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THE MAGAZINE OF CMU'S SCHOOL OF COMPUTER SCIENCE

SUMMER 2021
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Bridging what divides us

The Salad Days of AI

Students Create Digital Green Thumbs to Nurture Vegetables in Automated Greenhouses

Nidhi Jain has never had much luck growing plants.

"I've tried to work with plants, but they didn't want to work with me," said the senior computer science major from California. "So I've stuck to succulents."

Green thumb or no, last fall Jain and her classmates in the School of Computer Science's Autonomous Agents course applied their knowledge of artificial intelligence, including machine learning and computer vision, to grow lettuces and radishes in small, automated greenhouses. Without ever seeing or touching their plants in person, they worked in groups of three to nurture their sprouts, writing programs that made all of the decisions on adjusting light, humidity and soil moisture based on sensor data.

Reid Simmons, who teaches the course with Stephanie Rosenthal, said using AI to grow vegetables is a good way for students to put into practice the knowledge of AI-based autonomous agents that they learned in class. Agents have applications in many areas, such as self-driving cars, intelligent factories and smart homes. Automated greenhouses proved a good match to the need for a course exercise.

theLINK

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.

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A Year Unlike Any Other

The School of Computer Science is, at its core, a collaborative collection of diverse minds, interested in solving some of the biggest problems human beings face. Since March of 2020, the pandemic has relegated us all to working primarily from home, outside of our natural hive of ideas buzzing around one another, long enjoyed while working and collaborating on campus.

I would like to thank the entire SCS community for taking on the massive challenges of conducting their work from home, isolating as it has been, and for successfully conducting their research, taking and teaching online classes, working on projects, and myriad tasks that go into keeping SCS running. It has not been easy, but the SCS community has prevailed.

Next, I want to congratulate every member of the SCS community for continuing the high level of accomplishment, especially during a time where connecting with collaborators has presented challenges. Some of these accomplishments show up in the pages of this issue. From CS Pathways partnering to provide free Wi-Fi to local communities to help bridge the digital divide, to the decades of work with NASA missions leading up to and contributing to the recent Mars landing — alumna Vendi Varma drives the Mars robot from her lab here on Earth — SCS continues to look near and far to solve problems both remotely and at home.

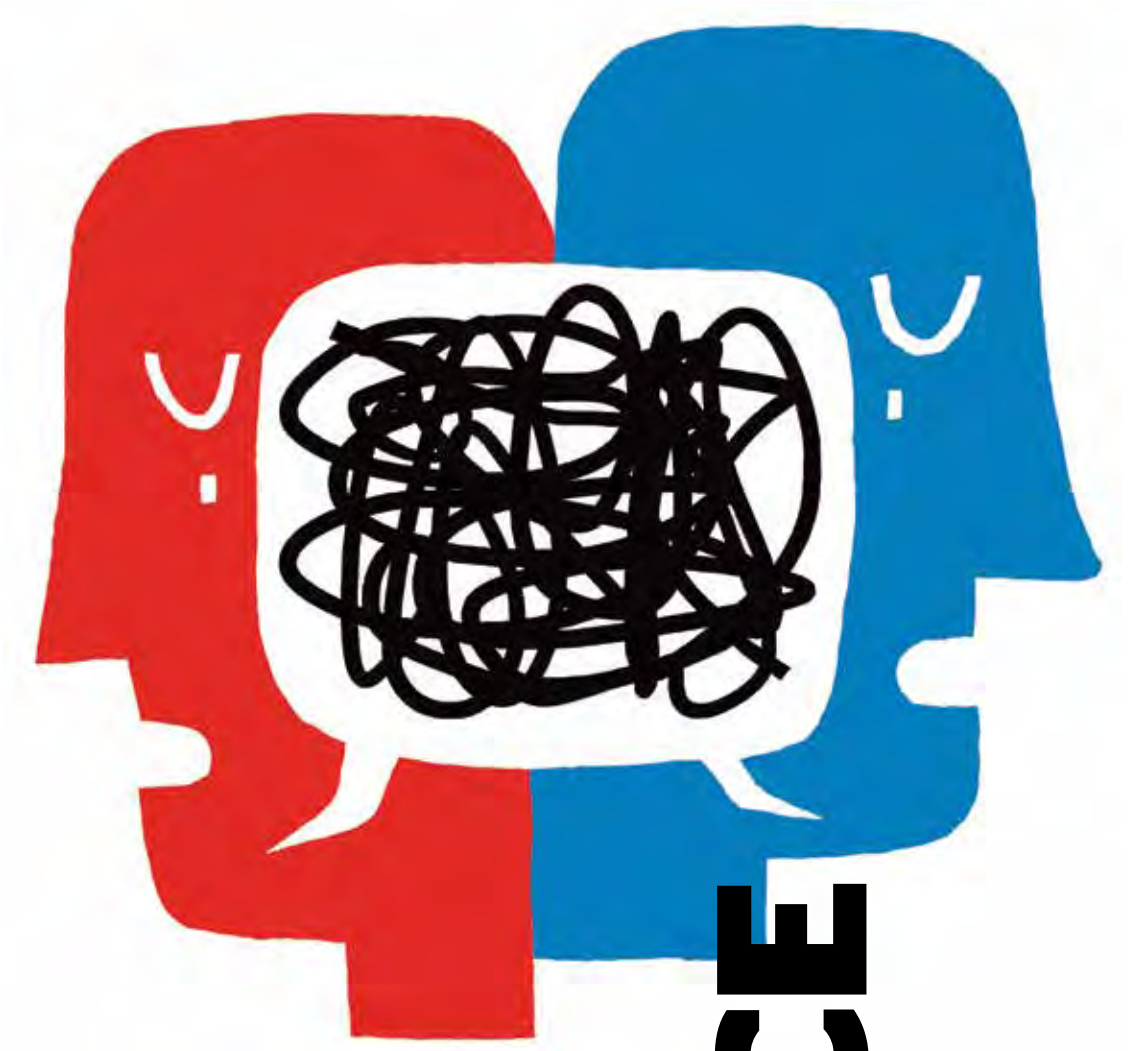
As the COVID-19 pandemic stormed across our nation and the world, we look especially to India and the humanitarian crisis occurring there. The spike in new cases this spring is alarming, and we must not ignore the plight of those with limited access to the tools and vaccines to combat this pandemic, not only because it affects us all, but also because it is the right thing to do.

In that same spirit, we look locally at the gap not only in technology but also in prosperity. Please read about the appointment of Illah Nourbakhsh as the first director of the Center for Shared Prosperity, the mission of which will be to take on the prosperity gap in the Pittsburgh area. In the wake of the killing of George Floyd and protests over police violence and murders, we are now more keenly aware of the inequalities in our society and within our own communities. SCS has long stood in opposition to institutional racism and bias. However, the time has come to take the next step and work to ensure a more equitable experience.

I'm pleased to announce that Jodi Forlizzi has accepted the role of Associate Dean for Diversity, Equity and Inclusion. Jodi is the right person to lead SCS in this direction and will build the team that, along with the efforts of our entire community, will lead SCS to a more inclusive and equitable place for our students, faculty and staff. Most of the work lies ahead, so please get involved by checking the DEI pages of the SCS website for more information on our progress.

Additionally, I'd like to note the difference between the need to make SCS more equitable, which we are at work doing at all levels, but also to make SCS a welcoming community for all. We can easily fall into the trap of looking to our associates and colleagues being from around the world and feel as if things are fine within SCS. I encourage the SCS community to look not just to those within our circles of connection, but to seek out those in our community who might feel disconnected, not included or isolated. The change we seek lies within each of us and requires each to do our part to open lines of communication, welcome the ideas and contributions of all members of our community, and to create within our school an open and inclusive culture that welcomes everyone, as well as offering equal access to opportunities.

Martial Hebert
Dean, School of Computer Science



THE SCIENCE OF POLITICAL POLARIZATION

CHRIS QUIRK

Political polarization in the United States so noticeably on the rise in recent years has, according to the recent findings of a team of Carnegie Mellon researchers, reached the point where the same words can mean different things to those on the left and right sides of the political spectrum. We may now be, to paraphrase George Bernard Shaw, one nation, separated by a common language.

Ashiqur KhudaBukhsh, a project scientist in the School of Computer Science's Language Technologies Institute, along with **Mark S. Kamlet**, University Professor of Economics and Public Policy, Founders University Professor **Tom Mitchell**, and research engineer **Rupak Sarkar** studied the vocabularies of commenters on network news videos on YouTube, and found that the meanings of particular terms used by political opponents were near precise opposites. "We presume we are speaking in English," said KhudaBukhsh, "but our political discussions are happening in two different languages." KhudaBukhsh presented the team's paper, "We Don't Speak the Same Language: Interpreting Polarization Through Machine Translation," at the 35th AAAI Conference on Artificial Intelligence in February 2021.

"WHEN WE TRANSLATE FROM ONE NEWS SOURCE LANGUAGE TO ANOTHER, IN AN IDEAL WORLD NOT FRAUGHT WITH POLARIZATION, OF COURSE ALL THE WORDS SHOULD TRANSLATE TO THEMSELVES FROM LANGUAGE TO LANGUAGE."

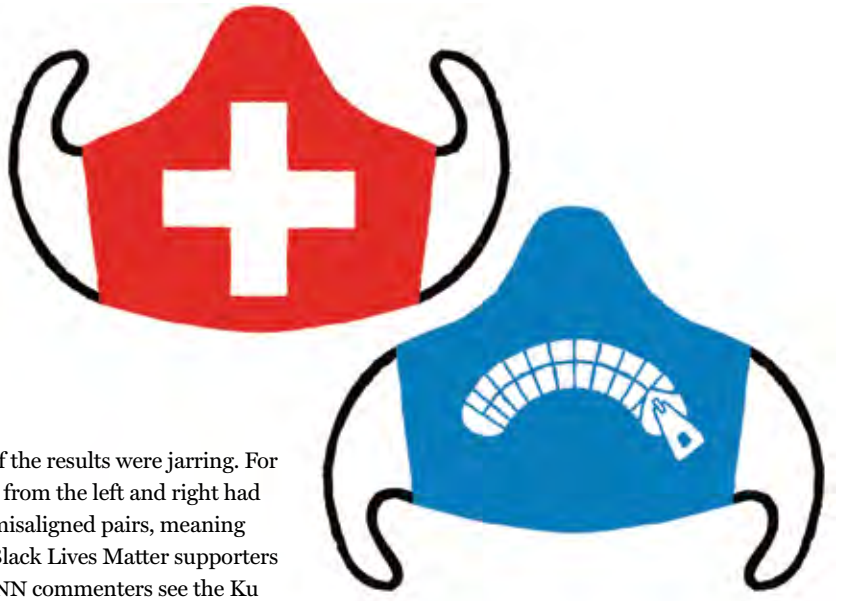
— ASHIQUR KHUDABUKHSH

The algorithms primarily used to perform language translation, like Google's word2vec, take as their source a 1957 insight by linguist John Wirth, "You shall know a word by the company it keeps." The algorithms work spatially, setting words in relation to others as they appear in the data set. Given the word "hat," nearby might be the word "head" or "straw," and a bit further away you might find "fedora" or "winter." To translate "hat" into Italian, an algorithm could essentially work backwards from the locations of "testa" (head) or "paglia" (straw) and the other words nearby on the Italian graph to infer that "cappello" equaled "hat."

The insight the research hit on was to separate online speech of left-leaning and right-leaning commenters into separate "languages" and translate terms from one language into the other to find similarities and differences. "I believe it is a novel approach," said Mitchell. "I don't think anybody's thought about machine translation to go from Democrats to Republicans."

To run their experiment, the team captured and processed more than 86 million comments from videos on YouTube produced by media sources like CNN, MSNBC, Fox News and One America News Network (OAN), an outlet founded by pro-Trump businessman Robert Herring. Then they created a language for each news source. Finally, they compared terms across the languages, effectively translating words from one news source language to another. "When we translate from one news source language to another, in an ideal world not fraught with polarization, of course all the words should translate to themselves from language to language," said KhudaBukhsh.

But that isn't what happened. When the team looked at the location of the word "mask" in MSNBC language, and interpolated backward from related terms in OAN language, in the exact same position they found instead the word "muzzle." Where the CNN language map showed "socialist," Fox language had "capitalist." Where Fox language had "radical," CNN language yielded "supremacist." The team called these misaligned pairs, and in example after example, they found opposing terms The polarity and implications of these misaligned pairs present a stark divergence between audiences. "You immediately see in the mask-muzzle example that there is a debate surrounding how wearing a mask is interfering with freedom of speech," noted KhudaBukhsh. The divisions stretched into climate policy, where "solar" in CNN translates to "fossil" in Fox. Some of the results were jarring. For instance, commenters from the left and right had "BLM" and "KKK" as misaligned pairs, meaning Fox commenters see Black Lives Matter supporters similarly to the way CNN commenters see the Ku Klux Klan. "Those differences were disturbing," said KhudaBukhsh.



Diversity of opinion and spirited debate may be the lifeblood of a healthy political system, but Kamlet says the team's results point to divisions between political factions that aren't resolvable via the typical political protocols. "There's a common way of thinking about policy differences. One person may want nine aircraft carriers for the national defense. Eight would be a little worse, 10 better. Someone else wants six. We can disagree politically, but there's a nice, natural order." For Kamlet, the study shows evidence of a much more precipitous social fracture, citing in particular occurrences of what the team calls trigrams, three-word terms that operate as misaligned pairs in the parlance of left and right. Analyzing thousands of occurrences, the team found "black lives matter" and "all lives matter" to be misaligned pairs in the CNN and Fox languages. The trigrams are mathematically more significant than single-word pairs given the unlikelihood [that] three units being so precisely matched across languages. "It's hard to see how the polarization could be more extreme than it is," said Kamlet.

In looking to social media for the massive data set needed to produce their study, the researchers were being pragmatic, but also landed in the cauldron of one of the causes of the polarization they surveyed. Divisive speech and extreme content are not just unfortunate byproducts of online life. Social media companies frequently profit from them, as inflammatory content is catnip for users, and engagement translates into profit. Social media platforms seeking a competitive edge seem to have a hard time spurning the allure of the baser tendencies of our nature. "Sadly, I agree that controversy generates more eyeballs on your site than boring stuff, so social media might be hurting its profit if they produce a more simple discussion," Mitchell said. "The same thing can be said about news organizations like MSNBC and Fox. I think it's good for their profit to be extreme."

Evolving structural issues are also destabilizing the political status quo, said Kamlet, citing gerrymandering as a prime culprit. "Social media can be an echo chamber, but gerrymandering has the same effect of sending people toward the extremes."

"CONTROVERSY GENERATES MORE EYEBALLS ON YOUR SITE THAN BORING STUFF, SO SOCIAL MEDIA MIGHT BE HURTING ITS PROFIT IF THEY PRODUCE A MORE SIMPLE DISCUSSION."

— TOM MITCHELL

"GIVEN THE VARIED FORCES THAT HAVE CREATED THE POLITICAL FISSURES IN OUR SYSTEM, IT WILL BE NECESSARY TO WORK ACROSS THE DIVISIONS BETWEEN SILOED DISCIPLINES TO FIND SOLUTIONS."

— MARK S. KAMLET

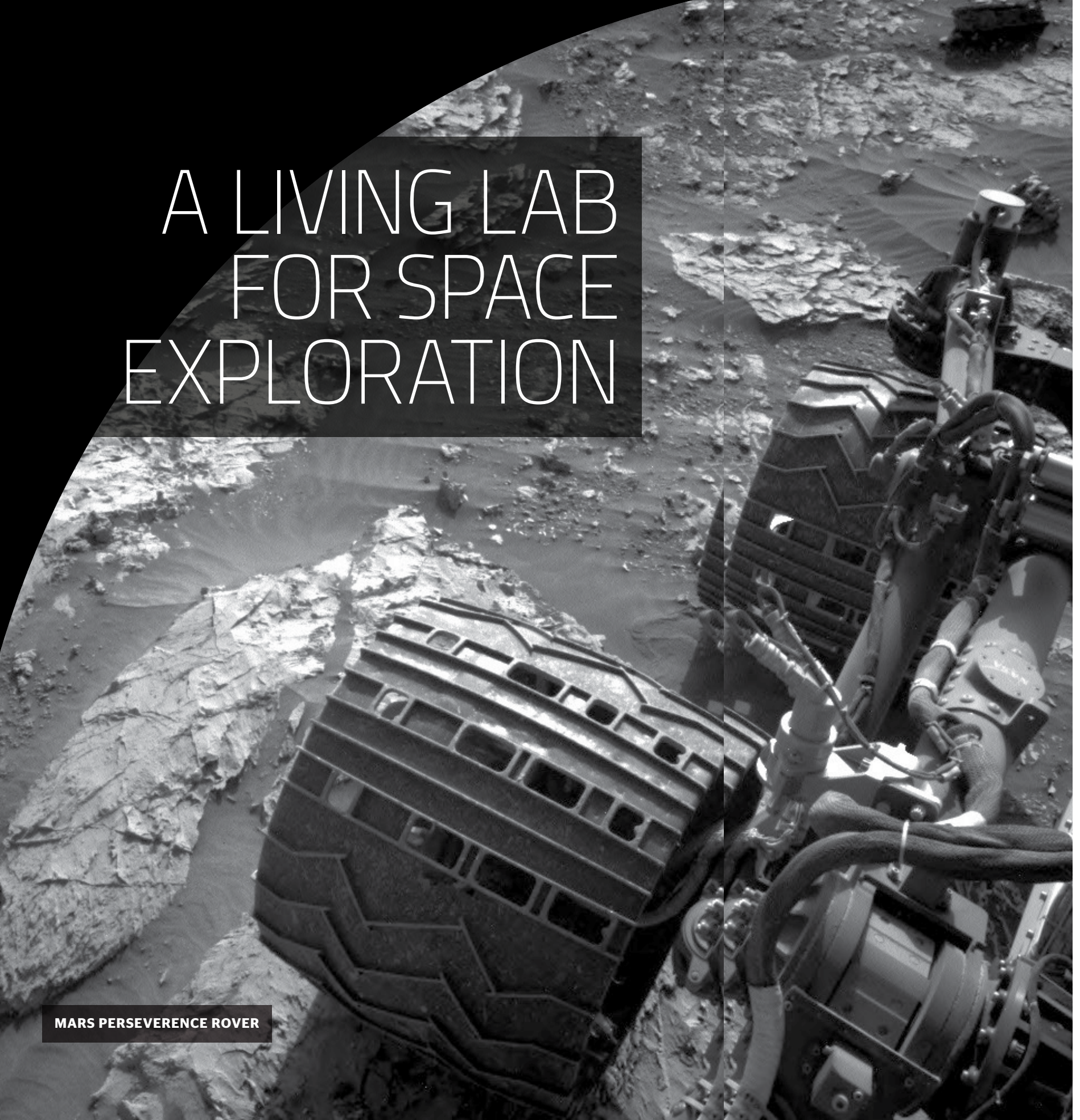
Most developed democracies have an upside-down, U-shaped statistical distribution of political opinion — a large group in the center, and long tails to the left and right. "In political science they call this the distributed voter theorem," he explained. "If the president gets way off one way or the other, there are checks and balances." Gerrymandering throws the political system out of whack by pushing elected officials farther out along the curve. "There may only be around 20 truly competitive congressional districts at this point, so if you are a Republican running in a safe district, you're not afraid of a Democrat coming out of the woodwork to beat you, but you're frightened to death of a challenge in the primary from the right."

While the team's research has shined a bright, unflattering light into the crevices riddling the country's political culture, the broader applications of their work may be just beginning. Mitchell has been ruminating on using the tool to revolutionize polling methods. "This paper is kind of an indicator of a broad movement toward detailed data analysis of very large-scale social media for the purpose of understanding where their agreements and disagreements, and what their opinions are," he said. "I think it's fair to ask if, in the coming decade, political polling will be replaced by something that's more accurate and based on monitoring what tens of millions or hundreds of millions of people are saying. It could be a tool for polling predictions and even candidates in political races to understand in a more precise way what voters are thinking."

According to Kamlet, given the varied forces that have created the political fissures in our system, it will be necessary to work across the divisions between siloed disciplines to find solutions. "Disciplines can speak their own languages too, and disciplines can be hard to connect," said Kamlet. "But when you can get domain expertise and technology strengths together like we are able to do, that's a very potent thing."

As an alternative to squelching online hate speech, KhudaBukhsh, along with colleagues Shriphani Palakodety, an engineer at Onai, and Jaime Carbonell, who was the Allen Newell Professor of Computer Science until his death last year, studied the potential for boosting positive speech. "Little attention is given to the possibility that non-hate-speech in social media discussions could have a beneficial societal impact," KhudaBukhsh said. Reviewing online comments in India and Pakistan in 2019, when border skirmishes between the two nations broke out in Kashmir, the researchers found that as the two nations edged closer to war, online speech became less forceful. "Peace-seeking comments heavily outnumbered war-seeking comments, and there was an outpouring of comments and likes in a way I'd never seen before," said KhudaBukhsh. "I believe social media discussions contain a lot of positive content, and if they don't get drowned by hate, this world could be a much better place." ■

A LIVING LAB FOR SPACE EXPLORATION



MARS PERSEVERENCE ROVER

MARK ROTH

As the Mars Perseverance rover made its descent to the red planet on Feb. 18, 2021, **Andrew Johnson (CS 1997)** sat nervously in the control room, waiting to see if the Lander Visual System (LVS) he helped design would work properly. Adding to the tension was the fact that every signal he received was old news — messages from the past — because it took just seven minutes for the craft to descend to Mars, but 11 minutes for its signals to reach Earth.

Watching his instruments intently, Johnson received notification and shouted "LVS System valid" — a huge relief, since in the flight's final moments he was convinced "that our system had not turned on." A few seconds later, Perseverance touched down safely on Mars and the Jet Propulsion Laboratory (JPL) Control Room staff at the California Institute of Technology erupted in cheers.

Beginning at a remarkable 2.6 miles above Mars, the LVS took photos of the surface during descent, comparing them to images previously captured by the Mars Reconnaissance Orbiter circling high above, and automatically rotated each image to match those taken by the orbiter. "The challenge is to get it to work perfectly the first time you ever use it," said Johnson. "And if it doesn't work perfectly, you've cost the taxpayers a lot and wasted years of work. So yes, it's stressful all along, and it certainly builds to a peak during the actual landing moments."

Andrew Johnson (CS 1997) with the Lander Visual System for the Perseverance Mars rover

William "Red" Whittaker, Founders University Research Professor in The Robotics Institute

Robotics students testing the Iris rover

Johnson stands alongside several notable CMU graduates working on Mars and Moon missions at JPL, and he is part of the long list of space exploration experts who received their basic training at CMU's Robotics Institute and School of Computer Science.

Widely considered the world's premier training and testing site for advanced field robots, CMU assumed a natural leadership position in supplying scientists for America's space missions. Over the past 40 years, its robots have probed damaged nuclear reactors, trekked across Antarctica and are now about to head to the Moon.

From the beginning, the Robotics Institute, under the leadership of **William "Red" Whittaker**, Founders University Research Professor, operated on the principle that the best way to advance the science of robots is to put them to work in real-world situations.

"The notion of field robotics was really created at the Robotics Institute," said **David Wettergreen**, Research Professor at the institute and a longtime colleague of Whittaker. "Applying these systems in the world is an important part of their technological development, and provides insight into what's necessary to be successful. From the early days of The Robotics Institute, in putting robots in the real world — nuclear reactors, mines, farms or just Schenley Park — we learned there is important scientific knowledge in integration and testing outside the laboratory."

The next big test of the field robotics approach will be rovers that have undergone tests in a variety of situations on Earth in preparation to land on the Moon.

SCS GOES TO THE MOON

If everything goes according to plan, the shoebox-sized rover Iris will arrive on the surface of the Moon next year, courtesy of a lander developed by Astrobotic Technology, a spinoff company from CMU located on Pittsburgh's North Side.

The Astrobotic Peregrine lander will deliver several payloads to the surface of the Moon at Lacus Mortis, touching down in a pit roughly the size of Heinz Field. On board the lander will be the compact Iris rover, developed by a team of students at CMU under the mentorship of Whittaker. Also on board will be MoonArk, a highly collaborative digital art project developed by hundreds of people and spearheaded by Carnegie Mellon's School of Design.

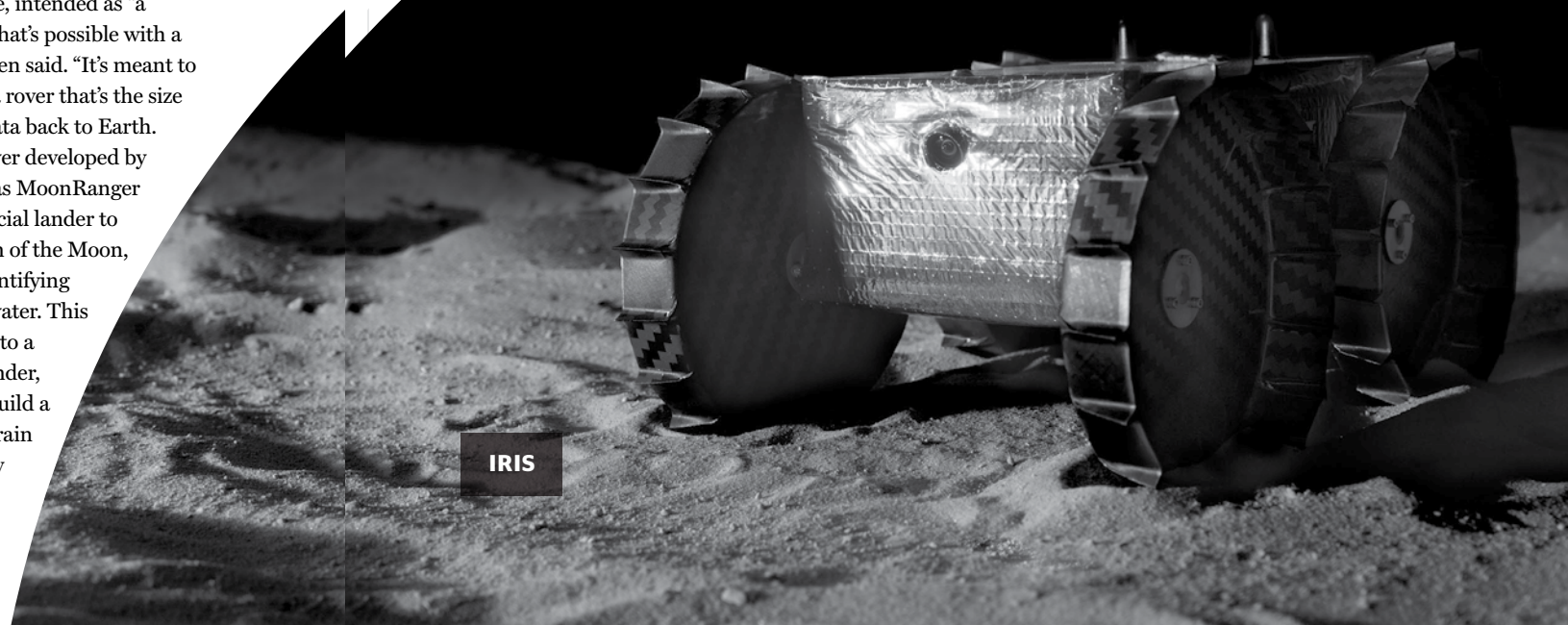
Iris, weighing in at just 4.4 pounds, contains a camera and has the ability to move to locations at the direction of controllers on Earth. It operates on a battery with a limited life, intended as "a technical demonstration of what's possible with a very limited mass," Wettergreen said. "It's meant to show you don't have to send a rover that's the size of a small car" to get useful data back to Earth.

Following Iris, a larger rover developed by Astrobotic and CMU known as MoonRanger will launch aboard a commercial lander to explore the south polar region of the Moon, with a particular focus on identifying areas with an abundance of water. This rover will be able to range up to a quarter mile away from its lander, using cameras and lasers to build a model of the surrounding terrain and chart a path toward likely

David Wettergreen, Research Professor at the Robotics Institute

"You don't have to send a rover that's the size of a small car to get useful data back to Earth."

—DAVID WETTERGREEN



IRIS

TO EXPLORE IS HUMAN...

Edgar Mitchell

Not only does Edgar D. Mitchell (E 1952) hold the distinction of being one of only 12 humans to set foot on the Moon, but he also entered in one of the greatest computer hacks in space exploration history. Just over 50 years ago, on Feb. 5, 1971, Edgar Mitchell and Alan Shepard orbited the Moon inside their lunar excursion module Antares. While preparing to land on the moon's surface, the two men ran through the checklist and discovered an abort signal lighting up incorrectly. A soldering short was later found to be the cause, but they found that tapping the abort signal panel made the signal go away, though it intermittently returned. Four times. If the signal triggered on during Antares' descent, even erroneously, it would activate the abort sequence, cancel the landing and automatically return Antares to a safe orbit.

NASA was coming off the tragic Apollo 13 mission and desperately needed a landing to show the American public that they were back on track in lunar exploration.

The challenge became how to reprogram the Apollo guidance computer so the erroneous abort code would not fire. However, the hardwired system had read-only memory. There would be no software solution.

Here's the hack they came up with: Computer programmer Don Eyles figured out that the abort signal could be overridden if the guidance system already thought an abort was in progress. So, he wrote a few lines of code and instructed Mitchell to key them into the system:

You can listen to the audio of Mitchell keying in the hack here: https://www.youtube.com/watch?v=oZZe-xXx9_o&t=192s

While they still had to make a few adjustments with the thrusters for landing, the hack saved the Apollo 14 mission and allowed Edgar Mitchell to be the sixth person to set foot on the Moon.

Mitchell, who was also the backup lunar module pilot for the Apollo 10 and Apollo 16 missions, died on Feb. 4, 2016, at his home in West Palm Beach, Florida.

ASTROBOTIC PEREGRINE LANDER

locations for ice. On board MoonRanger, a Neutron Spectrometer System developed by NASA will find water by detecting how neutrons emitted by the Sun are modulated by hydrogen bound up in ice in the soil.

The purpose of searching for water on the Moon is not to find ancient signs of life. Rather, any ice found on the Moon could be invaluable for future space missions. Moon ice could not only provide water for astronauts to drink, but they could also split the water into hydrogen and oxygen to provide breathable air and rocket fuel for missions to such places as Mars, Pluto or the moons of Jupiter.

"One of the challenges to space exploration," Wettergreen said, "is getting enough fuel off the surface of the Earth to get to Mars or Europa or Pluto. If water on the Moon can be extracted, it's actually more efficient to get fuel from the Moon than to launch it into orbit from the Earth."

Finally, Astrobotic and NASA plan to launch a much larger lander known as Griffin in 2023. This lander, weighing more than 1,000 pounds, will have seven rocket engines, as well as dedicated power and communication capabilities. NASA expects the mission to carry the VIPER — Volatiles Investigating Polar Exploration Rover — that will include instruments and a drill designed to extract water on the Moon.

DRIVING ROBOTS ON MARS

Vandi Verma (CS 2005), chief engineer for robotic operations for the Mars Perseverance rover, plays a key role in the exploration of the red planet. Working with JPL, Verma's Robotics Operation mission encompasses how Perseverance moves, collects samples for later analysis and interacts with the first mini-helicopter on Mars.

One of the innovations that Verma worked on for the Perseverance rover is its robotic arm, used to collect samples from the planet. In the past, scientists on Earth have resorted to using a terrain model to guide robotic arms. But Perseverance has software that allows it to autonomously build a terrain model in order to detect the movement of its arm and to prevent it from hitting the rover's body or hazards on the ground.

"This is my fourth Mars rover," Verma said. "I've been driving almost 13 years now, and you bring the experience from one rover to the next. You get very familiar with only seeing what the rovers' sensors can see."

And while she loves the overall engineering challenge of planning the rovers, Verma still gets a thrill out of remotely driving them around Mars. Because the planetary explorers' computers have to be hardened against radiation damage, they are not very powerful. This means it remains more effective for people on Earth to plan routes for the rovers and steer them to sites of interest, deciding when it is safe to allow the rovers to engage in autonomous driving — all using algorithms first developed at CMU.

"I've been driving almost 13 years now, and you bring the experience from one rover to the next. You get very familiar with only seeing what the rovers' sensors can see."

—VANDI VERMA (CS 2005)

"If water on the Moon can be extracted, it's actually more efficient to get fuel from the Moon than to launch it into orbit from the Earth."

—DAVID WETTERGREEN

DANTE

While at CMU, Verma worked with robots in Chile's Atacama Desert, which the university uses as a stand-in for Mars because of its austere, bone-dry landscape.

Looking back on her experience at Carnegie Mellon, Verma said she "learned as much from my classmates and peers as from the faculty because we were all doing cutting-edge research in the field. You're out there in the student lounge while you're playing foosball and discussing your algorithms with each other."

The no-second-chances nature of her current work excites Verma. "There's a difference when you're designing a robot that is doing something humans can't," she said. "You want to push the envelope, but there is no replacing a part."

THE KEY PROTOTYPES

Over the past four decades, Carnegie Mellon developed a long line of robots that roll, walk, slither and hop, all with a variety of purposes and each an important step in its own right. But in the ramp up to robots exploring space, two stand above the rest: Dante and Zoë.

Dante, a walking robot developed in the 1990s by Whittaker and Wettergreen, rappelled down the sides of active volcanoes. The prototype, tested at Mt. Erebus in Antarctica in 1992, held hope of sampling magma inside the volcano crater. However, technical problems, including a severed fiber optic cable, ended the field test early.

A second Dante robot fared better, exploring the Mt. Spurr volcano in Alaska for more than five days in 1994, sometimes operating autonomously and at other times under direction of human controllers stationed miles away.

The Dante robots demonstrated that a field robot could operate at least partly on its own in environments that were too harsh or dangerous for humans — a simulacrum for what many space missions require.

Today, CMU roboticists continue development on a robot named Zoë, an autonomous scientific exploration device deployed primarily in the harsh Atacama Desert. Verma worked on earlier iterations of Zoë, which has been operational for the past decade.

Wettergreen is careful to note Zoë's shortcomings as well as its strengths. On the plus side, "it doesn't get tired. It's precise and repeatable, and it knows

REACHING FOR THE STARS:

Judith Resnik Astronaut and Engineer

Entering CMU with a perfect SAT score of 1600, **Judith Resnik (E 1970)** let her adventurous and brilliant mind shine early in life. After earning her bachelor's degree in electrical engineering, Resnik went on to get her Ph.D. from the University of Maryland.

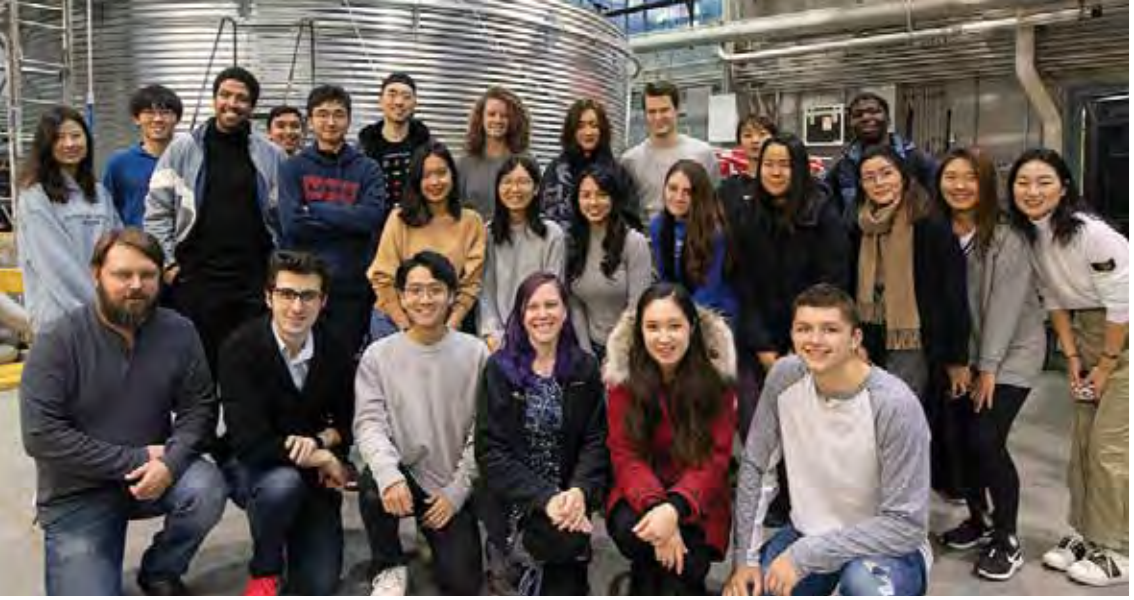
When the NASA Astronaut Corps opened its applicant pool to women, Resnik was one of six chosen from more than 8,000 applicants. Resnik wanted to be the first American woman in space, but was the second. She was the first Jewish American in space.

Resnik put her engineering talents to work as a mission specialist aboard the space shuttle Discovery on its initial mission in 1984. She helped create the shuttle's robotic arm and was in charge of its operation while onboard.

Judith Resnik died aboard the space shuttle Challenger, when it exploded over the Atlantic Ocean, 73 seconds into its flight on Jan. 28, 1986. Much of the country watched the explosion live or on replay, as all seven crew members onboard perished. It was a moment that all Americans alive at the time remember where they were when they heard the news.

Resnik received many honors during her life and in the years following. Many schools have been named after her and, of course, CMU dedicated the Resnik House dormitory on campus. The Resnik Challenger Medal is awarded each year by the Society of Women Engineers to the woman who contributes innovative technology to the exploration of space.

Members of Tau Beta Pi, the National Engineering Honor Society, help maintain a memorial to Resnik, located at the base of Hamerschlag Hall.



Just some of the many students on the teams that put CMU robots like Zoë into space

exactly where it is," he said. On the minus side, it knows what to do and how to do it, but not why. People have the advantage of a larger perspective and intuition, and can draw on their experience," said Wettergreen. "Robots haven't yet come up with a hypothesis that they can test as they explore."

The ability of robots to act on their own will be increasingly vital the further away space missions get from Earth, Wettergreen noted.

While radio communication with Mars takes nine to 20 minutes, radio communication with Europa, a watery moon of Jupiter, would take 10 1/2 hours. One goal of a Europa mission might be to tunnel through the moon's icy oceans and explore the liquid water beneath.

"The communication back to Earth will take days," said Wettergreen. "You're not going to hear from that robot until it gets back to the surface. We've told it to look for life, but what does life look like? It's hard to imagine doing that by remote control. It's got to be able to make those decisions, interpret the data, explore on its own and then come back and communicate results."

From Dante testing volcanic gases in the 90s to Zoë seeking out microorganisms in the deserts of Chile today, Carnegie Mellon experts have continually added power, flexibility and autonomy to their field robots, in the hopes that one day, a truly independent robot may become our first pioneer in the vast reaches of space.

THE NEXT BIG STEP

Simple as it is, CMU's Iris rover will be the first unmanned American rover to land on the Moon.

Scheduled to leave Earth as part of the Peregrine payload sometime in 2022, Iris represents the work of nearly 70 CMU students over many years.

"The vision, design and implementation for this robot are driven by amazing student power — unprecedented for a space venture of this ambition and technical challenge," said Whittaker. "It requires the highest standards of commitment, collaboration and cross-disciplinary skill, as well as incredible resourcefulness."

Once there, Iris will not be the swiftest or most technologically advanced rover ever put on a space mission. But it marks an early entry of what will be known as CubeRovers — lightweight planetary travelers that can be used by all sorts of companies and organizations that want to engage in space exploration but don't have enormous resources.

And it's yet another example of the reality-based training that CMU robotics students get week in and week out, making them prized job candidates around the world.

"Our graduates are all over the place," said Wettergreen, "and in many cases are involved in the cutting-edge research that is creating new technologies or moving things from the lab into the real world." ■

"The vision, design and implementation for this robot are driven by amazing student power — unprecedented for a space venture of this ambition and technical challenge."

— WILLIAM "RED" WHITTAKER

ZOË

Amplifying Emergency Medicine Capabilities Using AI, Big Data

Staff Sgt. Luke Sciulli

NIKI KAPSAMBELIS

In the early morning darkness of Jan. 18, 2018, **Staff Sgt. Luke Sciulli** and a fellow Green Beret entered a building in southern Afghanistan, planning an attack with a small group of commandos.

In the next moment, the building collapsed around them, changing Sciulli's life forever. Unbeknownst to the soldiers, the building had been booby trapped with explosives, which detonated when they entered.

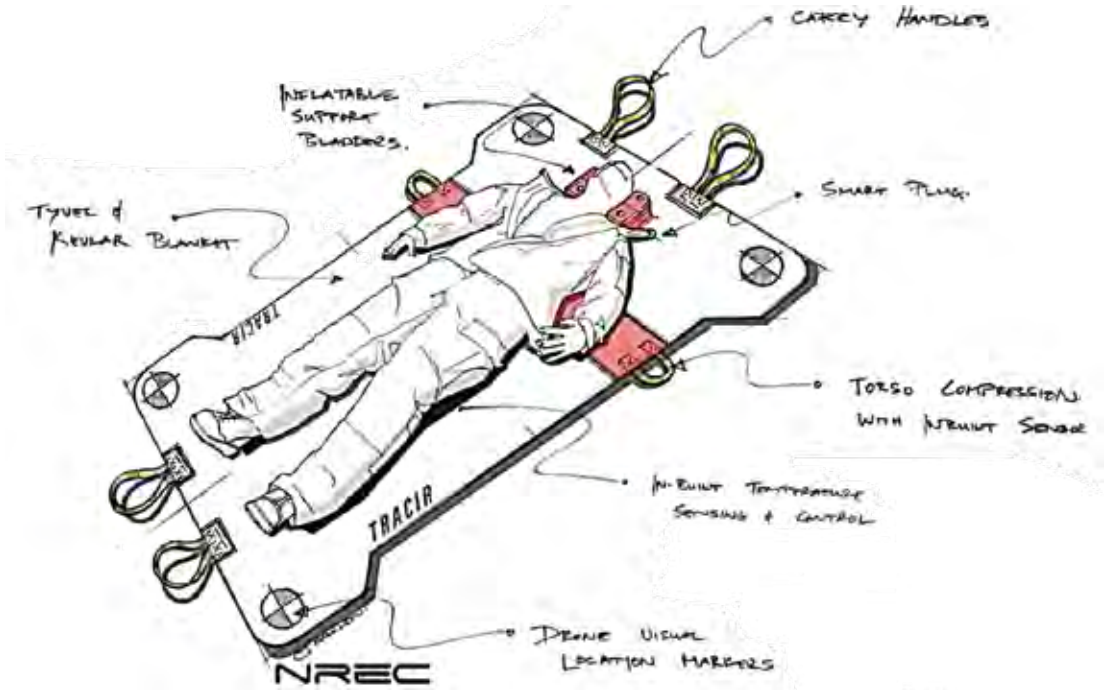
"I just remember a really loud explosion going off, seeing some rubble and debris," said Sciulli, who served as the unit's assault team leader and senior medical sergeant. Briefly losing consciousness, he woke a few second later to a pitch-black world; his night vision goggles had been knocked off by the explosion.

He also couldn't move. At first he thought he'd been pinned under rubble; in reality, he had suffered a severe spinal injury.

The explosion represented the first domino to fall in a chain of events that brought Sciulli back to his hometown of Pittsburgh and more specifically to Carnegie Mellon's School of Computer Science. He is now a senior research analyst for a team working to build robots driven by artificial intelligence that can amplify what Sciulli did as a medic in order to save more people like Sciulli the casualty.

"One of the biggest things [the explosion] opens up is: I'm obviously a certified and qualified medic for my team, but that doesn't mean the medic doesn't get hurt," explained Sciulli. "Somebody has to step up and take care of me."

And that somebody just may be a robot in a backpack, thanks to a project led by Artur Dubrawski, a research professor at the Robotics Institute.



"The amount and complexity of this data are beyond human capabilities to comprehend and internalize in real time, so it's an excellent target for AI."

— Artur Dubrawski
Alumni Research Professor
of Computer Science
in the Robotics Institute

FROM BATTLEFIELD TO HOMELAND

Dubrawski serves as the principal investigator of RoboTrac (Robotic Trauma Care in the Field), a project that also involves Robotics Institute faculty Howie Choset, Chris Atkeson and John Galeotti. This Department of Defense-funded endeavor seeks to develop robotic and AI solutions for the field by multiplying the capabilities of medics. It requires pushing boundaries of what can be accomplished in practice by using advanced ultrasound imaging, precise robotic manipulation, soft and compliant actuation, and artificial intelligence to automate complex tasks in austere settings that are currently performed by highly-trained medical personnel. Ultimately, the technology could help those who are injured in remote areas, far from any hospital or other emergency medical care, or in traffic accident or natural disaster scenarios where immediate access to advanced intensive care may not be readily available.

"It looked pretty obvious that many young men and women died after being wounded in combat situations, but they could be saved if sufficient support had been provided to them," Dubrawski said.

He works on the project in partnership with his close friend, Dr. Ronald Poropatich, a professor of medicine at the University of Pittsburgh and director of Pitt's Center for Military Medicine Research, Health Sciences. Dubrawski also has worked with critical care physicians and nurses at Pitt's medical school for more than a decade.

Poropatich, deployed several times while serving as a pulmonary critical medicine physician in the U.S. Army, leads a sister project called TRAuma Care In a Rucksack (TRACIR), which Dubrawski also supports. Both projects include Pitt critical care medicine faculty Dr. Michael Pinsky and emergency medicine Drs. Frank Guyette, Lenny Weiss and David Salcido, reflecting a true team science approach. Both TRACIR and RoboTrac, which were funded by the U.S. Department of Defense in 2019, focus on military and civilian applications. The projects draw on large hospital data sets provided by medical helicopters flying around four states as part of the UPMC network, as well as data from all stages of intensive care from surgeries to step-down and intensive care units.

"The amount and complexity of this data are beyond human capabilities to comprehend and internalize in real time, so it's an excellent target for AI," explained Dubrawski. The tools currently in development quickly prioritize information for health care professionals, improving the speed and accuracy of the decisions to create better outcomes at a lower cost.

According to Poropatich, interest in the concept of AI medical support in the battlefield picked up after an October 2017 ambush of the Army's 3rd Special Forces Group in Niger, killing four Green Berets. A drone flying overhead provided reconnaissance, but had no medical capability.

"That was a wakeup call to the Army," said Poropatich.

The project develops robotics that must be small enough to fit into a backpack that a drone could drop near the wounded or injured person. The backpack would then open on its own, and a vest would inflate and crawl to the patient and mechanically stabilize them. The vest would be embedded with ultrasound and vital sign sensing capabilities that diagnose what's wrong and inform necessary treatment.

In hospitals, equipment in the intensive care unit collects much needed diagnostic information. But according to Dubrawski, these bedside monitors often raise false alarms, saturating the attention of clinical personnel. His group has been working with clinicians at Pitt to develop a highly precise algorithm that fishes out the real alerts. The team is testing the tool in a pilot study.

Poropatich said the team used data from approximately 60,000 trauma patients ranging in age from 18 to 55 and mapped the data to their medical records, with identities removed, to determine what treatments led to better outcomes. The information allows the team to tell its robots what to do to optimize emergency care in the field.

Using the same technology, the sensors in the robotic backpack would accurately measure what the wounded soldier needs, then direct the robots to perform life-saving functions, such as injecting fluid into the veins or inserting a tiny balloon via a catheter into an artery to stem the rapid loss of blood. Work also includes robots that can treat a collapsed lung or a blocked airway. And then ideally, according to Poropatich, the drone could take the wounded person off the battlefield.

To date, the team has created the early stages of some individual components and is testing the capability of robotic needle insertion as well as ultrasound-guided visualizations into models of human tissue built to resemble a body, known as human phantoms.

But to truly recreate what a medic does, they needed somebody to mimic. And that somebody, as it turns out, is Luke Scuilli.

THE LONG ROAD HOME

After the explosion in Afghanistan, Scuilli was first taken to Germany for spinal decompression surgery before undergoing reconstructive pelvic surgery at Walter Reed National Military Medical Center in Bethesda, Maryland. He also underwent spinal surgery and spent five months using a wheelchair while completing extensive physical and occupational therapy.

Among his many visitors was former Pittsburgh Steelers offensive tackle Alejandro Villanueva (TPR 2009), who won a Bronze Star as an Army ranger. When Villanueva visited, he brought Ron Poropatich with him. And Poropatich told Scuilli about the project.

At the time, Scuilli needed to concentrate on his recovery, which included learning how to walk again. But a year later, after his discharge, he moved back home to the Pittsburgh area, reached out to Poropatich and asked to hear more.

"I was trying to think of ways that I could do something fulfilling and something that would utilize my expertise without moving to the D.C. area," explained Scuilli, who had been a firefighter for the city of Beaver Falls, Pennsylvania before joining the Army. So Poropatich put him in touch with Dubrawski.

"CMU has the greatest robotics team in the world, and the University of Pittsburgh has some of the greatest physicians in the world," said Scuilli. "What they didn't have was somebody to consult with on battlefield medicine."

"CMU has the greatest robotics team in the world, and the University of Pittsburgh has some of the greatest physicians in the world. What they didn't have was somebody to consult with on battlefield medicine."

— Staff Sgt. Luke Scuilli

Scuilli sees his role as advising the team on what protocols most closely resemble a medic's work in a combat setting. For example, the anesthesia a physician uses in an operating room differs from what a medic would carry into the field.

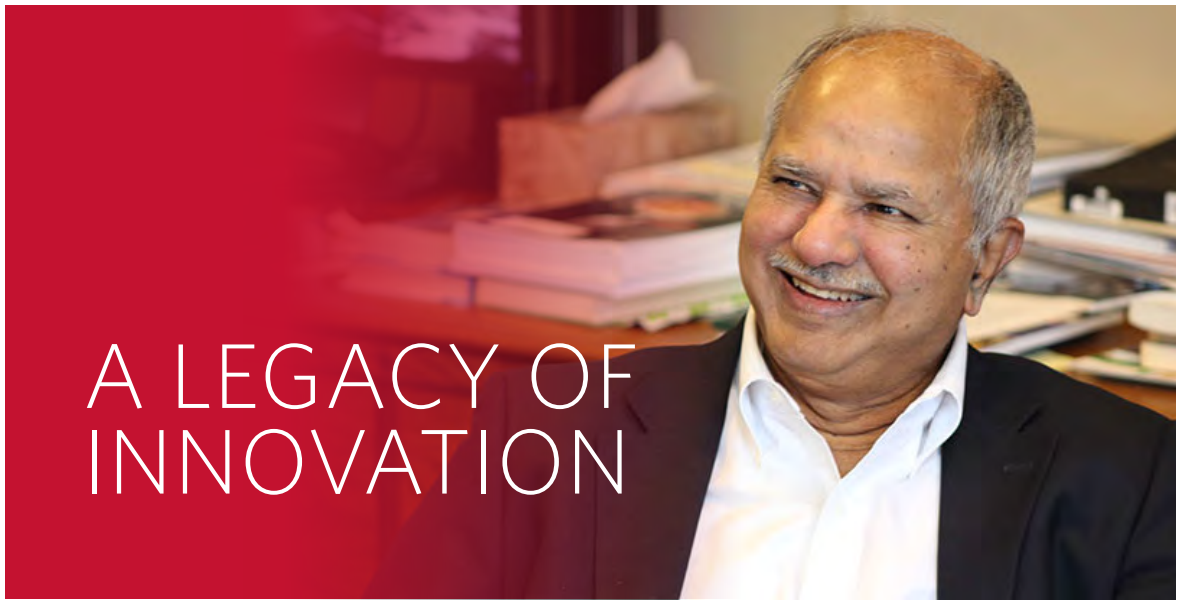
Ultimately, the project — which the Army would like to see completed by 2028 — could prove to be a game changer for civilian patients, say Dubrawski and Poropatich, particularly in rural parts of the country where trauma care is scant or nonexistent, and where hospitals are rapidly disappearing.

"The concept [focuses on] how we augment care with technology, with clinical care support tools, with algorithms that are driven either autonomously or semi-autonomously," Poropatich said.

For Scuilli, working on the project has been both personally and professionally rewarding.

"It wasn't until I got involved in this project that it showed me there as more to life than being a Green Beret. At first, I didn't see it. It wasn't until I found something to dedicate my focus and attention to that it really started turning things around for me," Scuilli said. ■

EDITORS' NOTE: While fulfilling his senior researcher duties at CMU, Luke Sciulli volunteered his hands-on medic expertise in a COVID-19 intensive care hospital in New York City, set up by his fellow former and current special operations soldiers. He attended to critically ill patients and served as a hospital supervisor.



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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.

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CONTACT Jenny Belardi, *Chief Advancement Officer, School of Computer Science*
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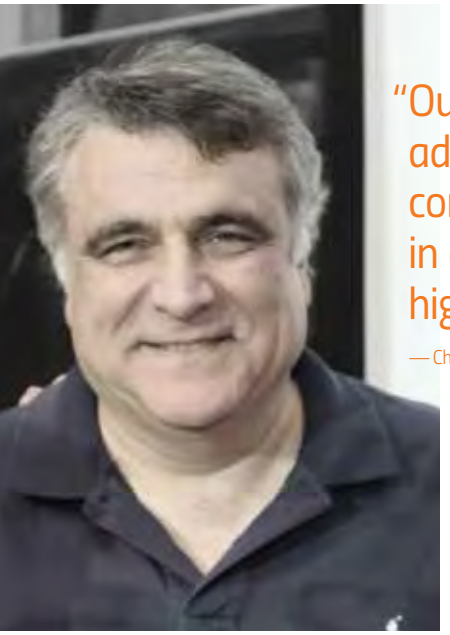
Using Online Ads to Identify Human Traffickers

AARON AUPPERLEE

Ads peddling the victims of human trafficking hide among millions of escort listings online. While identifying similar ads could be the key to taking down a human trafficking organization, the sheer volume of listings — with new ones added each day — makes the task a daunting one for law enforcement.

Christos Faloutsos, the Fredkin Professor in Artificial Intelligence, leads the SCS team working to simplify that task. By adapting an algorithm first used to spot anomalies in data, like typos in patient information at hospitals or errant figures in accounting, to identify similarities across escort ads, the algorithm scans and clusters similarities in text and could help law enforcement direct their investigations and better identify human traffickers and their victims, said Faloutsos.

"Our algorithm can put the millions of advertisements together and highlight the common parts," Faloutsos said. "If they have a lot of things in common, it's not guaranteed, but it's highly likely that it is something suspicious."



"Our algorithm can put the millions of advertisements together and highlight the common parts. If they have a lot of things in common, it's not guaranteed, but it's highly likely that it is something suspicious."

— Christos Faloutsos, Fredkin Professor of Computer Science and InfoShield team lead for SCS

Working with researchers from McGill University, the team calls the algorithm InfoShield, and presented a paper on their findings at the IEEE International Conference on Data Engineering (ICDE).

According to the International Labor Organization, an estimated 24.9 million people are trapped in forced labor. Of those, 55% are women and girls trafficked in the commercial sex industry, where most ads are posted online. The same person may write ads for four to six victims, leading to similar phrasing and duplication among listings.

"Human trafficking is a dangerous societal problem which is difficult to tackle," lead authors Catalina Vajiac and Meng-Chieh (Jeremy) Lee wrote. "By looking for small clusters of ads that contain similar phrasing rather than analyzing standalone ads, we're finding the groups of ads that are most likely to be organized activity, which is a strong signal of (human trafficking)."

Vajiac is a Ph.D. student in the Computer Science Department. Lee worked on InfoShield while a visiting student at CMU and will continue to do so when he returns to pursue his Ph.D. Other authors included fellow Tartans Faloutsos and Namyong Park, a Ph.D. student in CSD. Reihaneh Rabbany, a former post-doctoral researcher at CMU who is now an assistant professor in the School of Computer Science at McGill, and her students Aayushi Kulshrestha and Sacha Levy collaborated on the research. The team was assisted by experts from Marinus Analytics, a spinoff of CMU's Robotics Institute that uses artificial intelligence, machine learning, predictive modeling and geospatial analysis to combat sex trafficking.

To test InfoShield, the team ran it on a set of escort listings in which experts had already identified trafficking ads. The team found that InfoShield outperformed other algorithms at identifying the trafficking ads, flagging them with 85% precision. Perhaps more importantly, it did not incorrectly flag any escort listings as human trafficking ads when they were not. False positives can quickly erode trust in an algorithm, Faloutsos said.

Proving their success was tricky. The test data set contained actual ads placed by human traffickers. The information in these ads is sensitive and kept private to protect the victims of human trafficking, so the team could not publish examples of the similarities identified or the data set itself. This meant that other researchers could not verify their work.

"We were basically saying, 'Trust us, our algorithm works,'" Vajiac said.

To remedy this, the team looked for public data sets they could use to test InfoShield that mimicked what the algorithm looked for in human trafficking data: text and the similarities in it. They turned to Twitter, where they found a trove of text and similarities in that text created by bots.

Bots will often tweet the same information in similar ways. Like a human trafficking ad, the format of a bot tweet might be the same with some pieces of information changed. Rabbany said that in both cases — Twitter bots and human trafficking ads — the goal is to find organized activity.

Among tweets, InfoShield outperformed other state-of-the-art algorithms at detecting bots. Vajiac said this finding was a surprise, given that other algorithms take into account Twitter-specific metrics such as the number of followers, retweets and likes, and InfoShield did not. The algorithm instead relied solely on the text of the tweets to determine bot or not.

"That speaks a lot to how important text is in finding these types of organizations," Vajiac said.

Despite working on algorithms for forecasting and anomaly detection for 30 years, this was the first time Faloutsos applied one to stopping human trafficking. He and the team hope their work plays a role in helping law enforcement rescue victims and in reducing human suffering.

The team talks to experts weekly to learn more about human trafficking and efforts to end it. The more they learn, the more passion they put toward stopping it.

"You see how relevant and impactful your work could be," Rabbany said. "And you see how much work there is to be done, how much room for improvement there is and how much you could bring to the table." ■

The InfoShield Team:

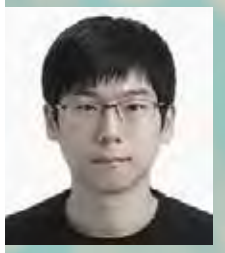
Namyong Park, Ph.D. student in SCS

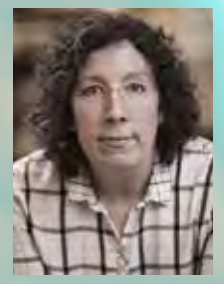
Cara Jones of Marinus Analytics

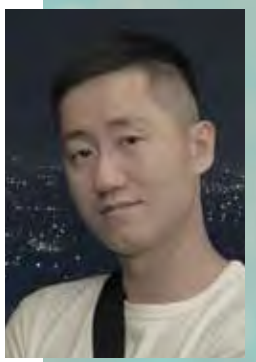
Reihaneh Rabbany, former post-doc researcher at CMU

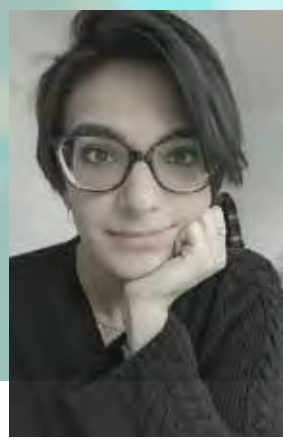
Jeremy Lee, lead author and research scholar in CSD

Catalina Vajiac, lead author and Ph.D. student in CSD









INTERNET TO SPAN

CRISTINA ROUVALIS

When the pandemic hit in March of 2020, Allen Charles Langston's two teenage children scrambled to keep up with their remote classes at Cornell High School in Coraopolis, Pennsylvania. Without home internet service, they pounded out hours of homework on tiny phone screens and traveled to public spaces to connect to free Wi-Fi.

"It was tough," Langston said. "My daughter went to the library a lot." The technical problems exacerbated the already jarring problems of his children transitioning from in-person classes — surrounded by their friends — to the isolation of remote learning.

Their virtual classroom experience improved dramatically in August when they gained access to free high-speed internet. The Langstons and other families living in the Coraopolis-Neville Island, New Kensington-Arnold, and Homewood neighborhoods have signed up for an innovative program called Every1online. "It's great," said Langston, the assistant basketball coach at Cornell High School. "It's made everything much easier."

Every1online is a joint venture between Meta Mesh Wireless Communities, a Pittsburgh-based nonprofit, the School of Computer Science's CS Pathways program, and a host of other community partners. As part of the pilot phase that began during the summer of 2020, the Langstons and other families are able to get online using the internet services of neighboring businesses and residences. Meta Mesh installs access points on the exterior of buildings, projecting unused donated bandwidth to create pockets of public Wi-Fi.

THE DIGITAL DIVIDE

Part of the Every1online team (from left): Ashley Williams Patton, founding director of CS Pathways in SCS at Carnegie Mellon with Evan McCann, project manager, and Sam Garfinkel (DC 2020) interim executive director of Meta Mesh Wireless Communities.

Sam Garfinkel (DC 2020), far right, and Meta Mesh team members installing Wi-Fi equipment at the water tower in Coraopolis.

The team intends for the pilot program to act as a stopgap measure only. "Ultimately, we don't want to depend on a neighbor's ability to donate bandwidth," said **Sam Garfinkel (DC 2020)**, interim executive director of Meta Mesh Wireless Communities and CMU master's in rhetoric recipient.

The team's work now focuses on a more permanent solution — mounting an antenna on top of the Cathedral of Learning in Oakland and directing the wireless signal to other high points throughout the community, such as the water tower in Coraopolis. These towers then direct the signal to equipment installed in nearby homes. A larger dish antenna provides extended range, allowing it to cover anyone in Coraopolis or Neville Island with line of sight to the water tower. To provide the necessary bandwidth, Meta Mesh purchases bandwidth from KINBER, a statewide nonprofit.

Of course, building a nonprofit internet network has its share of challenges. The transmission of the signal relies on achieving a clear line-of-sight between transmitter and receiver, which buildings and trees often obstruct. "It's been hard to find specialized laborers to climb radio and cell towers during the pandemic," Garfinkel said. "Because this is a novel project, timelines have been charted as we work through each aspect."

For years, educators, policymakers and others have warned the public about the inequities caused by the digital divide, the term for the gulf between people who can afford high-speed internet and those who remain priced out. COVID-19 laid bare those inequities and widened the gap as some students have fallen behind during hybrid and fully online instruction. The issue pierced the public consciousness after a photo of a child doing his homework in the parking lot of Taco Bell went viral.

Ashley Williams Patton, founding director of CS Pathways at the School of Computer Science at Carnegie Mellon, works on solutions to these inequities. "Access to computer science isn't equitable, with many students finding their journey limited by circumstances outside of their control," said Patton. "CS Pathways exists to level the playing field. We believe that all students — especially those who are traditionally underresourced and underestimated in STEM fields — deserve access to the sorts of programs that help them decide if theirs is a future in computer science."

In most years, CS Pathways offers free summer camp programs for middle school students, but in 2020, the pandemic prevented these offerings. Patton and Maggie Hannon, associate director of Carnegie Mellon's Simon Institute and a member of the project, decided to pivot and ask overworked teachers how they could help.

"Our entire point is to make computer science more accessible to all learners, regardless of their circumstances or access to resources."

— Ashley Williams Patton

Teachers pointed to the lack of access to technology as the cause for some of their students falling further behind. "How are we supposed to teach online if our students don't have access? The technology isn't there or there is only one computer at home,'" Patton recalls them saying.

Patton said students who struggle to find public internet expend too much energy doing basic assignments. "There's a huge cost to students not having safe, reliable internet."

There's also the potential for privacy issues. "If a child is going to have a private conversation with a school official in a crowded parking lot, that is going to be a problem," Garfinkel said. "It just becomes clear that students should have access to a private, password-protected connection that they can safely access from their homes."

Garfinkel said reliable home internet is not a given for many families. Most people assume reliable home internet to be prevalent, but Garfinkel holds a different view. "We realized that it is not just a few people who can't afford a $90 internet bill every month," she said. "It's middle class, working folks, people who have been negatively impacted economically by this pandemic."

Even families with existing home networks sometimes found themselves overburdened by the unusual circumstances. "What happens when you're working from home and you have three school-aged children who need the internet?" Garfinkel said.

While the technology belongs to Meta Mesh, Patton can tap Carnegie Mellon's faculty and student resources for technical advice. But she said the project is as much about community links as technological ones. "How do we work with the community? How do we make sure that the people who are most in need are being reached? How do we make sure it doesn't cost the communities anything?" As part of the SCS's goal to become a good partner and increase access to computer science skills, Patton works closely with the other community groups in the project, including the staff at the Cornell School District in Coraopolis,

Coraopolis Water Tower

“It just becomes clear that students should have access to a private, password-protected connection that they can safely access from their homes.” — Sam Garfinkel (DC 2020)

New Kensington Arnold District and Homewood Children’s Village, a nonprofit that helps children and their families.

Kristopher Hupp, director of technology & instructional innovation at Cornell School District, called the lack of technology in many homes a huge issue. “People just don’t understand that children who come from economically challenged circumstances sometimes don’t have access to books, computers, devices and the internet,” said Hupp.

Even students who have smartphones at home may not be able to connect to video calls. Some students have no access at all. To address the problem, the school district installed free Wi-Fi in green spaces in town, including a pavilion on school property. However, on cold or rainy days, it was hard for students to work outside.

Langston’s children, 15-year-old Malia and 14-year-old Allen, were able to put together a patchwork of solutions to complete their work and even remained on the honor roll despite all the roadblocks.

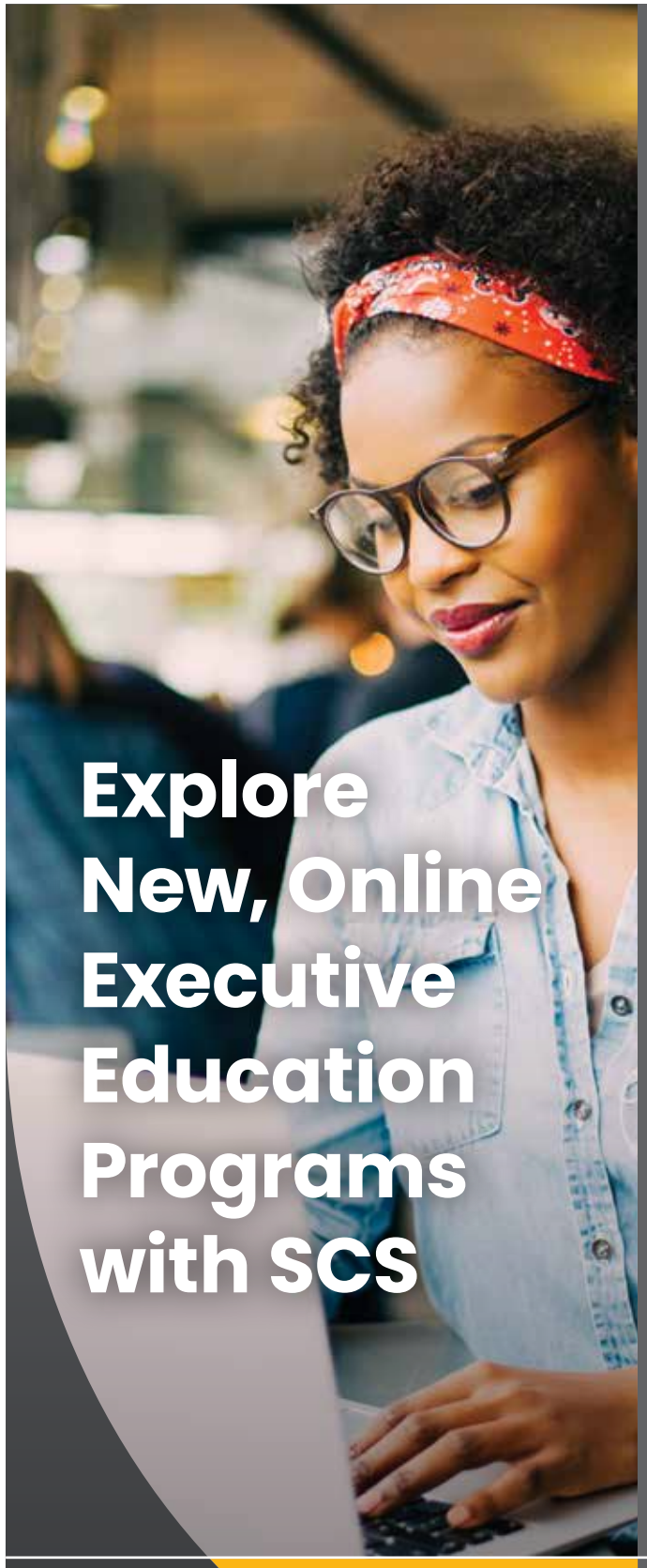
But many other students fell behind, Hupp said. One potential reason is the stigma associated with not having wireless access. “Some students do not want to explain that they were unable to complete the assignment because they do not have internet access. Students sometimes find that taking a zero is preferred to admitting that they do not have internet access. It is tough because teachers also don’t want to put students on the spot in front of other students.”To remedy this, the school district calls parents to ask if they have internet access and explain the Everyone1online options for access.

Access issues extend beyond families with school-age children. Many older people also need the internet to access basic services. The program is open to the entire community and covers the full cost of internet service for the first year. After that, the partnership is seeking sponsors from the community to pick up the ongoing costs.

The project has received additional support from foundations in Pittsburgh. Sam Reiman, director of the Richard King Mellon Foundation, said, “The Foundation was pleased to support this important effort to give more children ready internet access. And the remote learning environments necessitated by COVID made internet access not just important, but essential.

“Internet access is just as important to successful learning today as paper and pencils were for prior generations,” said Reiman.

Patton agrees. Students who can’t access the internet during the pandemic could end up losing a year or more of education. “They won’t make it up. We’re committed to making sure that community members are able to access a resource that we think should be a utility.” ■



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One Size Doesn't Fit All: The Near Future of Cancer Treatments

SHILO REA

An oncologist delivers a cancer diagnosis to her patient, who is visibly and understandably upset. As the doctor begins to outline treatment options, the concerned patient listens intently, holding on to hope that the plan that the doctor recommends will work for her. The doctor bases her recommendation on the fact that the treatment has shown success in people with similar types of cancer.

Weeks later, after several grueling rounds of treatment, the doctor informs the patient that the cancer has not responded to the drug and offers a new drug therapy to try. Precious time has been lost and the patient's fear for their survival heightens.

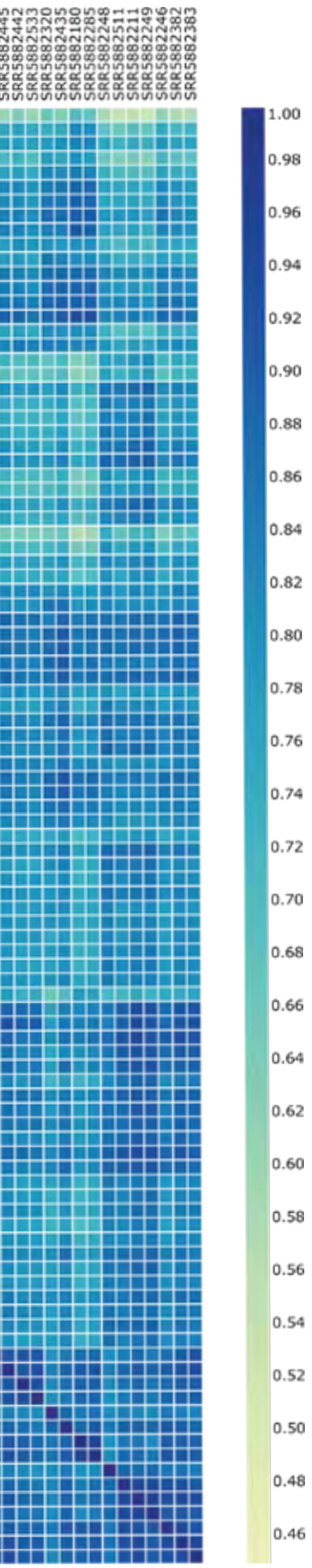
It is a story that is far too common.

School of Computer Science researchers are working to remove some of the guesswork in cancer treatment. Ocean Genomics, a Carnegie Mellon University spinout co-founded by Carl Kingsford, envisions a future for medicine where an individual's genetic makeup informs these decisions. By providing drug manufacturers and physicians with better tools, Ocean Genomics can assist them to develop and prescribe specific treatments for individual patients.

Kingsford, the Herbert A. Simon Professor of Computer Science, has spent his career creating novel computational methods that analyze genomic data. Specifically, he has focused on ways to interpret what happens when a person's DNA decodes instructions for making proteins or other molecules — a process called gene expression. Kingsford's recent work involves designing techniques to analyze the sequences of messenger RNA (mRNA) molecules, which are the products of gene expression and indications of each gene's activities.

"Drug companies and researchers have the data. We developed a number of tools to analyze gene expression data and they became popular," Kingsford said. "It's not easy to support [the tools and researchers] in an academic context, so we started Ocean Genomics to build and extend these tools to be accessible and useable in translational contexts."

Combining machine learning and artificial intelligence techniques, Ocean Genomics provides a cloud platform for users to perform gene expression analyses and access to expert support services. This allows users to compare the RNA expression levels of multiple genes in samples under various conditions and can give clues into how gene expression differs between healthy and diseased samples, and in response to therapies.



Ocean Genomics' tools offer high computational efficiency with speed and accuracy, a significant deficiency for other available programs. For example, once 50 samples are uploaded, results are typically available in a single day.

The company's early success points to it leading a transformation in the field of precision medicine. They recently partnered with researchers from Samsung Medical Center in Seoul, South Korea, to predict which gastric cancer patients will not respond well to the popular drug Pembrolizumab — all based on their gene expression features.

Pembrolizumab, an immunotherapy drug that targets and blocks PD-1 proteins in T-cells, prompts the T-cells to attack cancer cells. Some patients respond very well to the treatment while others develop resistance after the initial round.

Ocean Genomics' platform extracted features, generated classifiers, performed quality checks and delivered comprehensive analyses from 55 patient samples and related metadata within 24 hours. They provided early evidence suggesting seven genes that may be related to Pembrolizumab becoming ineffective in those patients, providing the basis for potential follow-up studies.

"This type of insight will help providers determine which treatment will help which patients based on biomarkers," said Kingsford. "And it will help treatment makers develop more targeted options."

In order to move this work further, Ocean Genomics is also involved in working with drug companies on biomarker development.

"We are translating ideas from the DNA world into RNA-based biomarkers. Immunotherapies and cancer therapies are expensive to create and to administer. Since they don't always work for all patients, we are looking at how they could be improved," Kingsford said.

In another promising discovery from a large clinical trial in Japan, Ocean Genomics identified an early signal for a gene expression pattern that may be predictive of whether a patient will respond to a particular drug.

Outside of cancer treatments, the team currently works with a pharmaceutical company on a neurodegenerative disease with their mRNA analysis tool for single cells. Dr. Stanley Marks, chairman, director of clinical services and chief medical officer of UPMC Hillman Cancer Center, who is on Ocean Genomics' scientific advisory board, said, "RNA identification can guide therapies for patients, and Ocean Genomics is actively engaged in moving the field."

"We are translating ideas from the DNA world into RNA-based biomarkers. Immunotherapies and cancer therapies are expensive to create and to administer. Since they don't always work for all patients, we are looking at how they could be improved."

Carl Kingsford, Herbert A. Simon Professor of Computer Science

In March, the company announced a strategic partnership with Geninus, a leading full-service genomics laboratory out of Seoul, South Korea, to advance research and clinical applications with hospital, academic and biotechnology clients. The companies will launch Ocean Genomics' advanced AI-based transcriptome analysis and biomarker platform (txome.ai) on the cloud and on location in Korea. Geninus will use txome.ai to expand its CancerSCAN clinical diagnostics program, and the two companies will also co-develop a series of RNA-informed predictors of drug response for research and clinical use.

"Genome analysis for precision cancer medicine is becoming an essential process in hospitals," said Woong Yang Park, Geninus CEO. "Gene expression analysis on tumor tissue RNA can deliver critical information for targeted therapy and immunotherapy."

Through Ocean Genomics, Kingsford reinforces his personal commitment to mission-driven work by expanding the reach of accurate gene expression analysis. In late 2020, the company received a $235,000 grant from the Chan Zuckerberg Initiative, a new kind of philanthropy dedicated to using technology to help solve some of the world's toughest challenges, including eradicating disease.

While it's unusual for a business to receive CZI funding, the award will allow Ocean Genomics to improve their open-source projects Salmon (bulk RNA sequencing) and Alevin (single-cell RNA sequencing). It will also fund creating tutorials and documentation so more researchers and practitioners can use their advanced features and contribute to the projects.

Increased participation could lead to more rapidly developed personalized cancer treatments, giving patients the benefits of science- and data-based treatment options, as well as the peace of mind they need to battle this deadly disease. ■

The Doctors DeYoung

HEIDI OPDYKE

Brothers Andrew and Henry DeYoung accomplished something very few siblings ever do: They successfully defended their doctoral theses at Carnegie Mellon University within a few weeks of each other. Henry defended his in December 2020, and Andrew defended his in January 2021.

From left: Andrew DeYoung (S 2010, S 2021), Henry DeYoung (CS 2008, CS 2012, CS 2020)

Both brothers have spinal muscular atrophy, a progressive neuromuscular disease that restricts the use of their hands and requires them to rely on breathing equipment and wheelchairs. Their compromised immune systems cause them to be careful about germs — even a cold could be fatal.

"The disease does progress very slowly," Andrew said. "We're fortunate it's been a really slow progression."

Muscular atrophy has not stopped either brother, however, from excelling in their chosen fields. Henry, 35, started as an undergraduate in SCS in 2003. After being accepted, he and his parents met with Mark Stehlik, then assistant dean for undergraduate studies, Larry Powell, then director of the Office of Disability Resources, and Mike Murphy, then Dean of Student Affairs.

"I was so impressed with this kid and his desire to learn. What educator wouldn't love that?" Stehlik said. "As a university, we should help brilliant minds advance independent of any other considerations."

Stehlik worked to find ways to help Henry participate in classes. One way was figuring out how to allow him to attend courses in Wean 7500, where many Computer Science courses — including Introduction to Computer Systems — take place. At the time, the auditorium had no place for Henry to safely park his wheelchair, which is longer than most. Stehlik worked with Jim Skees, then director of SCS building facilities, to cut a vertical slice out of a retaining wall and build a platform where Henry could park his wheelchair.

"The Henry DeYoung notch survives to this day," Stehlik said.

The willingness of faculty and staff helped make the transition to college possible. Henry would introduce himself to professors before classes started to discuss his situation and find ways to participate as much as possible.

"It's a testament to the creativity of people at CMU. Many of them said, 'We've never done this before, but we'll figure it out,'" said Henry. "In my experience, everything went really smoothly. Mark Stehlik was welcoming, but so were all of the individual professors that I had for my courses."

When Andrew looked at colleges, he applied to the University of Pittsburgh and MIT — his father's alma mater — but CMU was at the top of his list as well.

"I was hoping I would get accepted. I knew I wanted to go there," Andrew said. He started in the Mellon College of Science's Chemistry Department in 2005 and graduated in 2010 with a 4.0. "CMU's culture of openness is really what made all of this possible," he said.

Karen Stump, teaching professor and director of Undergraduate Studies & Laboratories in the Chemistry Department, has advised students for more than 20 years. She said that Andrew will remain one of the most impactful students she's ever worked with, both personally and professionally.

As an undergraduate, she worked with him to find a way for him to participate in lab courses. The solution involved having a graduate student to act as his hands, while he provided the direction for every step of each experiment.

"The graduate student became his hands," said Stump. "All three of us were very clear it was going to be Andrew directing. So Andrew would tell her specifically what to do, and she had to hold back if she knew it was wrong in terms of techniques or outcomes of the experiment unless there came a point where safety had to be taken into consideration. And in that way he was able to make mistakes.

"He was such a great partner in that process and very willing to do what he could because he wanted as much of an experience as he could get that mimicked what other chemistry majors got."

Working with Andrew influenced Stump and other faculty members to reconsider what it means to be in a lab for a student and how to develop courses.

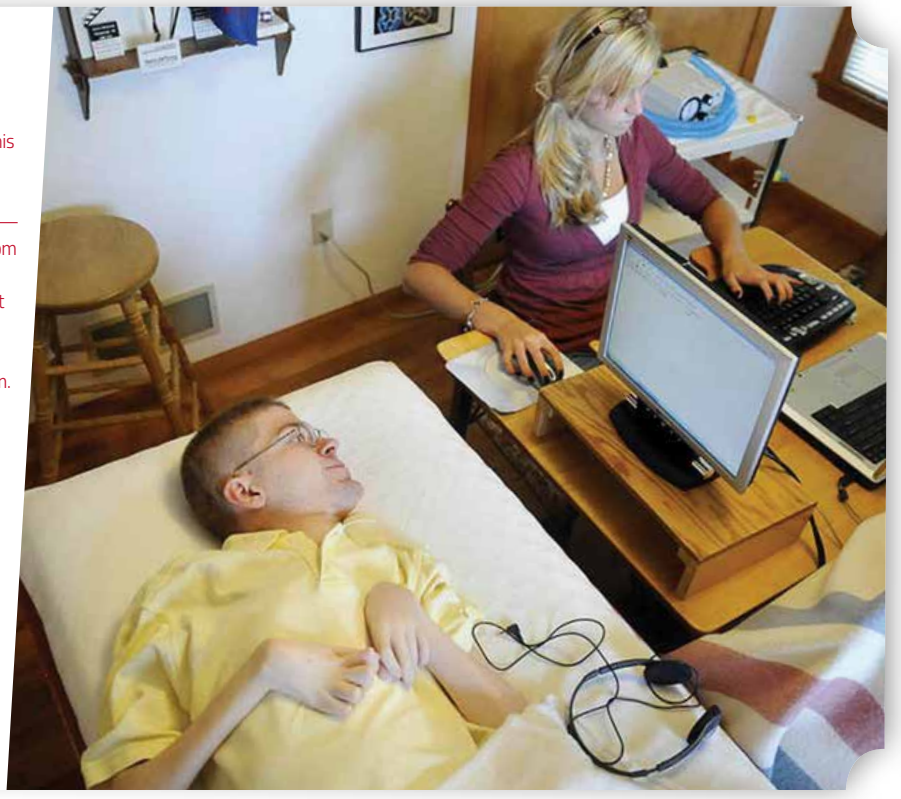
"When I first met Andrew there was a lot of thinking in my head, 'What does this mean?' and 'How do we do this?'" Stump said. "For most of us who worked with Andrew, we now go right away to the problem-solving moment. It was such a wonderful experience. Andrew helped us realize that there's value in education for everybody, and there are creative ways to accomplish your goals while also meeting the needs of the students."

Catherine Getchell became the director of the Office of Disability Resources after Powell retired in 2016. By then, the DeYoungs had been part of the community for more than a decade. Less than one percent of CMU students have permanent disabilities related to mobility, but she said that the DeYoung brothers' ability to self-advocate and initiate conversation with faculty is something all students with and without disabilities can learn from.

Henry and Andrew DeYoung at work from their home

Chemistry Professor Bruce Armitage with Andrew during his undergraduate commencement

Henry poses with Mark Stehlik, then the assistant dean of undergraduate studies in SCS.



Henry DeYoung dictates his answers to a homework assignment — word by word, symbol by symbol — to a student volunteer from Franklin Regional High School in 2008. Copyright Pittsburgh Post-Gazette, 2021, all rights reserved. Reprinted with permission.

"Students can reach out to the office at any time," Getchell said. "If they know they're coming to CMU and that they may require accommodations for a disability, we urge them to contact our office. They can also contact us as prospective students. A discussion with us about our services and the accommodations process may help them make their decision. We won't be able to make final decisions on any accommodations until after they accept admission, but we will happily talk about what they might need and what the options are."

Getchell added that no deadline exists to receive accommodations, although the sooner students reach out, the more impactful their accommodations will be.

The ability to succeed at school for both Henry and Andrew was a family affair, which included their parents, David and Joan DeYoung, and nurses and volunteers who helped them with day-to-day activities.

"Our days are incredibly shorter than most students," Henry said. "There's less time for work."

Daily routines include breathing treatments in the morning and evening as well as getting into their motorized wheelchairs. Because of their limited mobility, they dictate assignments to their parents or others to type.

"I will not pretend to understand what a day in the life of the DeYoung household is like. I will assert that it was not easy and pretty damn hard at times," Stehlik said. "It was their collective will and desire to succeed. It was an example of a struggle surmounted in a very good positive way. I'm glad CMU played a small part in that."

Henry graduated with his bachelor's degree in 2008 with a 4.0 before starting his graduate studies. His graduate adviser was Computer Science Professor Frank Pfenning. Because of Henry's compromised immune system, the two have met virtually since February 2019, the last time Henry was physically at the Pittsburgh campus.

> "It was their collective will and desire to succeed. It was an example of a struggle, surmounted in a very good positive way. I'm glad CMU played a small part in that."
>
> — Mark Stehlik

"Over all these years, it's been a real delight in working with him," Pfenning said. "Henry is very smart, dedicated and detail oriented. He has a love of research and inquiry and answering very fundamental questions."

Being a doctoral student is not just about being smart, Pfenning said. "It's originality that you need and to go where no one has gone before and forge your own path." For Henry's thesis, he studied proof-theoretic foundations of session-typed concurrency. The work relates to understanding the relationship between logic and computation and how multiple computers communicate through protocols.

"It's significant work that will have an impact," Pfenning said. "I'm really proud of what he accomplished. For any student to do this kind of work and write this kind of thesis is a great accomplishment. That he was in the circumstances he was just adds to that."

Andrew works in Chemistry Professor Hyung J. Kim's lab. Kim was department head when he started as an undergraduate.

"Andrew is one of the most brilliant students I have had," Kim said. "He's probably the most conscientious worker. He always has followed up on whatever we discussed and things I mentioned in passing. He has been great, and he pays attention to all of the details."

Andrew's thesis related to theoretical work on molecular dynamics simulations. He studied energy storage systems, in particular carbon-based super capacitors.

"Super capacitors are like batteries but are able to charge and discharge more quickly. One application of super capacitors is in electric vehicles," Kim said.

Kim said that Andrew has been exceptionally motivated to do research.

"When I took Andrew into my group, I was concerned because of his physical limitations and how much he can do. But he really put in a lot of effort, and his will was really strong," Kim said. "That's how and why he is where he is today."

Both Henry and Andrew will likely continue to be part of the CMU community. Henry recently began postdoctoral research with Pfenning, and Andrew is in making similar arrangements with Kim.

"I would love to continue to work with Andrew," Kim said. "I really like interacting with him on science."

SCS REMEMBERS
ADOBE FOUNDER AND PH.D. ALUM

Charles Geschke

Aaron Aupperlee

A creator of software that revolutionized the way people collaborate, Charles M. Geschke left his mark on Carnegie Mellon University long after earning his degree.

"Chuck" Geschke, who received a Ph.D. in computer science from CMU in 1973 and continued to give back to the university throughout his life, died April 16, 2021, at 81.

"An influential leader in the software industry for nearly 50 years, Chuck Geschke helped to expand the usability and accessibility of computers for a broad audience," said CMU President Farnam Jahanian. "He also embodied the best qualities of the CMU alumni and computer science communities: a commitment to his colleagues, their work, and a culture of collaboration and generosity. He will be greatly missed in the computing community and the world."

Geschke co-founded Adobe in 1982 with John Warnock, a colleague from Xerox. The pair's first product was Adobe PostScript. Later innovations included Portable Document Format (PDF) technology and the powerful photo and video editing tools in Photoshop and Premiere.

CMU awarded Geschke an honorary doctor of science and technology in 2013. In 2012, Chuck and Nan Geschke endowed the directorship of the Human-Computer Interaction Institute (HCII). Geschke credited his CMU education and the network of people he established at the university as an important ingredient to his success.

"Chuck Geschke embodied the best qualities of the CMU alumni and computer science communities: a commitment to his colleagues, their work, and a culture of collaboration and generosity."

— Farnam Jahanian, CMU President

am pleased to support the Human-Computer Interaction Institute," Geschke said in 2012. "The way people relate to technology has a great impact on their lives, so it seems to me that research in human-computer interaction is a natural place where CMU can innovate."

Jodi Forlizzi, the Charles M. Geschke Director of HCII, said the institute's association with Geschke is a great honor and inspiration.

"We try every day to live up to the high standards that Chuck set," Forlizzi said.

Those who worked closely with Geschke, including his long-time business partner Warnock, said the pioneer will be missed.

"I could never have imagined having a better, more likable or more capable business partner. Not having Chuck in our lives will leave a huge hole and those who knew him will all agree," Warnock said in a statement from Adobe.

Adobe CEO Shantanu Narayen called Geschke a guide and a hero for the company and the technology industry. In an email to employees, Narayen wrote that Geschke contributed to groundbreaking software that "revolutionized how people create and communicate."

"As much as his inventions changed the world, it is his focus on people, purpose and culture that has profoundly impacted each of us at Adobe," Narayen wrote. "He believed that good ideas come from everywhere in the company and that it's not only what we do but how we do it that matters most. He dedicated much of his time and talent to various philanthropies and community organizations throughout his lifetime."

Nan Geschke told the Mercury News that family came first for her husband.

"He was a famous businessman, the founder of a major company in the U.S. and the world, and of course, he was very, very proud of that, and it was huge achievement in his life, but it wasn't his focus — really, his family was," she said. "He always called himself the luckiest man in the world."

Geschke's network of friends at CMU and in the world of computer science remained strong throughout his life.

"Throughout his career, Chuck remained true to his principles, serving stockholders, customers, employees and community," said Jim Morris, professor emeritus and former dean of the School of Computer Science. "I am grateful — personally and as a member of the CMU community — for Chuck and Nan's friendship and generosity."

Geschke retired as president of Adobe in 2000. He served as chair of the board until 2017 and then as a board member until 2020, when he became an emeritus board member. Geschke received the Marconi Prize in 2010, the equivalent of the Nobel Prize for the field of information technology. In 2008, he was elected to the American Academy of Arts and Sciences, and in 2009 President Barack Obama awarded him the National Medal of Technology and Innovation. ■

IN MEMORY OF CMU PROFESSOR
WHO EARNED TURING AWARD

Edmund Clarke Pioneered Methods for Detecting Software, Hardware Errors

Byron Spice

Edmund M. Clarke, University Professor Emeritus at Carnegie Mellon University and co-recipient of the 2007 Turing Award — computer science's equivalent of the Nobel Prize — died Dec. 22, 2020, of COVID-19, following a long illness.

Clarke, together with his Harvard University graduate student, E. Allen Emerson, and, working separately, Joseph Sifakis of the University of Grenoble, developed an automated method for detecting design errors in computer hardware and software. Called model checking, it is widely used and has helped to improve the reliability of complex computer chips, systems and networks. The Association for Computing Machinery (ACM) awarded the Turing to the three scientists for this achievement.

"With Ed Clarke's passing, the world lost a giant in computer science and CMU said goodbye to a beloved member of our community," said Farnam Jahanian, president of Carnegie Mellon University. "Ed's pioneering work in model checking applied formal computational methods to the ultimate challenge: computers checking their own correctness. As systems become ever more complex, we are just beginning to see the wide-reaching and long-term benefits of Ed's insights, which will continue to inspire researchers and practitioners for years to come."

"He was a shining example for both the faculty and students, and he is missed by all of us."

—Martial Hebert, dean of Carnegie Mellon's School of Computer Science

Clarke earned his Ph.D. in computer science at Cornell University in 1976. He taught at Duke University and then Harvard before joining CMU's Computer Science Department in 1982, where his research group continued to pioneer formal verification and automatic theorem proving. He is one of the founders of the Computer Aided Verification conference and was the former editor-in-chief of the journal Formal Methods in Systems Design.

He became an emeritus professor in 2015.

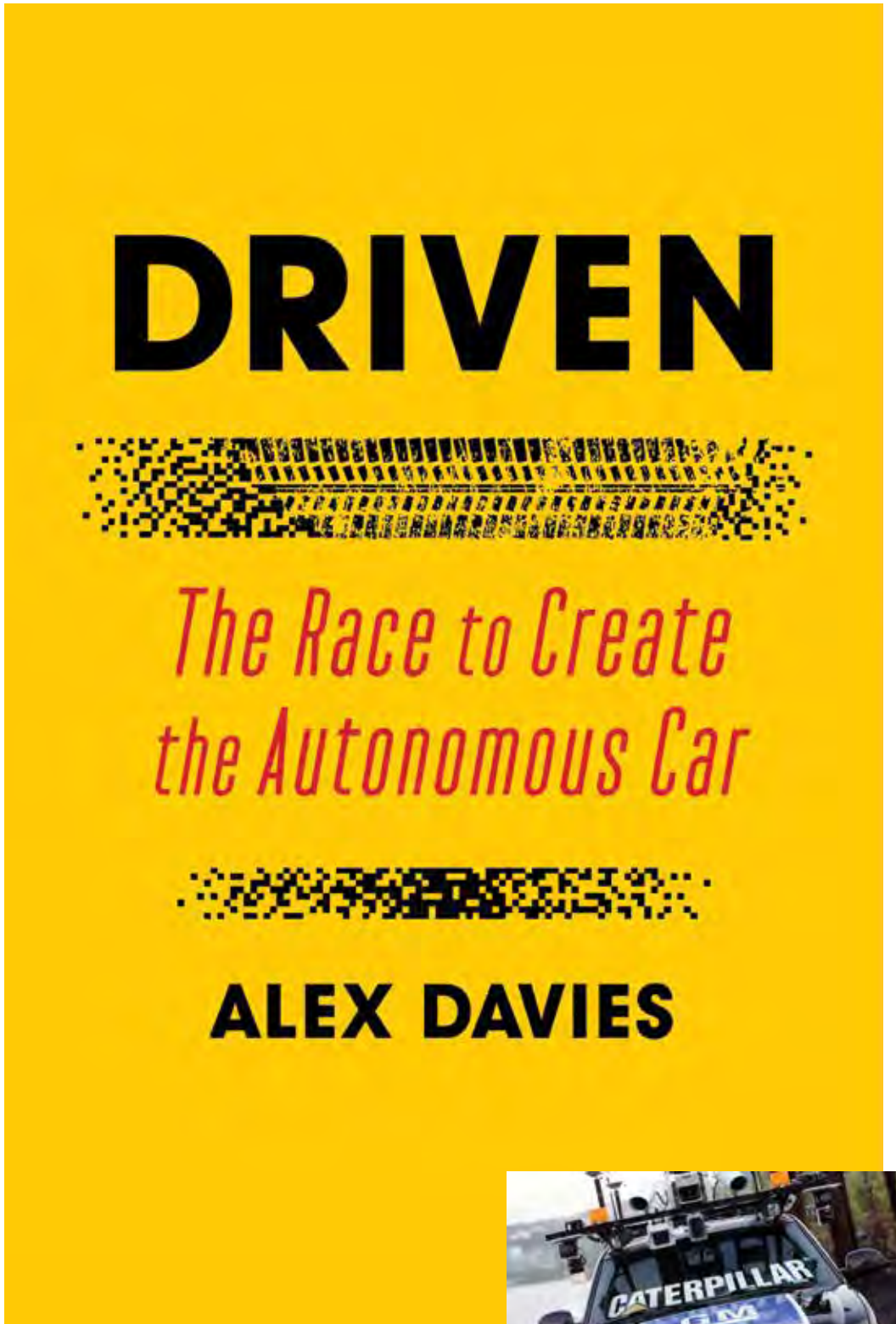
"Intellectual rigor was a hallmark of Ed Clarke; it earned him computer science's highest honor and through him infused the Computer Science Department for more than 30 years," said Martial Hebert, dean of Carnegie Mellon's School of Computer Science. "He was a shining example for both the faculty and students and he is missed by all of us."

In 1995, Clarke was the first recipient of the endowed FORE Systems Professorship and in 2008 was named a University Professor, CMU's highest faculty honor. He is the co-recipient of the 1998 ACM Kanellakis Award, the 1999 Allen Newell Award for Excellence in Research, the 2004 IEEE Harry H. Goode Memorial Award and the Conference on Automated Deduction's 2008 Herbrand Award for Distinguished Contributions to Automated Reasoning. In 2014, the Franklin Institute presented him its Bower Award and Prize for Achievement in Science for his leading role in the conception and development of techniques for verification of computer systems.

"Ed Clarke was a brilliant researcher but also a kind and caring individual," said Randal E. Bryant, Founders University Professor of Computer Science Emeritus and former dean of the School of Computer Science. "I especially admire his ability to mentor Ph.D. students and postdoctoral researchers, many of whom have had major impact throughout the world through their research."

He is survived by his wife, Martha, the graduate admissions coordinator for the Computer Science Department and School of Computer Science until her 2014 retirement. He also is survived by three sons, James Clarke of Portland, Oregon; Jonathan Clarke of Decatur, Georgia; and Dr. Jeffrey Clarke of Durham, North Carolina; and six grandchildren.

If you are interested in contributing to Ed's continuing impact on SCS students, the family invites you to make a gift to the Edmund and Martha Clarke Endowed Graduate Fellowship in the School of Computer Science. ■



Boss, winner of the 2004 DARPA Grand Challenge

The Tartan Racing team celebrates victory in the 2004 DARPA Grand Challenge.

The following is an excerpt from the book *DRIVEN: The Race to Create the Autonomous Car*, by Alex Davies, which tells the story of the quest to develop the driverless car. The story begins with the events leading up to the Defense Advanced Research Projects Agency (DARPA) 2004 Grand Challenge, which the CMU Tartan Racing team won, lifting CMU and Pittsburgh as key players in the world of autonomous vehicles.

By January of 2007, with ten months to go before the Urban Challenge, Tartan Racing was well on its way. Its twin robots were running slalom courses amid the rubble and dirt mounds of the steel mill site, with the Pittsburgh skyline visible in the distance. They had completed multi-checkpoint missions and begun running through those devilish four-way stops. With the harsh winter setting in, it was time to head west. Not to the Nevada Automotive Test Center this time, but to the Phoenix suburb of Mesa, Arizona. Tartan's partner, General Motors, had invited them to its hot weather proving ground. At the expansive, well-equipped facility, the team took over an available workshop and fell into a familiar, brutal work schedule: wake up, work, eat whatever food someone hauled in, sleep, repeat. Six weeks before the start of the qualifying round, they decamped again. Back in 2003, racer Chip Ganassi had taught the Red Team to practice the way you race. [Tech lead Chris] Urmson figured DARPA was likely to host the Urban Challenge on a military base, since it would never be able to close down public streets for a robot melee, and he thought it would be nice to get away from GM's overly bureaucratic bailiwick. A quick internet search for disused bases led him to California's Central Valley.

A two-hour drive southeast of San Francisco, Castle Air Force Base had opened in 1941 as a flight school for American pilots headed into battle over Europe and the Pacific. When it closed in 1995, some of its nearly three thousand acres went to an air museum. Another chunk hosted a high-security prison. The rest lay mostly fallow, the soil contaminated by the fuels, oils, and chemicals that come with keeping warbirds in the air. But it had a large street network, a hangar to work out of, and room to run wild. So Urmson struck a deal with local officials, and the dozen or so core members of the team made camp in the abandoned officers' quarters. Conditions were grim. The place teemed with black widow spiders. One room contained a mess

of feathers and bones a lunching coyote (or something) had left behind. When Mike Taylor, a Caterpillar engineer embedded with the team, noticed a pain in his foot one day, he took off his boot to find a pair of puncture marks in his pinky toe. His best guess was that a bat must have bit him in his sleep. On the advice of his father, a veterinarian, he called up the California Natural Resources Agency and asked if they had reports of rabid bats in the region. The answer came back in a worryingly grim tone: "Rabid bats are everywhere." Taylor headed to a doctor, took a rabies shot to the butt cheek, and went back to work.

The occasional wild animal interaction, in any case, wasn't as scary as the ordeals Bob Bittner dreamed up for Boss. An army and navy veteran who'd once worked as a foreman at the Pittsburgh steel mill the team had turned into a test site, Bittner didn't write code, but he'd worked with enough computing systems to know how to look for their weaknesses. As the Tartan testing lead, he created a twenty-five-page playbook that mimicked everything the govvies might throw at Boss: four-way stops where another vehicle went out of order, parking lots barely wide enough for the SUV to turn around, labyrinths that tested the bot's ability to navigate. To run these scenarios, team members would drive their rental cars or the handful of vehicles GM had sent over, rearranging the cones and barrels that represented assorted obstacles and the overturned plastic gutters that stood in for curbs. For the riskier tests, they used an inflatable car (nicknamed Stanley) on rollers. Bittner ended each session with a half-hour "free for all," where everyone did whatever he could think of to make Boss break a rule or otherwise trip up. Here, they were less worried about what DARPA concocted than what other teams' imperfect robots might do. They'd drive straight at the Tahoe, go the wrong direction down a one-way road, pull up alongside it and juke into its lane, and challenge it with whatever other nonsense they could imagine.

Those tests turned up software bugs and key information about where Boss was vulnerable. They also revealed the unexpected results that changes to a big, interconnected system can have, like an algorithm focused on intersection precedence that somehow deleted Boss's ability to execute three-point turns. In the final weeks before the race, the team turned its attention to hardening its system, and tracking down errors in the voluminous code. Sitting at the desks they'd set up in an old hangar, they celebrated each squashing of a software bug by hitting a red plastic button (akin to the Staples "That Was Easy" button) that played the Imperial March, the Star Wars tune that accompanied the approach of Darth Vader. Every repeat of the leitmotif signified another step toward the victory that had eluded them in the desert.

Excerpt from *DRIVEN* by Alex Davies.
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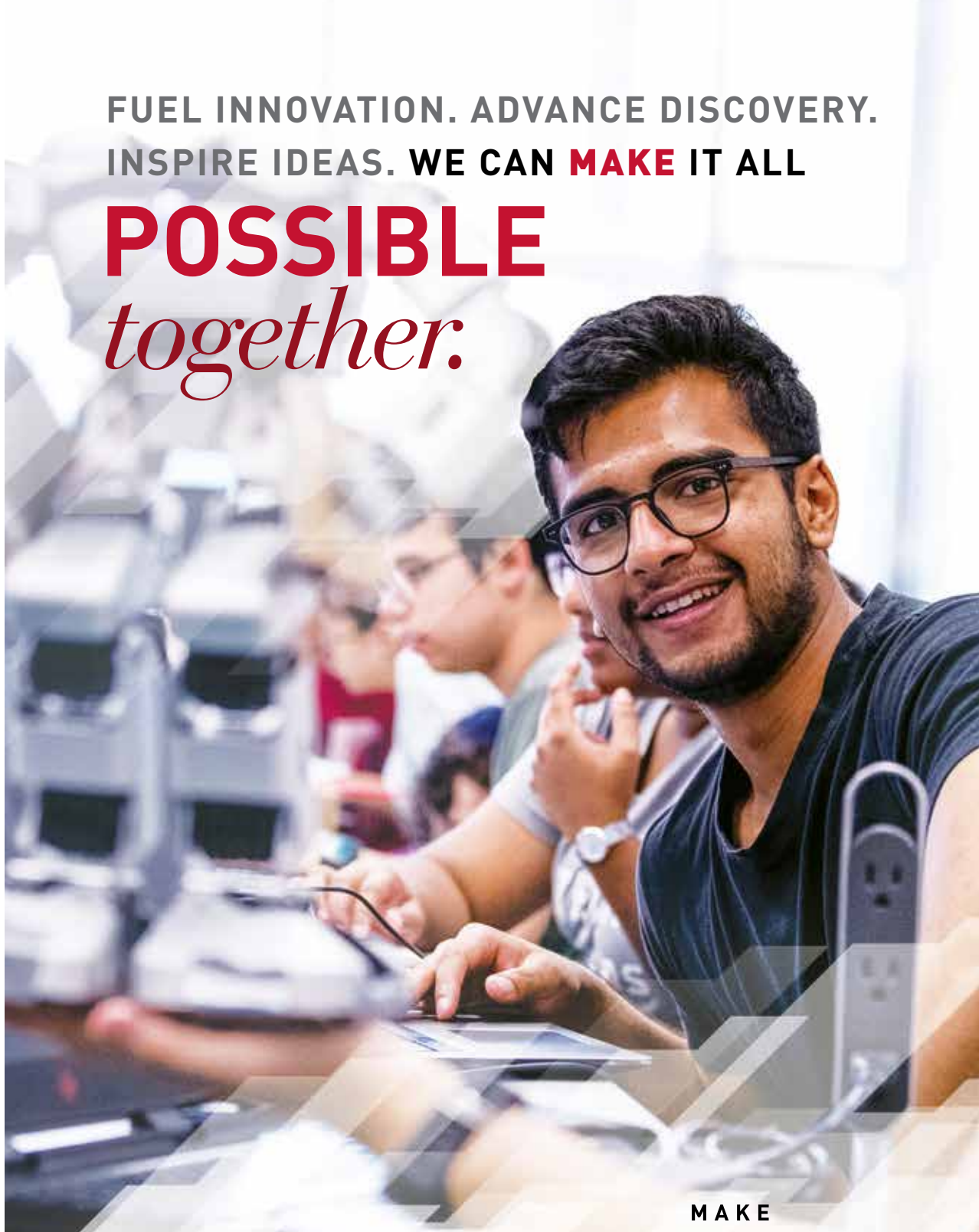
FUEL INNOVATION. ADVANCE DISCOVERY.
INSPIRE IDEAS. WE CAN MAKE IT ALL
POSSIBLE
together.



Carnegie Mellon University
School of Computer Science

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FORLIZZI NAMED ASSOCIATE DEAN OF DIVERSITY, EQUITY AND INCLUSION FOR SCHOOL OF COMPUTER SCIENCE

Aaron Aupperlee

Jodi Forlizzi will lean on her background as a designer to address what she called "a truly wicked problem" in her role as the inaugural associate dean of Diversity, Equity and Inclusion in the School of Computer Science.

"I'm trained as a designer, and many systemic design practices apply to this work," said Forlizzi, the Charles M. Geschke Director of the Human-Computer Interaction Institute since 2017 and faculty since 2000. "We can start by making small changes that could have great impact."

Forlizzi helped initiate some of those changes in her work as the Diversity, Equity and Inclusion lead for the school. Under her guidance, SCS has started documenting important processes including those for hiring, onboarding, offboarding, reviews, promotions, and award and committee selections. The school has also gathered and centralized outreach activities to better coordinate and update them as needed.

Forlizzi has also led the charge to create a Broadening Participation in Computing Plan and expand the number of GEM fellowships to increase the participation of underrepresented groups at graduate levels in engineering and science.

"We've been chipping away at it steadily, but DEI work is slow. It's incremental, and sometimes it takes a long time for any one action to have an impact," Forlizzi said.

Among her first tasks will be to prioritize the work of Carol Frieze, the former director of the Women@SCS and SCS4All programs. Frieze recently retired, and Forlizzi does not want her work to fade. Additionally, Forlizzi sees a need to expand mentorship opportunities for the diverse cadre of faculty, staff and students the school hopes to attract.

Forlizzi's appointment comes at a time when the spotlight is on institutions to react against racism. Wanda Heading-Grant recently started as CMU's chief diversity officer and vice president for Diversity, Equity and Inclusion, and schools across campus are appointing associate deans of DEI. Forlizzi said the unsettled nature of the U.S., with protests, rallies and calls for social justice, suggests that conditions are ripe for radical change.

"Now is the time for action," Forlizzi said.

Martial Hebert, the dean of the School of Computer Science, said the unsettled nature of the country and the calls for action are reminders of the importance of this work. He said improving diversity, equity and inclusion is a major priority for both the school and the university, and Hebert is confident Forlizzi is up to the task.

"She's enthusiastic about the topic, and it has always been important for her," Hebert said. "But it's not just one job or one person. It's changing and evolving the practices at the school. What really makes a difference is to have the school change, to have all of us change."

Forlizzi earned a self-defined Ph.D. in human-computer interaction in 2007 and a master's degree in interaction design — both from CMU. Her bachelor's degree is in illustration from the University of the Arts in Philadelphia.

Forlizzi was elected to the Association for Computer Machinery's CHI Academy for her significant, cumulative contributions to the development of the human-computer interaction field. In 2020, Forlizzi was named an ACM fellow.

JESSICA HAMMER NAMED HCII INTERIM ASSOCIATE DIRECTOR

Aaron Aupperlee

Award-winning game designer Jessica Hammer will level up as she takes on the role of interim associate director of the Human-Computer Interaction Institute in the School of Computer Science.

"We are lucky to do exceptional research and teaching at the HCII. Even better, we get to combine the two to shape the future of human-computer interaction," said Hammer, the HCII's Thomas and Lydia Moran Assistant Professor of Learning Science. "I want to make sure that all members of our community — from our first-year undergraduates to the most senior faculty — can contribute to this mission."

Hammer, who has often learned the hard way how to develop a game to meet its vision, said that her training will help her make sure the department's practices and organizations are best suited to meet its goals.

"I want to help create a department where our work is not just impactful, but also joyful," Hammer said.

Hammer will take on the new role while the HCII's current director, Jodi Forlizzi, transitions to her position as the associate dean for Diversity, Equity and Inclusion in SCS and reduces her duties as department head.

"I have enormous respect for everything Jodi has accomplished as director of the HCII. She has helped us get through globally challenging times and has empowered others in the department to learn to lead from her," Hammer said. "We will be conducting a search for a new director, and part of my role as associate director will be providing leadership continuity to the department. I'd like to help the new director quickly master the basics of the job, so they can move on to reinforcing what's already great at the HCII and figuring out where they can help us grow."

Hammer holds a joint appointment with CMU's Entertainment Technology Center. She earned her B.A. at Harvard University, her M.S. from the NYU Interactive Telecommunications Program and her Ph.D. in cognitive studies at Columbia University.

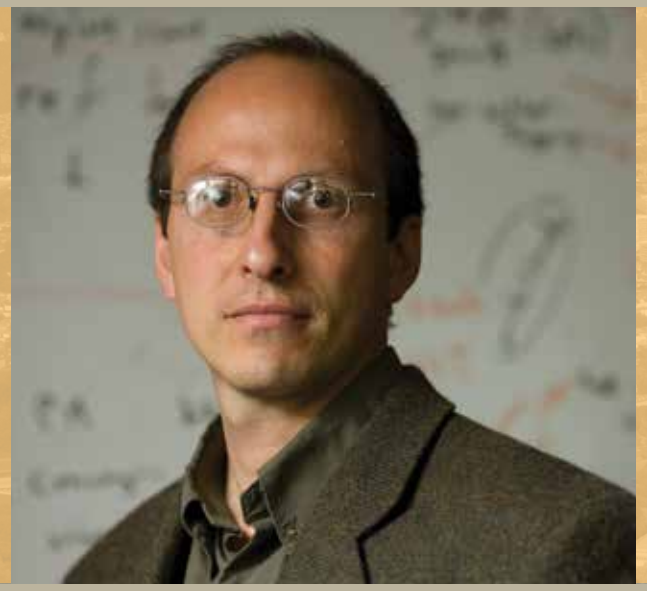
CARNEGIE MELLON, HEINZ ENDOWMENTS LAUNCH CENTER FOR SHARED PROSPERITY

SCS Professor Illah Nourbakhsh Will Serve as Inaugural Executive Director

Carnegie Mellon University and The Heinz Endowments announced a sweeping initiative to leverage the university's internationally recognized strengths in applied research to address longstanding barriers to equity and foster economic empowerment in the greater Pittsburgh region. The Center for Shared Prosperity aims to create a sustainable and replicable model for community-university collaboration, with a focus on deploying solutions for socioeconomic inequities and making measurable progress toward greater economic prosperity and overall well-being of residents.

"Through its unique model of collaboration in which community members and university faculty and staff work together as peers, and the development and distribution of social and technological innovations with real-world applications, the center will help to dismantle barriers to shared prosperity and equity," said Illah Nourbakhsh, the K&L Gates Professor of Ethics and Computational Technologies in the Robotics Institute, who will serve as the center's inaugural executive director. "The Center for Shared Prosperity will be laser-focused on creating direct, sustainable impact on Pittsburgh by bringing research into practice."

The Heinz Endowments has committed $30 million over six years to fund the creation and launch of the center, as well as support for initial real-world projects identified by community partners. The grant, the largest in The Heinz Endowments' history, includes funding to develop, pilot and scale region-wide interventions to identify and address structural barriers to access and opportunity. A portion of the grant will establish an endowment to support the center's work in perpetuity.



Illah Nourbakhsh, the K&L Gates Professor of Ethics and Computational Technologies in the Robotics Institute and inaugural executive director of the Center for Shared Prosperity

"As a university- and community-wide effort, the Center for Shared Prosperity will apply a comprehensive methodology to CMU's engagement across Western Pennsylvania and will leverage our unique expertise to help residents benefit from the innovation economy," said Farnam Jahanian, CMU president. "The Heinz Endowments and CMU have worked together for decades on projects that support Pittsburghers, and this new initiative will expand our community collaborations at a particularly critical moment. With both the pandemic and the rapid pace of technological change contributing to a widening opportunity gap, the solutions proposed through the Center for Shared Prosperity will help our region address societal barriers and will also serve as a model that can be replicated in communities across the country. We are grateful to The Heinz Endowments and its board for their generous support and partnership."

Names in the News

Severin Hacker and Luis von Ahn

Guy Blelloch

David Woodruff

Maxine Eskenazi

Luis von Ahn and Severin Hacker, founders of Duolingo, were honored when the company was named to Time Magazine's list of most influential companies.

The Language Technologies Institute's Maxine Eskenazi was selected as a fellow of the International Speech Communication Association.

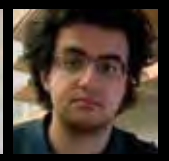
Pravesh Kothari, Nihar Shah, Virginia Smith, Nathan Beckmann and Sivaraman Balakrishnan, are SCS-affiliated faculty who have been awarded inaugural Google Research School Program grants.

The IEEE Computer Society honored Guy Blelloch with the 2021 Charles Babbage Award for his contributions to parallel programming, parallel algorithms and the interface between them.

David Woodruff received the Herbert A. Simon Award for Teaching Excellence in Computer Science.

To date, seven SCS professors, Lining Yao, David Held, Ioannis Gkioulekas, Ameet Talwalkar, Pravesh Kothari, Fei Fang and Andreas Pfenning have received National Science Foundation Career Awards.





Lining Yao, David Held, Ioannis Gkioulekas, Ameet Talwalkar, Pravesh Kothari, Fei Fang and Andreas Pfenning






Ember Liu, Neil Thawani and John Stamper

Scott Hudson

Lorrie Cranor

Ember Liu, Neil Thawani and John Stamper are winners of the Schmidt Futures Forum on Learning: Tools Competition.

Lorrie Cranor was named co-director of the Collaboratory Against Hate: Research and Action Center.

Lujo Bauer and Matt Fredrikson are part of a research team that won a U.S. Department of Defense (DoD) Multidisciplinary University Research Initiative (MURI) Award.

Scott Hudson was awarded a Lifetime Achievement Award in Research by the Association for Computing Machinery's Special Interest Group in Computer-Human Interaction (SIGCHI).

HCII's Jessica Hammer, along with Melissa Kalarchian of Duquesne University, won the Shape of Health Competition sponsored by the U.S. Department of Health and Human Services for their activity-boosting video game for young girls.

Manuel Blum and Jodi Forlizzi were named 2020 Association for Computing Machinery Fellows.

Abhinav Gupta was awarded 2020 J.K. Aggarwal Prize by the International Association for Pattern Recognition.

Jessica Hammer

Manuel Blum

Abhinav Gupta

Lujo Bauer

Matt Fredrikson

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COMMENCEMENT 2021

SCS students, socially distanced during commencement, find ways to express passion for their dreams.