilt University.

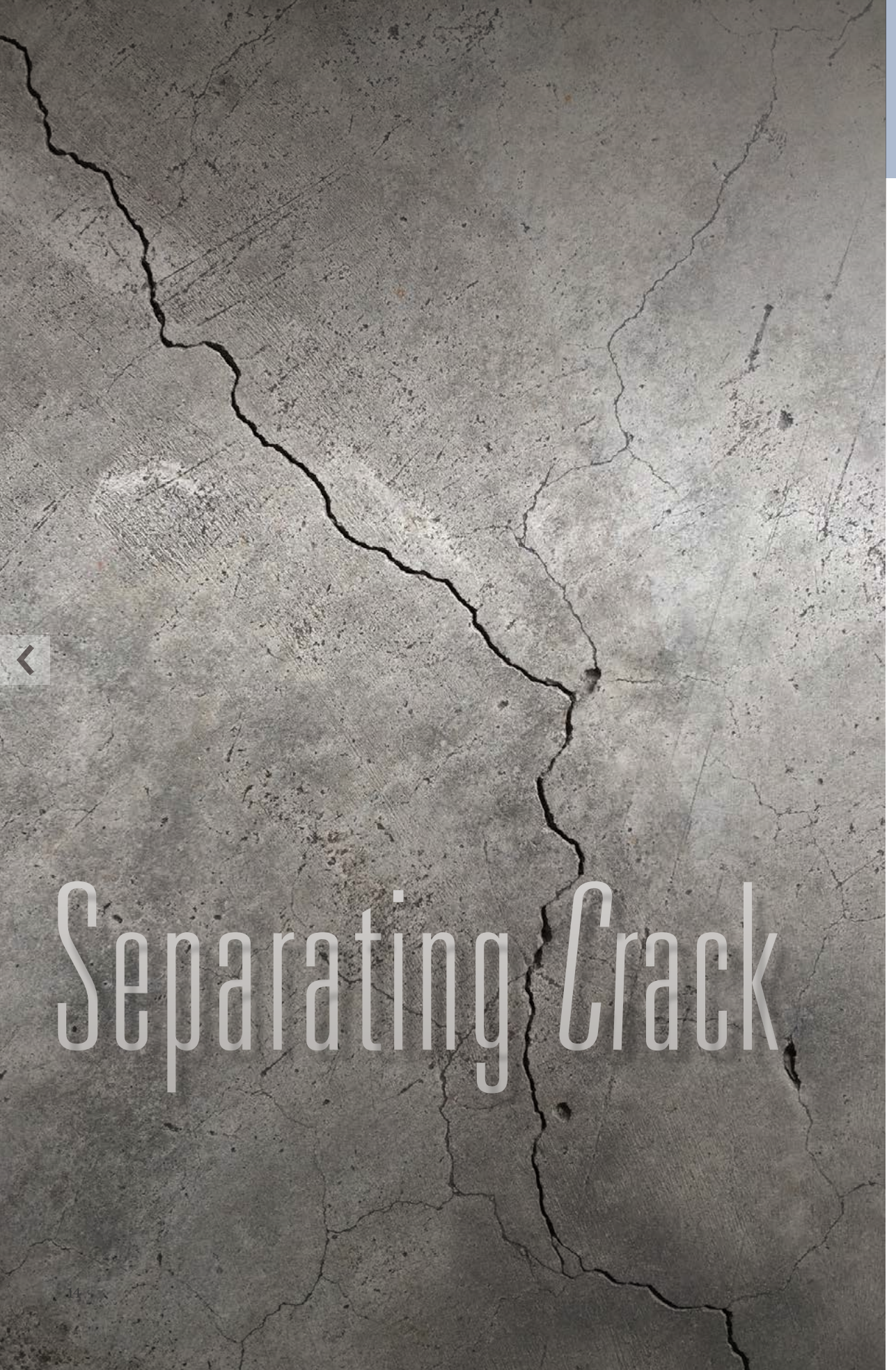
"I expect accessibility work will very much influence the future of how we all interact with computers."

Jeffrey Bigham

The group shared their findings at CHI 2022.

Rigorous analysis of implementing accessibility into research methods is scarce. Bigham and his collaborators extensively outlined where and how accessibility should be taken into account throughout the research process, including recruitment, interviews and interactions that are part of the data-gathering process. Working from established concepts in critical disability studies, they also made practical suggestions scholars could use to overcome barriers that leave out or hinder the input of disabled persons in future studies.

"Since accessibility directly grapples with the larger part of the interaction space than is typically assumed, I expect accessibility work will very much influence the future of how we all interact with computers," Bigham said. "I think the work being done to adapt user interfaces to a person's current abilities and context have huge implications for how we might benefit from devices that adapt to where we are and what we're doing." ■



Separating Crack from Fiction

Researchers in CMU's Robotics Institute are using specially developed drones and new methods to detect cracks in concrete to better monitor and inspect infrastructure like bridges.

The collapse of Pittsburgh's Fern Hollow Bridge was a dramatic reminder of that fact. The exact cause of the collapse won't be known until the National Transportation Safety Board completes a months-long study, but Carnegie Mellon University researchers have developed autonomous drone technology that someday might prevent similar catastrophes and lessen mishaps caused by deterioration.

Working with Shimizu Corp., a Tokyo-based construction and civil engineering company, the Robotics Institute researchers built a prototype drone designed for monitoring bridges and other infrastructure. As part of that effort, they recently unveiled a new method that enables automated systems to more accurately detect and monitor cracks in reinforced concrete.

Rust never sleeps, and cracking concrete doesn't get a day off either.

Byron Spice

Sebastian Scherer, associate research professor of robotics and leader of the CMU team working with Shimizu, said the crack-detection method was one of several technologies that the university developed for the project, which concluded in February 2022. The researchers built a working prototype of a bridge-monitoring drone that employs the crack-detection system and plan to use it at the Frick Park site of the Fern Hollow Bridge to make a detailed model for the post-collapse analysis.

"The automated technology we developed for the Shimizu project is designed to prevent this type of collapse via comprehensive mapping, crack detection and structural analysis that would be too much work if it were done by hand," Scherer said. "Today, typically you only do spot checks on critical parts, since an exhaustive survey and analysis would be too slow. Automated defect-detection technology would enable inspectors to check bridges more frequently and perhaps identify problems before failures occur."

Kris Kitani, associate research professor of robotics, led the research team, whose system improves existing crack-detection algorithms by 10%.

Their system relies on a computer vision framework known as a convolutional neural network (CNN), a class of artificial neural networks commonly used to analyze visual imagery. This framework can readily identify animals and objects such as vehicles and production parts. But Jinhyung "David" Park, a senior in the Computer Science Department majoring in artificial intelligence and a member of Kitani's research team, noted that these systems have much more difficulty detecting cracks.

"Cracks, unlike these other objects, are very thin — often only two or three pixels wide in images," Park said. They also have extremely irregular shapes and can be obscured by marks or shadows on surfaces.

"The automated technology we developed for the Shimizu project is designed to prevent this type of collapse via comprehensive mapping, crack detection and structural analysis that would be too much work if it were done by hand."

SEBASTIAN SCHERER
Associate Research Professor in the Robotics Institute

The Fern Hollow Bridge Collapse in Frick Park, Pittsburgh

Even when existing systems detect a crack, they cannot always determine how wide it is. They often overestimate the size, which makes it difficult to accurately determine if the crack is a serious defect or whether it might be expanding.

The researchers addressed the problem by using reinforcement learning, a form of artificial intelligence. In this game-like approach, the computer uses trial and error to develop tactics for solving a problem while maximizing its performance based on rewards and penalties.

This approach is commonly used to improve the performance of robotic arms, Park said. In those cases, a robotic system uses reinforcement learning to analyze the space surrounding a robotic arm to determine which motions would best enable the arm to accomplish a goal.

As adapted by the CMU researchers for crack detection, reinforcement learning allows a computer system to analyze each pixel within an image. Rather than decide how to move a robotic arm, the system calculates the probability that each pixel is part of a crack.

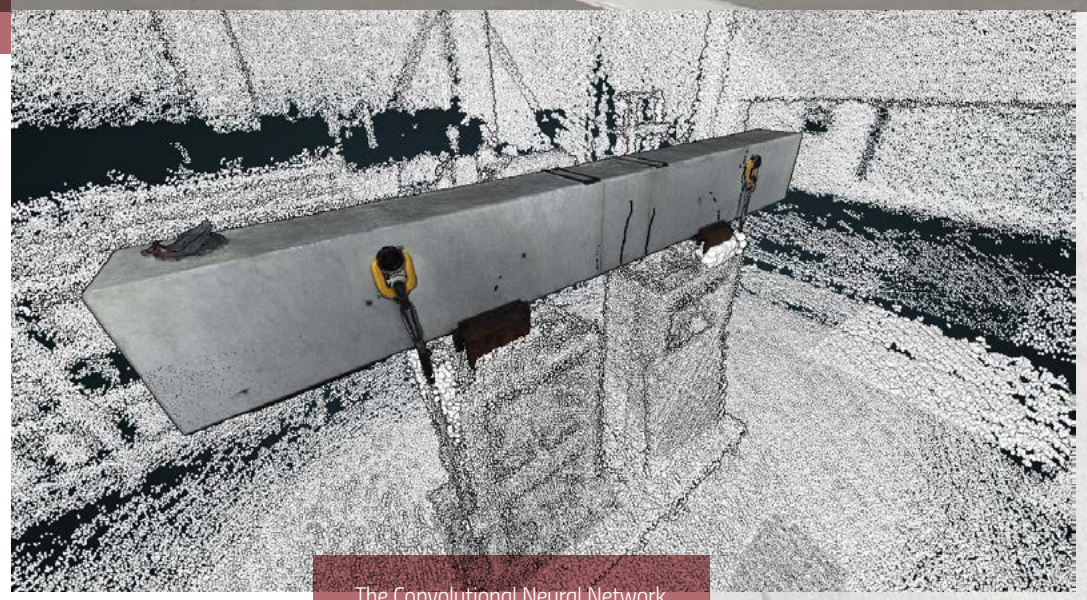
"That might sound time-consuming because we're considering every pixel," Park said. "But our reinforcement learning agent is convolutional, so it does these predictions asynchronously for every single pixel at once."

This technique enables the system to not only detect cracks at high resolution, but also to calculate the probability that separate cracks might be part of one larger crack.

"If you have a crack that's kind of shaped like this" Park said, extending the thumb and pinky of his right hand, "and another one here" — extending his left thumb and pinky near his right hand — "but they're disconnected in the middle, maybe the network can recognize, hey, these cracks are actually parts of the same crack."

The team presented its crack-detection work in September at the IEEE International Conference on Image Processing (ICIP 2021) in Anchorage, Alaska, where it won the Best Industry Impact Award. In addition to Park, who was the lead author, Kitani's team included Yi-Chun Chen, a Robotics Institute master's student in computer vision; and Yu-Jhe Li, a Ph.D. student in the Robotics Institute and the Electrical and Computer Engineering Department. ■

Drone flying beneath a bridge, testing the system and collecting data.



The Convolutional Neural Network analyzes each pixel to determine if it is part of a potentially dangerous structural crack.

BUILDING EQUITY IN THE NEXT GENERATION OF COMPUTER SCIENTISTS

KEVIN O'CONNELL

SCS teams increase access to computer science and technical education for younger, more diverse audiences

With great authority comes great responsibility. This adage has been attributed to various people in positions of power, from President Teddy Roosevelt to Spiderman. Though repackaged with each reprise, it remains a truism: those in powerful positions must not use that power to maintain their own advantage, but to lead in a manner that benefits all.

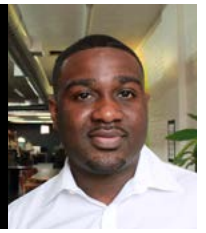
Now that computer literacy and tech fluency have become key access points to better careers, and now that technology powers nearly everything from healthcare to the service industry, farming and beyond, SCS continues its mission to expand access to those who reside on the more challenging side of the technology gap, especially those from traditionally under-resourced communities.

Darla Coleman, executive director of SCS' Diversity, Equity and Inclusion initiatives believes the benefits of diversity work both ways. "It's important to have representation within SCS because it brings us diverse thought and perspectives," said Coleman. "With each different person belonging to a specific group, we gain access to different modes of thoughts, while fostering an inclusive community."

Alongside on-campus programs like Women@SCS, SCS4All and SCS4Accessibilty that seek to welcome diverse groups to campus and help them find a home here, several SCS programs are making computer science education accessible to as many young people as possible, especially in under-resourced communities and in places where they would not otherwise exist. The programs aim to reach students at young ages, long before they might ever attend CMU, regardless of if they attend at all.

DARLA COLEMAN
Executive Director of SCS' Diversity, Equity and Inclusion

"It's not that coding is too hard, or computer science is too difficult. It's about exposure and practice. And having the wraparound services to be able to mentor and help students succeed." MAXIMILIAN DENNISON, Director of Beta Builders



CS PATHWAYS + BETA BUILDERS

"Less than 50% of American high schools offer computer science classes," said **Ashley Patton**, director of CS Pathways, an initiative that offers a variety of outreach programs designed to provide people from under-resourced areas access to computer science education. "And the computer science curriculum being offered happens overwhelmingly in wealthy districts, particularly suburban and primarily white districts. CS Pathways exists to address this problem."

Under an ever-broadening umbrella of programs, CS Pathways has recently partnered with Beta Builders, a local organization that goes into Pittsburgh communities to teach kids how to code.

"If you don't have any technology skills, you absolutely won't be prepared for the 21st century," said **Maximilian Dennison**, director of Beta Builders. Dennison and his partner Anthony Harper started the program to break down the barriers they saw preventing people in their community from accessing job opportunities in technical fields.

"It's not that coding is too hard, or computer science is too difficult," said Dennison. "It's about exposure and practice. And having the wraparound services to be able to mentor and help students succeed." The program's goal closely aligns with CS Pathways goals; hence the partnership arose.

Beta Builders is free for the campers, but there have been other hurdles to increasing attendance. In addition to the cost of the camps and the perceived difficulty of computer science, Dennison points to the idea that young kids in his community still see professional sports as a viable path to a good income – not technology jobs. "Until I'm walking down the street and kids are talking about robotics instead of Steph Curry or Lebron James, there's work to be done," said Dennison.

Normalizing the tech industry in his community is personal for Dennison, too. "The program attacks all the issues that students that come from my community and look like me are facing," he said. "If you get a job in tech, you're going to have sustainability. You're learning a skill set that's for the future, so you'll always be able to feed your family and take care of your responsibilities and not be in that struggle."

Dennison believes that if Medgar Evers or Dr. Martin Luther King, Jr. were alive today, they would be saying the thing that we need to be getting into now is tech, because it is the biggest thing that affects the most people. "I just feel like with the time I have on Earth, I love the fact that we are pushing kids toward a better future," he said.

The program is just three years old, but graduates of Beta Builders now attend computer science programs at Penn State and UC Berkeley. "They come back in the summer and help us teach some of the courses," said Dennison.

Patton said that CS Pathways is always asking how they can create experiences that transform the entire trajectory of a person's life, and the partnership with Beta Builders is one of their many initiatives. A career in tech can do much more than impact the life of the person gaining the access and the knowledge to the career. "The kids are the biggest part of why we do this, but it's also about how they go on to enriching their communities," said Patton. "It can have a generational impact."

CMU CS ACADEMY

An SCS outreach program with big potential for impact is CMU CS Academy, which offers completely free online computer science curricula for middle school and high school classrooms.

The online, graphics-based courses feature 24/7 online support and auto-graded exercises for students, as well as professional development and a teacher portal filled with resources. This level of support allows teachers to improve their own abilities while focusing their attention on their students.

"You have to act like a leader if you want to be a leader," said **David Kosbie**, associate teaching professor and co-founder and director of CS Academy. "It's not just a title. It's something you earn." Along with co-founder **Mark Stehlik**, associate dean for outreach, the pair want to teach one million students.

"A lot of people think that goal is somewhere between delusional and extraordinary hubris, or maybe just a joke," said Kosbie. "But it is none of those things to us. We mean it."

The growth of CS Academy since its pilot year in 2017 can only be described as exponential. The launch group in 2018 had about 400 students. Since then, more than 176,000 students have used the curriculum utilizing 120 million program runs. The growth is remarkable, especially considering that it has yet to be adopted wholesale by a major U.S. school district. "We are more than 1/6th of the way there," said Kosbie. "We're going to get to a million students. We are going to satisfy the initial target and we fully intend more."

(continued pg. 24)

CMU CS ACADEMY CURRICULA

CS1 Computer Science 1, the original pilot course for high school students

AP CSP - CS Principles, modules created in collaboration with code.org that complement the Advanced Placement course and test

CS2, an applications-based course

CS3, the capstone course currently being piloted; carries with it the benefit of college credit for students who complete it, backed by SCS

CS0, designed for pre-high school students and gives schools and out-of-school instructors the freedom to offer the program in different ways, as an elective, club or after-school program

"We're going to get to a million students. We are going to satisfy the initial target and we fully intend more." DAVID KOSBIE, Co-founder and Director of CS Academy

> "Our eyes were opened to the fact that just because we built this curriculum and offered it for free, it wouldn't have the impact we thought it would in certain parts of the world unless we did additional work." DAVID KOSBIE

As CS Academy forges ahead, the team realizes that exponential growth will not always be the norm. And they've begun to recognize and move into the next frontier: offering their courses in Spanish. "We anticipate in the next year or two, our Spanish-speaking students will grow in number to be equal to our English-speaking students," said Kosbie. "We expect continued, aggressive growth."

Sophia DeJesus, assistant program manager who heads the Spanish program, recently trained teachers in Puerto Rico and has been in talks with government officials in Costa Rica. Adopting the program doesn't work the same way in these countries as it does in the U.S. because often there's a minister of education or someone appointed by the government to approve the curriculum. So, the strategy, as Kosbie notes, must be different.

"In the U.S., it's hard to get broad adoption across a state, but it's easier to get into a particular school. So, you start building up that way. In Central and South America, it's harder to get in, but once you do, you might open the entire country."

Offering a Spanish version helps growth in U.S. cities like Houston, Miami and Los Angeles with high numbers of Spanish-speaking students, especially ESL students. These students could be in an English-speaking classroom and yet do their work in Spanish, which some might find attractive.

Kosbie sees the expansion of the curriculum to Spanish as the natural next step to provide access to all. "Our eyes were opened to the fact that just because we built this curriculum and offered it for free, it wouldn't have the impact we thought it would in certain parts of the world unless we did additional work," he said. "And that work, expanding into a language of need, therefore, became part of the mission."

CMU CS ACADEMY

ACADEMY.CS.CMU.EDU

THE ROBOTICS ACADEMY

Founded nearly 20 years ago by Robin Shoop, director of educational outreach for NREC, and John Bares, the former director of NREC and now CEO of Carnegie Robotics, Carnegie Mellon Robotics Academy (CMRA) has long delivered curriculum and computer science education to those who might not otherwise have access. Of the various outreach programs offered under the umbrella of the Robotics Academy, two stand out in furthering their mission to teach computer science and STEM in underserved areas and communities: the SMART program, a robotics technician pre-apprenticeship program, and the P3G (Player-Programmed Partner) Game Design outreach workshops. Both programs first targeted underserved communities in Pittsburgh but have experienced substantial growth since.

SMART

Witnessing decades ago the large number of tech companies spinning off from NREC and SCS, Bares foresaw the need for workers, as well as the need for good jobs in Pittsburgh. Now, the CMRA workforce development program strives to get underserved learners on a pathway toward a career in robotics — specifically, as robotics technicians. Initial funding for the project came from the ARM (Advanced Robotics for Manufacturing) Institute.

"First we interviewed and observed robotics technicians as well as the hiring managers at advanced manufacturing and tech companies to draft the KSA, or knowledge, skills and attitudes list," said **Vu Nguyen**, co-director of the Robotics Academy and software engineer in RI. From this information, the team developed coursework around five micro-certification areas of need: electrical, fabrication, software, mechanical and robotics integration. Each SMART course provides foundational knowledge in its area and coursework that is project-based and hands on.

A wide range of people showed up to the first SMART cohort, ranging from ages 16 to 28, many of whom had dropped out of high school, were working on their GEDs or who didn't have a plan yet for their future.

"To reach learners up to 28 years old, we partner with folks in the communities who have the keys and rapport with the kids," said Nguyen. Typically, these community partners are program directors teaching life skills, interview skills, tech or financial literacy courses. The SMART program integrates their tech program alongside these established programs.

Creating the micro-certification courses provides the training material and assessment needed to be successful as a robotics technician. Next, CMRA worked with community partners to directly deliver the training to underserved communities around the Pittsburgh region. The program received additional funding from Pittsburgh workforce investment board, Partner-4Work. And thus, the SMART-ER (SMART Extended Reach) program was born. The program worked with seven different community partners, in eight different underserved areas in the Pittsburgh region. Though the program is a pre-apprenticeship and does not connect participants directly to jobs upon completion, the skills they receive do prepare them for the burgeoning world of robotics and tech manufacturing.

"We started 20 years ago when there were barely any schools that had robotics programs," said Nguyen. "Since then, we've taught hundreds of teachers every single year and everyone we talk to has some form of

> "They learn about testing, iteration design, prototyping and in the end, they are designing a game even if they don't realize it." VU NGUYEN, Co-Director of Robotics Academy

robotics programs — and they're still growing them." While much remains ahead to give all kids access to robotics, seeing the growth of the program regionally, nationally and globally gives Nguyen a tremendous sense of pride.

"I came from nothing," said Nguyen. "My parents came from Vietnam with two trash bags for their luggage. I grew up in Bloomfield and went to Pittsburgh Public Schools. And I felt like I was given so much that I want others to have that opportunity for a good career."

P3G Game Design

The Player-Programmed Partner Games Design program (P3GO is an NSF-funded project that seeks to increase access to informal STEM education in out-of-school time settings. Using a game-design oriented program, students learn about human-robot interaction in a co-robotic context, while developing a game along the way. The project poses the question: how can we get kids to learn about co-robotics (working alongside robots), to code and enjoy it, without even knowing they're coding? The answer: gamifying the process of making a game.

P3G teams take the first few weeks of the outside-of-school program to simply ask the kids questions about the games they already play. "We amass all that data," said Nguyen, "the things they like and don't like, the types of characters they enjoy. The team's game designers and programmers develop a game prototype containing the features the kids requested. Then the teams present the game back to the kids and ask for feedback. Whatever the kids don't like, the team changes. Whether the characters are too realistic or if they'd rather they throw a football instead of wielding a battle-axe, the team does another iteration.

"They learn about testing, iteration design and prototyping, and in the end, they are designing a game even if they don't realize it," said Nguyen. "When we showcase the games, students say 'I made this game. I'm one of the creators.' And having them identify with the process is when we know they're hooked."

Once completed, the playable games are available at www.cmu.edu/roboticsacademy/Research/p3g.html

Nguyen clearly has fun designing games with the kids. "Each game is different because they have been designed by different cultures and different communities," said Nguyen.

Alongside the SMART and P3G projects, CMRA develops curricula and teaching resources for educators around the globe. The Robotics Academy curricula is available online at no cost. Anywhere from 30-50,000 users a month access the system.

"We hear from teachers around the world that thank us for putting this out there. Hearing them actually using our materials and our programs, that's cool to see," said Nguyen.

The examples included in this story represent only a portion of the programs SCS devotes to providing free computer science curricula and experiences to those who need them. Programs have been created to provide access for middle schoolers, community college students, and more. In essence, everyone who might want access. Regardless of if these individuals end up pursuing computer science as a career, SCS recognizes its stake in opening up this world of opportunity, to offer our knowledge and resources so that others may demonstrate their potential in the field.

"Each of us have people in our lives that 'poured' into us and helped us to become who we are," said Darla Coleman. "On a grander scale, SCS wants to pay it forward. There's no obligation, but there's a strong sense of contributing to humanity that is important."

SEEING BENEATH THE SURFACE

Convolutional Neural Network Framework Examines Ultrasound Images and Improves Detection of Subcutaneous Cancer Cells

MEGAN HARRIS

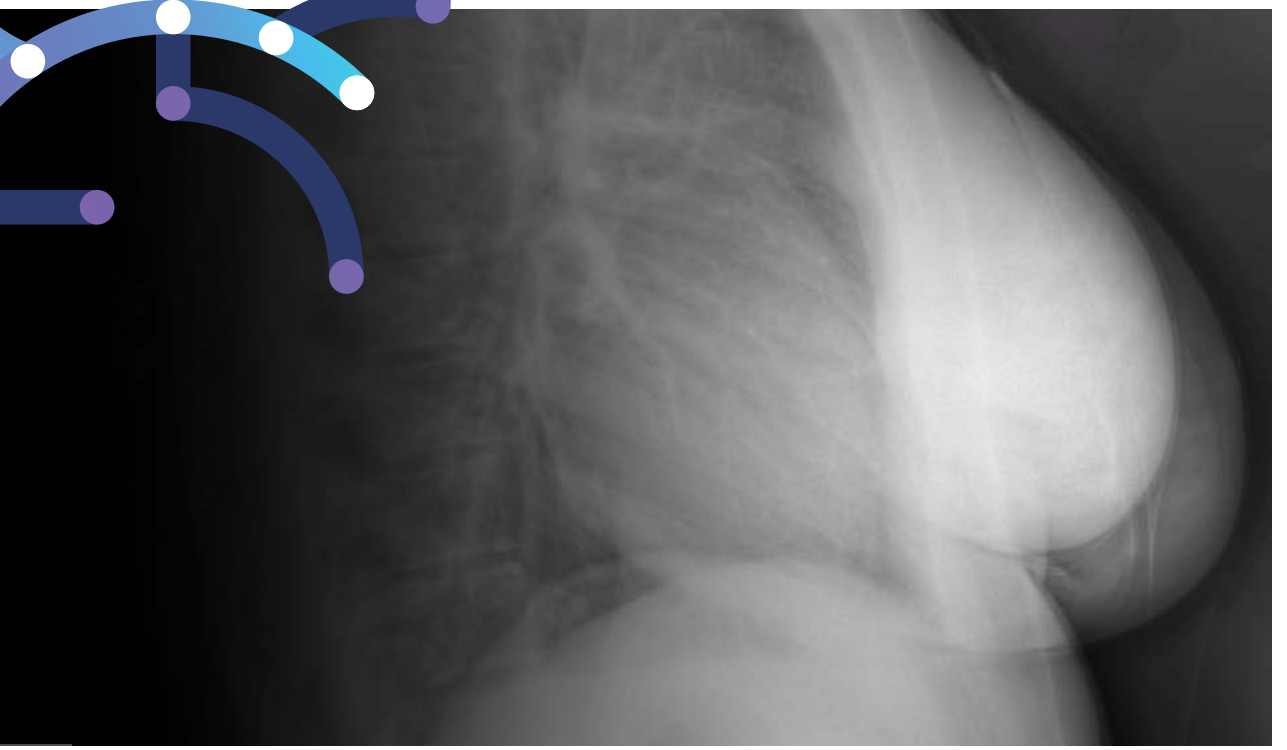
Precision is paramount in most stages of scientific research. A Robotics Institute's weekly roundtable discussion recently honed in on an essential idea: what exactly does it mean for an image to be fuzzy?

At its core, an ultrasound is an image of gathered high-frequency sound waves. Each component part is a collection of pixels, and until now, humans have been tasked with interpreting them to make or better understand a medical diagnosis.

But what if AI could do better.

"Ultrasound is the safest, cheapest and fastest medical imaging modality, but it's also arguably the worst in terms of image clarity," said John Galeotti, a systems scientist with CMU's Robotics Institute and adjunct assistant professor in biomedical engineering. "The research here is ultimately about teaching AI to process detail in an ultrasound that typically doesn't get used. So just by having that extra information, the AI can make better conclusions."

Through interdisciplinary research, collaborations and teaching, Galeotti has been working for years to improve patient outcomes by focusing on the tools of science and medicine. His most recent work introduces W-Net, a novel Convolutional Neural Network (CNN) framework that uses raw ultrasound waveforms in addition to the black-and-white ultrasound image to semantically segment and label tissues for anatomical, pathological or other diagnostic purposes. Initial findings were published in the journal Medical Image Analysis in February of 2022.



"To our knowledge, no one has ever seriously tried to ascribe meaning to every pixel of an ultrasound on a regular, ongoing basis, so it's not that we crossed some invisible barrier of never being able to do this and now we can," said Galeotti. "It's more that AI was pretty bad at this, and thanks to W-Net, it has the potential to be much better."

For even highly trained humans, healthy or distressed tissue can be tough to confidently discern. Fuzziness in the image could indicate disease or pathology, but how much fuzziness is worrisome? Beyond the subcutaneous layer, brightness, breaks and indents in various lines may suggest a need for further testing. Either way, the technology is limited and patient care has been dictated by subjective human assessment.

W-Net goes further by attempting to label every pixel without the use of a predetermined background classification for the entire static image. Galeotti's team recently applied the idea to breast tumor detection, which in tests, outperformed established diagnostic frameworks.

The group has since returned to pulmonary applications, which is where much of their work has focused since the pandemic took hold in 2020.

It all started with Baltimore-based plastic surgeon Dr. Ricardo Rodriguez, who was looking for a better way to monitor the treatment of irradiated breast tissue after the injection of reconstructive fat cells. He wanted to see how the fat changed or helped heal the damaged tissue, so he called and wrote letters to imaging specialists near and far. Galeotti answered that call.

"As a clinician, I used to look at an ultrasound and it was completely unintelligible. Like a snowstorm," he said. "I see something; it's obviously there. But our brains aren't equipped to process it."

Rodriguez wondered, what if a screen could better show people what they're looking at?

"We needed to create a deep-learning model that could understand the reading and present it to both clinicians and patients on a screen. And not in a way that requires years of training. Let's make it obvious so you can interact with it, emotionally and intellectually."

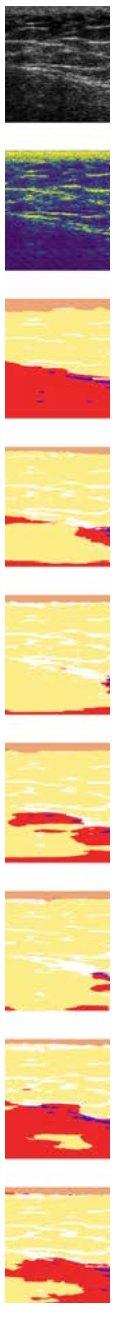
Gautam Gare, a Ph.D. candidate still working alongside Galeotti got an early crash course in radiography — learning from medical professionals how to label bits of lung scans and recognize markers for disease or pathology. He's processed thousands of individual scans, each bringing the AI system closer to performing the same tasks on its own.

"It was a big learning curve," Gare said. "When I started, I didn't even know what an ultrasound image looked like. Now I understand it better, and the potential for this research is still really exciting. No one is exploring the raw data exactly the way we are."

In recent months, much of that labeling work has moved to a team of pulmonary specialists at Louisiana State University in Baton Rouge, under the care of professor of medicine and physiology Dr. Ben deBoisblanc. Finding a pulmonary partner took time, Rodriguez said, until he turned to his own family. In addition to serving as the director of clinical care services at the Medical Center of Louisiana, deBoisblanc is also Rodriguez's wife's cousin. It was a happy accident when the two crossed academic paths; deBoisblanc said he wasn't initially interested in ultrasound, but as he learned more about how technology could be applied — and got to know the team — he went all-in.

"I've always been a geek — to this day, I'll sit on my spin bike and read journal abstracts for fun — but this team is different. We have so much respect for each other, and a deep sense of collaboration and curiosity. They're easy to work with, and they're a lot of fun."

"The research here is ultimately about teaching AI to process detail in an ultrasound that typically doesn't get used." John Galeotti, Systems Scientist in the Robotics Institute



With deBoisblanc's group of about a dozen LSU clinicians sharing and labeling lung scans, Galeotti's team has been able to refine the process. On Thursdays, the primary team of Galeotti, Gare, Rodriguez and deBoisblanc can virtually review the scans for biomarkers, or labels, often with the help of the clinicians themselves. With more scans come adaptations in the definitions. These meet-ups give them a chance to adjust, and in turn, improve the technology.

Though it remains labor intensive, Rodriguez said it's all a part of step one — teaching the AI to understand the signal. Step two involves translating that data into an image physicians and patients recognize as a better version of an ultrasound. deBoisblanc takes it a step further.

"As the technology improves, we'll need to look for clinical correlations, and that's where we are now. The third part is testing those outputs. We're not even close to that yet." But to his mind, the market is ready for their work.

"Twenty years ago, you had to be a radiologist to understand this stuff. Now I'm pulling a little unit around from patient to patient on my morning rounds. Imagine a battlefield or an ambulance en route to a hospital, where someone with little to no training could point a device at an injured or incapacitated person and know immediately what might be wrong. It's the perfect time to let AI assist from here."

The W-Net convolutional neural network allows for deeper analysis of ultrasound images that are relatively fuzzy to the human eye.

Responsible AI

Hoda Heidari Seeks to Apply Social Awareness to Developing Technologies

SUSIE CRIBBS

Growing up in an eventful corner of the world like Iran, Hoda Heidari developed a keen interest in history, politics and economics as a teenager. But she also excelled at math and computing, even earning a medal in the Iranian National Mathematics Olympiad as a senior in high school — a feat not common for a woman. It wasn't until she earned a bachelor's degree in computer engineering and began exploring graduate programs that she realized she could combine her passion for computing and social sciences into one career. Thus, her interest in responsible AI was born.

"I believe that our collective values are the bond that holds us together. We must be careful that the technologies we build reflect these values or we risk the technology tearing us apart," Heidari said. "For better or worse, technologists are in a position to impact people's lives and social dynamics. We need to recognize our power and wield it responsibly."

Heidari completed her Ph.D. at the University of Pennsylvania, working with Michael Kearns, a professor in the Department of Computer and Information Science, on her dissertation, "Essays in Algorithmic Market Design Under Social Constraints." She held post-doctoral appointments at ETH Zurich and Cornell University before joining the School of Computer Science's Machine Learning Department in fall 2020. She knew CMU offered the environment where her interdisciplinary research could thrive."

Carnegie Mellon appealed to me as my academic home because of its collaborative and multidisciplinary atmosphere," said Heidari, who has a joint appointment in the Societal Computing program in the Institute for Software Research. "I got the impression that CMU wouldn't hold me to the confines of the traditional definition of computer science. I would be not just permitted but encouraged to explore various methods and perspectives, form and grow interdisciplinary collaborations, and take risks."

Now in her second year as an assistant professor, Heidari has begun a robust research program that explores the social and ethical aspects of artificial intelligence. Specifically, she is interested in evaluating bias and unfairness at different stages in the process data scientists and engineers use to create automated decision-making systems — what Heidari refers to as the machine learning pipeline. In creating decision-making tools, researchers first decide whether it is appropriate to apply machine learning technologies to the problem at hand, given the available data. If so, the next step involves inspecting the data and cleaning up any glaring biases. Then, researchers create a statistical model of that data that can be used to make predictions about never-before-seen-instances. Next, the model is tested and validated. Finally, if all goes well, the model is deployed in the real world, where it should be monitored for unintended consequences.

Each of these stages involves normative choices: Should the technology be used at all? If so, what statistical model is most appropriate for the data? What methods should be used to test and validate the model? Under what conditions will the model be deployed? Will the model's predictions help humans make decisions, or will the tool decide autonomously? And finally, to what extent can we foresee the long-term consequences of deploying the model in real decision-making environments?

These decision points are where Heidari's research comes in. Her work measures unfairness and determines places in the pipeline where it might sneak in. In a world where throwing automation at nearly every problem has become incredibly common, her work is more relevant than ever.

"My research attempts to understand the origin of algorithmic unfairness in predictions produced by machine learning models. For example, is the quality of the input data the main culprit or does the type of statistical model fail to capture the distinct statistical patterns in various data segments?" she said.

Heidari's work in this area got a boost last year from an NSF-Amazon Fairness in AI Award for her project "Achieving Fair Societal Outcomes in ML Applications to Education, Criminal Justice, and Health and Human Services." She was one of three CMU faculty members to earn the award. The trio's conversations sparked the Responsible AI initiative, a university-wide effort dedicated to designing, developing and deploying AI responsibly to provide effective mechanisms for accountability and transparency and create a more just and equitable world."

> **We [Technologists] need to recognize our power and wield it responsibly.**
>
> Hoda Heidari,
> Assistant Professor in ML and ISR

CMU has always been at the forefront of artificial intelligence, and we firmly believe that it should and will play a similar trailblazing role in Responsible AI. What distinguishes us from other research institutes of the same caliber is our willingness to engage with a variety of expertise and experiences. I believe this openness is vital to progress in the Responsible AI domain," Heidari said. "Our faculty have already made tangible positive impacts beyond academic circles. The goal of the Responsible AI initiative is to amplify that impact and give visibility to the great work happening here at CMU."

Clearly Heidari has already begun making her mark, even though she started her CMU career during the COVID-19 pandemic and wasn't even on campus until last year.

My favorite memory was getting the keys to my office in the Gates-Hillman Complex after a year here," she said. "That was an exciting moment. It made it real for me that I am a faculty member now, and I have the chance to build my research agenda at my dream academic home."

GIRLS OF STEEL

CMU-sponsored Youth Robotics Team Competes in the World Championship

KEVIN O'CONNELL

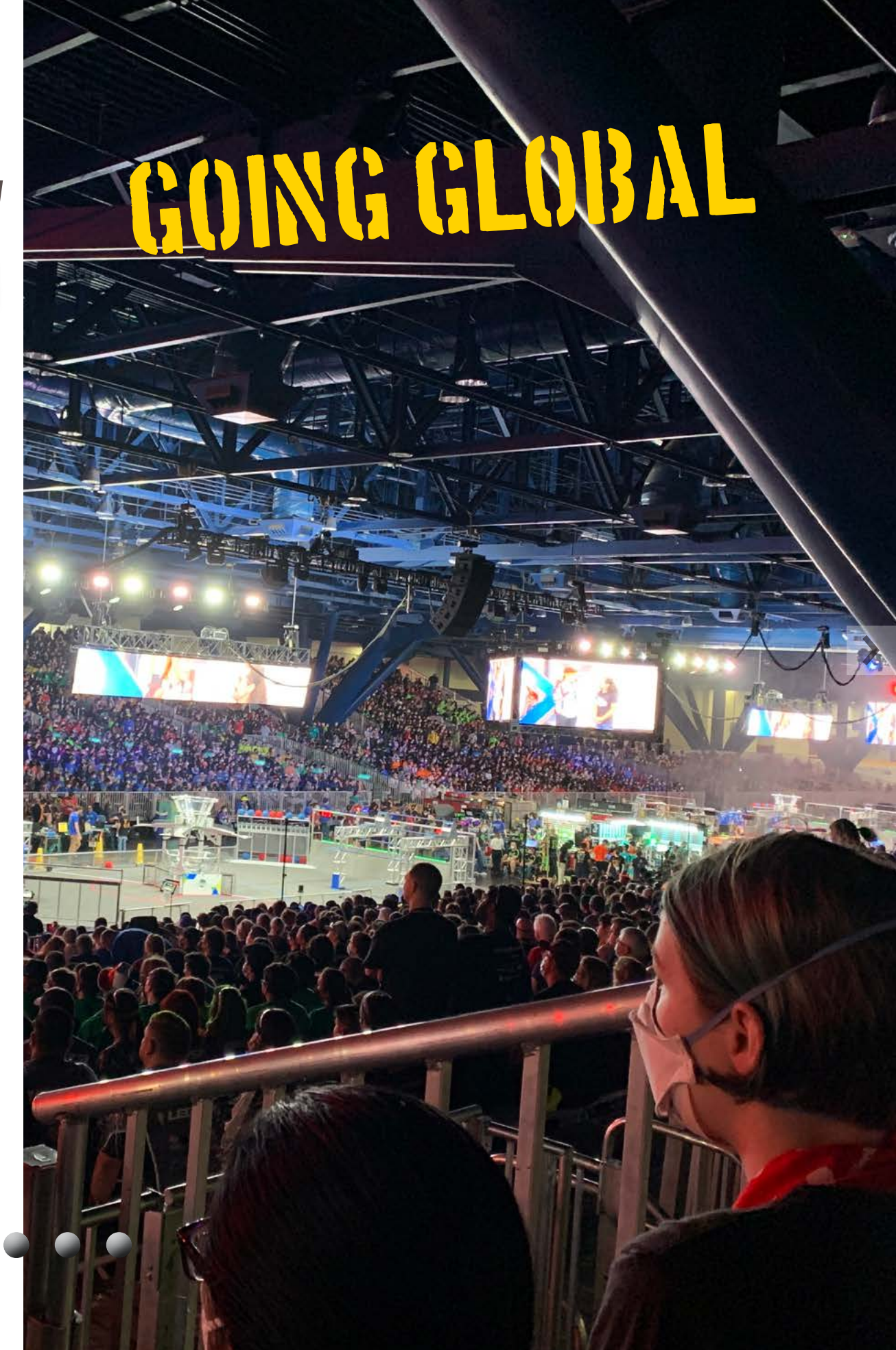
Six full-length basketball-sized fields of competition stack alongside one another on the floor of the George R. Brown Convention Center in Houston. The packed grandstands teem with fans. The jumbotrons above show highlights of the action on the field while announcers whip the crowd into a frenzy with play-by-play commentary. Flashing lights and blaring music add to the excitement as cheering crowds rise to see the competition heat up across the floor.

It's a frenetic scene.

This basketball-meets-gymnastics competition set in a rock concert/science fair is the 2022 FIRST Championship — the world championship of youth robotics.

Held April 20–23, 2022, it was the first time the championship has happened in three years, due to the Covid pandemic.

GOING GLOBAL



Pittsburgh's Girls of Steel robotics team traveled to Houston to compete against the best of the best in youth robotics, pitting their robot against 600 teams from more than 100 countries. Teams designed, built and programmed their own robots, most of which stood 4-5 feet tall and weighed in at roughly 125 pounds.

The Girls of Steel, sponsored by Carnegie Mellon University, qualified for the world championships by first winning the Engineering Inspirational Award at the Greater Pittsburgh Regional Competition at California University of Pennsylvania. They then double qualified by garnering the Regional Chairman's Award at the Buckeye Regional Competition in Cleveland as well.

During the championship, teams were divided into six different divisions. The divisions each had 75 teams and were appropriately named after George Washington Carver, Isaac Newton, Galileo Galilei, John A. Roebling, Grace Hopper and Alan Turing. Play consisted of matches between two alliances, red vs. blue, which reformed from match to match. Each alliance consisted of three teams of robots. The robots moved about quickly, scoring points by scooping up balls and shooting them into stacked funnels and then acrobatically climbing and hanging from sturdy bars mounted across theater trusses before time expired. Human team members operated the robots remotely from behind plastic shielding off the field of play.

"It's been an amazing experience ... I've not only had a chance to discover new innovations, but I've been able to interact with people from around the world." Sreyashi Mondal, Junior, Pine Richland High School

A few members of the Girls of Steel team with their robot Lightning McQueen

Lightning McQueen in action, competing in the 2022 FIRST World Robotics Championship at the Houston Convention Center.

Lightning McQueen, the Girls of Steel's robot, performed well — better than the teamed hoped in many instances — as their alliances won five matches and lost five. Though they did not advance to the final rounds of the competition, the girls represented themselves and their technical prowess very well.

"It's been an amazing experience," said Sreyashi Mondal, a junior at Pine Richland High School. "I've not only had a chance to discover new innovations, but I've been able to interact with people from around the world. I've learned so much from walking through the pits and speaking to teams about what makes their robot special. I am so grateful to be here."

Meeting teams from around the world is centerpiece of the experience at FIRST, and the Girls of Steel took full advantage. Since the Girls of Steel program has been running for 20 years, several of the adult mentors with the team are alumni of the program and have friends who mentor other teams. The team's mentors were able to make the rounds and introduce the girls to different people, allowing them to make connections themselves.

"We got to see and compete against the best teams from all over the world," said George Kantor, professor in the Robotics Institute (RI) and the Girls of Steel's lead mentor.

By all accounts, the Girls of Steel remain a highly recognizable and popular team at the competition. The team's mission to empower everyone, especially women and girls, to believe they are capable of success in science, technology, engineering and math resonates strongly with the FIRST organization. Terry Richards, outreach program manager in RI, said, "Our pit was always surrounded by a throng of people wanting to meet our students and learn more about the team. Our team buttons flew off the shelf as fast as we could put them out."

"They're inspired for next year," Kantor said. "The team got a lot of energy, and they're already working hard to think about what lessons they can take away from this, both from what they did this year and what they learned from talking to and observing other teams."

2022 GIRLS OF STEEL Team Members

Ciara Anderson
Ariella Avigad
Somdatta Basu
Justine Bennett
Megan Cassady
Elise Chu
Diya Cowlagi
Nina Cranor
Elizabeth Crookston
Maggie Davis
Maeve Dever
Natalie Ficca
Alex George
Susanna Getty
Anuva Ghosalkar
Teadora Gildengers
Grace Goslin
Samhita Gudapati
Katherine Hu
Rayna Huang
Amanda Hulver
Amy Jin
Janise Kim
Jessie Lee
Harshitha Lingam
Kameron Locy
Elizabeth Maier
Mia Maurizio
Lauren Michaels
Sreyashi Mondal
Aria Narasimhan
Madeleine Ng
Swathi Padmanabhan
Dustana Roberts
Mahika Shetty
Rishika Somireddy
Aditi Srivastava
Tara Staresinic
Kelly Tai
Aditri Thakur
Justina Wang
Ashley Wei
Gloria Wen
Hannah Yang
Mary Zagrocki

Girls of Steel team members, identified by their red polka-dotted capes, control the actions of their robot remotely.

Challenges of the Pandemic

This year's team faced substantial obstacles to be able to compete at all, much less make it to the world championships. Two years of pandemic shut down everything. When they were able to meet in person in the fall of 2021, heavy restrictions still hampered any potential for progress. Then, when the new year kicked off in 2022, the team was shut down from meeting again by the Omicron variant of Covid.

To overcome this, the team figured out how to do things online and remain effective. As it turned out, programming was one of the easiest activities to move online. To keep from falling behind, the team developed a simulator for their robot so the programmers could develop code and run tests until they could interact with the real robot in person.

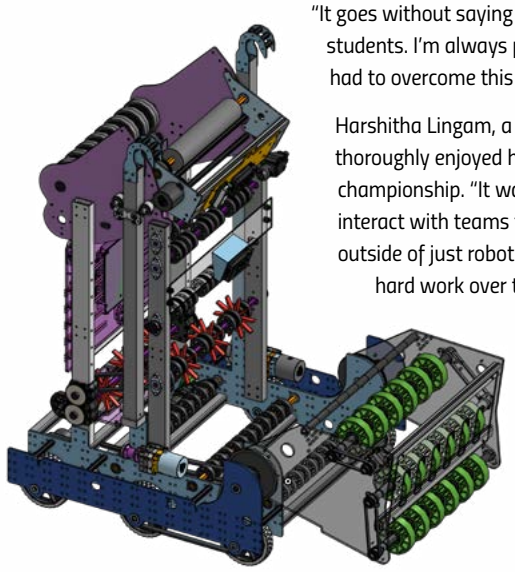
The design team also made use of a cloud-based computer aided design (CAD) program called Onshape for remote and simultaneous collaboration. It is kind of like Google Docs but for CAD. Using Onshape, each smaller subsystem team within the greater Girls of Steel team could work on their individual part of Lightning McQueen while also seeing the whole picture of how it was all going to fit and work together. This was key to making good use of time while the team had to work remotely.

They spent a lot of time on Zoom as well, talking and addressing the little details that often fall through the cracks, like ordering the right parts and making sure they had the right tools, so that when they were ready to build, they weren't missing something vital.

Time was going to be tight, but when they were able to meet in person, the team's organization and innovative efforts paid off. They had everything lined up and procured everything they needed, allowing them to be incredibly efficient putting it all together.

"It goes without saying that I'm ridiculously proud of this group of students. I'm always proud of the students, but the challenges they had to overcome this year were daunting," Kantor said.

Harshitha Lingam, a sophomore at South Fayette High School, thoroughly enjoyed her first experience competing in the world championship. "It was such a cool experience being able to see and interact with teams from all over the world and get to know them outside of just robotics! It truly was so awesome to see all of our hard work over the season come to fruition."



Onshape Computer Aided Design software allowed the Girls of Steel to collaborate and continue working on their robot during the pandemic shutdowns. This image is a working design of Lightning McQueen used by the team.

"Our pit was always surrounded by a throng of people wanting to meet our students and learn more about the team. Our team buttons flew off the shelf as fast as we could put them out."

Theresa Richards, Outreach Program Manager in RI

Commencement

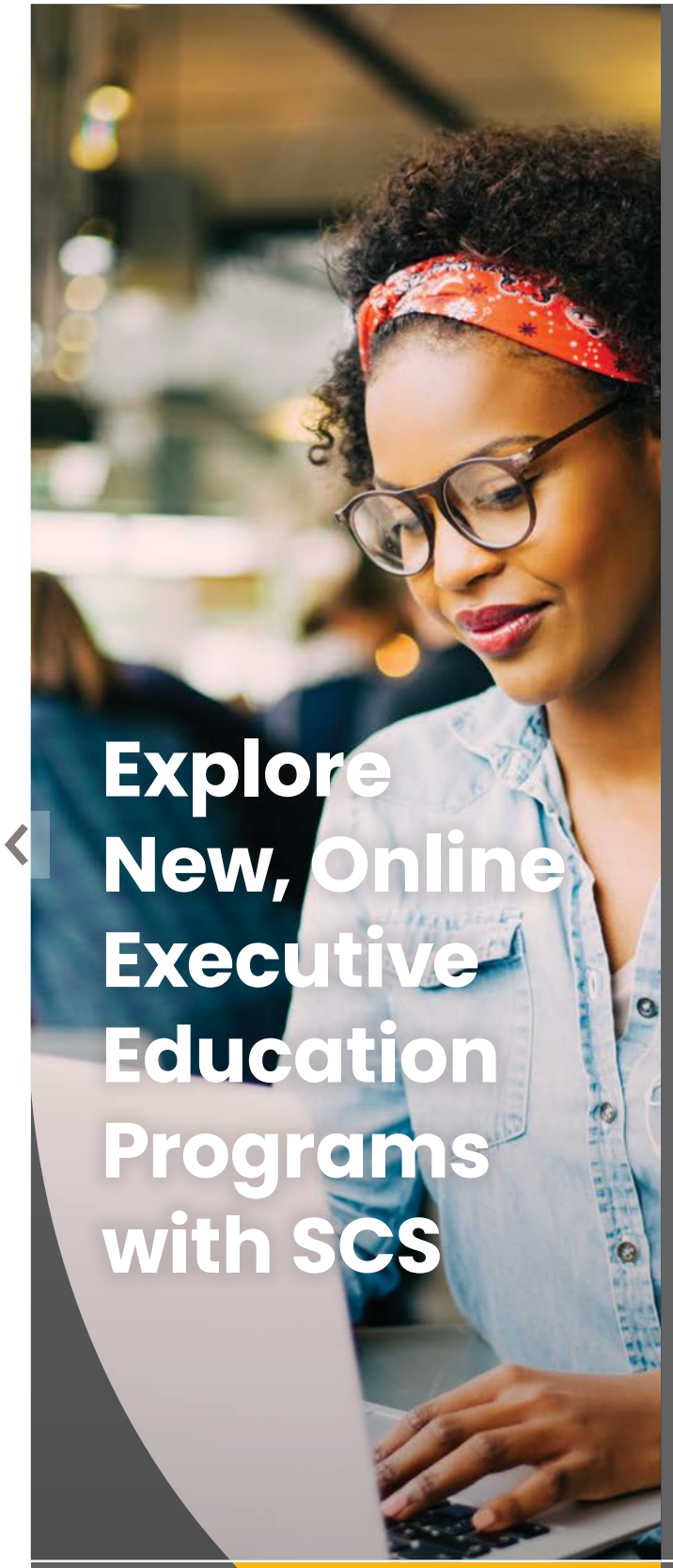
Returns in Person!

As SCS celebrated our first in-person commencement in three years, the class of 2022 took full advantage! The classes of 2021 and 2020 who missed the opportunity to participate in commencement exercises due to the pandemic were welcomed back as well. A joyful commencement weekend to all, times three!

PHOTOS *by* ELAN MIZRAHI

Congratulations
Classes of
2022
2021
2020


Congratulations
GRAD!



Explore New, Online Executive Education Programs with SCS

SCS's online Executive Education programs are developed by our faculty who are world-renowned for their innovative methods and approaches to teaching. We remain among the foremost technology educators in the world and continually lead the rankings for computer science education. Our Executive Education programs are designed to provide technology practitioners and organizations with access to the tools and skills necessary to solve today's technology challenges.

We are collaborating with online education provider Emeritus to offer these programs. By working with Emeritus, we are able to broaden access beyond our on-campus offerings in an engaging online format. These cohort-based programs combine online content with live virtual TA sessions:

- Machine Learning: Fundamentals and Algorithms
- Introduction to Artificial Intelligence
- Introduction to Computer Vision
- Introduction to Natural Language Processing
- Introduction to Deep Learning
- Introduction to Software Engineering
- Algorithms and Data Structures
- Programming with Python

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CMU alumni and employees are eligible for a 30% discount on our online Executive Education programs.

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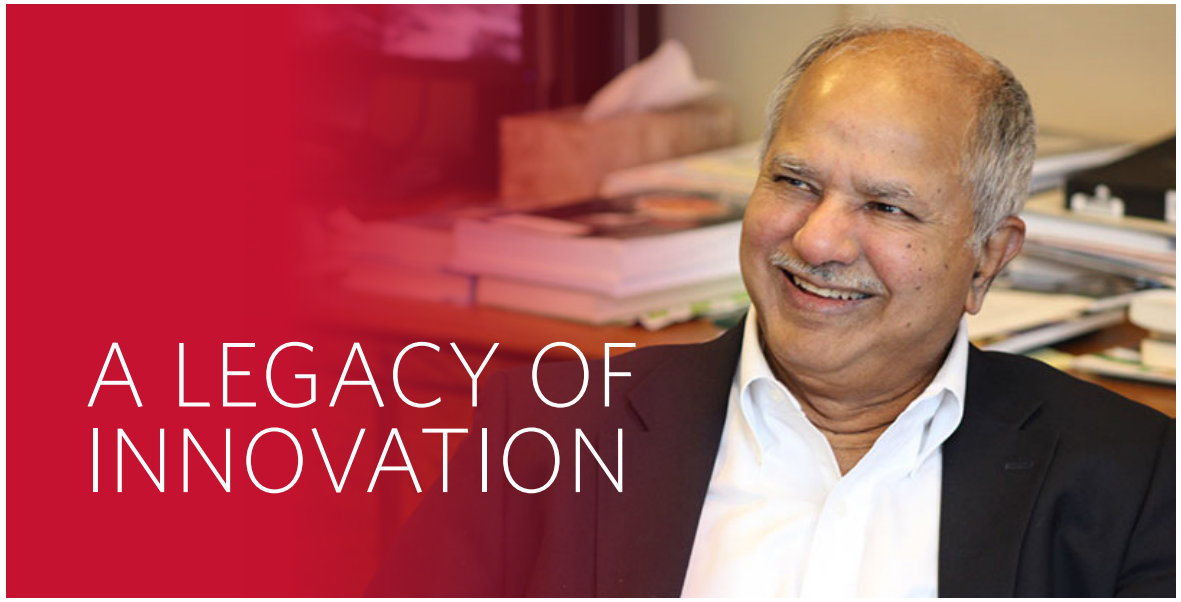


A LEGACY OF INNOVATION

GIVE TO THE RAJ REDDY FUND FOR ARTIFICIAL INTELLIGENCE

Raj Reddy's contributions to artificial intelligence cannot be overstated. As founding director of the Robotics Institute and a former dean of Carnegie Mellon University's School of Computer Science, he oversaw revolutionary developments in autonomous driving, computer vision and speech recognition (where he was personally a pioneer). The Raj Reddy Fund for Artificial Intelligence celebrates Raj's devotion to CMU, the School of Computer Science and AI in general.

BE A PART OF THE FUTURE OF AI

When you contribute to the Raj Reddy AI Fund, you acknowledge and celebrate the lasting impact Raj has made on the field. At the same time, you invest in the students, faculty and research that will change how humans and technology interact for generations to come.

VISIT cs.cmu.edu/funds/raj-reddy-endowed-fund-artificial-intelligence

CONTACT Jenny Belardi, *Chief Advancement Officer, School of Computer Science*
412-268-8810 ■ jbelardi@andrew.cmu.edu

Carnegie Mellon University
School of Computer Science
SCSatCMU

NSF AWARDS CMU RESEARCHERS $3 MILLION

To Accelerate Next-Gen Networking, Computing

Aaron Aupperlee

Carnegie Mellon researchers in the School of Computer Science and College of Engineering will use nearly $3 million in funding from the National Science Foundation (NSF) to help develop intelligent, resilient and reliable next-generation (NextG) networks.

The NSF awarded $37 million to 37 different projects at universities across the country.

The investment, called RINGS — short for Resilient and Intelligent Next-Generation Systems — is a public-private partnership that focuses on accelerating research to increase U.S. competitiveness in NextG networking and computing technologies, and ensure the security and resilience of NextG technologies and infrastructure.

Heather Miller, **Claire Le Goues** and **Ben Titzer**, all faculty in the Institute for Software Research, will receive $930,000 for RINGS: Language-Agnostic Resilience Engineering at the Edge with WebAssembly. They aim to make applications running at the edge more resilient. The team will develop an approach to full-stack resilience engineering that will enable secure, effective and performant edge computation in NextG systems. The research will focus and build on WebAssembly, which is emerging as the common underlying language-agnostic execution platform in new edge computing environments.

"Essentially all software that we use as a society, such as online banking, searching for nearby restaurants and even streaming services, is now networked," Miller said. "Through this project, we will have new tools that, if broadly used, can result in fewer outages of critical networked services that society depends on."

Giulia Fanti and **Vyas Sekar**, both faculty in the Department of Electrical and Computer Engineering (ECE) and part of CMU's CyLab, will receive $1 million for RINGS: Enabling Data-Driven Innovation for Next Generation Networks via Synthetic Data. The project aims to address the shortage of data needed to drive research and development of NextG systems through the use of synthetic data. The team will explore how to extend recent advances in an area of machine learning called generative modeling to create synthetic models of networking datasets.

"Synthetic datasets are randomized datasets that exhibit the same statistical patterns as real data, without the need to explicitly share original source data.

"Through this project, we will have new tools that, if broadly used, can result in fewer outages of critical networked services that society depends on."

Heather Miller, Assistant Professor in ISR

Unfortunately, synthetic data generation techniques have classically suffered from poor data quality." Fanti said. "This project will tackle interdisciplinary challenges spanning networking, machine learning and privacy to develop synthetic data-enabled workflows for supporting data-driven operations in the next generation of networked systems."

Anthony Rowe, a professor in ECE and member of CyLab, will team up with Jeffrey Bilmes at the University of Washington on RINGS: Bumblebee: A Neural Network Transformer Architecture for Summarization and Prediction in Interactive XR Applications. The team will receive $1 million to develop a fast, resilient and adaptive general neural network transformer-based architecture for interactive extended reality applications using machine learning. Extended reality (XR) couples virtual content with the physical world through technologies such as virtual and augmented reality.

"These applications are compute-intensive, latency-sensitive and bandwidth-hungry, making them ideal drivers for next-generation communication architectures," Rowe said. "However, the current technology struggles to meet the high demand of XR workloads."

The project will result in a system that will improve XR applications like augmented-reality-guided surgery, search and rescue, digital telepresence and automotive heads-up displays.

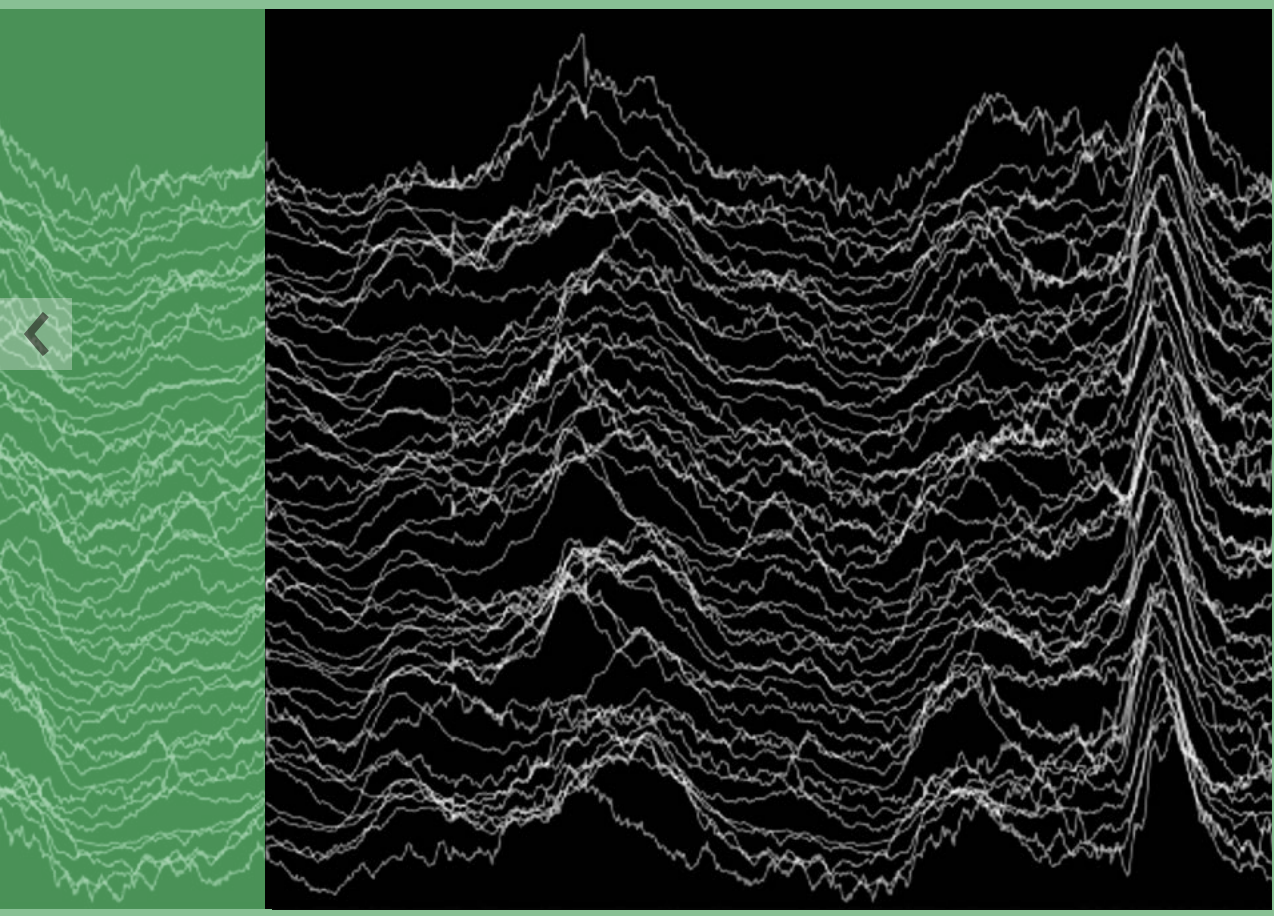
The RINGS program is NSF's single largest effort to date to engage public and private partners to jointly support a research program. Private sector partners include Apple, Ericsson, Google, IBM, Intel, Microsoft, Nokia, Qualcomm and VMware. Government partners include the U.S. Department of Defense's Office of the Under Secretary of Defense for Research and Engineering and the National Institute of Standards and Technology.

"The RINGS program is a visionary and ambitious effort that will benefit many critical aspects of societal infrastructure, and will have long-term, transformational impacts on the next generation of network systems," said Gurdip Singh, director of the NSF's Division of Computer and Network Systems. "I am excited to see how awardees under this program lead the path toward new communication capabilities that improve our lives, from education to infrastructure and national security."

Delphi Group, University of Maryland, Meta

HONORED FOR COVID-19 SURVEY

Aaron Aupperlee



"There was no template for this survey. We've been responding to a public health crisis in real time."

Robin Mejia , Assistant Research Professor in Statistics and member of the Delphi Group

CMU's Delphi Group and their collaborators have earned two awards from the AAPOR for their work on the COVID-19 Trends and Impact Survey. The survey data shown here summarizes the percent of respondents from all 50 states who knew someone with COVID-like symptoms over a two-year period.

Carnegie Mellon University's Delphi Group, the University of Maryland Social Data Science Center and Meta received two awards from the American Association of Public Opinion Research (AAPOR) for their work on the COVID-19 Trends and Impact Survey.

The AAPOR awarded the researchers the Policy Impact Award and the Warren J. Mitofsky Innovators Award. It is the first time a single project has received two awards in the same year from AAPOR, the professional society for survey scientists.

"We are honored to be recognized for this work along with our many collaborators who have made it possible, and we're grateful to the millions of survey respondents who provided crucial data for understanding the pandemic," said Alex Reinhart, an assistant teaching professor of statistics and data science at CMU and a member of the Delphi Group.

The COVID-19 Trends and Impact Survey (CTIS) is the largest public health survey to date. CMU conducts the survey nationally, and the University of Maryland runs it internationally. Each day, a random sample of Facebook users are asked to answer questions about COVID symptoms, risks, mitigating behaviors, mental health, testing, vaccination and more.

"There was no template for this survey. We've been responding to a public health crisis in real time," said Robin Mejia, an assistant research professor in statistics and a member of the Delphi Group. "It's been amazing to work with this team as we have updated the survey, built the data infrastructure and provided the information to those who need it."

The survey started in April 2020 and has collected 106 million responses worldwide. Such detailed data has never been available during a public health emergency. The survey helped public health officials understand how to save lives and safely reopen public life, and informed researchers on the social, economic and health effects of the pandemic.

"This project is a great example of a collaboration between disciplines and a partnership between several institutions, public and private," said Frauke Kreuter, a professor in the Joint Program in Survey Methodology at the University of Maryland. "All partners shared our aspiration for methodological rigor and worked furiously to create quick access to information."

The Policy Impact Award recognizes outstanding research that improves policy decisions, practice and discourse. The award committee applauded the efforts of the CTIS in tracking trends in COVID-related topics and the impact that the survey results have had on government policies around the world. The committee also recognized the ability of the CTIS to provide geographic granularity that made the results of the survey useful at nearly all levels of government.

The Warren J. Mitofsky Innovators Award recognizes innovations in the field such as new theories, ideas, applications, methodologies or technologies. The award committee honored the CTIS for its novel use of social media; best survey practices at a global scale; enterprise speed to collect timely, critical data through a public-private partnership with transparent methodology; and immediate and broad API access to the public and microdata access for researchers worldwide.

"Ultimately, our goal was to support health partners to offer informed public health decisions," said Curtiss Cobb, vice president of research, demography and survey science at Meta. "We are proud that this innovative partnership has proven effective in advancing public health insights during a global pandemic and look forward to exploring how we can further support health partners."

SCS PH.D. STUDENTS DESIGNED AND TAUGHT NEW COURSE

to Make Computer Science More Welcoming and Inclusive

Aaron Aupperlee

The Computer Science Department's new course focusing on issues of justice, equity, diversity and inclusion in computer science and society got its start when a group of graduate students decided to create the training they wished they had received.

And after hundreds of hours of work by 15 Ph.D. students — pilot programs, countless conversations with faculty and students, data gathering, and developing and tweaking course material — CS-JEDI: Justice, Equity, Diversity and Inclusion is now a required part of the curriculum for incoming Ph.D. students in computer science. It's also being looked at as a model by both other departments in the School of Computer Science and universities elsewhere.

The course was created and taught by Abhinav Adduri, Valerie Chen, Judeth Choi, Bailey Flanigan, Paul Göelz, Anson Kahng, Pallavi Koppol, Ananya Joshi, Tabitha Lee, Sara McAllister, Samantha Reig, Ziv Scully, Catalina Vajiac, Alex Wang and Josh Williams — all doctoral candidates in SCS who represent nearly every department in the school. The team received Carnegie Mellon University's 2022 Graduate Student Service Award and were honored during the Celebration of Education Award Ceremony on Thursday, April 28.

"This team of 15 students have done exemplary service to CMU, which will pay dividends for years to come. They saw a problem on campus and took it upon themselves to find a constructive, evidence-based solution," a group of computer science professors, including Srinivasan Seshan, the head of the Computer Science Department (CSD), wrote about the students. "Developing the course was an enormous effort that took more than 1,300 student-hours. The team has displayed the leadership, scholarship and hard work that we hope to see in our students."

Bailey Flannigan and Ananya Joshi, Ph.D. students and primary instructors of the JEDI course.

The motivation for the course began in 2020 when members of the team informally surveyed Ph.D. students in CSD, many from historically underrepresented groups, and found that many students mentioned encountering unwelcoming and distressing behavior from other students, faculty and staff. Students surveyed described struggling to address issues they faced; not knowing how to intervene on the behalf of themselves and their peers; and being unsure who to involve when handling issues with advisors, professors, collaborators and students.

The survey prompted the team to create a course for new Ph.D. students to prepare them to engage with a diverse community. The team developed the curriculum and worked with students, faculty and staff to refine it.

Several students said they enjoyed the course and valued hearing the experiences, opinions and perspectives of others. Students also said that they wouldn't have typically picked the course but were glad they did.

The course gave Cori Faklaris, a Ph.D. student in the Human-Computer Interaction Institute, a language for discussing diversity, equity and inclusion issues, and a space to engage in these issues with fellow students.

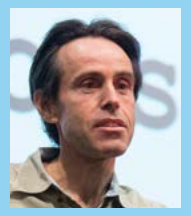
"These discussions helped me devise strategies for interrupting or forestalling myself from acting on my biases, such as rehearsing different language or how to offer support but not advice when it is not requested," Faklaris wrote. "I learned the value of seeing allyship as an action, not an identity, in that we need to put energy and time into specific behaviors to help others even when they don't ask for it."

Shuyan Zhou, a Ph.D. student in the Language Technologies Institute who took a version of the course in 2021, wrote that the class taught her the basic concepts about diversity, equity and inclusion that helped her understand systematic biases and what individuals can do to address them. She said the course allowed her to become more compassionate and empathetic toward members of the SCS community and reflect on her personal experiences.

"This class makes me feel like the community I live in actually cares about students' well living — some staff members are committing to improving the DEI and well-living of the students, " Zhou said.

Faculty at other universities, including MIT, have contacted the team about adapting the course for their institutions. The team is working to make the materials and other details of the course open source so any institution could adopt it and teach it. The team aims to make teaching CS-JEDI as accessible as possible so computer science becomes more inclusive and welcoming, both nationally and globally.

Names in the News


Howie Choset

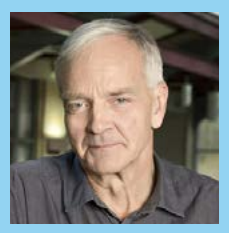

Jessica Hammer


Ken Holstein


Joshua Kangas


Lea Albaugh

SCS faculty and grad students had a strong showing at this year's Celebration of Education Awards. CMU honored faculty members **Howie Choset, Jessica Hammer, Ken Holstein** and **Joshua Kangas** for their dedication to education and teaching. Ph.D. student **Lea Albaugh** and a team of 15 SCS grad students also received awards.


Martial Hebert


Robert Kraut

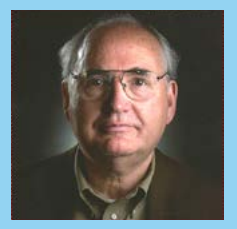
Martial Hebert and **Robert Kraut** were recently elevated to the rank of University Professor, the university's highest distinction for faculty members.

Computational biology junior **Daniel Schaffer** was named one of CMU's three 2022 Goldwater Scholars.

The Society for Science included computer scientists **Mary Shaw** and **Dana Scott** in its recent list of notable alumni from the Science Talent Search program.

LTI Professor **Alex Waibel** has been elected a fellow of the International Speech Communication Association.


Mary Shaw


Dana Scott


Daniel Schaffer


Alex Waibel

William "Red" Whittaker, University Founders Research Professor in the Robotics Institute, received the inaugural Pittsburgh Robotics Impact Award.

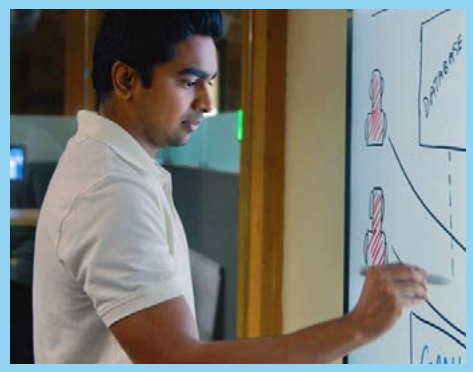
Researchers in SCS and the College of Engineering will use nearly $3 million in funding from the National Science Foundation to help develop intelligent, resilient and reliable next-generation networks.

SCS alum **Rahul Ramakrishnan's** work could one day play a key role in growing fresh, healthy food for people around the world.

Robert Harper, professor in CSD received the 2021 ACM SIGPLAN Programming Languages Achievement Award in recognition of his significant and lasting contributions to the field.


Robert Harper


Red Whittaker


Rahul Ramakrishnan

Part of Something Bigger

I fundamentally believe investing in education has a multiplicative impact on society. And I am proud of CMU's commitment to giving this opportunity to budding innovators irrespective of their economic background, made possible through the various funds. For all the numerous doors CMU SCS experience opened for me, giving back a tiny bit through mentorship and contributing funds makes me feel part of something bigger.

ANIRUDH KOUL (SCS 2012)

Expert in Ethics and AI Joins CMU

School Will Receive $3.5 Million to Support Work

Aaron Aupperlee

This fall, **Vincent Conitzer** will join the faculty in the School of Computer Science, where he earned his master's and Ph.D. He is currently a professor of new technologies, computer science, economics and philosophy at Duke.

Vincent Conitzer expects much to be the same when he returns to Carnegie Mellon University.

It will still be the best place in the world for computer science and the technical expertise will still be unmatched. Many of the colleagues, professors and even his Ph.D. advisor will also still be around.

But don't be surprised if the renowned artificial intelligence researcher and ethicist appears lost in the corridors and hallways of the Gates and Hillman Centers. When Conitzer was finishing his graduate work in computer science in 2006, he spent his time in Wean Hall. Gates wasn't built yet.

"Once I'm in Gates, I'm lost," Conitzer said of recent returns to campus.

Tuomas Sandholm, the Angel Jordan University Professor in the Computer Science Department (CSD) and Conitzer's Ph.D. advisor, is excited to have his former student back on campus and looks forward to collaborating and teaching courses with him.

"Vince is a star, and I had a wonderful time working with him back in the early 2000s," Sandholm said. "Since then, he has had a meteoric rise to become one of the leaders in the field. I am thrilled that we were able to recruit him back to CMU."

Conitzer's rise to the top is evidenced by Duke granting him a double promotion in 2011, elevating him straight to full professor from assistant professor, without a stop at associate professor. At the time, he was the youngest full professor at the university.

At CMU, Conitzer's main appointment will be in CSD, where he will lead the new Foundations of Cooperative AI Lab (FOCAL). He will have affiliate and courtesy appointments in the Machine Learning Department, the Department of Philosophy in the Dietrich College of Humanities and Social Sciences, and the Tepper School of Business. Conitzer will also continue his part-time appointment at the Institute for Ethics in AI at the University of Oxford.

FOCAL will research how to make artificial intelligence systems cooperate with each other and with humans. Conitzer's work with FOCAL will be supported through a $3 million gift from the Center for Emerging Risk Research and a $500,000 gift from the Cooperative AI Foundation.

The Center for Emerging Risk Research, based in Basel, Switzerland, believes that AI will play an increasingly large role in society over the coming decades, and that it's important to ensure that cooperative intelligence is an important part of AI systems.

"We're delighted to be supporting the founding of FOCAL and the important work they will do," the center said.

The London-based Cooperative AI Foundation selected FOCAL as the recipient of its first major grant.

"With the increasing ubiquity and capabilities of AI systems, it is more important than ever that we develop firm foundations underlying their interactions with one another, and with humans," the group said. "We are therefore glad to be supporting the excellent work of Professor Conitzer and his collaborators at FOCAL, whose research on this topic will help to improve the cooperative intelligence of advanced AI systems for the benefit of all humanity."

Conitzer's work with FOCAL will become increasingly important as algorithms and AI become more prevalent in society and start to perform more complex tasks or are asked to make complicated decisions. These developments could lead to AI systems in conflict either with each other or with the humans they are intended to support.

"At this point, we don't have too many situations in which independent AI systems interact, but the worry is that we're going to see a lot more in the future," Conitzer said. "And increasingly, we'll see AI have more control in the decisions to be made."

This is where Conitzer's background in ethics and philosophy comes into play. While it may seem that an easy solution is to bar AI from making decisions with ethical concerns, that will not always be practical. The speed, scale and scope of the problems and the decisions to be made will eventually outstrip human capacity. A self-driving car cannot ask for human input before it makes a decision. The scale of content moderation on social media already tests how much human moderators can handle. And complex algorithms and marketplaces are needed to handle the scope of factors that must be considered when matching potential organ donors with recipients.

"We need ethics in our computer science education. It's important, and I think it is something that is missing," Conitzer said. "We need to bring this into our curriculum, but it's hard. The traditional teaching of the high-level principles guiding ethical decisions clashes with the precision computer scientists need for their code."

Conitzer's research spans many thorny areas in artificial intelligence and ethics. He studies questions about the implications of systems that are more intelligent than humans, and weighs the pros and cons of explainable machine learning. Yes, the algorithm used to set someone's bail should be interpretable, but no, the algorithm predicting whether a tumor is malignant doesn't necessarily have to be. What about fairness? What about bias? What about autonomous weapons systems?

"It does keep me up at night sometimes, but that is because I think we can tackle these issues and produce better outcomes," Conitzer said. "These are things worth thinking about, and generally, I'm an optimist."

Ever the optimist, Conitzer is certain he will quickly learn his way around Gates.

Honoring Raj Reddy

Raj Reddy, a pioneer in the fields of robotics, artificial intelligence and speech recognition, was awarded an honorary doctor of science and technology degree during CMU's 2022 Commencement.

Already the Moza Bint Nasser University Professor of Computer Science and Robotics and the founding director of the Robotics Institute, Reddy, a former dean of SCS, has had an impact on SCS and the field of computer science that cannot be overstated. Reddy served as co-chair of President Clinton's Information Technology Advisory Committee from 1999 to 2001 and has received many awards from around the world, including the 1994 Turing Award.

"Raj is truly a living legend," said CMU President Farnam Jahanian. "He has also been an inspiration to countless students, alumni and collaborators who have benefited from his wisdom, mentorship and example."

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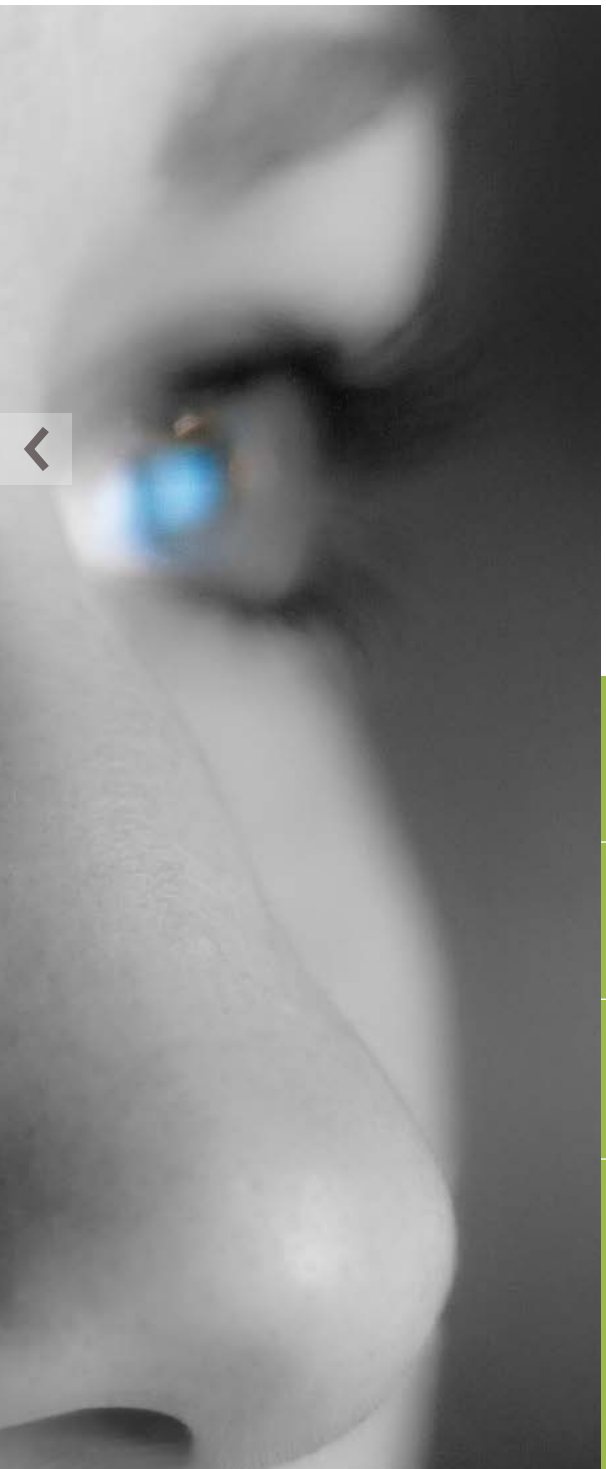

Fall 2022 Calendar of Events

Fall Regional Alumni Events
Visit cs.cmu.edu/calendar for events in your area.

September 12
Virtual Technical Opportunities Conference

September 20
In-person Technical Opportunities Conference

October 28-29
Homecoming Weekend