

Carnegie
Mellon
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the **LINK**

THE MAGAZINE OF CMU'S SCHOOL OF COMPUTER SCIENCE

WINTER 2021
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**CMU'S
TEAM EXPLORER**



**Down for the
Subterranean
Challenge**



the LINK

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.



Studying The Unknowable

Decision-making algorithm research to help model the evolution of the universe.

The origins of the universe have always been an unknowable phenomenon and a question that has plagued scientists since its inception.

How did the universe form? What were the conditions and the physical laws governing those conditions at the time of the inception of everything that currently exists?

The Simons Collaboration on Learning the Universe — directed by Greg Bryan, a professor of astronomy at Columbia University, will repeatedly select sets of initial conditions, predict how they would be observed now, compare that to data observations of galaxies and gas, and then compute the likelihood of those initial conditions.

Aarti Singh, an associate professor in the Machine Learning Department, will use her research on decision-making algorithms, applying machine learning for closed-loop, accelerated modeling of cosmological simulations. Machine learning can speed up the modeling by factors of millions or billions by training on the relatively small samples of full simulations.

This international collaboration includes researchers from CMU, Columbia University, Harvard University, Princeton University, Lawrence Berkeley National Labs, the Flatiron Institute and international partners from Canada, France, Germany and Sweden.

the LINK

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Looking Back,

Archivists in the Hunt Library, working with faculty in the Robotics Institute and across campus, are taking a thorough look at CMU's remarkable history of robotics with The Robotics Project, a multi-phase, multi-year project that not only preserves CMU's storied legacy in robotics, but also enhances our understanding of the people and technologies that helped create the scientific discipline, field of practice and cultural force that is robotics.

Occasionally, even as scientists, it can be helpful to look back at our accomplishments not only to give important milestones their proper recognition, but to give us perspective to continue our push forward to uncover what comes next. In this issue of *The LINK*, you will discover many instances where SCS students and faculty have reviewed past experiences — both recent and distant — in order to boldly step into the future.

Team Explorer, fresh off competing in the three-year DARPA Subterranean (SubT) Challenge, looks back on lessons learned during their admirable performance to push toward new technologies that were non-existent before the competition began, to bring them to market and to the world of robotic exploration for places where humans cannot or should not go.

Our Student Spotlight features Kayo Yin, a remarkable graduate student in the Language Technologies Institute, who has surveyed current areas of focus and sees the path forward to include American Sign Language as an important and (until now, neglected) field of study.

We recently celebrated the official opening of the JPMorgan Chase & Co. AI Maker Space: the first makers' space of its kind with a focus on the creation of software. The new space offers students from across campus access to necessary tools including robots, drones and smart devices so that they may collaborate on innovative AI agents.

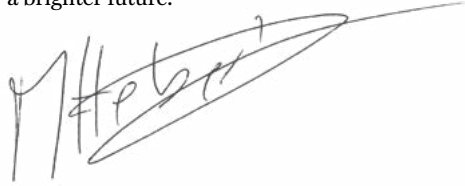
Moving Forward

A little more than 15 years ago, Matthew Johnson-Roberson, then an undergraduate student in the Robotics Institute, wanted to make his mark in the field. And that he did, most recently serving as an associate professor of engineering at University of Michigan's Department of Naval Architecture and Marine Engineering and the Department of Electrical Engineering and Computer Science, as well as the co-director of UM's Ford Center for Autonomous Vehicles. I'm pleased that he's returned to campus as the next director of the Robotics Institute, the sixth in our history. We welcome him back to SCS as he will help shape next generations of CMU roboticists.

Our Institute for Software Research's Kathleen Carley and her team are pouring over conspiracy theories perpetuated on social media to find the root sources of misinformation in order to help people think more critically in a digital world. This work parallels efforts from within the SCS community to study how AI can assist in large-scale problems such as global

food security, healthcare, the future of transportation and consumer privacy in a networked world. As you will also read, these efforts have resulted in CMU being part of four National Science Foundation AI Institutes.

As global and complex challenges continue, our work emerges as key to finding solutions. We look back to the time when we were not able to gather, a time when the pandemic laid bare inequalities in our society. We do this to learn the lessons of our experiences, both individual and shared, and use them as inspiration to continue working toward a brighter future.



Martial Hebert
Dean, School of Computer Science



LESSONS LEARNED
FROM THE

SubT Challenge

2020

AARON AUPPERLEE

As the countdown started, a boxy robot with four big wheels carrying a host of cameras, sensors, communication equipment, autonomy software and the computing power to make it all work together, rolled down a ramp into a dark tunnel.

It did not know where it was, what was ahead of it or where it was going. *It was there to explore.*

Over the next hour, more robots followed. Wheeled robots rolled through passageways, tunnels and caves with rocks, rails and obstacles. They pivoted around tight corners and passed through doorways and openings just centimeters wider than their axles.

The Spot robot, a dog-like quadruped often seen dancing in carefully planned and choreographed demos, walked down the ramp onto unknown footing, adjusting its balance and gait as it scanned the terrain ahead.

Drones flew through narrow corridors, bumping into and bouncing off walls. Collisions like these would typically send a drone crashing to the ground, often



Team Explorer offloads the wheeled R3 and legged Spot robots, taking them to the starting gate of the SubT Challenge final stage in Louisville, Kentucky

Round 1: Research Mine Tunnels

in a heap of parts. But these drones rebounded, righted themselves and returned to their flight.

Team Explorer deployed eight robots for the final round of the Defense Advanced Research Projects Agency (DARPA) Subterranean, or SubT, Challenge — a three-year competition during which teams from around the world raced to develop robotic systems that could autonomously operate in underground environments like caves, mines or subway stations for search and rescue missions.

Over the course of the competition, Team Explorer created robots and drones tough enough to bang into walls, roll and walk over ruts, rails and rocks, and find their way through dark, unknown and treacherous terrain. The robots worked in unison, telling each other where they had explored, pointing out areas of the course for others to explore, and passing along information about what they had found to each other and the humans staged at the course entrance.

And for most part, the robots acted autonomously, searching the course and coordinating amongst one another with little “hands-on” control by the team.

“I think back to three years ago and what we were thinking about was essentially science fiction then,” said Sebastian Scherer, an assistant professor in the Robotics Institute and a co-lead of Team Explorer. “Teams of drones zipping around and ground robots just going out exploring, it was just not a thing. And now, we’d feel very comfortable sending a drone into some random environment and thinking it will have a really high chance of coming back.”

Team Explorer, a mix of students, faculty and staff from CMU and Oregon State University, lived up to its name during the final round of the SubT Challenge. The team’s fleet of robots mapped nearly the entire course, earning the team the Most Sectors Explored award for investigating more of the course than any other team.

In total, eight teams competed in the SubT finals. As their robots explored and mapped the course, they searched for artifacts that would be important to first responders during an underground search and rescue mission, objects like dummies staged as survivors, cellphones, tools, backpacks, vents and even the presence of harmful gases.



Team Explorer co-leads Sebastian Scherer (far left) and Matt Travers (far right), and team member Shibo Zhao (center-left), confer with SubT Challenge official (center-right) about their upcoming run.

Round 2 : Abandon

The team accurately identifying the most artifacts won, and would take home the \$2 million top prize. Second place won \$1 million and third \$500,000. Team Explorer placed fourth, missing out on the money by only a few points.

"I'm proud of this team. This was hard, and we really rose to the challenge," said Matt Travers, a systems scientist at the RI and a co-lead of Team Explorer.

DARPA staged the SubT Challenge to accelerate the development of technologies that would enable robots to assist with search and rescue operators in underground environments that are too dangerous, dark or deep for humans. The challenge forced teams to design robotic systems that could operate when communication, vision and mobility would be compromised. The precision needed to maneuver in these situations, the complexity of the coordination and logistics, and the sheer amount of data needing to be gathered made this challenge too large for humans to manage without the help of autonomy.

The first round of the SubT Challenge, the Tunnel Circuit, took place in August 2019 in a research mine operated by the National Institute for Occupational Safety and Health in South Park Township, outside of Pittsburgh. Team Explorer decisively won that round. Round two, the Urban Circuit, was held in February 2020 inside an abandoned, never-commissioned nuclear power plant at the Satsop Business Park near Olympia, Washington. Team Explorer placed second. DARPA canceled round three, the Cave Circuit, because of the pandemic.

"I think back to three years ago and what we were thinking about was essentially science fiction then."

—SEBASTIAN SCHERER



Co-lead Matt Travers and team operator Chao Cao review video footage gathered during the run of their ground robots.

Abandoned Nuclear Power Plant

The final stage took place in September 2021 at the Mega Cavern, an old limestone mine in Louisville, Kentucky. Inside the mine, DARPA built a course that incorporated the tunnel, urban and cave circuits of the previous rounds. The finals course included a narrow mine with rails running down the center and obstacles: rocks, barrels and supplies cluttering the sides. There were tight cave sections with stalactites and stalagmites. DARPA even built a subway station with a platform, rails disappearing into a tunnel, hallways, storage areas and support pillars.

Timothy Chung, DARPA's program manager for the SubT Challenge, said first responders and members of the military invited to watch the final competition walked away impressed. The competitors demonstrated the effectiveness of teams of robots working with teams of humans. In an hour, the robots were able to map and search a course that would have taken professionals far longer. The teams demonstrated uses of ground robots, drones and quadrupeds far exceeding what many thought possible.

"Without a doubt, we have accelerated the timeline of this technology making it into the hands of people who could save lives," Chung said. "Some of the SubT technologies are ready for showtime."

Chung expects further development and commercialization of technologies pioneered during the challenge to happen within a matter of years. That's fast, considering it took a decade or longer for technologies developed during the autonomous vehicle challenges in the 2000s to arrive on city streets. Industries such as construction, infrastructure inspection, real estate appraisal and others are interested in SubT technologies, said Chung.

"This technology will pay significant dividends in the future," Chung said. "It will extend well beyond the subterranean environments. I think we'll see that above ground, in the air and in buildings."

To push this technology forward, Team Explorer made advancements in both hardware and software. The team's simultaneous localization and mapping (SLAM) software, which allowed the robots to construct a map of the course while they explored it, performed so well in early competitions that other teams used versions of it as they competed at the finals. Work out of Oregon State University, headed by Geoff Hollinger (SCS 2007, 2010), an associate professor of mechanical engineering in Corvallis and Team Explorer co-lead, developed software that helped robots make decisions, see objects and explore better.

Co-lead Geoff Hollinger of Oregon State University carries one of Team Explorer's small drones.

Far right: Team member Hongbiao Zhu holds netting to allow the Spot robot to walk into the practice area.



“Without a doubt, we have accelerated the timeline of this technology making it into the hands of people who could save lives.”

—TIMOTHY CHUNG, DARPA SUBT PROGRAM MANAGER

A student at Oregon State University developed an algorithm to maximize the use of marsupial robots — robots that carry other robots. The algorithm determines where and when to best deploy the second robot to maximize exploration capabilities. During the finals, Team Explorer successfully used a marsupial robot, launching a drone off the back of one of its ground robots once it encountered stairs in the urban part of the course.

Other research examined the behavior trees of robots, or how a team of robots determines the tasks for individual robots. This was useful to Team Explorer as its robots decided where to go, but it will also be useful to robots in other environments. Emily Scheide, a master’s student at OSU when she worked with Team Explorer, is now a Ph.D. candidate at the university studying how behavior trees can help robots assist children with disabilities.

“Anywhere you have a multi-robot system making tough decisions, this will be used,” Hollinger said.

Team Explorer built their own robots and drones for the competition. The wheeled ground robots, named R1, R2 and R3, were built smaller and more agile as the

competition went along. R1, the team’s first robot — a 400-pound beast — was still effective in the finals, exploring the urban circuit and launching a drone. R3, the newest and smallest of the ground robots, used its size and articulated body to make it deep into the finals course, navigating tight cave sections where other robots feared to tread.

However, the plucky robot’s ambition may also have been its downfall. As R3 worked its way to the back of the course, it encountered a steep grade that led to a cliff. The robot triumphantly summited and began exploring the edges of the cliff, until it got a little too close. R3 tumbled about 20 feet down the cliff, coming to rest on its side. Had R3 been able to report back what it saw during its run through the course, the number of artifacts identified might have pushed Team Explorer into first place.

Throughout the competition, the development of the drones had its ups and downs. The team’s early drones had six propellers and no prop guards. They crashed often. To lighten the payload, the team tried to design a drone that used only cameras to see, not LIDAR, but darkness and dust ruled out that approach.



Round 3:

*"You don't have to be too afraid
of hitting the walls,...
It gives you a little more freedom."*

—VAI VISWANATHAN (SCS 2020)

Team Explorer members at the SubT Challenge in Louisville, Kentucky.
Humans: (back row, from left) Ryan Darnley, Chao Cao, Rohit Garg, John Keller, Geoff Hollinger, Bob DeBortoli, Sebastian Scherer, Graeme Best, Matt Travers;
(front row, from left) Steve Willits, Ian Higgins, Peigen Sun (Bacon), Bill Drozd, Lucas Nogueira, Hongbiao Zhu, Shibo Zhao, Greg Armstrong.
Robots: (back row, from left) Spot, R2, R3, R1;
(front row) a canary robot (center) flanked by two small drones.



Old Limestone Mine

Additionally, Team Explorer built an all-metal drone. It was indestructible, but too heavy. Then the team moved the propellers from above the drone's payload to below it. They also added a robust propeller guard that allowed the drone to bump into walls and obstacles. These modifications, coupled with flight control software that adjusted roll and pitch when a drone did bump into something to keep it flying, produced a design that caught the attention of other teams at the Urban Circuit competition.

It also caught the eye of a few companies, inquiring about the design. That led Vai Viswanathan, a member of Team Explorer who left after earning his master of science in robotics from CMU, and Jay Maier, a mechanical engineering student at the University of Pittsburgh, to spin off the technology and found Canary Aero. The company makes drones that can carry a heavy payload and get close to and even bump into objects without crashing.

"You don't have to be too afraid of hitting the walls," Viswanathan said. "It gives you a little more freedom."

Canary Aero already has a few commercial customers lined up. Team Explorer used a Canary 15, named for its 15-inch propellers, in the finals. The drone's collision tolerance was certainly put to the test. While exploring the urban portion of the course, the Canary drone bounced off the walls in a narrow hallway. Seemingly spinning out of control and headed for the ground, the drone righted itself and kept on going.

Robots, whether on the ground or in the air, are not typically designed to bump into things. Team Explorer's were. The team incorporated robust designs and software that allowed their air and ground robots to hit walls and survive, and to free themselves from getting stuck. Scherer said robots typically stay away from those situations.

"But that's not always the right answer for something that explores," Scherer said. "Sometimes you need to bump." ■





THE GLOBAL REACH OF CMU AI

SCS to Lead Four National Science Foundation AI Institutes

CHRIS QUIRK



Global health care, the future of transportation, food security, consumer privacy in a networked world — as intractable problems accrue and grow, artificial intelligence is increasingly being called upon as part of the solution. Carnegie Mellon AI researchers have stepped up to help surmount these obstacles where large data sets must be analyzed and patterns discovered to find answers.

Now, the National Science Foundation has teamed with the U.S. Department of Agriculture, the U.S. Department of Homeland Security, as well as corporate sponsors Accenture, Amazon, Google and Intel to provide \$220 million in grants to create 11 new institutes specifically dedicated to AI research across a wide range of sectors.

“I am delighted to announce the establishment of new NSF National AI Research Institutes as we look to expand into all 50 states,” said National Science Foundation Director Sethuraman Panchanathan. “These institutes are hubs for academia, industry and government to accelerate discovery and innovation in AI. Inspiring talent and ideas everywhere in this important area will lead to new capabilities that improve our lives from medicine to entertainment to transportation and cybersecurity, and position us in the vanguard of competitiveness and prosperity.”

Carnegie Mellon School of Computer Science and School of Engineering faculty have taken on leadership roles in four research concentrations of these new AI Institutes.





AI Institute for Resilient Agriculture (AIIRA)

GEORGE KANTOR (left)

Research Professor and Senior Systems Scientist, Robotics Institute

SRINIVASA NARASIMHAN (right)

Interim Director and Professor, Robotics Institute



George Kantor, a research professor at the Robotics Institute, will be working with the AI Institute for Resilient Agriculture (AIIRA), based at Iowa State University. “I’m really excited about bringing this broad range of AI expertise in the Robotics Institute and the Machine Learning Department here into this new domain,” said Kantor. As with all the institutes, conducting world-changing research in each particular field by applying AI techniques and tools, ultimately results in the goal of solving pressing issues that affect human lives worldwide.

One of the main objectives of AIIRA is to build digital replicas of plants for research purposes, with the goal that the replicas will enable farmers to find ideal cultivars that can withstand increasing climate uncertainty and increase yields to help address world hunger. Robots developed in the project will speed complex jobs like selective pollination while providing on-the-ground updates on the health of crops.

The task of modeling an entire plant from the get-go is enormous, said Kantor, so the strategy is to first model individual plant systems separately. He offers photosynthesis as an example. “For this preliminary model, look at the sunlight, look at properties of the plant that you’ve measured, look at the temperature, and then predict how much the plant is photosynthesizing at any given time,” he explained. “There will be a lot of models like that, and we’ll improve them bit by bit. The main contribution of our research will be to glue the individual systems together with machine learning, and you can use that to simulate everything about the plant.”

Eventually, Kantor hopes to produce what he calls digital twins – a virtual copy of a plant that could be used for experiments through simulation.

“This will allow us to analyze how the plant grows, and then expand that to see how the plants grow at the field scale,” Kantor said.

Kantor will also employ robotics to do first-hand observation of crops. In addition to doing arduous and labor-intensive tasks like pollinating particular plants for optimal pairings and inspecting the physical condition of the plants, the robots will simultaneously collect data used to advance knowledge of the crops, creating an expanding information loop. Eventually, the modeling could be predictive of how plants might respond to new weather patterns of the future. “This is extremely important in terms of creating more resilient plants for the climate changes that are coming,” said Kantor.

Kantor will partner with Srinivasa Narasimhan, interim director and professor at the Robotics Institute, who has been doing breakthrough research with non-line-of-sight imaging. Narasimhan will “be developing cameras that can look into plants, and actually see below the surface,” Kantor said. “It will be very exciting to take that information and incorporate it with these plant models.”

While the AI and other tools Kantor and his fellow researchers develop stand at the vanguard of AI’s evolution, he emphasizes the years of sweat equity that have made the project possible. “Our team has been working in agricultural robotics for over a decade now, and we’ve had a whole series of projects — like using intelligent robots in the orchard — that will help us bring artificial intelligence out into a field and do things with it,” Kantor said.

[Read more about this research in the Winter 2016 issue of The Link.](#)



Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING)

REID SIMMONS

Research Professor, Robotics Institute, Computer Science Department

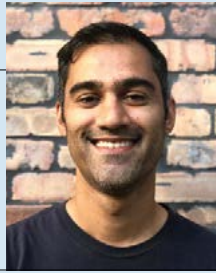
Reid Simmons, a research professor at the Robotics Institute and in the Computer Science Department, is working with the Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING), which will reside at the Georgia Institute of Technology. With the growing numbers of older Americans in need of daily assistance, and the workforce increasingly unable to keep up with the need, AI-CARING is devoted to finding ways to help aging adults remain independent through the use of coordinated and collaborative AI and robotics. "Our findings will provide fundamental research for human-AI collaboration applications," said Simmons.

The home health care environment is rich with physical and informational complexity and creating ways to provide assistance is a major challenge. Simmons gives the example of a support unit gauging changes in a person experiencing physical or mental decline over time. "It may be gradual or sudden, like from a slip or fall, but we have to be able to track that and adapt," he said.

The AI will need to work with a network of family, friends and clinicians to be successful. Each person the AI interacts with in its assignment of caring for an elderly individual will have a different role and will require different information. A son-in-law may not need medical data but would need to know about scheduled appointments with doctors or clinics to arrange transportation. Likewise, an in-home caregiver may need important information from the prior caregiver's shift to provide necessary assistance, which the AI could deliver reliably. "Everyone in the network is going to be different, and that means their actions will be unpredictable," said Simmons. "That's a huge issue."



Paramount to the AI-CARING's mission are important ethical questions and the challenges to meet them. The privacy of the medical information the AI works with will have to be preserved, while also making critical data available to those caregivers who need it, said Simmons. "There are things about someone's condition you may tell a doctor, but you would not be willing to tell a neighbor, or even the person themselves for fear how they might handle it at a given moment. So, the AI will have to be able to understand what information needs to be conveyed, to whom and at what level."



AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE)

GAURI JOSHI (left)

Assistant Professor, Electrical and Computer Engineering

AMEET TALWALKAR (right)

Assistant Professor, Machine Learning

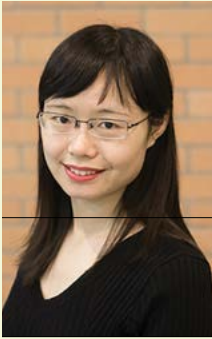
Ethics also drives the work that will be done at the AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE). While it may simplify matters for engineers, it's no longer preferred practice to store large amounts of potentially identifiable personal information used to improve networks and devices on cloud servers. Gauri Joshi, an assistant professor in the Electrical and Computer Engineering Department, and Ameet Talwalkar, assistant professor in the Machine Learning Department, will head Carnegie Mellon's work with AI-EDGE to develop new tools to maximize the learning capacities on individual devices to protect consumer data while improving network efficiencies. The institute will be based at Ohio State University.

AI that can keep the data on users' phones and devices private while still channeling small packets of critical information to algorithms based in the cloud will vastly improve the performance of the network

and the predictive capacities of devices and other things, such as self-driving vehicles. "Instead of taking all the data from where it's being generated — on smartphones or smart devices — and moving it to a central server, doing all the processing and moving the final model back, the idea is to do as much as possible directly on the smartphone, car or device," Talwalkar explained.

The technique, called federated learning, employs the computing resources on a remote device to teach the AI on the device itself, and upload an anonymized summary of that information to a server. There, the server aggregates the information with other user updates. "This is going to be the default in all small devices," said Joshi. "Currently we don't have the scalability in the algorithms to handle so many devices because it's been deployed maybe for thousands or at most millions of devices, and the scale of some of these systems is a billion devices."





USDA-NIFA Institute for Agricultural AI for Transforming the Workforce and Decision Support

WENZHEN YUAN

Assistant Professor, Robotics Institute

At the USDA-NIFA Institute for Agricultural AI for Transforming the Workforce and Decision Support, Wenzhen Yuan, an assistant professor in the Robotics Institute, will work with researchers at Washington State University to improve agricultural processes, thus maintaining healthier, hardier crops, and bigger harvests. Yuan, whose research involves AI, robotics and sophisticated sensor devices, is developing robotic devices that could inspect and report information for analysis. Yuan's research will extend from examining the readiness of fruit for picking to providing information on the prime moment to harvest crops. "Humans are not very good at quantitative tasks, and they can be inconsistent," said Yuan. "The AI will help us be more rigorous in our analyses and make better harvesting and other kinds of agricultural decisions."

With four of the 11 AI institutes having recruited SCS faculty to spearhead research, the school again demonstrates its capacity for attacking some of the biggest global challenges out there. "We like to work on important things, and we all have to eat, so that's pretty important," Kantor said. "Automated tractors were one of the things that Red Whittaker worked on more than 30 years ago, so agriculture has always been a target application in our field, and there's a historical legacy for it here at Carnegie Mellon." ■



A portrait of Raj Reddy, a middle-aged man with grey hair and a mustache, wearing a dark suit jacket over a white shirt. He is smiling and looking slightly to the right. The background is a blurred office setting with papers and a desk. A large red semi-transparent rectangle is overlaid on the left side of the image, containing the text 'A LEGACY OF INNOVATION'.

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

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Heated Conversations and Cold Realities

How Disinformation About Climate Change
Is Rooted in Conspiracy Theories

NIKI KAPSAMBELIS

In 2017, about the time the United States withdrew from the Paris Agreement on climate change mitigation, chatter on social media platforms also began heating up.

From chemtrails to flat-earth hypotheses to melting glaciers, climate-change deniers volleyed conspiracy theories back and forth across cyberspace, mounting an increasingly polarized discussion about a topic that has long generated debate among the general public, if not among scientists.

KATHLEEN M. CARLEY

Professor, Institute for Software Research and
Director, Center for Computational Analysis of Social and Organization Systems



“Conspiracy theories disinformation, so if you find forms of disinformation.”

Such significant disagreement discourages public policy that could more effectively address climate change, reasoned Aman Tyagi, then a doctoral student in engineering and public policy who graduated in 2021. But by better understanding the mindset of climate-change deniers, Tyagi believes scientists and others who recognize climate change as real could potentially design better strategies for communicating with doubters and possibly change their minds.

Together with Kathleen M. Carley, a professor in the Institute for Software Research and director of the Center for Computational Analysis of Social and Organization Systems (CASOS), Tyagi tackled conspiracy theories in a 100-week sojourn through Twitter. They collected 38 million unique tweets for analysis from more than 7 million unique users by searching for the terms: “climate change”; “#ActOnClimate”; and “#ClimateChange”.

They published the paper “Climate Change Conspiracies on Social Media” as part of the working paper series at the 2021 International Conference on Social Computing, Behavioral-Cultural Modeling & Prediction and Behavior Representation in Modeling and Simulation. A forthcoming paper, “Heated Conversations in a Warming World: Affective Polarization in Online Climate Change Discourse,” uses similar methods to analyze the widening divide between factions.

The idea is to root out disinformation and trace its journey as it connects different, yet related ideologies, Carley said. By understanding how and where these

individual threads join together, researchers gain a fuller perspective on how they compose a wider tapestry of belief systems.

“When you’re doing disinformation work, it’s helpful to look at conspiracy theories,” she said. “They’re at the extreme end of disinformation, so if you find those, you often find other forms of disinformation.”

Sorting the authors of those tweets into climate change believers and nonbelievers was a herculean task made feasible through the use of ORA-PRO, a commercial network analytic tool that grew from software developed by CASOS. The tool’s algorithm used hashtags and URL links in the tweets to classify 3.1 million users as disbelievers and 3.9 million as believers.

Carley and Tyagi then identified links between the tweets and popular conspiracy theories, searching for keywords and terms such as “deep state,” “illuminati,” “flat earth” and “chemtrail.” They also identified bots, or automated accounts that pose as actual people and contribute to the spread of disinformation, using CMU’s Bot-Hunter, another CASOS-developed tool.

Tyagi and Carley found that most climate change deniers subscribed to two particular conspiracy theories: the chemtrails theory, which claims that plumes left in the sky by airplanes contain toxic chemicals that were purposely added to poison the public; and, the geoengineering theory, which claims government experiments cause climate change.

are at the extreme end of those, you often find other

AMAN TYAGI (ENG 2015, 2018, 2021)

AI/NLP Research Data Scientist. Procter & Gamble



The variations on disinformation are a form of modern myth-making, said Carley, in that they represent an attempt to explain phenomena the person doesn't understand. They become a way of weaving together a lot of kinds of disinformation; it becomes a way of substantiating conspiracy theories.

Low-credibility websites posing as news outlets seem to bolster the disinformation

by reinforcing false claims, Carley added. In reality, the content comes from marketing firms, or people looking to support an agenda — even from the state-sponsored media of U.S. adversaries.

“You see lots of variety, but there is that common core,” said Carley.

Key takeaways from the research focus on recommendations for combating false information. Tyagi and Carley suggest using the findings to better target messages about climate change, taking into account the existing beliefs and tendencies of nonbelievers.

For example, policymakers should work to debunk chemtrail and geoengineering theories, knowing how closely they align with climate change doubters. But beyond that, social media platforms should curtail sharing of disinformation, said Tyagi.

Platforms appear to be listening. In September 2021, YouTube announced that it would remove videos making false claims about COVID-19 vaccines.

Such work is critical in an era when “everyone has their own loudspeaker, so much is intertwined, and people are finding information based on algorithms of social media,” said Tyagi. “There’s no accountability for ‘news’ that has been reported by pseudo-media.”

Compounding the problem, thanks to the increased cost of producing traditionally sourced news, more legitimate sources are drying up, leaving “news deserts” in their wake, said Carley. Filling the gap are “pink slime” sites, which pose as local news but actually originate in other countries. Named after the paste used as a filler in processed meat, pink slime sites tend to be hyperpartisan, often using automated story writing. And while fact-checking sites also have proliferated, some people view them as biased, Carley noted.

The solution, Carley believes, lies in teaching people to think more critically in a digital world, and for companies, universities and schools to foster trust by employing social cybersecurity experts who maintain a “clean air space” of credible information — perhaps including some kind of objective, such as a Good Housekeeping-style seal of approval that identifies a site as legitimate.

Research on disinformation is very valuable,” Carley added. “It helps give awareness of just how much disinformation is out there and how people are being played. It’s become this way of keeping people from even participating in the democratic process.” ■





LETTING IMAGINATION RUN WILD

CMU Invites Students
to Explore AI
with Opening of the
JPMorgan Chase & Co.
AI Maker Space

**AARON
AUPPERLEE**

Reid Simmons has stopped trying to guess what students will come up with next.

As head of Carnegie Mellon University's undergraduate program in artificial intelligence, Simmons watches what some of the most creative minds are doing with AI, and they never cease to amaze him. And now as the director of the newly opened **JPMorgan Chase & Co. AI Maker Space**, Simmons will have a front row seat for collaborative and transformative developments.

"We want students from all over the university — from engineering, business and fine arts — to come and use their creativity to make interesting things happen," Simmons said. "Giving students the freedom to let their imaginations run wild is really what this space is all about."



The JPMorgan Chase & Co. AI Maker Space officially opened, November 10, 2021. Remarks from leaders at CMU and executives from J.P. Morgan underlined the benefit of creativity and collaboration the space will foster and the access it provides students to technology that will change the world.

A Fetch robot—a mobile manipulator students will have access to in the AI Maker Space—cut the ceremonial ribbon opening the space, demonstrating only the tip of what will be possible when the brightest minds from across campus use AI to tackle the world’s toughest problems.

“As unprecedented advances in AI and machine learning continue to transform our daily lives, the JPMorgan Chase & Co. AI Maker Space will empower CMU students and researchers from a variety of disciplines to shape this exciting future,” said CMU President Farnam Jahanian. “On behalf of the entire CMU community, we are grateful for our invaluable partnership with JPMorgan Chase, and we look forward to the hands-on learning, creativity and collaboration that this unique facility will inspire.”

The space is supported by JPMorgan Chase & Co., which founded its AI Research program to explore how technology can predict and affect economic trends, stop financial crime, protect data and improve ways customers interact with businesses. Manuela Veloso, now emeritus faculty after 26 years researching and teaching AI in the Computer Science Department and heading the Machine Learning Department, joined JPMorgan Chase in 2018 to lead the company’s AI research efforts.

“We’re incredibly excited about the grand opening of the JPMorgan Chase & Co. AI Maker Space at Carnegie Mellon. We are looking forward to helping play a role as talented students pursue their ideas and interest in AI, and we can’t wait to see the work that comes out of the space.”

—Manuela Veloso,
Head of AI Research at
JPMorgan Chase



“As unprecedented advances in AI and machine learning continue to transform our daily lives, the JPMorgan Chase & Co. AI Maker Space will empower CMU students and researchers from a variety of disciplines to shape this exciting future.”

—CMU President Farnam Jahanian

“We’re incredibly excited about the grand opening of the JPMorgan Chase & Co. AI Maker Space at Carnegie Mellon,” said Veloso, head of AI Research at JPMorgan Chase. “We are looking forward to helping play a role as talented students pursue their ideas and interest in AI, and we can’t wait to see the work that comes out of the space.”

The 2,000-square-foot facility will give all CMU students access to robots, drones, smart appliances, virtual- and augmented-reality devices, and high-end computers. The space also boasts a 12-foot by 12-foot drone cage with motion capture cameras, and a kitchen with smart appliances.

Students will also be able to use software packages associated with the space’s state-of-the-art hardware to develop cutting-edge AI technologies. These hardware and software packages are far beyond what typical students would have at their disposal. Students will also have access to a variety of massive datasets, which they can use in their projects. The JPMorgan Chase

AI Research team will share synthetic financial datasets, which can help students better prepare and train AI and machine learning algorithms.

Students could use one of several robots in the space — Baxter, Fetch or Pepper — for training, testing and experimentation. The \$100,000 Fetch robot that cut the ceremonial ribbon Wednesday could operate in systems for loading or unloading the dishwasher, bringing people items from the refrigerator or assembling furniture. The drone cage could be a place where students from the School of Computer Science, College of Engineering and School of Drama stage a flying, 3D art production. Using smart devices and appliances and augmented and virtual reality, students will explore the future of work and play.

“Investing in the next generation of technology talent is critical,” said Samik Chandarana, chief data and analytics officer for the Corporate and Investment Bank at J.P. Morgan, “with the AI Maker Space, students will get hands-on experience

“This space allows people, no matter what department they are in, to have tools available to them to take the next step in exploring AI in their fields.”

—Reid Simmons, Director, JPMorgan Chase & Co. AI Maker Space

and the resources to develop concept solutions for years to come.”

The AI Maker Space is on the first of the newest, largest buildings on CMU which is also home to the Tepper School and the Swartz Center for Entrepreneurship. CMU students will have access and the space is a place where students from many disciplines collaborate.

“AI is becoming ubiquitous across almost every department has something to it,” Simmons said. “This space allows people, no matter what department they are in, to have tools available to them to take the next step in exploring AI in their fields.”

The space will open to students at the start of the spring 2022 semester, and students who use the space can enroll in training courses to learn how to use the technology. Some courses will have projects that are hosted at the space, helping to familiarize students with the technology. The space will have a full-time lab manager and several part-time student assistants. ■

Visit the [JPMorgan Chase & Co. AI Maker Space](#) webpage for more information about the space.



CMU leaders and executives from JPMorgan pose with a Fetch robot at the grand opening of the JPMorgan Chase & Co. AI Maker Space inside the university's Tepper School of Business.



The Higashi Algorithm

Machine Learning Offers High-Definition Glimpse
of How Genomes Organize in Single Cells

NIKI KAPSAMBELIS

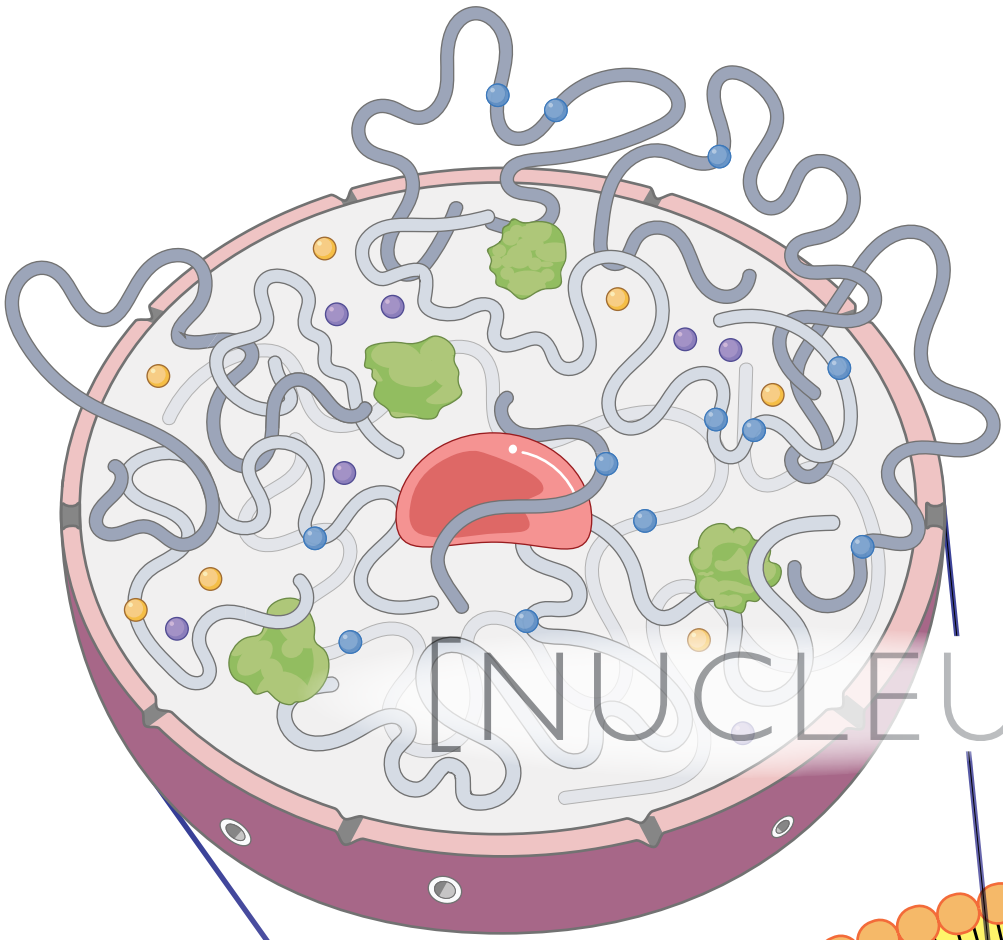
Within the microscopic boundaries of a single human cell, the intricate folds and arrangements of protein and DNA bundles dictate a person's fate: which genes are expressed, which are suppressed, and — importantly — whether they stay healthy or develop disease.

Despite the potential impact these bundles have on human health, science knows little about how genome folding happens in the cell nucleus and how that influences the way genes are expressed. But a new algorithm developed by a team in Carnegie Mellon University's Computational Biology Department offers a powerful tool for illustrating the process at an unprecedented resolution.

The algorithm, known as Higashi, is based on hypergraph representation learning — the form of machine learning that can recommend music in an app and perform 3D object recognition.

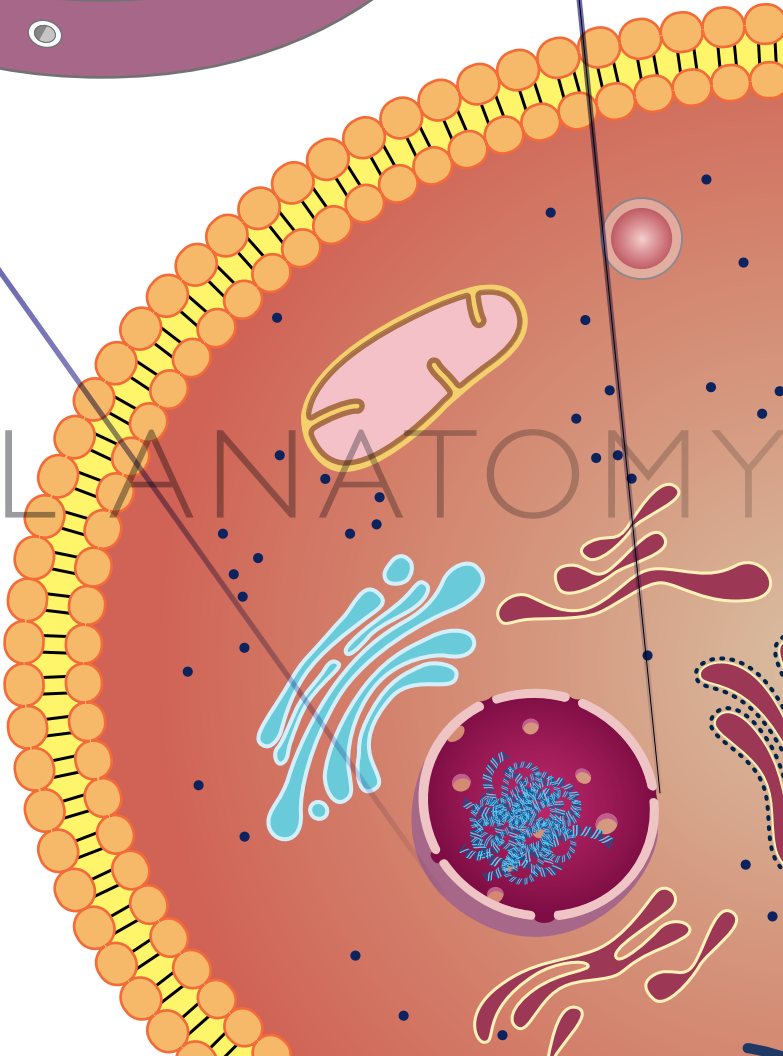
School of Computer Science doctoral student Ruochi Zhang led the project with Ph.D. candidate Tianming Zhou and Jian Ma, the Ray and Stephanie Lane Professor of Computational Biology. Zhang named Higashi after a traditional Japanese sweet, continuing a tradition he began with other algorithms he developed.

"He approaches the research with passion but also with a sense of humor sometimes," Ma said.



[NUCLEUS]

[CELL ANATOMY]





Left to Right: Jian Ma, the Ray and Stephanie Lane Professor of Computational Biology
Ruochi Zhang, Ph.D. student in Computer Science
Tianming Zhou, Ph.D. student in Computational Biology

“The variability of genome organization has strong implications in gene expression and cellular state.”

JIAN MA
RAY & STEPHANIE LANE
PROFESSOR OF
COMPUTATIONAL BIOLOGY



Their research was published in *Nature Biotechnology* and was conducted as part of a multi-institution research center seeking a better understanding both of the three-dimensional structure of cell nuclei and how changes in that structure affect cell functions in health and disease. The \$10 million center was funded by the National Institutes of Health and is directed by CMU, with Ma as its lead principal investigator.

The algorithm is the first tool to use sophisticated neural networks on hypergraphs to provide a high-definition analysis of genome organization in single cells. Where an ordinary graph joins two vertices to a single intersection, known as an edge, a hypergraph joins multiple vertices to the edge.

Chromosomes are made up of a DNA-RNA-protein complex called chromatin that folds and arranges itself to fit inside the cell nucleus. The process influences the way genes are expressed by bringing the functional elements of each ingredient closer together, allowing them to activate or suppress a particular genetic trait.

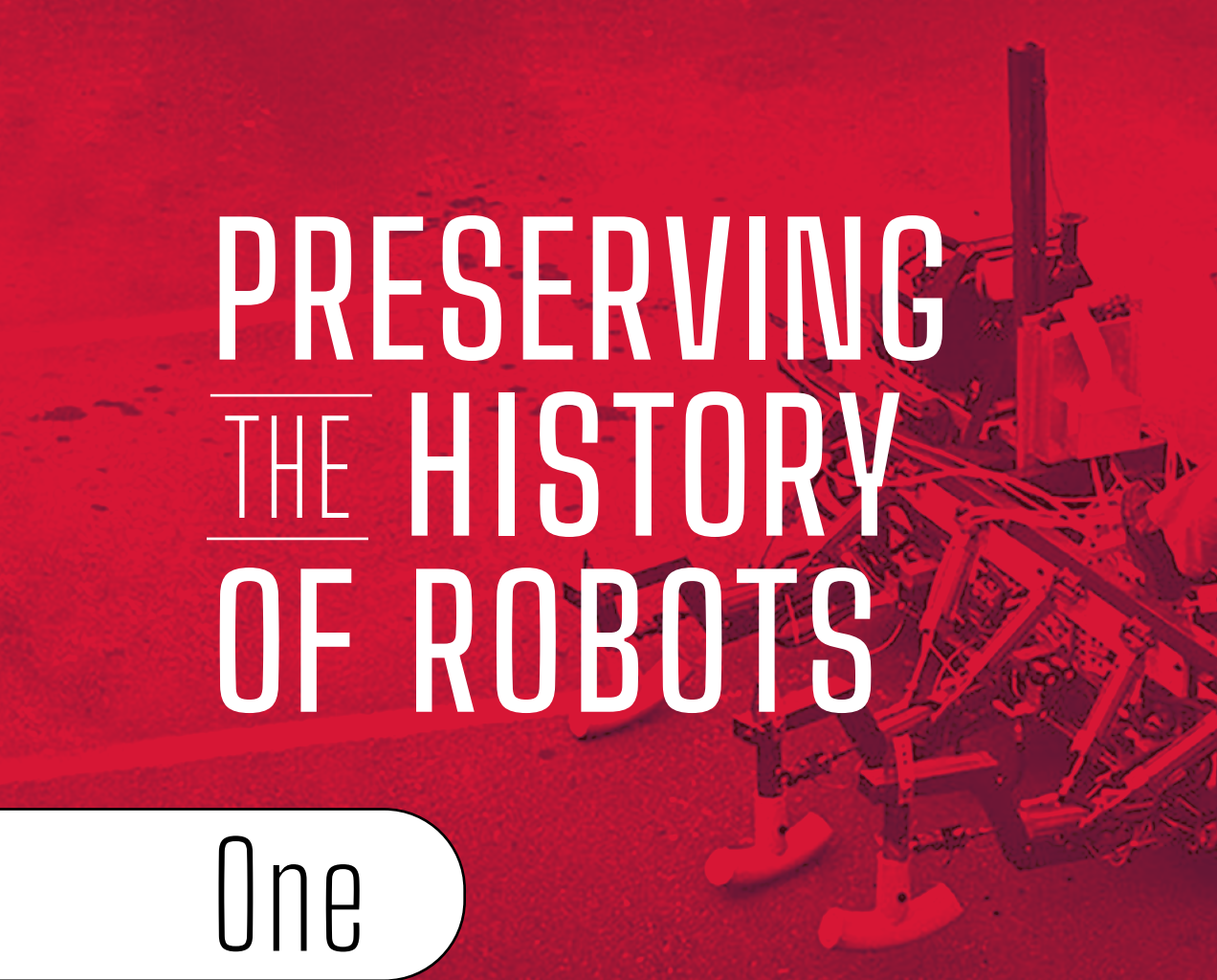
The Higashi algorithm works with an emerging technology known as single-cell Hi-C, which creates snapshots of chromatin interactions occurring simultaneously in a single cell. Higashi provides a more detailed analysis of chromatin's organization in the single cells of complex tissues

and biological processes. This analysis allows scientists to see detailed variations in the folding and organization of chromatin from cell to cell — including those that may be subtle, yet important in identifying health implications.

“The variability of genome organization has strong implications in gene expression and cellular state,” Ma said.

The Higashi algorithm also allows scientists to simultaneously analyze other genomic signals jointly profiled with single-cell Hi-C. Eventually, this feature will enable expansion of Higashi's capabilities, which is timely given the expected growth of single-cell data Ma expects to see in coming years through projects such as the NIH 4D Nucleome Program his center belongs to. This flow of data will create additional opportunities to design more algorithms that will advance scientific understanding of how the human genome is organized within the cell and its function in health and disease.

“This is a fast-moving area,” Ma said. “The experimental technology is advancing rapidly, and so is the computational development.” ■



PRESERVING THE HISTORY OF ROBOTS

One

Disassembled

Part

at a Time





In a nearly empty parking lot at Carnegie Mellon University, a strange hulking mechanical insect lurches forward, one spindly leg at a time. Stranger still, there's a rider on top, telling it where to go.

It is December 12, 1982, and **Ivan Sutherland** (ENG 1959), esteemed computer scientist, is being filmed as he takes a test run on his Trojan Cockroach. He's not sure the ride will go exactly as planned. "Because," as he says in the video, "it's the first time that I've driven the machine using the foot pedals, we may have a little excitement later on."

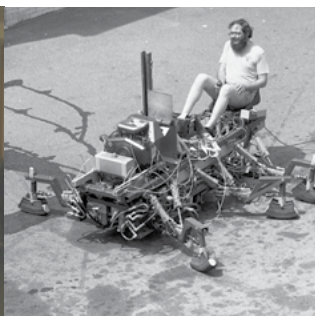
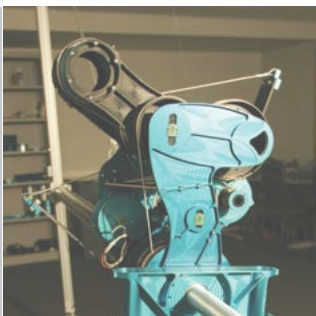
But the hydraulic-powered bot follows his commands with precision, lumbering forward, backward and sideways. It even makes a 180-degree turn. Sutherland bounces a little on the seat, but the robot keeps its balance.

Though no crowd witnessed this profound moment — where one of the first walking robots carried a human — a videographer captured the scene. The grainy footage is being preserved as part of a new interactive, virtual exhibit called The Robotics Project. A collaboration between University Libraries and the School of Computer Science, it will explore the legacy of robotics and Carnegie Mellon's leadership role in a field that has shaped modern society.

TROJAN COCKROACH

A six-legged robot that was the first capable of carrying a human

1979



ROBOTS THEN & NOW

BOW LEG
HOPPER

A one-legged hopping robot that established the principle of dynamic balance

1982

“ We want to preserve robotics artifacts that are currently in attics, basements and closets, all around the campus and beyond — in people's homes and offices and warehouses.”

KATHERINE BARBERA,
LEAD ARCHIVIST FOR THE ROBOTICS PROJECT



The project will tell the story of robotics through a collection of early robots and disassembled bot parts, as well as photos, videos, notes, emails, drawings, code, interviews with some of the pioneers and even trading cards for kids and interested collectors. Believed to be the first of its kind in the world, The Robotics Project will tell the story of the Carnegie Mellon roboticists who pushed the boundaries of

what autonomous machines could do for society, ideas that we take for granted today.

Even though Carnegie Mellon has led the field since its inception and has attracted top talent from around the world in establishing The Robotics Institute in 1979, University Archives has so far had a relatively sparse record of robotics history in its collection.

“We want to preserve robotics artifacts that are currently in attics, basements and closets, all around the campus and beyond — in people's homes and offices and warehouses,” said Katherine Barbera, lead archivist for The Robotics Project.

With many of the important robotics milestones stored on VHS tapes, compact discs and other obsolete formats that decay over time, the history and legacy could be lost forever, if not found and preserved.

Tracking down old robots for the exhibit can be challenging because the people who make them tend to be tinkerers who reuse materials, taking their bots apart to recycle the pieces into a new project. “There is a lot of cannibalizations,” Barbera said. “How do you tell the story of an artifact that no longer exists in its original form?”



REMOTE RECONNAISSANCE VEHICLE

Surveyed and cleaned the flooded basement of the crippled Three Mile Island nuclear reactor

1990



HIPNAV

The first computer-assisted surgery system





For example, only a few isolated parts of Sutherland's Trojan Cockroach remain. "It's not even like we have a whole leg. We have parts of a leg," Barbera said. Those fragments were saved after Sutherland's son found them in the garage of his Squirrel Hill home and turned them over to Carnegie Mellon.

Building the Robot Archive, the first exhibit of The Robotics Project, is available online and gives a behind-the-scenes peek at how roboticists collaborated with archivists to preserve this history. <https://exhibits.library.cmu.edu/roboticsproject> The Alfred P. Sloan Foundation provided funding for this first phase of the project.



ROBODOG

CMU teams sweep all divisions at the world championship RoboCup using RoboDog

1998



LOOKING BACK TO MOVE FORWARD

In mid-November 2021, The University Libraries opened a soft launch of Looking Back to Move Forward / A Re:collection of Robotics at Carnegie Mellon, located in the new first floor gallery of Hunt Library. Looking Back to Move Forward is the first physical exhibit offering a window into the ongoing work of The Robotics Project. It is scheduled to open officially in the Spring of 2022.

Through more than 40 robots and archival artifacts, the exhibition invites viewers to revisit material moments in the history of robotics and to explore a variety of research areas that CMU is known for — field robotics, artificial intelligence and human-robot interaction. With personal recollections from the people who made it all happen and a look inside the process of archiving robots, this exhibition engages the ongoing interplay between the past and the future in robotics research.

The curators are Katherine Barbera and Kathleen Donahoe, with art direction by Heidi Wiren Bartlett. The exhibition is located on the first floor of Hunt Library, in the recently renovated Emma Ochiltree Sharp Alcove.

Barbera collaborates on the project with **Chris Atkeson**, a professor in the Robotics Institute, who has been collecting robot artifacts for years. Atkeson and his former graduate student, **Daniel Pillus** (CFA 2016), started collecting bot artifacts and formed a makeshift robot museum in the hallways of Newell-Simon Hall.

Atkeson noticed that the kids attending the university's Cyert Center for Early Education were fascinated by the exhibit — especially the soft inflatable robots he created to help people dress, eat and comb their hair. Unlike the metal bots that could potentially hurt someone while helping them dress or fall over and injure a human, a soft robot can follow the movements of humans while helping them eat or dress. His soft bots became the inspiration for the character Baymax in the Disney movie "Big Hero 6."

However in 2020, the fire marshal alerted the school that the robots and other memorabilia had to be removed from the hallway because they blocked a fire lane. Barbera helped Atkeson move the valuable artifacts to the library's archives, and The Robotics Project was born.

"Faculty like Chris are invested in this history, not only because they were part of it, but because they see the potential for folks to want to interact with these materials in the future and learn from them," Barbera said. "He had a lot of foresight in lovingly saving these artifacts."

It takes a loving approach because some robot prototypes are extremely fragile. One juggling robot made by Atkeson was fashioned with duct tape.

"There's a certain aura that exists around robotics for folks who are outside of the field," Barbera said. "We tend to think of the finished product, and we don't think of the processes

Chris Atkeson, professor in the Robotics Institute, holding Baymax dolls from "Big Hero 6," inspired by his soft bots



SOFTBOT

Soft, inflatable robots help people dress, eat and comb their hair



behind it. So, they make the prototype with what is available — duct tape, string, pieces of wood.” These makeshift fasteners are easily and quickly torn down, reassembled and then discarded, making any images or films of them all the more historically valuable.

The videos and photos of the project also tell the stories of important pioneers such as Sutherland, a Carnegie Tech graduate who returned to campus decades later. “He is better known as the father of computer graphics,” Barbera said. “A lot of people were surprised to hear of his long-standing interest in robotics as well.” In the ‘80s, he partnered with Carnegie Mellon to develop what became the Trojan Cockroach.

Another major aspect of the project catalogs the rich history of autonomous vehicles at CMU. In 1986, a Carnegie Mellon team created the Navigation Laboratory (Navlab 1), an electric-blue Chevy van that was one of the first cars to be controlled by a computer. A video of the NavLab 1 cruising along at 2 miles per hour is a feature of the online archive. The archive also contains a photo of the team standing in front of that vehicle and also a trading card of Navlab 7, a 1996 white Pontiac Bonneville. The legacy of NavLab and its pioneering role in the field of computer vision for the field of self-driving cars, is on display.



NAVLAB 1

An early pioneer in controlling a car by a computer

THE PERSONAL ROVER

A programmable robot that allowed a fun way to explore technologies necessary for scientific exploration



PEARL

A mobile robotic assistant for the elderly

2010

2005



BOSS

Led by Red Whittaker, Tartan Racing wins the 2007 DARPA Grand Challenge with BOSS



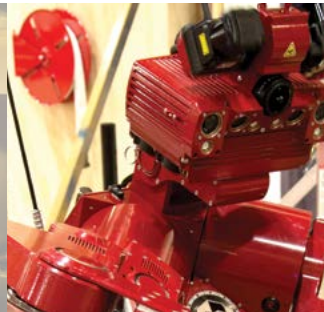
“Intelligence is asking for help. That is what it’s all about. You figure out a few things, and you ask for help.”

MANUELA VELOSO

However, many more innovations and emergent fields within robotics require preservation. In 1982, Haruhiko Asada, then a visiting research professor in the Robotics Institute, and his colleagues there developed the first direct drive robotic arm — an arm with articulated joints directly coupled to high-performance torque motors. Because the arms did not have any gears, they were not stiff, making them more compliant during human-robot interactions. For example, a direct-drive arm on a personal care robot would be able to help someone dress with less

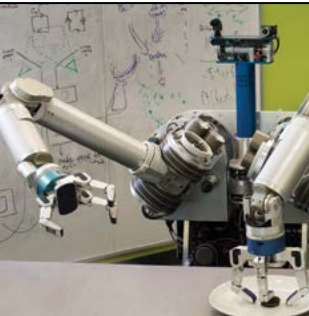
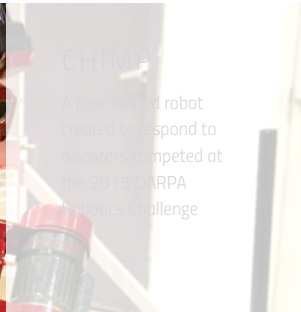
MOON LANDER

A robot capable of landing a payload rover onto the lunar surface, using sensors, rockets and mapping software for precision landings



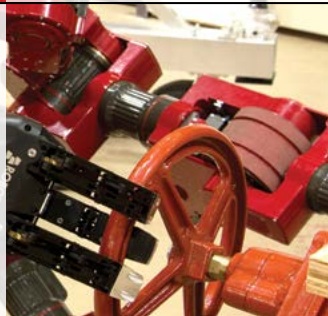
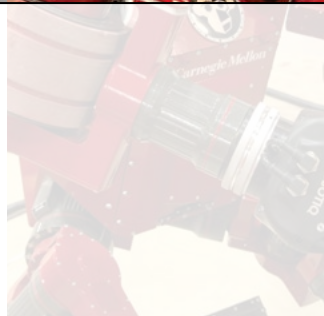
CHIM

A four-wheeled robot created to respond to disasters competed at the 2015 DARPA Robotics Challenge



HERB

Short for Home Exploring Robot Butler, a bi-manual mobile manipulation platform



risk of injuring them. That original robotic arm is still on display on the fourth-floor hallway between Newell-Simon and Wean Halls.

To add context to the robotic artifacts, the archivists are adding video oral history interviews with some of the pioneers. In one video clip, **Manuela Veloso**, professor emerita in the School of Computer Science, discusses her pioneering work on Symbiotic Autonomy with CoBots, which is short for collaborative robots that do multiple tasks in an uncertain environment. In a video interview as part of the project, Veloso discusses how she came up with the idea of a CoBot asking humans for help, such as pressing the button on an elevator.

Some of her colleagues initially thought the idea was heresy. She recalls them saying, “Oh my God, she is cheating. What do you mean — ask for help?” Robots, after all, are supposed to be autonomous. But in the interview, Veloso said, “Intelligence is asking for help. That is what it’s all about. You figure out a few things, and you ask for help.”

The Robotics Project, which began online but now has its first physical exhibit in the first-floor gallery of Hunt Library, intends to be a place that would appeal as much to a lay person or student as it would to scientists and computer historians.

Robots have long fascinated sci-fi fans, but with their prevalence in everyday life — self-driving cars, meal delivery robots in hospitals, and assistive technology for people with disabilities — interest in the field has never been higher.

“There is a sense that you are bringing something to life,” Atkeson said. “You don’t just want a robot locked in a museum case. But when it begins to move, it feels alive. That is very appealing.” ■

If you are interested in making a philanthropic contribution to The Robotics Project, please contact Morgan Walbert, Director of Development at mwalbert@andrew.cmu.edu to learn

PROFILER 2

A rugged, mobile robot that enabled safe and remote mapping in underground mines

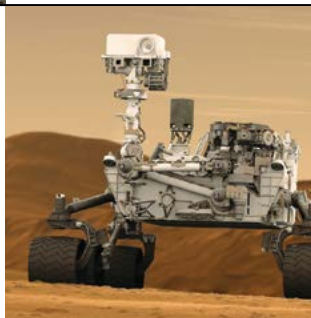


PERSEVERANCE

Operated remotely on Mars, this Rover seeks signs of ancient life and collects samples of rock and soil for possible return to Earth

2022

2020





Beyond Grateful

A life changing-experience brings Kayo Yin (SCS 2022) to CMU and drives her visionary research.

At age six, Kayo Yin (SCS 2022) moved with her family from Japan to Paris, and she quickly began to learn the importance of language.

"My mother struggled to learn French," Yin said. "It made everything from going to the grocery store and doctor visits to connecting with people challenging."

Yin, now a master's student in the Language Technologies Institute, eventually became fluent in Japanese, French, Mandarin and English, propelled by spending time in different places. She found learning local cultures considerably easier when she could communicate with people.

But Yin and her mother have the ability to hear, and they primarily use spoken languages. Learning to speak, write and read a new spoken language is becoming increasingly easy with resources such as automatic translators and language learning apps.

During her college years at Ecole Polytechnique in Paris, Yin volunteered at a homeless shelter where she met a deaf woman.

"Being deaf made her isolated," Yin said, "Growing up, she didn't have access to sign language classes. She could speak and write, but still couldn't fully express herself or make meaningful connections with people."

Yin started learning French sign language and pursued sign language translation as part of her undergraduate research. This life-changing experience helped bring Yin to Carnegie Mellon and the LTI.

Her research on machine translation focuses on breaking down communication barriers between people, especially those with disabilities and those who speak less common languages.

Natural language processing uses computers to understand what humans say and write, helping people communicate through tools such as machine translation, voice-controlled assistants and chatbots. But it primarily concentrates on spoken language, excluding the more than 200 signed languages around the world and the nearly 70 million people who rely on them to communicate.

"Siri is great for English, but not all languages. There isn't a Duolingo-type app for the deaf. I want to widen access to all communities," Yin said. "We can use what we know already about spoken language and build tools using computer vision to help a whole family of languages that are overlooked."

Her vision has gained significant traction. Over the summer, Yin co-authored "Including Signed Languages in Natural Language Processing," that won the Best Theme Paper at the 59th Annual Meeting of the Association for Computational Linguistics. The paper's recognition has sparked discussions at CMU and other institutions to include sign language in more research. Yin has been contacted by researchers from around the world about potential collaborations.

She is beyond grateful.

"I'm driven by having my work apply to the real world and to real people," Yin said. "With signed languages, I'm interested in how they work and how meaning is conveyed, and then using that knowledge to make an impact." ■

FRANÇESKA XHAKAJ
Assistant Teaching Professor,
CSD/HCI

*Educational technologies,
learning science*

Meet the New SCS Faculty

ZACKORY ERICKSON

Assistant Professor, RI

*Lead, Robotic Caregiving and
Human Interaction Lab
Exploring intelligent physical
human-robot interaction, with
applications in health care robotics*





Check out the 2021 **Lightning Research Talks** on the SCS YouTube channel to learn more about research projects our new faculty are working on!

<https://bit.ly/3ICxG7D>



CHRISTINA HARRINGTON

Assistant Professor, HCII

Evaluation and ergonomic assessment of consumer products, user research, inclusive and accessible design for special populations, user experience design, design research methods



ZHILIAO JIA

Assistant Professor, CSD

Systems and machine learning, accelerating deep learning computations on modern hardware platforms populations, user experience design, design research methods



**DIMITRIOS
SKARLATOS**

Assistant Professor, CSD

*Computer architecture,
operating systems, security*



PATRICK PARK

Assistant Professor, ISR

*Social networks, computational
social science, societal
computing, online communities*

WENNIE TABIB

Systems Scientist, RI

*Active perception, sensing and perception,
aerial robotics, field robotics*



Meet the New SCS Faculty



SHUBHAM TULSIANI

Assistant Professor, RI

Computer vision, 3D vision and recognition, world modeling, perception for robotics, robot learning



WENTING ZHENG

Assistant Professor, CSD
(CyLab)

System security, applied cryptography populations, user experience design, design research methods

[PHOTOS NOT AVAILABLE]

STEPHANIE BALZER

Assistant Professor, CSD

Developing type systems and verification logics for proving correctness and safety of concurrent programs

ZAKIA HAMMAL

Systems Scientist, RI

Computer vision, machine learning, multimodal human behavior modeling

NEW ROBOTICS INSTITUTE DIRECTOR READY TO SHAPE FUTURE OF ROBOTICS

CMU Alum Matthew Johnson-Roberson to Head Robotics Institute

Aaron Aupperlee

Much has changed since Matthew Johnson-Roberson last walked the halls of Carnegie Mellon University's Robotics Institute. In the 15-plus years since Johnson-Roberson graduated, robots have proven they work. They can navigate city streets and sidewalks. They can fly autonomously to inspect bridges, buildings and tunnels. And they help in homes, hospitals and offices.

Johnson-Roberson, who earned a bachelor's degree in computer science from CMU's School of Computer Science in 2005, will have a chance to help shape the next generation of robotics and roboticists when he returns to campus in January 2022 as the new director of the Robotics Institute.

"We're at a really important inflection point in the trajectory of robotics," Johnson-Roberson said. "It is a larger field. There are more students interested in robotics, and people are building systems that work. We have an opportunity to determine how we want to deploy robotics in the world and how can we use that technology to produce the most good."

Johnson-Roberson will be the Robotics Institute's sixth director. Professor Srinivasa Narasimhan has served as an interim director of RI since 2019, when Martial Hebert left his post as head of the institute to become dean of SCS.

"Matt's expansive background and expertise equip him well to lead the development of robotic systems across RI and SCS," Hebert said. "The Robotics Institute, the School of Computer Science and the entire Carnegie Mellon community are thrilled to welcome Matt back to campus and excited to work with him."



Matthew Johnson-Roberson, who earned a bachelor's degree in computer science from CMU in 2005, will return to campus in January as the new director of the Robotics Institute.

Johnson-Roberson was most recently an associate professor of engineering in the University of Michigan's (UM) Department of Naval Architecture and Marine Engineering and the Department of Electrical Engineering and Computer Science. He co-directed the UM Ford Center for Autonomous Vehicles, and both founded and led the Deep Robot Optical Perception (DROP) Lab. Johnson-Roberson also co-founded Refraction AI, a delivery robotics company focusing on last-mile logistics.

After graduating from CMU, Johnson-Roberson earned his Ph.D. at the University of Sydney. He completed a post-doctoral fellowship at the KTH Royal Institute of Technology's Centre for Autonomous Systems in Stockholm and a research fellowship at the University of Sydney's Australian Centre for Field Robotics. Johnson-Roberson joined the faculty at UM in 2013 and taught courses related to underwater vehicle design and autonomy, computer vision and self-driving cars.

"It's an honor to come back and work with some of the same people who inspired me," Johnson-Roberson said. "Part of this job will be figuring out how to affect change and preserve what was amazing about RI in first place. I want to keep the best bits while looking forward."

Johnson-Roberson caught the robotics bug during his junior year at CMU. He wanted to use computer science to do something bold and make the world a better place. In the halls of the RI, he stumbled across Professor Red Whittaker and the Red Team autonomous vehicle racing program. Johnson-Roberson stuck with the program, working on Sandstorm and H1ghlander — the team's entries in the 2004 and 2005 DARPA Grand Challenges where driverless vehicles raced through the desert near the California/Nevada border.

Whittaker called Johnson-Roberson a "technological adventurer" and said the enthusiasm and determination with which he devoted himself to his projects impressed him. For Johnson-Roberson, the work was an opportunity to get involved in top-level research as an undergrad. And it was a chance to attempt the impossible.

"It was a moonshot. It was very unclear if it was going to work," Johnson-Roberson said. "But it altered the entire structure of my career. After the 2004 challenge, robotics was it. I was locked into what I wanted to do. If I had not done that challenge, I don't know what I would be doing."

continued

I want to build an environment that brings more voices to the table. That benefits everybody in the community,"... and leads to what I think universities do so well — inspire thought, discussion, debate and conflict that leads to better and newer ideas.

Matthew Johnson-Roberson (SCS 2005)

A project with Professor Chris Atkeson further sharpened Johnson-Roberson's focus. The two worked on a camera system to detect falls in nursing homes. The project showed Johnson-Roberson how robotic systems could be deployed in the world to help people. Atkeson said Johnson-Roberson was an independent undergrad who clearly wanted to develop technology to make people's lives better.

"You don't often find people that are so passionate," Johnson-Roberson said of Whittaker and Atkeson. "And that passion is just incredibly contagious."

Now Johnson-Roberson returns to CMU to lead the department responsible for shaping so much of his research and work. As robots become more common in everyday life, roboticists continue to wrestle with questions around the potential societal consequences they pose and the equality of their benefits. The younger generation of students is pushing these challenges to the forefront while also expressing changing expectations for the field, the university and the faculty.

Johnson-Roberson likes the constant influx of new students with new perspectives. Young people are incredibly passionate and excited about seeing and affecting change in the world, and Johnson-Roberson is excited to make that happen in the RI.

"I want to build an environment that brings more voices to the table. That benefits everybody in the community," Johnson-Roberson said. "As we begin to expand inclusion, you begin to see the chaos, but hopefully and ultimately, the benefits of having a more diverse conversation. And that leads to what I think universities do so well — inspire thought, discussion, debate and conflict that leads to better and newer ideas."

Johnson-Roberson said he is looking forward to celebrating Spring Carnival once again but was disappointed to learn that the "O" is no more. He doesn't know where he will get his late-night, greasy food fix. ■



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CMU COMPUTER SCIENTISTS USE ALGORITHM TO INNOVATE ROOTS OF DEMOCRACY

Aaron Aupperlee



CSD Ph.D. candidates Bailey Flanigan (left) and Paul Gözl (right) were part of a team that developed an algorithm to maximize the randomness and fairness of choosing a citizens' assembly.

When 30 Michiganders convened last fall to draw up recommendations for tackling COVID-19, an algorithm developed in part by Carnegie Mellon University computer scientists helped bring them together.

The Citizens' Panel on COVID-19, organized in Michigan by the nonprofit "of by for" is an example of a citizens' assembly — a political instrument with roots in ancient Greece that is experiencing a modern-day resurgence. One of the biggest challenges in organizing these assemblies, both in ancient times and today, is deciding who should serve. The assembly needs to be representative of the population as a whole, but the selection should be random, with all volunteers having an equal chance of being chosen.

Bailey Flanigan and Paul Gözl, both Ph.D. candidates in the Computer Science Department, were part of a team that developed an algorithm that maximized the randomness and the fairness of sortition, the process of choosing a citizens' assembly. Other researchers involved include Anupam Gupta, a professor in CSD; Ariel Procaccia, a professor of computer science at Harvard's School of Engineering and Applied Sciences and a former CMU professor; and Brett Hennig from the Sortition Foundation, a UK nonprofit organizing citizens' assemblies. The team used a version of their algorithm to help select the panel in Michigan and recently published their work on a similar algorithm in *Nature*.

“I’m motivated by addressing inequities in people’s experiences and, in particular, inequalities in people’s access to political power.”

Bailey Flanigan

“Sortition is one of the most exciting approaches to try to innovate democracy,” Gözl said. “There is concern that democracy is backsliding. Dissatisfaction in government has risen. Polarization has risen. I truly think there are ways out of this if we do not take democracy as something that is set in stone and try to innovate on it.”

Citizens’ assemblies date back to ancient Athens, where public offices were filled by citizen volunteers selected by random lottery instead of elections. These volunteer assemblies drafted, debated and passed laws; made major foreign policy decisions; and controlled military budgets.

Citizens’ assemblies are making a comeback. In 2019 and 2020, citizens’ assemblies in France and the United Kingdom convened to draft measures to address climate change. Citizens’ assemblies in Ireland have led to changes to the Irish constitution that legalized abortion and same-sex marriage. The panel in Michigan crafted 12 recommendations and offered them to local, state and national policymakers as a way out of the pandemic.

“I’m motivated by addressing inequities in people’s experiences and, in particular, inequalities in people’s access to political power,” Flanigan said. “Something like sortition allows decisions to be made by people who are informed while also giving a more diverse group of people direct influence over political decisions.”

Previous methods for selecting citizens’ assemblies resulted in some participants having essentially no chance of being selected, raising questions about the fairness of the process. To address this, the team’s algorithm generates hundreds or thousands of panels from the participants and selects one. The process gives each participant as equal a chance as possible of being selected.

“Ideally, a citizens’ assembly acts as a microcosm of society,” Procaccia said. “Whether this goal is realized in practice, however, depends on exactly how assembly members are chosen.”

The open-source algorithm has already been used to select more than 40 citizens’ assemblies by organizations in countries including Denmark, Germany, the U.S., Belgium and the U.K. Going forward, the researchers will continue working with practitioners to learn from their experience about how these new selection algorithms can be made even more useful. ■

Names in the News



Top to bottom: Karan Ahuja, Priya Donti, Ryan Shi, Yasmine Kotturi, Kayo Yin



Jessica Hammer



Huan Zhang



Zico Kolter

SCS graduate students **Karan Ahuja**, **Priya Donti**, **Yasmine Kotturi**, **Ryan Shi** and **Kayo Yin** have been named 2022 Siebel Scholars.

Jessica Hammer, the Thomas and Lydia Moran Associate Professor of Learning Science and the interim associate director of the HCII, will receive the Best Interdisciplinary Approach to STEM Education Award at the 25th Annual Carnegie Science Awards Celebration next month.

Jan Hoffmann, an associate professor in the Computer Science Department, has received an Amazon Research Award for his work on serverless computing.

SCS researchers **Huan Zhang** and **Zico Kolter**, led a team to victory in the 2021 International Verification of Neural Networks Competition with an open-source tool that can provide a guarantee of the behavior of a critical part of modern AI.

Alon Lavie, a consulting professor in the LTI, received the 2021 Makoto Nagao Award of Honor from the International Association for Machine Translation for his outstanding contributions to machine translation.

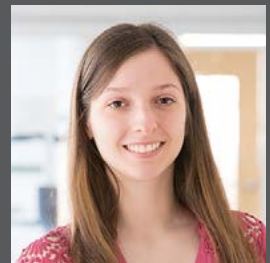
Jenna Wise, a software engineering Ph.D. student in the Institute for Software Research, has been named a 2021 Google Ph.D. Fellow in programming technology and software engineering.



Jan Hoffman



Alon Lavie



Jenna Wise

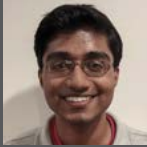
SCS IN THE NEWS



Fei Fang



Tuomas Sandholm



Souradip Ghosh



Chirag Gupta

A group of **LTI master's students** earned top honors for their dance app, "Twerk Out," at Cornell University's BigRed/Hacks hackathon last month.

Faculty members **Fei Fang** and **Tuomas Sandholm** both earned awards at the 2021 International Joint Conferences on Artificial Intelligence for their significant contributions to the field.

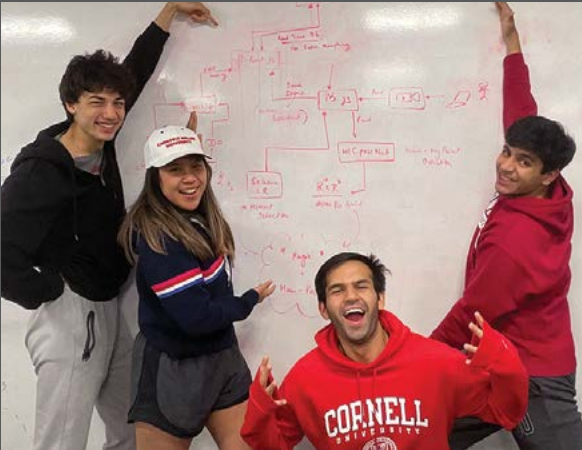
The Department of Energy has named computer science Ph.D. student **Souradip Ghosh** one of its Computational Science Graduate Fellows.

Machine learning Ph.D. candidate **Chirag Gupta** has received a Bloomberg Data Science Ph.D. Fellowship.

Assistant Professor **Aaditya Ramdas** has received the Bernoulli Society for Mathematical Statistics and Probability's New Researcher Award.

New faculty member **Dimitrios Skarlatos** received the joint 2021 ACM SIGARCH & IEEE CS TCCA Outstanding Dissertation Award along with **Goran Žužić**, who earned his Ph.D. in computer science from CSD in 2020.

Machine Learning faculty member **Virginia Smith** and SCS Ph.D. candidate **Priya Donti** have been named to MIT Technology Review's annual list of Innovators Under 35.



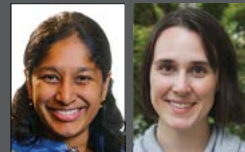
LTI Master's Students: Alex Li, Athiya Deviani, Ranadeep Singh and Abuzar Khan



Aaditya Ramdas



Dimitrios Skarlatos, Goran Žužić



Priya Donti, Virginia Smith

IN MEMORY OF AN AUTHOR AND FRIEND

Pamela McCorduck's Contributions to the Birth of AI Continued Through Her Generosity

Aaron Aupperlee



Pamela McCorduck, an author who wrote some of the first novels and histories about AI and was a generous friend of CMU, died October 18, 2021. She was 80.

As scientists laid the foundations of artificial intelligence, Pamela McCorduck was there.

The inquisitive, kind, gracious and open-minded woman soaked up the beginnings of modern technology through conversations and interactions with the researchers shaping the field.

McCorduck described herself as an eyewitness to the birth and growth of AI. She was possibly best known for her 1979 book, “Machines Who Think,” which chronicles the history of AI from the dreams and nightmares of ancient poets and prophets to the scientific discoveries of the 20th century. The novel contains the famous quote, “Artificial intelligence began with the ancient wish to forge the gods.”

“I think her life was shaped by curiosity,” said Lee Marona, McCorduck’s brother-in-law. “Being in the world of all of these incredible scientists, she had endless thoughts and questions, and each question with Pamela seemed to garner another question, to dig deeper.”

McCorduck’s encounters with computer scientists began in the 1960s at Stanford University. There, she worked alongside Edward Feigenbaum, who earned his bachelor’s degree and Ph.D. from CMU and would go on to receive the ACM Turing Award, considered the Nobel Prize of computing, and be known as the father of expert systems. McCorduck co-authored “The Fifth Generation” with Feigenbaum in 1983. Feigenbaum regarded McCorduck as one of three deep friendships he had sustained from those days.

“Now I have only two,” Feigenbaum said. “This is a deep personal loss. It is also a big loss for the AI community. Until recently, she continued to be a bridge between AI and the humanities.”

Raj Reddy, a pioneer in robotics, artificial intelligence and speech recognition who won the Turing Award with Feigenbaum, met McCorduck when he was a graduate student at Stanford. She was gracious and friendly, Reddy said, but he didn’t know at the time she was an aspiring author.

“Many encountered AI for the first time through her writings, and she influenced what people thought about the field as it was developing.”

—Raj Reddy, CMU's Moza Bint Nasser University Professor of Computer Science and Robotics

“Her books on AI turned out to be popular and widely cited,” said Reddy, CMU's Moza Bint Nasser University Professor of Computer Science and Robotics, the founding director of the university's Robotics Institute and a former dean of the School of Computer Science. “Many encountered AI for the first time through her writings, and she influenced what people thought about the field as it was developing.”

McCorduck lived in Pittsburgh in the 1970s and taught in the University of Pittsburgh's English Department. Her husband, Joseph Traub, was the second head of the Computer Science Department — then part of the Mellon College of Science.

During her time in Pittsburgh, McCorduck came to know many of the researchers working in computer science at Carnegie Mellon. She often told a story of enticing Herbert Simon to stop on his walk home from campus by offering him sherry. The story was captured in the University Archives' recording of McCorduck's Oral History.

“Pamela was around Carnegie Mellon during a formative period of our Computer Science Department and computer science in general,” said Martial Hebert, dean of the School of Computer Science. “She was an early and hugely influential chronicler of artificial intelligence at CMU and elsewhere, and her writing — including direct conversations with many of the giants of the field — helped define the way we view, in her words, machines who think.”

McCorduck left Pittsburgh in 1979 when Traub went to New York to start the computer science program at Columbia University. The pair, however, remained connected to and good friends of CMU throughout their lives.

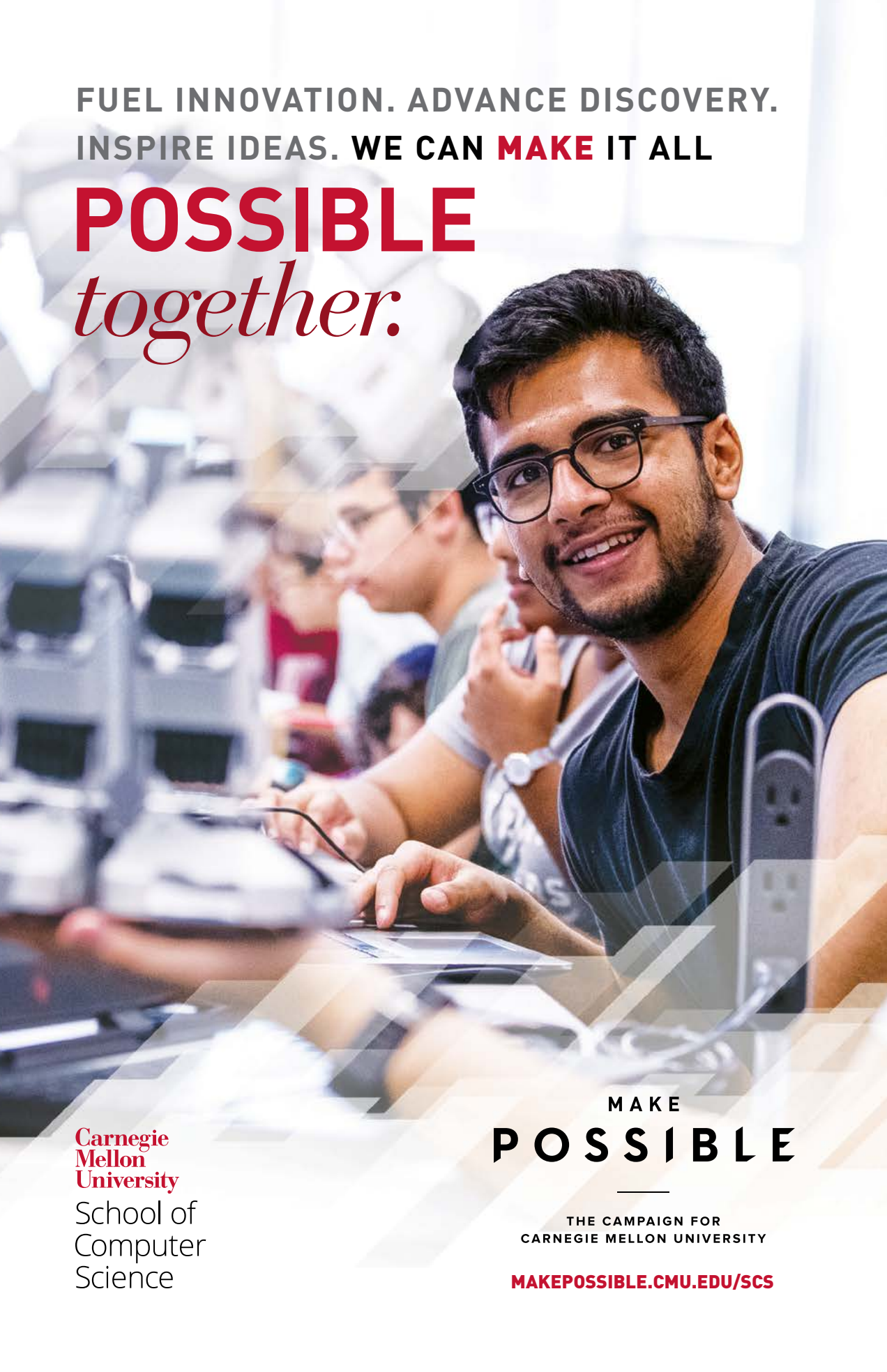
Upon completion of the oral history interviews conducted with researchers involved in AI for “Machines Who Think,” McCorduck donated the transcripts, research and related materials to the University Archives in 1978. CMU's Pamela McCorduck Collection includes audio cassettes of interviews with notable researchers such as Simon and Allen Newell. University Libraries featured highlights from the collection in its 2018 exhibit that celebrated McCorduck's work and her contributions to the history of AI, “Shoots of Green: Innovation at CMU.” Traub also donated his papers to the archives in 2004.

In 2018, McCorduck gave CMU letters, books and other writings by Traub; rare books by 19th century mathematician and computer pioneer Charles Babbage; and more than 50 mechanical calculators, encryption devices, and early computers from the collection she and her husband had amassed. The collection contained slide rules, a Power Mac G4 Cube and a pair of Enigma machines — encryption devices used by the German military to keep secrets safe during WWII. Thousands of Enigma machines were made during the war, but only about 350 are thought to survive. The pair in the Traub-McCorduck Collection are among the 70 or so on display in museums and institutions around the world.

“The University Libraries and Archives have benefited generously from Pamela's and Joe's support,” said Dean of Libraries and Director of Emerging and Integrative Media Initiatives Keith Webster. “Their collections will inspire and impact CMU students and researchers for years to come, just as ‘The Fifth Generation’ influenced the trajectory of my career when a professor handed it to me in 1984.”

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So that they can enjoy their own journey



Carnegie Mellon was so instrumental for my life's journey. When I entered CMU for the Ph.D. program, I had just come to the U.S. and didn't know much about anything. Carnegie Mellon taught me everything: from fundamentals of computer science, to how to do world-class research, to effective communication, and even surviving the cultural shock of coming to America! I learned so much, and the learning laid the foundation for my future development and my happiness in the years to come. I can't say enough of "Thank You!" to Carnegie Mellon, and it's only appropriate that I now do my part to support CMU and more students, so that they can enjoy their own journey!

KE YANG M.S. 2002, PH.D. 2004

Language Technologies Institute Friends Unite to Create Chinese Alumni Fellowship

Collaborative Gift Among Largest in LTI History,
Will Support Students in Need

AARON AUPPERLEE

Ying Zhang took charge of fun activities during his time at Carnegie Mellon University's Language Technologies Institute. It was the early 2000s, and the institute was new, small and close-knit. Zhang, better known as Joy, became fast friends with his fellow LTI students.

Joy organized movie nights and trips skiing, hiking and rafting. He even hosted a party in his tiny apartment to watch the Pittsburgh Steelers win the 2006 Super Bowl.

And 15 years later, looking at a photo of the group celebrating that championship in the streets of Oakland, Joy sees his friends and what they have become. Some founded successful companies. Others are high ranking executives at top firms.

"We had very strong connections back then, and we remained connected even after we graduated," Joy said. "Our careers benefited from these connections, and now we want to help others have the same opportunities."

THE ALUMNI BEHIND THE GIFT:



Ying "Joy" Zhang
(SCS 2002, 2009): past
CMU faculty and staff;
director of engineering and
data science, Airbnb



Xin Liu (SCS 1999):
principal software
engineer, Airbnb



Jiangbo "Max" Miao
(SCS 2005): founder,
chair and CEO, Zhoupu
Data Technology

The friends, all LTI alumni, have come together to make one of the largest donations to the institute in its history. Totaling about \$1.2 million, the gift will establish the LTI Chinese Alumni Fellowship, providing valuable funding to LTI graduate students in need.

The idea for the gift started small. Conversations about donating to CMU between Joy and a fellow LTI alum at Airbnb, Xin Liu, led to thoughts of making a joint gift. Emails, Zoom meetings and messages in a WeChat group of Chinese LTI alumni followed. As the group grew, so did the size of the gift.

“This gift demonstrates the character of our alumni and underscores the lasting impact of the relationships fostered in the School of Computer Science,” said Martial Hebert, dean of SCS. “These friends, who helped each other through their studies and their careers, are collaborating once again to help students.”

Carolyn Rosé, professor and interim director of the LTI, said the new fellowship will fuel innovation among students looking to take the lead in carving out their own research. Research funded through more typical channels comes with more constraints.

“A fellowship offers a student the opportunity to do something new and cutting-edge. If there is an innovative idea, they can just go for it,” Rosé said. It provides freedom. You can do something risky. You have a safety net.”

This will be the LTI’s first fellowship from former students for current students. And it will come from some of the institute’s first master’s and

Ph.D. graduates, said Jamie Callan, a professor in the institute and a past interim director.

The alumni behind the gift joined the LTI not long after it transitioned from the Center for Machine Translation. Callan said the institute was a small family at that time. Yi Zhang, one of the donors, was Callan’s first Ph.D. student.

“Their creativity, dedication and hard work helped establish the LTI as a leader in language technologies research and education,” Callan said. “They will always hold a special place in our hearts, and we are humbled by their generosity now.”

Joy is proud of the fund the alumni put together, but he hopes it does more than support a fellowship in the LTI. He was inspired by the stories of Andrew Carnegie and Mao Yisheng, who received the first Ph.D. from Carnegie Tech and was a renowned bridge engineer and educator in China. Both were immigrants who benefited from coming to the United States and then gave back.

Perhaps the gift will inspire other alumni to give back, too, Joy said.

“This fund, although small, is a gesture to show that contributing to the university can be meaningful,” he said.

Anyone — from alumni to parents and friends — interested in contributing to the LTI Chinese Alumni Fellowship can contact Sandra Zhao, associate director of international development, at sandrazhao@cmu.edu or through WeChat at [sandrazhao2](https://www.whatsapp.com/channel/00299a61111111111111) for more information.



Rong Yan (SCS 2004, 2006): CTO, Verishop



Yan Liu (SCS 2004, 2006): professor and director of the Machine Learning Lab, University of Southern California



Yi Zhang (SCS 2001, 2005): professor, University of California, Santa Cruz; and co-founder, Rulai

[Photos not available]

Yanxin Shi (SCS 2007)

Jian Zhang (SCS 2004, 2006): founder, Alphon Technologies

Wei Xu (SCS 2000): chief scientist of general AI, Horizon Robotics

SCS ANNUAL GIVING
BY THE NUMBERS (FY21):

1,468

DONORS TO SCS

\$1,252,795

IN ANNUAL FUND GIFTS TO SCS
(A 70% INCREASE OVER FY20)

\$100

MEDIAN GIFT SIZE

693

DONORS WHO HAD NEVER
MADE A GIFT TO SCS BEFORE

331

DONORS TO SCS
CROWDFUNDING CAMPAIGNS
&

\$47,279

IN SCS CROWDFUNDING GIFTS

Impact Report: Dean's Innovation Fund

The School of Computer Science (SCS) is renowned for the entrepreneurial spirit of its students, faculty and researchers. Thanks to the support of donors, the Dean's Innovation Fund allows the dean to support valuable new ideas that aren't covered by the operational budget or research grants. The dean can also use this fund to improve the quality of life for graduate and undergraduate students.

This past year, the Dean's Innovation Fund supported further development and expanded deployment of **Diderot**, an online teaching system that enables instructors and professors to provide a highly engaged and engaging learning experience.

Currently, Diderot is used for all core courses at SCS. Bringing together content, communication and computing, it is a unique and incredibly robust online teaching system, far surpassing the performance of commercially available software systems. **Umut Acar**, an associate professor in SCS, had actually developed Diderot years before the COVID crisis. Acar was writing a book for one of his courses and he wanted his students to be able to write feedback on the book, ask questions and interact with the content in a convenient way. Dissatisfied with the options available, he decided to write it himself. And with that, Diderot was born. His students loved it, and as word spread, demand for its use spread, too.

When COVID-19 struck, disrupting all "normal" ways of doing things, Diderot became a lifeline for instructors, especially those teaching the core courses. Almost immediately, thousands of students began using Diderot each semester. Last year, 20 courses used Diderot. In all, since it became more broadly available in spring 2019, 100 courses have used Diderot, enabling SCS to pivot fast, and switch courses online without sacrificing the quality and rigor of our world-leading curriculum. Entire books can be uploaded with sections released at the instructor's discretion, exams can be administered, videos can be embedded — and there is a basic autograding feature

as well. It runs 24/7 and is extremely popular among students. Students can take notes on what they read, ask questions for instructors to reply to, comment and discuss ideas with classmates. In fact, students report spending 60% of their time on Diderot. The program serves more than 1,000,000 requests per day.

Diderot is in high demand by instructors because the engagement rates are so high among students. In addition to Diderot, the Dean's Innovation Fund recently supported our groundbreaking undergraduate degree in artificial intelligence, the first of its kind in the nation. SCS faculty, staff and students constantly have incredible ideas they'd like to execute, and the Dean's Innovation Fund lets us seize these opportunities and address timely challenges.

Your support plays a vital role in making all of this happen. Carnegie Mellon University is leading the way in life-changing education and world-changing research, and your generosity makes that possible. Thank you for creating the resources needed to enhance the experience and opportunities available to SCS students and faculty.

Did you know...For many members of our SCS community, donating appreciated stock is a great way to give even more to CMU — and to maximize your tax benefit.

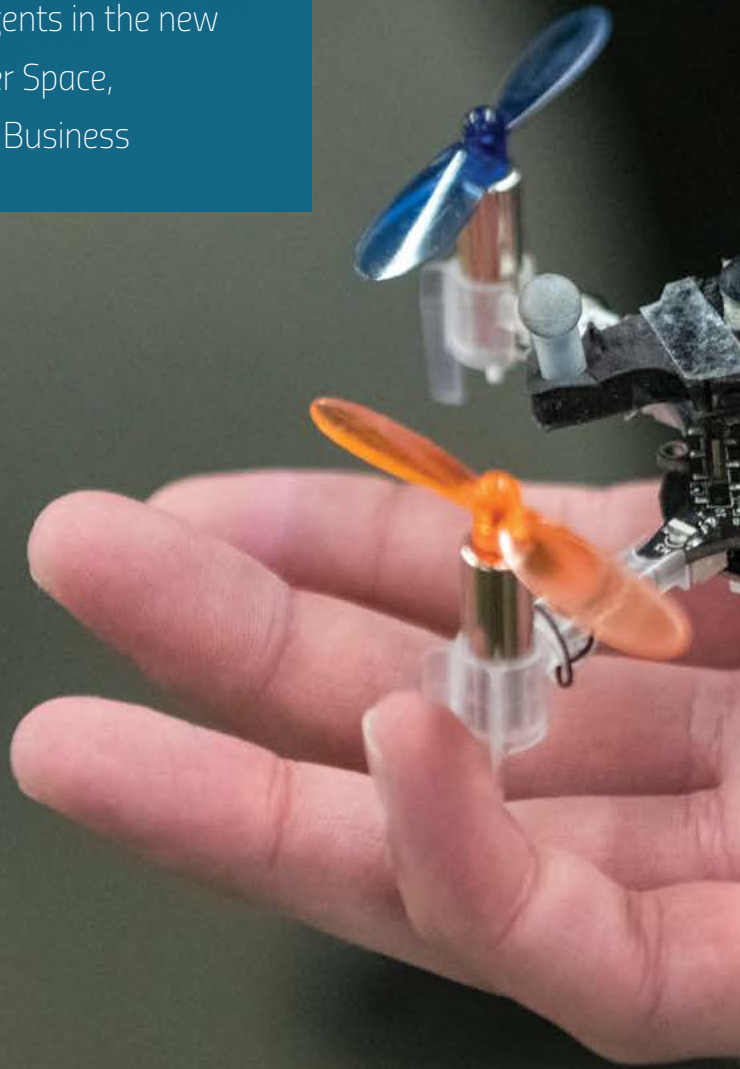
For more information, please contact Jenny Belardi, SCS Chief Advancement Officer, at jbelardi@andrew.cmu.edu, or visit <https://www.cmu.edu/engage/give/gift-planning/give-through-assets.html>.

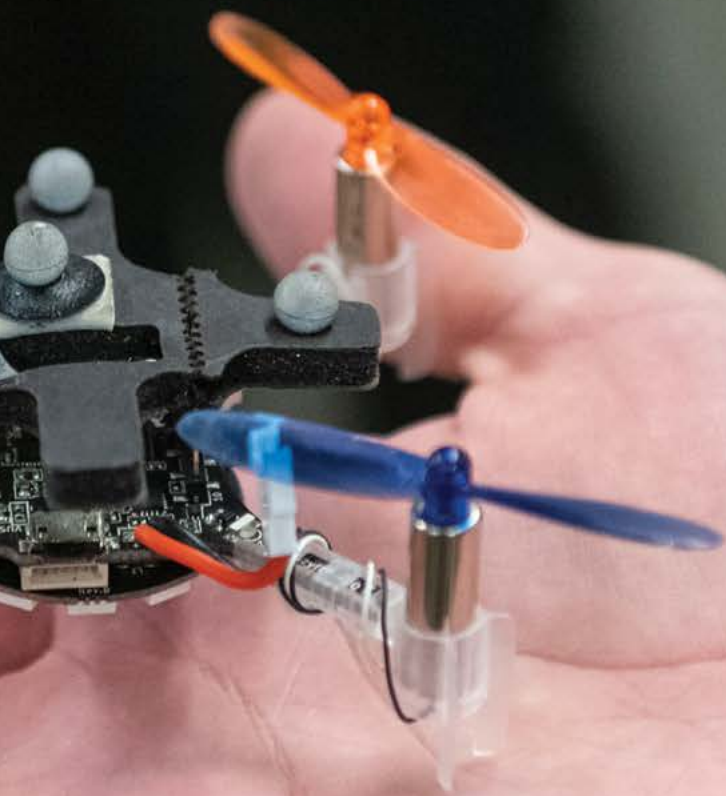
Without this scholarship I would not be attending CMU, and while I am sure I would have made the best of whatever situation I ended up in, my last two years at CMU have been the most formative and incredible years of my life. I am eternally grateful for being provided the opportunity to attend CMU and to be surrounded by kind and talented people in all directions, thanks in part to your support.

VICTOR ALFONZO, CLASS OF 2023

AI Takes Flight

This small drone and other robots serve as the tools student collaborators from across campus will use to create AI agents in the new JPMorgan Chase & Co. AI Maker Space, located in the Tepper School of Business





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School of Computer Science

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Calendar of Events

April 7-9

*Spring Carnival &
Reunion Weekend*

May 4

*Meeting of the Minds
Undergraduate Research
Symposium*

May 15

Commencement

A composite map compiled by Team Explorer using data gathered during an early stage of the DARPA SubT Challenge. (see pg. 6 inside)

