FOR 20 YEARS, CMU’S HUMAN-COMPUTER INTERACTION INSTITUTE HAS RE-SHAPED THE WAY WE INTERACT WITH TECHNOLOGY—AND EXAMINED THE WAYS THAT TECHNOLOGY SHAPES OUR INTERACTIONS WITH ONE ANOTHER

also inside:

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BONE PUTTY SHOWS PROMISE IN CLINICAL TRIAL
FOUR SCS PROJECTS MAKE POPSCI’S ‘BEST OF WHAT’S NEW’
The Link provides a mosaic of the School of Computer Science: presenting issues, analyzing problems, offering occasional answers, giving exposure to faculty, students, researchers, staff and interdisciplinary partners. The Link strives to encourage better understanding of, and involvement in, the computer science community.

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Cover illustration by
Lisa Rasmussen (A’84)
The first three months

I have had an excessively exciting and rewarding three months starting up as dean of the School of Computer Science.

The quick background is that I was a faculty member in robotics, computer science and machine learning from 1993 to 2006. I then went to Google Pittsburgh for eight years, and returned in my new role at the end of August.

I have reengaged with old friends throughout CMU—staff, faculty, administrators and plenty of alumni. And I have met a large number of extraordinary people for the first time, including our various student populations, many new faculty and recent alumni. These discussions have blown me away.

I especially enjoy the feeling of camaraderie: over and over, I hear passionate thinking of how we can make things better for everyone on campus. And of course, so many people here are deeply motivated by saving and improving lives around the world. And as for the students—our undergrads, master’s and Ph.D. students are all frighteningly sharp, humor-filled and full of common sense and drive.

So: Life is good. My heartfelt thanks to everyone for being so welcoming, and to all the thousands of people who have devoted themselves to building this magnificent enterprise over the years and decades. See you in the new year!

Andrew W. Moore
Dean
School of Computer Science

ABOUT OUR CONTRIBUTORS

Nick Keppler wrote this issue’s cover story on the 20th anniversary of the HCII. The finest product ever to come from Fredericktown, Ohio—besides airplane paneling—Nick is a Pittsburgh-based freelance writer whose work has appeared in Pittsburgh City Paper, Pittsburgh Magazine, The Village Voice, Nerve.com, Vice and Slate. He has also held editor positions at the Houston Press and the Fairfield County Weekly. He previously wrote about robotic surgery and the Never-Ending Image Learner for The Link. He can be reached at nickkeppler@yahoo.com.
Ready for blast-off

CMU spinoff Astrobotic is still focused on a Moon landing, but its new mission includes going below the lunar surface

By Meghan Holohan

On a clear February day in the Mojave Desert, a Masten Zombie rocket launched. It landed again on the same pad, 78 seconds later. That might not sound like much, but the little more-than-a-minute flight provided Astrobotic with valuable information that the team will use to win the Google Lunar X Prize.

“We selected a landing point and it landed on that landing pad,” says Kevin Peterson (E’02, ’04, CS’09), chief technology officer at Astrobotic, a CMU spinoff. When it comes to space travel, landings are not accurate; most crafts give themselves about a 10-kilometer window in which to touch down, he says. It’s the difference between landing “somewhere in Pittsburgh” or on the 50-yard line of Heinz Field, Peterson explains. “Apollo 11 missed its landing point by five miles,” he says.

The reason that February’s landing was spot on was the Astrobotic Autolanding System, or AAS. And AAS is just one of the reasons that Astrobotic, founded by William “Red” Whittaker (E’75, ’79), believes it’s going to win the Google Lunar X Prize. Created in 2007 by the X Prize Foundation, the Google Lunar X Prize encourages the development of space technology and exploration. The first team that successfully lands a rover on the Moon, drives it 500 meters and broadcasts high definition video back to Earth by December 31, 2015, wins up to $30 million. Of the 33 teams that

Astrobotic Technology’s newly developed autonomous landing system was tested June 20, 2014, in Mojave, Calif., when it controlled Masten Space Systems’ Zombie demonstration rocket.

Astrobotic’s Griffin lander can accommodate a variety of rovers and other payloads.
Using AAS, Astrobotic plans to place its lander accurately within a 100-meter ellipse. “This could be the most accurate landing system, if it’s successful,” Thornton says. “The technology is developing well and we’re happy with it.”

While $30 million might seem like a generous prize, it’s a fraction of what it takes to make it to the moon. In addition to the rovers, Astrobotic’s rocket and lander also will carry other research projects that have been waiting to hitch a ride to the moon—at a price of $1.2 million per kilogram. By transporting the other rovers as well as scientific payloads, the company will earn much needed money to fund its mission and future development of its technology.

If flying to the Moon sounds ambitious enough, what Astrobotic plans to do next seems like science fiction. After sending back the HD video and traversing the lunar landscape, the rover will attempt to capture images of the entrance to a cave beneath the lunar surface. If successful, the Astrobotic team will be the first humans ever to peer inside a lunar cave.

“The Apollo-era missions taught us a lot about moon rocks and dust—it was the pinnacle of human and technological pursuit at that time,” says Whittaker, who also serves as CMU’s Fredkin Professor of Robotics and director of its Field Robotics Center. But those missions “missed altogether the ice, missed altogether the pits, the holes, the skylights. Our destination is a pit—the first exploration in the moon. ”

Exploring the tunnels wasn’t originally part of Astrobotic’s mission. As the contest progressed, the team realized it needed to think big. “Lots of people think we’re crazy,” Peterson says, but the mission needed to be “exciting and important enough” to attract funding.

The tunnels, believed to have been created by volcanic activity billions of years ago, are a relatively new discovery. Although scientists long suspected there were tunnels below the lunar surface, there wasn’t convincing evidence until 2008, when Japan’s Kaguya spacecraft snapped images of a dark hole on the Moon. To the untrained eye it simply looks like a blemish on the surface, but researchers who analyzed...
After Astrobotic sets its Griffin lander onto the Moon’s surface, a rover will exit the lander, and the race will be on. And it will, indeed, be a race—in addition to a rover designed and built by Carnegie Mellon, Astrobotic plans to ferry rovers from other teams competing for the Google Lunar X Prize.

Astrobotic founder Red Whittaker (E’75,’79) says CMU’s newly developed Andy rover (at left) will move our scientific knowledge far beyond anything now known about the moon.

Sending human explorers to live in caves on the Moon may sound like something out of an episode of Doctor Who, but as Thornton points out, “there were plenty of people who thought that settling the New World was crazy. If you’re not pushing boundaries, you’re not doing something interesting.”

Meghan Holohan is a Pittsburgh-based freelance writer whose work frequently appears at MentalFloss.com and NBCNews.com. She wrote about Astrobotic in the Summer 2011 issue of The Link.

Astrobotic delivers ‘MoonMail’

As this issue went to press, Astrobotic announced that it is accepting orders for people who want to send a keepsake to the moon. For prices ranging from $460 to $1,660, users can reserve space on Astrobotic’s capsule and deliver any small, non-hazardous, inert item (for instance, a ring or sorority pin) to the moon. Visit www.astrobotic.com/moon-mail for more information.
Taking to the air

CMU’s Robotics Institute is a pioneer in the creation of land-based vehicles that can drive themselves; now, it’s exploring new missions in the air and on the water

By Meghan Holohan

After a traumatic accident, there is a 60-minute window of time—what physicians call the golden hour—when treatment will be most effective. But in the middle of a disaster, such as a wildfire, earthquake or hurricane, or in combat, reaching people in need of medical attention becomes especially challenging.

“Sometimes people will perish because rescuers cannot act,” says Sanjiv Singh (CS’91, ’95), a research professor in Carnegie Mellon’s Robotic Institute. The scope of the disaster may mean that rescuers cannot leave their posts, or that sending them into harm’s way might jeopardize their lives as well—making the situation worse. In such a situation, wouldn’t it be better to have an autonomous rescue vehicle that could be sent out to a victim, retrieve them and bring them back to safety?

Singh thinks so. Back in 2010, he was part of a team that included Piasecki Aircraft Corp. and the U.S. Army’s Telemedicine and Advanced Technology Research Center that successfully tested a navigation and sensor system that converted a helicopter into an autonomous vehicle.

“We showed how a helicopter could fly, build a 3-D map of the terrain and find how to land as close as possible to the rescue site,” he says.

Singh is currently part of a program to develop the sensor package and control software to allow an unmanned, full-size helicopter to fly to a disaster site, avoid obstacles, land at an unprepared landing site, retrieve passengers and then take off and fly to safety. In February, the technology was successfully demonstrated in Virginia, when an unmanned helicopter took off, avoided trees and safely landed, despite high winds and blowing snow. In August, Singh’s company, Near Earth Autonomy, and its partner, Aurora Flight Sciences, received a development contract to improve their system, allowing it to fly faster, in more difficult terrain and in bad weather, without GPS.

The 2010 test showed that autonomous helicopters could fly quickly and avoid obstacles. The helicopter used obstacle avoidance software to weave through trees and wires, something that only piloted vehicles were able to do at the time. But the system had a drawback; it built its terrain maps by overflying the pickup locations. If time is important and the area is dangerous, it might not be feasible for a helicopter to fly over a site. An autonomous helicopter needs to pick a place to land without studying all of the possible landing sites first.

Landing on an unknown site without first overflying the area—a so-called “hot landing”—is more risky, but also a likely possibility in a true emergency situation. Autonomous helicopters must be able to make these “hot landings.”
The two vehicles must be able to work independently while also communicating with one another to complete their mission. Searock and his CMU colleagues are responsible for working on the unmanned ground vehicle, a Land Tamer all-terrain vehicle. The vehicle incorporates the strengths of others developed at the Robotics Institute, including the Crusher off-road vehicle and Boss SUV, which won DARPA's 2007 Urban Challenge race. It also will have sensors that allow it to drive in a variety of conditions, both day and night, and the software shares information between the air and ground vehicles, Searock says.

Prior to starting his current role at CMU, Searock served in the U.S. Navy as a nuclear-qualified submarine warfare officer. "What we're trying to do is execute a complete integrated and autonomous air and ground mission (under conditions) that (are) only safe for robots," he says. CMU has now demonstrated mature autonomous technologies on the ground and in the air, Searock says, and he's looking forward to developing those technologies to support new missions, including on the surface of the ocean, and underwater. "I'm always excited to provide new robotic capabilities that help my fellow shipmates and soldiers and keep them safe," he says.
Getting to the good parts

LiveLight cuts hours of unwatchable video down to the most important segments, saving server space (and sanity)

By Scott Fybush

For most parents, videos of the baby are a one-way affair: they might shoot hours of their newborn cooing or squirming or crawling, but even the proudest mom, dad or grandparent has better things to do than actually watch all those hours in which, let’s be honest, there’s not much happening.

When Eric Xing, a professor of machine learning at CMU, had a baby five years ago, he knew that even in small iPhone doses, his videos weren’t very satisfying to show off. “The viewer and I needed to wait anywhere from 10 seconds to a minute” for the interesting parts of a video to appear, he recalls. “And then they would laugh or they would cheer, and they got satisfaction. But that’s not a very interesting experience, because most of the time we were waiting for the boring part in the videos to pass.”

Unlike most parents, Xing was ready to tackle the problem. For more than two years, he worked with Ph.D. student Bin Zhao (CS’11) to study the challenges of automatically editing videos down to only the most interesting parts. “This has been a primary problem in computer vision,” Xing says. Previous attempts have been based on the assumption that the whole video is already shot and available for analysis—but Xing says machine learning offers a different, more efficient approach.

Their technology, called LiveLight, “basically watch(es) the movie with you, and while it’s watching, it has this human-like intelligence to establish a dictionary of what might be interesting, what might be boring, and then based on that, makes a judgment on the subsequent segments in the video.” In November, LiveLight was selected for Popular Science magazine’s “Best of What’s New” as one of the top 100 technological innovations of 2014. (Four of the inventions on the list, including LiveLight, originated at SCS. See sidebar, next page.)

The exact nature of the algorithm behind LiveLight, Xing says, is the “special sauce” on which he’s obtained a patent. “While you’re watching the movie,” he says, “you basically are extracting key features from the movie—an interesting set of actions, or changes taking place during the movie, during the video.” Unlike earlier attempts, Xing and Zhao’s algorithm learns more about what’s “interesting” the more it watches by building a dictionary to describe what it’s seeing. “Once you use this memory to watch for the next few frames, you are going to be able to tell whether they’re
Four SCS projects are on PopSci’s ‘Best of What’s New’

Four inventions that trace their origins to the School of Computer Science have been honored by the annual Best of What’s New Awards by Popular Science.

This year’s winners, published in the magazine’s December 2014 issue, include LiveLight, a method for automatically editing out the boring parts of personal or security videos; the Flex System, a neck surgery tool based on snake robot research; 360fly, a panoramic video camera; and 3D Object Manipulation Software, a photo editing tool.

Cliff Ransom, editor-in-chief of Popular Science, says the magazine has been compiling the “Best of What’s New” awards for 27 years. The magazine’s editors review thousands of products in search of the top 100 innovations in 12 categories: Aerospace, Automotive, Engineering, Entertainment, Gadgets, Green, Hardware, Health, Home, Recreation, Security and Software.

In addition to LiveLight, the Carnegie Mellon winners are:

**3D Object Manipulation Software**, developed by Natasha Kholgade (CS’12), a Ph.D. student in the Robotics Institute; Yaser Sheikh, associate research professor of robotics; and colleagues. It uses available 3D models of common objects to enable photo editors to manipulate objects in three dimensions within a two-dimensional. Objects can be turned or flipped in any direction, even exposing surfaces not visible in the original photo. It is a winner in the **Software** category.

**Flex System**, a robot-assisted surgical device, developed by Howie Choset, professor of robotics, along with then-post-doc Alon Wolf and Marco Zenati of the Harvard Medical School. Medrobotics Corp., a company that the trio co-founded, has begun limited marketing in Europe of the flexible endoscopic system that enables surgeons to access and visualize hard-to-reach anatomical locations in the head and neck. It is a winner in the **Health** category.

**360fly**, formerly known as EyeSee360. It’s a rugged, waterproof and lightweight camera that provides a unique, 360-degree horizontal and 240-degree vertical view of the world. The Pittsburgh company, founded in 1998, expects to rollout the camera next year. The camera is a winner in the **Gadget** category.

similar to what you’ve watched before or whether it’s never been seen before in the dictionary … and then when you see something that is indeed very boring or repetitious, you are going to be able to label it as not useful, and you are going to delete it.”

As it’s learning, LiveLight can automatically edit the “interesting” parts together into a finished video, or it can offer a human editor a selection of “interesting” and “not interesting” moments to pick from.

Xing and Zhao quickly realized the technology was useful for more than just baby videos.

“We see a lot of long videos produced every day,” Xing says—not just endless hours of footage from surveillance cameras, but also streams of video being captured by GoPro cameras, Google Glass and other mobile video technology.

“It is very, very time-consuming for anyone to watch those videos and get the interesting moments out of them,” he says. “And suppose you are a Google Glass user and you turn your camera on to record, say, an hour’s worth of video. You know, just to upload all this information to some cloud server is a pretty expensive consumption of bandwidth. If an automatic program can carve that stuff out of the final version of the video, it will result in a shorter video that can be uploaded in a more economical way.”

Testing and refining the algorithm required an ample supply of hours of mostly-boring video, and Xing found it in abundance in various places, including “arbitrary movies from YouTube.”

After more than two years of development, Xing and Zhao were confident enough in LiveLight to post several demonstration videos (http://supan.pc.cs.cmu.edu:8080/VideoSummarization/) and to present the technology at the IEEE Computer Vision and Pattern Recognition Conference in Columbus, Ohio.

They’re already working to commercialize LiveLight through a startup, PanOptus Inc., for which Zhao is serving as CEO. [1]
“CMU has been an extremely friendly place for entrepreneurship,” Xing says. While PanOptus hasn’t yet signed any firm deals to put its technology into the marketplace, “we’ve had some serious customers who want to have our technology, and also some investors who want to put investments on that.”

In a world where most searches still involve text, Xing says LiveLight “is basically among the very few initial instances of doing serious machine learning on imagery data and visual data. It’s asking how to understand what people see instead of what people write or speak…and if there is a way to allow people to understand images and videos and be able to distill useful information out of them, I think that will really change the way people down the road communicate with each other and entertain each other.”

PanOptus isn’t the only company pursuing automated editing and interpretation of lengthy videos. John Sepassi, sales manager at IntelliVision, says his company is one of the survivors from an initial wave of interest in the field that immediately followed the 9/11 attacks. While he isn’t familiar with Xing’s LiveLight technology, Sepassi says demand for the sort of product he’s offering is growing. And as embedded processors become more and more powerful, he predicts the technology is going to be incorporated right into the cameras, “instead of being PC or server based.”

His company’s clients are especially interested in real-time alerts when a surveillance camera picks up something unusual; that function, he says, is more desirable in the marketplace right now than the ability LiveLight offers to deliver an edited video after the fact.

As for Xing’s original subject, now five and half years old, “he was very amused and proud” about being featured in the demonstration video for LiveLight. Xing uses the technology on his own iPhone, and he’s not shy about showing off his son’s video antics now that they’re being automatically edited.

“Even though it’s not perfect,” he says of his 30-second clips, “at least I’m not wasting people’s time.”

—Broadcaster and freelance writer Scott Fybush is based in Rochester, N.Y., where he operates NorthEast Radio Watch. This is his first Link byline.
Putting Watson to work

The question-answering system that bested two human champions on the game show “Jeopardy!” is preparing to move out of the lab and onto your phone.

By Linda K. Schmitmeyer

Technical competitions can spur world-changing innovations. Frenchman Nicolas Appert was awarded 12,000 francs for developing an airtight food-preservation process that allowed Napoleon to feed his far-flung troops, and canned food was born. Charles Lindbergh received a $25,000 cash prize for his solo flight across the Atlantic, beating his competitors (six of whom died trying) and long-distance air travel soon became routine.

SCS professor Eric Nyberg is hoping the spirit of competition will inspire students in a new course to develop an innovative, award-winning application for mobile devices using IBM’s Watson technology, the same technology that beat two Jeopardy! champions in an on-air match in 2011.

The course, “Intelligent Information Systems featuring IBM’s Watson,” was offered for the first time in the fall 2014 semester and is being taught by Nyberg (CS’92), a professor in the Language Technologies Institute; Alan Black, an associate LTI professor with expertise in mobile speech interfaces; and Norman Sadeh (CS’91), a professor in CMU’s Institute for Software Research and an expert in mobile devices. Members of the IBM Watson Group research team that developed the Watson technology also are presenting guest lectures.

“The students will marry Watson’s technology with the personalized and more geographically contextualized information you get from a mobile device,” says Nyberg, a leading researcher in question-answering, or QA, computers, a discipline focused on developing systems that can answer questions posed in natural language. In 2008, Nyberg led the team of CMU researchers who helped IBM create the Open Advancement of Question Answering initiative.
CMU computer scientists also contributed two important pieces of Watson's software—an algorithm which identifies the best written resources for answering a question about any given topic, and another algorithm which scores possible answers, helping Watson to identify which answer has the highest likelihood of being correct.

According to Nyberg, the students have access to a copy of Watson via the Watson Developer Cloud, but not to its source code. During the course, they are selecting an appropriate domain for their application; ingesting relevant data from that domain; testing, evaluating and training its responses; developing and designing a prototype; and creating a business plan for marketing the app.

“This is the first time IBM has given universities access to an instance of Watson via the Cloud for a course,” says Pam Induni, who leads the Watson University Engagement team, part of IBM’s Watson Group. Her team is working with CMU and nine other North American universities to offer a cognitive computing course leveraging Watson. (The other universities are New York University, Northwestern, Ohio State, Rensselaer, Stanford, the University of California at Berkeley, the University of Texas at Austin, the University of Michigan and the University of Toronto.)

On Jan. 9, 2015, students from the participating universities will pit their apps against one another in a competition at IBM headquarters in New York. They will be evaluated on the overall idea, the prototype, the quality of the dataset, their training of Watson, the business model and their presentation. The winning team will receive $100,000 in seed funding to create a startup for the prototype.

In a brainstorming session during Carnegie Mellon's first week of classes this fall, ideas for possible applications using Watson's technology spanned many domains: from the legal, where users might ask non-complicated questions, like what kinds of weapons can legally be carried in the city of Pittsburgh; to sports, where someone learning to hit a baseball could ask how best to execute a swing; to navigational, where one could plan a romantic getaway to a city at specified time—the user would receive recommendations for places to stay and sites to visit, and the computer might even suggest a schedule that optimizes the couple’s time together.

SCS junior Elan Rosenfeld, who says he signed up for the cognitive computing course for a chance “to learn a ton about machine learning,” says he likes the idea of developing a navigational app, which could utilize a user’s personal data, such as geographic location and search history.

“The challenge with developing (the trip-planning) app would be the size of the corpus, the amount of data Watson would be ingesting,” Rosenfeld says. He favors a prototype that could plan an individual night out in a single city, which would allow for more effective testing and training of the dataset.

“Then, if we decided we wanted to turn the prototype into an application, we could ingest data from other cities,” Rosenfeld says. “Certainly if it were deemed good enough to win $100,000 in seed funding from IBM, it would be worth making an app that could be used internationally.”

Whatever application the students will be presenting in January, they are being guided in their decision by CMU faculty and the IBM mentors who are working with the participating universities to provide technical and other support for the software. Ken Barker, a researcher in IBM’s Watson Group, is the course mentor for the University of Texas at Austin, where he was a research scientist for 11 years before joining IBM’s Watson Group in 2011.
Although the syllabus centers on developing innovative apps using Watson technology, the goal of the course is to build the cognitive skills necessary to create “an ecosystem of innovators” with expertise in such fields as machine learning, content lifecycle management and natural language processing, says IBM’s Induni.

“Cognitive is the next era of computing, and these courses are about developing the skills of the next generation of software developers,” Induni says. “Lots of industries will be implementing Watson technology, and they’ll need these very skilled employees. Out of CMU and the other universities will come the next generation of Watson developers, researchers and innovators.”

If history is a reliable guide, a technical competition is one way to make that happen. “It’s a friendly competition,” Nyberg says, “but it is a competition.” He and Ken Barker have been ribbing each other via email, even before the semester began. The two have worked together professionally for about five years, since Nyberg led the CMU team that helped develop Watson’s QA capabilities for IBM.

Barker calls it “a brotherly rivalry,” but adds, “tell Eric we’re coming for them!”

—Linda K. Schmitmeyer is a freelance writer and editor, and teaches in the Point Park University School of Communications.

CMU computer scientists contributed two important pieces of Watson’s software—an algorithm which identifies the best written resources for answering a question about any given topic, and another algorithm which scores possible answers, helping Watson to identify which answer has the highest likelihood of being correct.
In June 2014, Anind K. Dey was named the Charles M. Geschke Director of the Human-Computer Interaction Institute. A graduate of Simon Fraser University with a bachelor's degree in computer engineering, Dey also earned master's degrees in aerospace engineering and computer science, as well as a Ph.D. in computer science, from Georgia Tech. Prior to joining the CMU faculty in 2005, he was a senior researcher at Intel Research Berkeley and an adjunct assistant professor in the Electrical Engineering and Computer Science Department at the University of California at Berkeley. He spoke to Link Editor Jason Togyer.

**What was your first technology experience?**
My brother had a Texas Instruments device that was somewhere between a calculator and a computer. He’s seven years older than me, and was very interested in computing. It was the first device that he taught me how to program.

**Did he end up in math or computer science?**
He did a master’s degree in mechanical engineering. He was a roboticist for a while and now he’s in the IT industry doing computing.

**Was it your intent to become an engineer?**
It was. Partway through my undergraduate degree, I visited a company that made six-degree-of-freedom motion simulators for aircraft, and I thought that was what I wanted to do for the rest of my life. I said, “What do I need to do to get a job here?” They said “Leave Canada, go to the U.S., get a Ph.D. in aerospace engineering and then come back.”

**Why didn’t you stay in aerospace engineering?**
It wasn’t for me. But I was talking to some of my mentors at the time and they said that it seemed like based on my interests, I could do really well in computer science. I stuck it out for one more year to get a master’s degree in aerospace engineering—so now I get to tell my kids that I’m a rocket scientist! Then I switched into computer science, and ended up getting another master’s degree and a Ph.D. in computer science.

**Where is the line between computer engineering and computer science?**
It’s extremely fuzzy. It used to be that if you were doing software, you were doing computer science, and if you were doing hardware, you were doing computer engineering. Now I have students in ECE who would fit into our department in HCII. To me, the line is so fuzzy as to be non-existent.
Talk to me about the maker movement. What, in your mind, is triggering it?

A couple of things. Technology has become super-cheap, and really accessible. Before, you needed a strong skill set to use some of these technologies. Now, the tools are so supportive, even for novices, that someone can quickly put together software and hardware, and do things that they wouldn’t have been able to do before.

Some people look at Arduino or Raspberry Pi and say, “They’re just toys.” Are they a gateway to bigger science?

I think they are—particularly for young kids. Our kids at home started off just doing some very simple things in Scratch. We tried to keep them away from the technology, and they asked for more. Now, my 8-year-old daughter is working on an Arduino board with my wife and trying to build an MP3 player. It’s so accessible that kids are able to use their creativity to build some really interesting things. They’re not just sitting in front of the computer and playing games any more. I really think this is a great time. There’s this idea that everyone should be able to think in a computational way, and the maker movement is embracing that.

Will we see a payoff in 20 or 30 years?

I think we’ll see a huge payoff. You’ll have a population that has an innate understanding of how to use technology, and how to apply it, that I never grew up with.

Is there still a danger that people will become too dependent on technology—mere consumers rather than creators?

That’s a millennia-old debate. I do have this worry that sometime in the distant future we may reach a time when we’re totally dependent on technology, but I don’t think we’re anywhere close to that. And the human desire to be creative and to build and invent—I don’t see how it would ever go away.

How did you become interested in computer interfaces and HCI?

It was all because of my greatest mentor, my Ph.D. advisor at Georgia Tech, Gregory Abowd. He was a software engineer who had moved into HCI. He was the one who introduced me to it and helped me realize that it was an interesting field and that I could be successful in that field. Working with him on my Ph.D. was very much geared toward how people would interact with novel computing technologies.

We used to expect people to adapt to their computer. Now we expect the computer or interface to adapt to the people. That’s a major mind shift.

It is. I don’t think our technology is there yet. In order to really understand you, or be able to adapt to you, a system has to be able to understand your intentions. Not just what you did, but maybe why you did it, so it can be predictive and provide you the support you need, while at the same time being cognizant that you need to do some things for yourself. I think the idea of a system adapting to you is actually a lot more complex than we make it out to be sometimes.

What are your research interests now, broadly described?

The thing I’ve gotten most excited about recently is the idea that we can learn people’s routines over time. There are technologies we can use to understand your behavior, and that’s everything from your smart phone to the physical tracking device you might wear on your wrist. My particular interest now is trying to identify what is routine behavior, and what is not. This might be interesting, for instance, if you have someone who is at risk for cognitive decline. You can monitor routine behavior, and as soon as you start noting anomalous behavior, you might say this is the time when an occupational therapist should come and make a visit, or this person should go see their PCP right now. Similarly we’re working on some projects where we’re trying to automatically identify good drivers from bad drivers. What if you could understand what normal, good behavior was, and what anomalous, poor behavior was and try to adapt these or make these assessments more personalized? Our goal is not just to perform an assessment, but to actually use the assessment to be a teaching tool later.

How are we protecting people against invasions of privacy or loss of security when we’re collecting all of this data on their habits?

Our take on it, in our research group, has been that the data never leaves the device. If you’re always doing the processing locally to figure out if something is routine or not routine, then it’s just a collection of applications that can use that data, which hopefully are applications that you’ve installed and that you’ve given permission. There are applications that are malicious and can steal that data, and certainly privacy and security are questions that need to be addressed. Fortunately, we have a great group here at CMU that works on those kinds of problems.

What outside interests do you have?

My kids are my main hobby right now. We have two, ages 8 and 10, and I’m teaching my 8-year-old how to run—I used to be a sprinter in college. I also love to cook with my family—it’s one of my favorite activities. We spend a lot of time traveling together. I love to listen to music—although I’m probably the least musical person in the family. And I’m also a huge hockey fan. →
Inventing the
future

By Nick Keppler

In 1986, the most impressive computer on the market was Compaq’s 44-pound Deskpro 386, with its 32-bit microprocessor and four kilobytes of memory.

But at Carnegie Mellon University, Allen Newell was already picturing a future where computing power would keep increasing to nearly unimaginable levels. If Moore’s Law, which states that the capabilities of computers will double every two years, continued to prove true, there would (in a few decades) come computers powerful enough to perform nearly any function asked of them.

What would be next for computer science then? So Newell, an artificial-intelligence pioneer who had been one of the leaders of the university’s computer science programs since the 1960s, was focusing on the study of man’s relationship to machine. In 1983, along with CMU alumni Stuart K. Card (TPR’70, DC’78) and Thomas P. Moran (CS’74) of Xerox’s Palo Alto Research Center, Newell co-authored the book “The Psychology of Human-Computer Interaction,” which popularized the phrase, “human-computer interaction.”

Newell, who died in 1992, would be proud and perhaps amazed by what’s grown from the seeds he planted. For the past 20 years, CMU’s Human-Computer Interaction Institute has been the leader in what—as Newell predicted—has become one of the most vital subsets of computer science. And the researchers who founded the HCII, many of them Newell’s colleagues, “have become the all-stars of this field,” says Anind Dey, who was named the Charles M. Geschke Director of the Human-Computer Interaction Institute in June.

More than 200 alumni and past and present faculty members gathered in Pittsburgh Nov. 14, 15 and 16 to mark the HCII’s anniversary with a grand conference (and a party) that included workshops, demonstrations of current projects and tutorials. Sponsors included Visa, Google, Bloomberg, The Walt Disney Co. and Microsoft.

Founded in 1994, HCII was the first academic program to offer a Ph.D. in human-computer interaction. Today, the department’s 40 faculty members and 200 students—comprised of psychologists, cognitive scientists, graphic and industrial designers and computer scientists—together annually contribute about 10 percent of all the papers submitted to the Association for Computing Machinery’s CHI Conference on Human Factors in Computing Systems.

‘More central’ than computer science itself?

“Many departments can point to a few particular research projects that are important, but our strength is in our nimbleness and breadth of the impact of our research in the HCI area in general,” says Brad Myers, CMU professor of human-computer interaction, who helped develop the concept of user-interface toolkits and led CMU’s User Interface Software Group, which created the Garnet and Amulet systems for rapid development of graphical user interfaces.
In educational scope, too, HCII stands out, with more than 500 alumni, many of whom now hold leadership roles at other universities or in corporate research and development departments. HCII today offers undergraduate, master’s and doctorate degrees, and organizations such as Apple, NASA and the RAND Corporation regularly sponsor HCII’s research and even outsource problems in interface design to the department.

HCI “started out as a field where we tried to understand how people used computers,” says Dey, a member of the HCII faculty since 2005. Now, he says, “we’re at a place where we’re focusing not just on how to understand how people are using today’s technology, but using that information to guide the design of new technology.”

More than a generation after Newell predicted the importance of human-computer interaction as a research area, the rest of the world appreciates the usefulness of HCI, in part because computers are mediating nearly every aspect of our everyday lives—from shopping to job searching to looking for a spouse.

“(HCI) is becoming more central to computing than computer science itself,” says Jim Morris (S’63), former dean of the School of Computer Science and currently a professor of computer science and human-computer interaction. “Computer science has done such an incredible job of advancing the engineering and mathematics behind computing, that integration (of technology) into our world is now the bigger problem.”

There was a void of research into human-computer interaction in the 1980s and early 1990s—there were even doubts that HCI was a field worthy of study. But no one thinks that way today.

The void was filled, in large part, by CMU’s Human-Computer Interaction Institute—though the process of getting there wasn’t as neat and orderly as you might expect from an endeavor started and planned by computer scientists.

Roots in wartime studies of ‘pilot error’

The field of HCI traces its roots back to World War II, when the government funded university research into what was then called “human factors and ergonomics” in the design of airplane cockpits in order to decrease pilot error. But although industrial designers were studying the physical layout of controls for tools, vehicles and appliances, few people were applying the same principles to computer interfaces. Computer controls often consisted of little more than cryptically labeled knobs, lights, wires and buttons—the Altair 8800, one of the first popular microcomputers marketed to home users, was programmed from its front panel by using 24 nearly identical metal toggle switches.

In the mid-1970s, Xerox’s PARC research lab created the Alto—the first personal computer to combine use of a mouse with a graphical user interface that organized files on a “desktop.” Newell was a big fan of Alto. So was Apple co-founder Steve Jobs. While Xerox donated Altos to CMU, Massachusetts Institute of Technology and other universities, there were few research papers written about the system. Even Xerox failed to understand Alto’s importance, and stopped development in the early 1980s.

The importance of human-computer interaction just wasn’t obvious, either in industry or academia. “There were conferences on it here and there,” recalls Bonnie John (DC’84, ’88), currently an adjunct professor in the Human-Computer Interaction Institute, and then a CMU graduate student, “and there were some places that were good at it—the University of Colorado at Boulder, Georgia Tech—but there really weren’t many places focusing on it, certainly not any when we (in the ’80s) were coming up.”

Newell was CMU’s most passionate evangelist for bringing academic rigor and discipline to the study of HCI. “In the mid ’80s, he called a meeting of the (Department of Computer Science) and said we should do HCI,” recalls Morris, then the director of CMU’s Information Technology Center, which developed Andrew, the
“(HCI) is becoming more central to computing than computer science itself. Computer science has done such an incredible job of advancing the engineering and mathematics behind computing, that integration (of technology) into our world is now the bigger problem.” — Jim Morris

university’s revolutionary computer network that combined advanced applications with a GUI desktop environment. “About 40 people showed up and we were all enthusiastic,” Morris says. “As with many things, nothing happened because no one had a stake in it.”

To be sure, there was interest at CMU from people besides Newell. Before Duane Adams left his position as deputy director of the federal Defense Advanced Research Projects Agency, he sent email to all of his soon-to-be-former colleagues, imploring them to step up their research into HCI and software development. After leaving DARPA, Adams joined the CMU faculty, where he continued to push for more study of HCI. Nothing concrete happened until several months after Newell’s untimely death.

In 1989, along with cognitive psychologist Peter Lucas and industrial designer Joseph Ballay, Morris launched MAYA Design, a consulting firm that helped clients solve problems in human-computer interaction. But Morris stepped down from day-to-day leadership of MAYA to return to CMU and head the Computer Science Department. Now, along with Myers and Bonnie John, both then junior faculty members, Morris pressed ahead with plans for an HCI institute, at least partially to fulfill Newell’s wishes. One person they wanted to recruit was Robert Kraut.

Kraut was a Yale-educated psychologist who had faculty stints at Cornell and the University of Pennsylvania. He had a keen interest in group dynamics and how they’re impacted by technology. Kraut was not in academia at the time: He had moved into a job at Bellcore, one of the research and development groups that was spun out of the breakup of the Bell System. “I wanted back into academia,” Kraut says. “For the work I was doing, there were only two schools to consider—MIT and CMU—so I put some feelers out.”

Despite Kraut’s expertise in user interactions with technology, and despite his many supporters in the recently created School of Computer Science, hiring Kraut was seen as a no-go.

“The reaction of several faculty was that ‘Bob Kraut is a brilliant researcher, but he’s not a computer scientist … we’re not qualified to evaluate him,’” Morris says. “We ran into a lot of resistance inside CS.”

“One of the major reasons we wanted to found an institute (of HCI) was that we wanted to hire Bob Kraut,” agrees Myers, a graduate of MIT and the University of Toronto, who joined the CMU faculty as a research computer scientist in 1987.

As created in 1989 (see “Institutional Memories,” The Link, Summer 2014), the School of Computer Science had no departments—the faculty comprised one collective group, drawn together from the former Computer Science Department, the Center for Machine Translation, the Information Technology Center and the Robotics Institute. If there were a separate department within SCS that was dedicated to the social implications of computer use—instead of, for instance, software, algorithms and programming languages—it could have its own criteria for hiring. The idea of an HCI institute became a frequent topic at faculty meetings.

“The School of Computer Science was just getting too big,” Myers says. “It was monolithic. There were formal theory people and AI people, plus a few systems people. It made sense (for SCS) to branch out.”

There was another reason for creation of an HCI institute: gender balance. The School of Computer Science was almost entirely male, Morris says. “There’s just something about that culture of nerds talking to other nerds that excludes women, even women academics,” he says. He thought an institute with one foot in psychology—a field with better gender balance—would draw more female academics into the SCS.
Morris and other faculty members put the idea into a memo to Raj Reddy, then dean of SCS. Other contributors included John; Myers; CSD research scientist Roger Dannenberg (CS’81, ’83); Steve Shafer of the Robotics Institute; and members of CMU’s Psychology Department, including professor John Anderson, research associate Al Corbett and then-postdoc Ken Koedinger (DC’90).

“Computer science has not studied (HCI) issues adequately to date, but they are critical to the broadening issue of computers in society,” they wrote. “Accordingly, there are new opportunities for funding in this area; and CMU is poised to pursue them. However, we have been lacking an adequate framework within which to crystallize these studies and come to grips with its inherently interdisciplinary nature … we have concluded that the appropriate structure would be a new HCI Institute within the SCS.”

‘We had 10 pigs, and five chickens’

Reddy—founding director of the Robotics Institute—understood the advantages and flexibility that semi-autonomous institutes had within a school. CMU’s Human-Computer Interaction Institute was green-lit in 1994, with Morris as its first director. Kraut got his faculty appointment in 1993—a joint appointment between the School of Computer Science, the Department of Social and Decision Sciences in H&SS (now CMU’s Dietrich College), and GSIA (now the Tepper School of Business).

HCII was created with a “three-legged stool” approach: Computer science formed one leg of the stool, along with psychology (to understand how people could and would use computers) and design (to best present and acclimate technology to users).
Early research into the Internet surprises the industry

In the meantime, Kraut was conducting some of the earliest research into how people would use the Internet in their leisure time. Back in 1995, only 17 percent of U.S. adults were using the Internet on a regular basis, according to the Pew Research Center, and there was little data on what they were doing online. The National Science Foundation, Apple, Hewlett-Packard, Bell Atlantic and other firms agreed to sponsor “Homenet,” a project to study “residential Internet usage.” (Another sponsor was the U.S. Postal Service, which wanted some actionable insight into its suspicion that email would diminish its load of letters and paper documents.)

Kraut and his co-researchers provided 157 families in Pittsburgh, from a wide range of racial and economic backgrounds, with a computer and net access. They also held three-hour classes in which they explained to the families how to use the Internet.

They learned “the Internet was being used for socializing,” Kraut says. Thirty-five percent of respondents used it to communicate to people from afar, and 24 percent to communicate with those who lived nearby. Twenty-nine percent of users reported using the Internet for schoolwork, and 17 percent for reading news. Their discoveries wouldn’t surprise anyone in a post-Facebook world, but it was a shock, Kraut says, at a time when Vice President Al Gore was describing the Internet as an “information superhighway,” and most people were thinking of it as a place where you went to look up facts.

Yet the socializing didn’t make users feel more connected; in fact, Kraut says, those who reported socializing online felt more isolated. “They were investing social time with people they didn’t really have a connection with,” he says.

proposed a method called “Goals, Operators, Methods and Selection” as an alternative to costly, time-consuming field tests. GOMS was a kind of specialized model for the way that humans process information. It used measurements of motor skills to predict how well a skilled person could use a new program or device. With GOMS, “you could test machines before they were even built,” John says.

The NYNEX project was the perfect opportunity to prove the effectiveness of the GOMS method. The research project was dubbed “Project Ernestine,” after Lily Tomlin’s telephone operator character on “Laugh-In.”

Using video of operators in action, John and co-researchers were able to dissect every keystroke that went into taking a call and predict how long operators would take on the new stations, crunching the numbers through a GOMS analysis. The analysis found that the new workstations were turkeys. They were actually slower than the existing workstations; it would take the operator 0.63 seconds longer to handle the average call on them. Some baffling design decisions meant that operators needed more time to read the screen and make the actual keystrokes. The researchers then compared the theoretical model to one of NYNEX’s own field tests to see if they got the same results. They did not. More importantly, John’s GOMS analysis was able to predict results in six weeks; NYNEX’s field test took six months.
A sampling of HCII research highlights

From work interruptions to the tiny-ness of mobile device screens to memory impairment, researchers at the HCII are tackling both expected and unexpected dilemmas. Here are just a few.

**INTERRUPTIBILITY STUDY**

- **Years published:** 2001 to 2008
- **Principal Researchers:** Scott Hudson, Jodi Forlizzi and Robert Kraut
- **Sponsors:** National Science Foundation, Intel, IBM

**The problem:** Interruptions and the effort to refocus after them consume two hours of the average office worker’s day and cost the U.S. economy $588 billion a year, according to a survey from Basex, an information technology research firm. Although coworkers can see that you are busy and hold off asking you to put in $5 for Angela’s birthday cake, technology has allowed for an array of disturbances that don’t respond to real-life situations—from emails to phone calls to endless software prompts to update Microsoft Office and Adobe Flash. Can we create technology that knows when users shouldn’t be disturbed?

**The methods:** Using web cams, Hudson and his associates observed several groups of people working. One was a group of programmers. (“They represent concentration in the purest form,” he says.) Another was comprised of CMU administrators. All were asked at random but regular intervals how “interruptible” they were at the moment on a scale from 1 to 5. In the footage, the researchers looked for signs of “un-interruptibility,” ones that an electronic sensor could pick up, such as other people present, conversation happening, keyboard and mouse use, etc.

**The findings:** In one study, Hudson and company found that the presence of signals that could be picked up by a sensor accurately predicted a person’s self-reported state of un-interruptibility 76 percent of the time. That’s 3 percent better than a pool of other subjects tasks with viewing the footage and scoring how “interruptible” the subjects seemed. These findings could be put to use to create “smart office” software that automatically holds off alerting the person to a new voice mail or email whenever it sensed he or she was busy, or to smarter smartphones that can tell when to hold off on low-priority items, Hudson says. “We wanted to see if a phone or a computer could be programmed to be polite,” he adds.

**SKINPUT**

- **Year published:** 2010
- **Principal Researchers:** CMU’s Chris Harrison (CS’13) and Desney Tan (CS’04) and Dan Morris of Microsoft Research
- **Sponsor:** Microsoft

**The problem:** Handheld or wearable devices are ubiquitous. Everyone (well, almost everyone) has a smartphone, and smart watches are starting to take off as well. But there are still a limited number of things one can do on such a device due to the space limitations of the screen. “Graphic designers don’t work on iPhones,” says Chris Harrison, now an assistant professor in the HCI, “and no one writes their term paper on them.” What can you do on a screen of that size?

**The methods:** Working with Microsoft researchers in Redmond, Wash., Harrison sought a replacement for the touch screen that could be placed on the body itself. They considered a glove or other garment with touch sensors but then hit on a better idea: use the surface of the skin. “There are a lot of rich acoustics in your arm,” Harrison says, “It creates a different sound when you tap different places.” The system they designed, Skinput, was able to measure these sounds, creating the basis for an alternative to touch screens—an interface projected onto the forearm from a device worn from the arm or shoulder.

**The findings:** After many months of work, Harrison and his co-researchers created a usable prototype, one that could be mass-produced as cheaply as an iPhone. Still, some kinks remain to be worked out before Skinput based devices are available at your neighborhood Best Buy. “It has about 96 to 97 percent accuracy,” Harrison says. “That’s encouraging, but you need 99 to 100 percent accuracy; if your keyboard only worked 96 to 97 percent of the time, that’d be infuriating.” Also, it’s the size of a deck of cards, cumbersome and unsightly even to the tech crowd. “You’d look pretty dorky wearing this thing around,” Harrison says. “I’d even have a hard time imagining it worn at CMU and this is a pretty dorky place.”

**LIFEGLOGGING**

- **Year published:** 2012
- **Principal Researchers:** Anind Dey and Matthew Lee (CS’11,’12)
- **Sponsors:** National Science Foundation, Microsoft Research, Quality of Life Technology Center

**The problem:** 24.3 million people suffer from dementia worldwide, and according to the U.K. medical journal Lancet, the number will balloon to 81.1 million by 2040. In addition to lowering the quality of life of people suffering from dementia, memory impairment caused by the condition often causes friction between those afflicted and their families. “The caretakers will prompt them on events that happened just an hour ago,” Dey says. “It’s frustrating to the point of anger.”
All of this research was important, but Reddy had another message for the faculty of the new institute. They needed to provide education as well. Morris is characteristically blunt: "Raj told us … if we were going to make any money, we would need a master's program." The HCII began offering its first master's degree in 1995. The undergraduate program, offering a second major, began in 1997, and the doctoral program began in 2000. Last year, the HCII also added an HCI minor. "One day soon, I think we'd like to consider having an independent major and recruit students directly into our HCII program," Dey says.

Compared to other universities, HCII master's degrees compress about two years of work into a 12-month span. In addition to the core master's in human-computer interaction that launched the institute, HCII last year added a master's in education technology and learning science, or METALS, which started with seven students and now has 20. (See “Training teaching's technologists,” The Link, Summer 2014.)

At the heart of the HCII master's programs is a unique Capstone Project assigned to teams of students each year. In order to graduate, master's students must complete this real-life project sponsored by an outside corporation or agency, such as Google. Those agencies pay the HCII for the work produced by students; more importantly, they provide real feedback on real problems. “It is the hardest project you have ever completed,” says Jack Beaton (CS'07), who earned his master's degree in human-computer interaction and went on to work for Nokia and Accenture. His team's project was creating a handheld prototype of a device for logging technical issues and operational errors for NASA. It's still the most difficult problem he's ever worked on. Beaton says, "Everything I have done since has seemed manageable." In the fall of 2007, the HCII began offering a dual-degree master's program in partnership with Portugal’s University of Madeira. During 2013, the most recent year for which complete figures are available, HCII granted 66 master's degrees and two doctorates. The department had 91 master’s students and 39 doctoral students; as Morris had hoped, the ratio of men to women is almost even, according to figures supplied by the university.

The methods: After seeing a friend suffer memory loss due to traumatic brain injury, then-Ph.D. student Matthew Lee began to consider the use of recording devices to aid in memory. Lee and his advisor, Dey, found some promising prior research involving rapid serial visual presentation, or RSVP—a process where the afflicted person wore a camera that automatically took pictures that were shown back to them, rapid-fire. Dey and Lee hoped to improve on it. They recruited about 20 people with impaired memory from local support groups. Before events, such as dinner parties or weddings, they were outfitted with a Microsoft SenseCam, a wearable camera that took random photos but could deduce the best times for meaningful ones; for example, when human faces were present, or when the person was still, and therefore had probably stopped for something or someone. Using a combination of photos and audio from the day, Lee and Dey asked the participants to put together slideshows that would later help jog their memory of the day. For comparison, these were compiled in three different ways: by the memory-impaired person, by the person and his or her caregiver and using random audio and video from the day.

The results: The slideshows compiled with these methods "were better than the RSVP" in helping the subject retain memory, Dey says. The self-compiled slideshows were the most helpful, on average; if the subject compiled it him or herself, he or she was able to remember an average of eight details of the event a day after it happened, and six details of the event 28 days later, as opposed to six and four (respectively) if the caregiver compiled it. And the time spent making the slideshow as a team also was time well spent. One wife of a memory-impaired person said the process was “something we did together—which doesn’t happen often.” The process was an exercise in memory and it did help strengthen the memory, Dey says: “The participant was able to remember things not in the presentation, which was a really good sign.”

Adding an entrepreneurship leg to HCI education

One measure of the importance and effectiveness of HCII’s educational programs is the number of Ph.D. alumni who hold leadership positions at other institutions around the world, Myers says. “We can now trace influences down about five generations,” he says. 

The link.
HCII education still has its three traditional legs—design, psychology and technology—but a fourth leg is becoming more important, according to Dey. “I think it’s time that we add a business and entrepreneurship component to that,” he says. More and more alumni are landing jobs with boutique firms and startups, Dey says. “In terms of educational programs, our goal isn’t just to educate students, but also to make sure that there are jobs for them to get when they’re finished,” he says. “We need to start thinking about how we bring business acumen and business development into our program, particularly for our students who are going to go off and be practitioners of HCI in the field.”

The notable research by faculty members and grad students continues to add up. John Anderson worked on ACT-R, an ambitious program to reconstruct human cognition in programming language, perhaps the ultimate expression of the HCII’s study of the bridge between man and machine. Myers headed up Pebbles, a multi-project research trove that integrated smartphones and other handheld technology into the use of regular household appliances and personal computers. Jennifer Mankoff led StepGreen, an umbrella project dealing with limiting energy consumption.

Among research areas that continue to resonate, there is the work of professor of human-computer interaction and design Jodi Forlizzi, as well as that of Kraut and Kiesler. Forlizzi’s research into interaction design and social behavior has helped shape technologies ranging from on-screen displays to assistive robots that can help people with physical or mental challenges to live independently. Kraut and Kiesler’s continuing research into the social and interpersonal aspects of computer networks has both predicted applications such as Facebook and Twitter, and helped to shape them. “It might be hard sometimes to trace that lineage, but it’s there,” Myers says.

Kiesler, for instance, has done extensive studies into group behavior and decision-making among people collaborating on large, distributed projects via the Internet. She and Kraut, along with Paul Resnick of the University of Michigan and others, conducted a five-year research project to study the growth of online communities. The resulting book, 2012’s “Building Successful Online Communities: Evidence-Based Social Design,” examined both quantitative and qualitative data to find out why some communities (such as Wikipedia) seem to keep evolving, while others are torn apart by disruptive participants or wither and die from lack of interest.

The success of the Human-Computer Interaction Institute has been emulated in the academic world; John says she knew the HCII model was successful when she started to see other departments, at other universities, set up along the same lines that CMU had used. But as Dey points out, that also means that HCII now faces competition for students and funding that didn’t exist 20 years ago. “I think there are some unique opportunities that we have at CMU that make it hard for others to compete with,” Dey says. “Our ability to have this really interesting combination of faculty from multiple disciplines all in the same place, that we’re all together, and we all meet often, means that we’re able to come up with novel ideas on a fairly regular basis.”

Those “novel ideas” by HCII faculty members continue to win the respect of their peers around the world. In 2001, ACM’s Special Interest Group on Computer-Human
Interaction, or SIGCHI, created the “CHI Academy,” an honorary society for those researchers who have made the most important contributions to the field of human-computer interaction. Of 93 honorees, six are current HCII faculty members—Kiesler, Kraut, Myers, John, Scott Hudson and Forlizzi. Past CMU faculty members in the CHI Academy include Newell (who was elected posthumously) and the late Randy Pausch (CS’88), who was inducted a few months before his death in 2008.

Other members of the CHI Academy with CMU connections include Card and Moran (who were part of the first group of CHI Academy inductees, in 2001) and the University of Washington’s James Landay (CS’93, ‘96). Card, Moran and Kiesler also are recipients of SIGCHI’s Lifetime Achievement Awards (in 2000, 2004 and 2009, respectively).

**Human-computer interaction on-the-go**

One change in the work of the HCII has been both shaping and reacting to the shift from desktop computing to mobile computing on smartphones, tablets and other devices. “Our smartphones provide a wealth of data about how we really think and act,” says Jason Hong, an associate professor who joined the HCII in 2004. “From the time I get up to the time I go to sleep, there is this little device recording data about everything I do. Psychologists used to only have access to the attitudes that were observable in the lab and that people would freely give them. That’s no longer the case.”

Chris Harrison (CS’13), a recently recruited assistant professor, says he picked human-computer interaction, and the HCII, because he felt other branches of computer science had fewer new avenues to explore. Computer reliability and processing speed, for instance, isn’t the issue it once was. “The PC I had in high school crashed all the time,” Harrison says, “but my laptop hasn’t failed in months. In that short period of time, computer performance has improved so that it’s no longer an issue for most people.”

If researchers want to advance the field of computer science, Harrison says, they need to be looking beyond increases in computing power and instead increase the range of things people can do with that computing power. For fun, Harrison and a colleague recently crunched some numbers to compare the power of an early 1990s supercomputer with devices that can be purchased at Best Buy. They concluded that if a time-traveler from 2014 went back to 1994 (the year the HCII was founded) with an iPhone 6 in her pocket, she would possess the third-most powerful computer on the planet.

“We’ve figured out how to put these very powerful computers, by historic standards, in tiny devices, but so far we don’t do all that much on them,” Harrison says. “We send emails and texts and take Instagram photos, when they’re capable of so much more.”

Harrison is one of the young faculty members who are “expanding our worldview of human-computer interaction,” Dey says. “We have individuals who are combining human-computer interaction with games and behavior change,” he says. “Those are areas we’ve explored a little bit in the past, but with these new hires, we’re being able to explore them quite a bit more.”

Powered by the Internet and the mobile phone revolution, it seems that we’re all living in the future that Allen Newell predicted. “Thirty years ago, we couldn’t have predicted either of these technologies,” Dey says, adding that 30 years from now, “I expect there will be similar kinds of revolutionary technologies that will occur, that will cause our field to shift.

“It’s a little bit of a strange line to walk on,” he says. “In some ways, we have to be very reactive to what happens in the world, because we study the world and the people in it. In other ways, we’re trying to invent the future.”
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Introduction

When a person receives a traumatic injury to bone or tissue, platelets circulating in their blood are responsible for beginning the healing process. An array of growth factors and other signaling molecules are released into the injury site upon platelet activation, providing the cues needed to help orchestrate self-repair by the body.

It seems logical that collecting a patient's own blood plasma, concentrating the platelets and then injecting the concentrated plasma back into the injury site should accelerate healing and overcome the body's limitations to tissue repair caused by age, disease or when tissues lack a sufficient blood supply.

This type of therapy uses what is called concentrated platelet-rich plasma, or PRP. It is an exciting but somewhat controversial new treatment option for a variety of orthopedic and sports medicine applications. The highly publicized use of PRP therapies by professional athletes, including former Pittsburgh Steelers wide receiver Hines Ward, has created significant hype.

Unfortunately, with few controlled studies, evidence in many instances has been anecdotal, and a number of published studies have called into question PRP's effectiveness. One widely reported study examined the effectiveness of PRP to heal chronic Achilles tendon injuries, and found that PRP treatment was no more effective than the control treatment of saline. These mixed reports have created a skepticism regarding the use of PRP and any new PRP treatment.

In addition, PRP is not a simple, off-the-shelf treatment. It must be manufactured for each patient at the time of the procedure. Controlling the delivery of PRP at the site of injury is also highly problematic. There is also a great deal of clinical variability—patients' blood plasma varies widely in both the quantity and quality of platelets and growth factors.

An engineered material that can reduce this variability, and also be provided as a cost-effective, off-the-shelf product, can overcome the limitations of PRP while still augmenting healing in a safe and natural manner.

What are PBMs?

With these goals in mind, Carmell Therapeutics, a CMU spinoff company based in Pittsburgh, has developed solid, biologically active materials called plasma-based biomaterials, or PBMs. PBMs are designed to take advantage of the regenerative potential of PRP, but reduce its drawbacks. PBMs are made with pooled plasma units from multiple donors, collected in U.S. blood banks, and processed into plastic-like materials that remain bioactive. Pre-clinical data supports PBM biocompatibility and retention of growth factor activity, while clinical data described below support its safety and efficacy.

PBMs are inexpensive to manufacture. They are safe and can be supplied as an off-the-shelf product. They are also formable into complex 3-D shapes, and biodegradable with tunable biomechanical and degradation properties. Overall, PBMs represent a platform technology with significant potential to be a disruptive new therapy option in a variety of clinical applications, not only in major clinical markets, but also in developing countries, where the need is high, but the cost is a barrier to treatment.

The need for new healing products

There is a great need for effective, consistent and cost-effective products that can biologically enhance tissue healing. Injuries to connective tissue—tendons, ligaments and cartilage—are difficult to heal, requiring months of recuperation, and they often result in poor clinical outcomes.
Tissue and bone

Physicians have begun to look for ways to improve the healing of soft tissue and bone, and are rapidly embracing the use of autologous PRP—that is, PRP made from a patient’s own blood plasma—manufactured in the operating room, as it contains a concentration of natural growth factors and other proteins that appear to accelerate healing.

For example, one of the most common orthopedic repairs involves surgery to repair the meniscus, the cushioning cartilage in the knee. But only the outer 30 to 40 percent of the meniscus has a capillary blood supply, and thus a good chance of healing after surgery. Tears involving the area without a blood supply are rarely good candidates for repair. Bone repair is another area in need of biologic augmentation. Biologics are used to augment the healing in only 10.5 percent of the more than 1.2 million fractures to the arms and legs.

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If PBMs can mitigate the issues surrounding traditional PRP, they have the potential to be the basis for highly effective treatment options for bone and tissue repair and regeneration.

The history of biological plastics

Although PBMs represent an innovative and disruptive platform technology, the concept of making biological plastics from blood components is not a new idea. Fibrin-based plastic scaffolds were developed in the 1940s and successfully used during World War II as part of a U.S. defense research program to develop medical strategies for treating wounded soldiers.

Fibrin was refined from pooled, donated human plasma using methods developed by Edwin Cohn at Harvard. John Ferry, then at Woods Hole, led the effort to develop methods to form fibrin into 3-D plastics. From the 1950s onward, development and commercialization of fibrin-based plastics shifted to Hungary, and was based on more readily available fibrin from bovine-sourced blood plasma.

The purpose of these materials was to create bio-inert, biodegradable plastic components across a range of clinical applications, ranging from non-adherent barrier membranes for neurosurgery, to plates and materials for orthopedics. The high-temperature molding processes used to make most of these fibrin-based plastics, as well as their sterilization by autoclaving, destroyed any bioactivity. Furthermore, formaldehyde, sometimes used as a cross-linking agent to decrease the body’s absorption of these materials, was relatively toxic. Nevertheless, various forms of these plastics were successfully used over a broad range of clinical applications, including implants for bone resurfacing, neurosurgical applications, burn treatments and peripheral nerve regeneration.

Motivated by the idea that bioplastics could be made from blood components, as well as by the potential for PRP-based therapies, Carmell has set out to combine these ideas and to overcome the limitations of the WWII-era plastics and current PRP therapies.

About Carmell Therapeutics

Carmell was founded in 2007 to commercialize technology developed jointly at Carnegie Mellon University and Allegheny General Hospital. The company’s primary focus is on musculoskeletal trauma with products designed to accelerate healing and produce better clinical outcomes in treating injuries to all musculoskeletal tissues (bones, tendons, ligaments, cartilage and muscles). The co-inventors of PBM technology and the founders of Carmell—whose name is derived from “Carnegie Mellon”—are James Burgess, a staff neurosurgeon at Allegheny General Hospital in Pittsburgh who has an academic appointment at Drexel University and adjunct appointments at CMU’s Robotics Institute as well as George Mason University’s Krasnow Institute; Phil Campbell, a research professor in CMU’s Institute for Complex Engineered Systems; and Lee Weiss, a research professor in CMU’s Robotics Institute. Campbell also currently serves as the company’s chief scientific officer.

Weiss’ research focuses on development of advanced manufacturing processes such as bioprinting technology to create implantable scaffolds with spatially defined patterns of growth factors to aid musculoskeletal tissue repair. Campbell’s research involves bioavailability of growth factors, growth factor association and dissociation with various interstitial components, biopatterning stem cell behavior and tissue repair, biomimetic tissue engineered materials, musculoskeletal tissue repair and regeneration. Burgess is director of the clinical trials program for the Allegheny Health Network of hospitals and specializes in treatment of spine diseases and injuries.

In May 2014, Carmell was awarded a second Phase I Small Business Innovation Research grant in the amount of $157,000 from the National Institutes of Health to fund further research into PBMs.

How PBM is manufactured

Carmell manufactures PBM at its laboratory located within the Institute for Transfusion Medicine in Pittsburgh. Commercial PRP preparations, currently promoted for autologous-based therapies—that is, PRP using a patient’s
The manufacture of PBMs offers unique challenges. For instance, higher molding temperatures typically increase mechanical strength, but they also decrease the biological activity of the material, and thus its potential for healing. In addition to growth factor retention and release, growth factor fate is also a significant focus of the company's ongoing research. Each factor may be uniquely susceptible to the various processing conditions employed in manufacturing PBMs.

Determining individual growth factor fate requires not only the isolation and total recovery of each individual factor, but also determining the total individual growth factor activity. Unfortunately, recovering individual growth factors bound by the PBM matrix is nontrivial and the paucity of growth factor-specific activity assays impedes this work. As a result, aggregate biological activity as measured in a laboratory environment is used to evaluate PBM formulations. Because this only measures the freely released aggregate growth factor activity and not the potential activity retained in the PBM matrix, it is an incomplete measure of total PBM activity.

Clinical trial of Carmell’s bone putty

For a new technology to be truly disruptive, it must not only be functionally unique, addressing unmet clinical challenges, but also be cost effective, to be available to the masses. The rising cost of health care has become a central problem for hospitals, and represents a major barrier for new and expensive technologies, regardless of their effectiveness.

PBMs can be offered at relatively low cost, allowing this important new technology to benefit a wide population of patients. Not only is this an own donated blood—are based on removal of red blood cells and the concentration of platelets within a minimum volume of plasma. This process discards the bulk of the plasma that contains its own growth factors and other wound-healing constituents. The PRP used for PBMs fully utilizes both plasma and platelet fractions, thus maximizing the growth factors from both fractions.

Blood plasma and platelets, representing pooled lots from multiple donors, are clotted, freeze-dried, ground, mixed with other components and compression-molded into PBMs. These PBMs can take a variety of forms and physical properties, including flexible sheets, putties and even complex shapes, such as screws.

Any material derived from living tissue has the potential to vary greatly from lot to lot. This is especially evident in autologous PRP therapy; variability in the number of platelets and growth factors makes it difficult to predict which patients may respond well to PRP therapy. Additionally, certain growth factors are known to decrease with age, making it more likely that older patients will not respond well to PRP therapy; it is these older patients, however, who could benefit the most from a biologic acceleration of healing. With PBM products, the potential for lot-to-lot variability is reduced through the pooling of multiple units of plasma and platelets, sourced from a healthy, age-controlled donor population.

Current PRP liquid-based therapies have a relatively short-lived delivery, which calls into question the time frame of effectiveness, and has led some to utilize multiple PRP injections over several weeks. Because PBMs are engineered materials, the release rate of its growth factors can be controlled.

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Manufacturing novel biomaterials from human platelet-rich blood plasma represents a unique, but simple, value proposition with a material that encourages the safe and natural healing of damaged tissue.

Safety of pooled products
Safety is a primary concern when dealing with human tissue. This is one reason why PRPs using a patient’s own blood plasma, instead of from donor patients, are an attractive treatment option.

In manufacturing PBM, Carmell incorporates pooled plasma, which carries with it not only the burden of demonstrating safety quantitatively, but also overcoming perceptions or even fears of non-safety—this may be, especially, an issue with orthopedic physicians who have been taught that human tissues should never be pooled.

The blood plasma used by Carmell is prescreened for known blood-borne pathogens. The pool is then rescreened for known viral contaminants by using sensitive nuclear amplification technology assays. Additionally, multiple proprietary viral inactivation steps are employed to reduce potentially unknown enveloped and non-enveloped RNA and DNA viruses.

Due to their novel nature as well as their blood derivation, Carmell expects that PBM materials will be carefully reviewed and scrutinized by regulators in both the United States and Europe before clearance to market PBM products will be granted. While the regulatory pathway always represents an expensive and time-consuming barrier, it is an important and necessary one.

Conclusions
Manufacturing novel biomaterials from human platelet-rich blood plasma represents a unique, but simple value proposition with a material that encourages the safe and natural healing of damaged tissue.

PBM products have the potential to accelerate healing and reduce pain and complications, reducing the need for costly secondary procedures and enabling patients to return to work and their daily lives more quickly. The PBM technology enables the manufacture of products incorporating a concentration of natural growth factors at a relatively low cost—unique for any product containing a biologic, and truly disruptive.
Our annual summer SCS/ECE alumni events continue to be a favorite for our graduates and their families. This summer we held gatherings at Boston’s Museum of Science, San Francisco’s Computer History Museum, the Washington, D.C. offices of Sterne, Kessler, Goldstein & Fox, and at sea, on a boat cruising Seattle’s Puget Sound.

In early October, hundreds of alumni, parents and students joined us during Cèilidh Weekend for the kick-off celebration of SCS25—the 25th anniversary of the founding of the School of Computer Science. Talks and panel sessions examined the current state and future of computer science as well as robotics. Speakers included Serkan Piantino (CS’04), director of Facebook New York; James Gosling (CS’83), chief software architect of Liquid Robotics; and former CS department head Peter Lee, now vice president of Microsoft Research.

If you weren’t able to join us, you can find video of the talks on the SCS25 website (cs.cmu.edu/scs25). The celebration continues with additional events in the spring. Stay tuned for further announcements.

Fall also marked the first semester for our new dean, Andrew Moore, who returned to campus after leading Google Pittsburgh for the past eight years. As you can imagine, he’s been busy getting reacquainted with the school and meeting with as many people within the SCS community as possible.

One of his top priorities is getting to know you—our alumni—and he’s eager to share his ideas and plans for SCS over the next five years. Alumni will have a chance to hear from him at many of our upcoming regional alumni events around the United States. We hope you’ll take advantage of these opportunities to meet Dean Moore. Be sure to keep an eye out for our e-vites or check the SCS alumni calendar (cs.cmu.edu/alumni) for the latest event information.

None of these activities would succeed without our alumni community’s support. It’s been great seeing so many alumni participate this year in our outreach activities, and especially nice to see alumni reconnect for the first time since graduation. Our continued success and growth is dependent upon our alumni’s willingness to give their time, energy, expertise and resources.

I’m often asked what makes a successful alumni relations program. The question isn’t necessarily what, but who makes an alumni relations program successful. The answer

is simple: People. Establishing and maintaining meaningful relationships with our alumni is a key measure of success.

It’s important to also recognize the crucial role that donations play in the university’s drive to maintain excellence. Alumni contributions help, among other things, support faculty research, attract top students, establish student scholarships and fellowships, improve university rankings and build educational programs. Without these gifts, it would be difficult for the university to maintain the exceptional level of educational and research quality we have come to expect.

Gifts come in many forms, and a successful alumni relations program relies on one very important gift: the gift of time. Alumni relations programs strive to build, strengthen and sustain relationships with the alumni community. Success in building the community is dependent on the participation of alumni. The more alumni become involved, the more robust and valuable our alumni network becomes.

Alumni who volunteer their time to give talks, attend events, speak with high school students, recruit future graduates, participate on alumni boards or volunteer for SCS initiatives contribute immeasurably to our success. Alumni are our greatest voice and we rely on them to serve as advocates for both the School of Computer Science and the university.

As we head into the new year, I’d like to say thank you to all our alumni for their continued support, engagement and advocacy.

Remember the gift of time is one of the most immeasurable gifts you can give. Our continued success depends on it!

I hope you have a wonderful holiday season, and I look forward to seeing you in 2015.

Tina M. Carr (HNZ’02)
SCS Director of Alumni Relations
tcarr@cs.cmu.edu
Bay Area SCS and ECE alumni, faculty and friends met July 12 at the Computer History Museum in Mountain View, Calif.

San Francisco

Seattle

Seattle-area SCS and ECE alumni cruised Puget Sound on July 19.

Pittsburgh

Friends, grads and faculty from SCS and ECE gathered among artifacts from Pittsburgh history at the second annual Pittsburgh Alumni Networking Reception, held at the Heinz History Center Nov. 6. SCS Dean Andrew Moore and ECE Department Head Jelena Kovacević were on hand to share brief highlights from campus.
Arthur Tu

- B.S., computer science, Carnegie Mellon University, 2007
- M.S., logic, computation and methodology, Carnegie Mellon University, 2009

“In the startup world, everyone thinks that if you have a brilliant idea, people will throw money at you and want to join you,” Tu says. “But there are many smart people around the world. Maybe 50 of those people have the same idea, and 25 of them are already working on it.” Because of that, he says, success comes down to learning the foundations of your business, continual improvement of your processes, and then pivoting and executing correctly, again and again.

In 2010, a year after completing his master’s degree and working as a research associate at CMU, Tu founded LearnBop with then-Tepper MBA student Bharani Rajakumar (TPR’11). LearnBop is an intelligent, cloud-based tutoring platform that teaches math skills to students in kindergarten through 12th grade in much the same fashion as an expert human teacher would. Following LearnBop’s acquisition by a public education company in 2014, Tu joined the founding team at Elemental Path, a startup designing “smart” educational toys that can hold intelligent conversations with young children. The company won the grand prize in the IBM Watson Mobile Developers Challenge and is launching a crowd-funding campaign in early 2015 to bring a product to market by fall the same year.

Elemental Path’s technology allows the company to deliver education through a toy that can be picked up at any retail store, Tu says. The prototype is a toy dinosaur that can answer simple questions from small children—such as, “Why is the sky blue?”—and which can also teach children how to count and add numbers. “The major difference between this toy and its competitors is that almost nothing from the toy is a canned response—almost everything comes from the cloud,” Tu says. “It learns from the child as it has more and more data.”

Born in Nevada, Tu’s family moved to Taiwan when he was very young, and his extended family still lives there. His interest in using technology to teach skills to other people started early; Tu learned HTML, PHP, Java and CSS so that he could build a website to teach others how to code.

While pursuing his degree in computer science, he became very interested in philosophy and decided to get a double major in philosophy as well as a master’s degree in logic and computation, during which he investigated how humans make causal judgment based on quantitative cues. CMU LearnLab’s Ken Koedinger (DC’88,’90), Vincent Aleven and Ryan Baker (CS’05) helped shape his research interests, Tu says, along with ECE’s Bill Courtright (E’97), executive director of CMU’s Parallel Data Laboratory, Steve Ritter (DC’90,’92) of Carnegie Learning, and David Danks and Peter Spirtes of the Philosophy Department. And, he says, SCS’s Project Olympus provided key support to LearnBop in its early days.

“Carnegie Mellon exceeded my expectations—it ended up changing my life in many different ways,” Tu says. It made him more outgoing, he says, and also inspired him to look at problems from many different perspectives. “Engineers can’t just work in silos anymore,” he says. “You can’t design and build a product unless you know something about how people are going to use it—it has to have a very real application and purpose.”

—Jason Togyer (DC’96)
In the 1950s, computer science pioneers such as Herb Simon and Allen Newell were trying to build a thinking machine that would reason and solve problems using the same logical process as a human. By the 1990s, this traditional artificial intelligence research had been overshadowed by statistical machine learning. Taking advantage of extreme scale and powerful processors, statistical techniques have solved many problems in speech recognition, language translation and understanding images.

Yet although a computer such as IBM’s Watson can now answer fairly complicated questions, “it doesn’t really understand the stuff that it’s processing,” says Michael Witbrock, vice president of research at Texas-based Cycorp. “We’ve got machines that can do very shallow reasoning at scale, and that’s proved to be useful. Now it’s time to pay attention to cognition—the sort of things that provide intelligence worthy of the name.”

Cyc is developing Cyc, a project first launched by Doug Lenat in 1984 to create an AI that learns and reasons about problems using first-order logic—the holy grail that has tantalized researchers since the dawn of the computer age. But Witbrock says the rule-based AI systems of the 1950s and ’60s were hampered by the state of the art in computing. The Internet has now enabled collection of seemingly endless amounts of data. Multi-terabyte storage systems are inexpensive, as are reliable commodity processors.

“It’s an exciting time to be in AI, because computers are fast enough now that we can do fairly deep automated reasoning fairly quickly,” Witbrock says. “In retrospect, it was kind of ludicrous to think that you could build a reasoning machine out of the technology that was available. And even though we’ve got vastly more powerful computers today—more storage, huge data sources—automated reasoning is still a very difficult problem.” And modern AI research is very much informed by statistical machine learning, he says. “It’s not an ‘either-or’ situation,” Witbrock says. “There is an enormous potential for synergy.”

There’s also commercial potential in AI development, he says. “Why is speech recognition taking off? Because in the 1990s, there wasn’t the ecosystem in which it could flourish. Now, everyone has speech recognition on their smartphones. I believe we’re just beginning that process with general automated reasoning.”

Cyc is currently reading vast databases of literature to understand and develop theories about the biology of cancer. “It’s an area that needs AI, because the amount of information is just enormous,” Witbrock says. “The number of possible mutations that a particular person with cancer may have is just of incredible complexity, beyond the ability of any group of human beings to grasp—we simply can’t communicate with each other quickly enough. But the biology is also heterogeneous enough that we also can’t simply write a program to process all of the data.”

British physicist Stephen Hawking recently expressed his concern that AIs might become sentient, malevolent and harmful. “It’s not an illegitimate concern,” Witbrock says. “There are several technologies that it could be possible to lose control of in a bad way. One is nanotechnology, another is synthetic biology and a third is artificial intelligence. People for a long time have had sort of glib answers with respect to these threats, and why they may not be serious threats.”

But over the last few years, with the rapid development of computing power, researchers are giving serious thought to the problem of keeping future AIs in check, Witbrock says. “Looking at the behavior of large organizations such as corporations and universities—constructed intelligences built from people—we can learn a lot about how to mitigate the failure of artificially intelligent systems.”

Outside of the lab, Witbrock is active as a board member of Startout.org, a national organization that encourages entrepreneurship in the LGBTQ community. “All communities and affinity groups, as they develop, need to shore up their position in society,” he says, “legally, yes, but also including financially.”

—Jason Togyer (DC’96)
**MARY SHAW (CS’72) HONORED AT WHITE HOUSE CEREMONY**

Citing her innovations in computer science education, President Obama on Nov. 20 presented the National Medal of Technology and Innovation to SCS professor Mary Shaw (CS’72).

Shaw, who earned her Ph.D. in computer science at CMU, is the Alan J. Perlis University Professor of Computer Science in the Institute for Software Research. She was honored along with 18 other recipients of the National Medal of Science and the National Medal of Technology and Innovation.

“The story of these trailblazers reflects our bigger American story of constant transformation,” Obama said. “They represent the spirit that has always defined the American people, one of restless searching for the right solution to any problem; an inclination to dream big dreams; and an insistence on making those dreams come true.”

The president recounted how Shaw, as a young college student, was greeted in a busy engineering hall as she searched for the computer lab. “She says, ‘When I first showed up they handed me a user manual and told me to go read it and, silly me, I thought it was an invitation, so I did read it—and I came back,’” he said, drawing chuckles from the audience in the East Room.

Mary Shaw with President Obama

Shaw has served as chief scientist of Carnegie Mellon’s Software Engineering Institute. From 1992 to 1999, she served as the associate dean for professional education, and in 1997–98 was a fellow of the Center for Innovation in Learning.

Video of Shaw receiving the medal from President Obama may be found online at www.cs.cmu.edu/news/shaw-receives-national-medal-technology-white-house-ceremony

**COMPUTER VISION EXPERT TAPPED TO LEAD ROBOTICS INSTITUTE**

A native of Chatou, France, Hebert is a graduate of the University of Paris and joined the RI in 1984, just five years after it was founded. “I am honored and thrilled to now have the opportunity to work with the faculty, students and staff to shape the next phase of its journey,” Hebert says.

Hebert has worked on such high-profile projects as NavLab, and as part of the Quality of Life Technology Center led development of personal care robots that can see and understand the world around them. His group has developed approaches to object recognition and scene analysis in images, 3-D point clouds and video sequences.

“Martial is a widely admired and respected leader in robotics,” says SCS Dean Andrew Moore. “Over the years, he and the people who have worked with him have produced some of the most impactful work on robot vision and sensing that the world has seen. We are all very excited to have him lead one of CMU’s most important centers of excellence.”
There’s an old adage that if something valuable is given away for free, then you’re the real product. Smartphones wouldn’t be so smart without their apps, yet many free apps pin-point your location to deliver targeted advertising, or else they share your personal information with third parties without alerting you.

So which apps behave themselves and which don’t? A new CMU project, PrivacyGrade.org, can help sort them out.

The site automatically assigns letter grades to more than 1 million free Android apps, using a privacy model that the researchers developed based on the preferences of 725 users.

“These apps access information about a user that can be highly sensitive, such as location, contact lists and call logs, yet it often is difficult for the average user to understand how that information is being used or who it might be shared with,” says Jason Hong, associate professor in the Human-Computer Interaction Institute, who is leading the research project in the Computer Human Interaction: Mobility Privacy Security, or “CHIMPS,” Lab.

“Our privacy model measures the gap between people’s expectations of an app’s behavior and the app’s actual behavior,” he says. “Most people expect apps such as Google Maps to be able to access their location, but most are surprised and troubled to learn that a game accesses their location.”

More than 50 friends and colleagues gathered on Sept. 19 and 20 to salute Turing Award laureate Ed Clarke, FORE Systems University Professor of Computer Science.

The Clarke Symposium celebrated his work as well as the worldwide collaboration between members of the model-checking community that he helped to create and foster.

Model checking is a formal method for verifying the accuracy of computer hardware and software design in mission-critical systems. Clarke played a leading role in developing the field and currently directs Computational Modeling and Analysis of Complex Systems, a National Science Foundation-funded project that is extending model checking techniques to the study of other complex systems, such as the growth and spread of cancer cells.

The technical talks included presentations by Kenneth McMillan (CS’92) of Microsoft Research, Somesh Jha (CS’96) of the University of Wisconsin, and Dawn Song (CS’99), a former CMU faculty member now at the University of California at Berkeley.

A “smart headlight” system developed at the Robotics Institute that allows drivers to see through fog, snow and rain has been demonstrated on the streets of Pittsburgh.

The project’s lead engineer, Robert Tamburo, presented the current state of the team’s research on Sept. 10 at the European Conference on Computer Vision in Zurich, Switzerland.

The headlight system senses and tracks oncoming cars as well as raindrops, snowflakes and other water molecules. Instead of conventional headlights that use LEDs or halogen bulbs, the system uses technology similar to that deployed in high-resolution digital video projectors.

The combination of sensing and projecting technology allows the system to direct rays of light away from oncoming motorists, and also away from water molecules that reflect light and create glare.
‘WYVERN’ COULD HELP PROTECT WEBSITES FROM MALICIOUS CODING ATTACKS

A programming language being developed by CMU computer scientists could give programmers new protection against SQL attacks and other malicious code injections—among the most severe security threats facing the World Wide Web.

Wyvern allows programmers to construct programs using a variety of targeted, domain-specific languages, instead of writing an entire program using a general-purpose language.

It’s the work of a group led by Jonathan Aldrich, associate professor in CMU’s Institute for Software Research.

Many Web programming tasks require the use of multiple languages—HTML for Web pages, SQL for database queries, JavaScript for applications, and so on. Code created in one language is sometimes embedded into code created in another language. If not done carefully, computers can be left vulnerable to cross-site scripting attacks and SQL injection attacks.

An open-source project, Wyvern determines which sublanguage is being used within a program, based on the type of data the programmer is manipulating—text, numbers or more complex data structures. “Wyvern is like a skilled international negotiator who can smoothly switch between languages to get a whole team of people to work together,” Aldrich says.

GOOGLE FUNDS CMU RESEARCH INTO MORE EFFECTIVE ONLINE COURSES

CMU will begin a new, multi-year research effort to analyze and obtain feedback on massive open online courses, better known as “MOOCs.” Google is sponsoring the project.

Today’s MOOCs typically use lecture-style presentations without much interaction, and most students drop out of courses without completing them.

“Unless the MOOCs pay attention to how people actually learn, they will not be able to improve effectiveness, and will end up as just a passing fad,” says Justine Cassell, CMU’s associate vice provost of technology strategy and impact. She also serves as co-director of CMU’s Simon Initiative, a campus-wide effort to improve student learning through science and technology.

CMU’s research will tackle several different problems, Cassell says. The goal is to make online courses as successful as the best courses in brick-and-mortar classrooms.

‘SPLIDDIT’ ENSURES A FAIRER SHARE FOR EVERYONE

Whether it involves land, an inheritance or credit for an idea, the need to divide things fairly is full of potential pitfalls.

Ariel Procaccia

A group of CMU computer scientists led by Ariel Procaccia has developed Spliddit.org, which employs the latest mathematical and theoretical approaches to apportionment—and you don’t need an advanced degree to use it.

Finding ways to divide things without creating conflict has been a busy area of research among economists and mathematicians since at least the 1940s, says Procaccia, an assistant professor of computer science, but until now, the average person hasn’t been able to get access to the necessary formulae.

“It’s sort of surprising that nobody has previously implemented these algorithms so that they could be used by society at large,” he says.

The classic theoretical problem, Procaccia says, is cutting a cake into even portions, but even that gets complicated when more and more shares of cake must be divided, and especially when the person doing the cutting must account for factors such as “people who prefer more icing,” “people who prefer chocolate versus vanilla,” etc.
If you or someone you love is living with asthma, you know that a lot of different variables can trigger an asthma attack. But a computer program, designed by a CMU researcher, has tracked more than 100 variables for 400 people and identified various subtypes of asthma. That, in turn, could lead to more targeted—and more effective—treatments for asthma sufferers.

Wei Wu, an associate research professor in the Lane Center for Computational Biology, led the analysis of patient data from the federally funded Severe Asthma Research Program. She says many of the types of asthma identified by computer methods are consistent with subtypes already recognized by clinicians—types related to allergies, sinus disease and environmental factors.

But the analysis also identified clusters of patients that suggest new subtypes, including one in which frequent, severe asthma symptoms may be associated with poor quality of life, depression and obesity.

Most of the genetic risk for autism comes from variations of common genes carried by most people—not from rare variants, or from spontaneous glitches. That’s the result of a new report from an international team of researchers led by CMU’s Kathryn Roeder.

Published July 20 in the journal Nature Genetics, the study found that about 52 percent of the autism risk could be linked to common genes. Spontaneous mutations contributed less than 3 percent of the total risk. The research team used data from Sweden’s universal health registry to compare about 3,000 people, including those with autism and a control group. It’s the largest study of its kind to date.

The study also indicated that genetic factors outweigh environmental risks of autism.

Roeder is a professor of statistics and computational biology at Carnegie Mellon, and a leading expert on statistical genomics and the genetic basis of complex disease. She says the risk for autism is something like the genetic factors that lead someone to be tall, for instance. “Many small risk factors add up, each pushing a person further out on the spectrum,” Roeder says.

A poker-playing artificial intelligence designed under the leadership of CSD’s Tuomas Sandholm took top honors at this summer’s annual Computer Poker Competition in Quebec.

Sandholm developed Tartanian7 along with Ph.D. students Noam Brown (CS’14) and Sam Ganzfried (CS’09). Tartanian7 wasn’t programmed with the rules of poker. Instead, it learns about the game as a human would learn. As a result, it plays using strategies that professional human poker players probably wouldn’t employ.

Just as developing chess-playing programs that could defeat human champions was an earlier goal of artificial intelligence, creating AIs that can learn how to play strategy games such as poker is a current measure of the state-of-the-art in the field. The researchers say their goal isn’t a perfect computer poker player—it’s to understand how to develop computers that can independently acquire, explore and interpret new information, and then put that knowledge to practical use.

The international poker competition was launched by the Association for the Advancement of Artificial Intelligence in 2006.

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METHOD ALLOWS 2-D IMAGES TO BE ROTATED AND MOVED LIKE 3-D OBJECTS

Have you ever seen those TV shows where a lab technician is asked to manipulate a two-dimensional photo? “Rotate it and magnify it,” one character will say. It’s impossible, right?

Researchers at CMU’s Robotics Institute are helping to move those scenarios from science fiction to science fact.

In a paper presented at a SIGGRAPH conference in Vancouver, British Columbia, the team demonstrated their method of allowing 2-D photos to be turned or flipped as if they’re 3-D objects, even exposing surfaces not visible in the original photo.

A chair in a photograph of a living room, for instance, can be turned around or even upside down in the photo, displaying sides of the chair that would have been hidden from the camera, yet appearing to be realistic.

Natasha Kholgade (CS’12), a Ph.D. student in robotics and lead author of the study, says the new method starts with 3-D models of everyday objects that are readily available online, and then adds color, texture and lighting.

A 3-D photo editing system developed at Carnegie Mellon makes it possible to take a photo of an origami crane (top left) and turn it to reveal surfaces hidden from the camera, while maintaining a realistic appearance (top right). The same system allows users to multiply the number of taxis in the original photo (bottom left) and turn them to reveal unseen surfaces (bottom right).

CRACKS AND GRIME GIVE WAY TO A CLEAN WEAN

Love it or loathe it, two generations of computer science students and faculty have vivid memories of Wean Hall. They labored for long hours in the classrooms and labs of “Mother Wean.” And although some SCS departments decamped to Gates and Hillman in 2009, Wean remains home to an expanded Institute for Software Research, the Sorrells Engineering & Science Library and several computing clusters.

Over the last few months, however, the outside of Wean Hall has been taking on a different appearance. Working mostly at night, repair crews have been power-washing away more than 40 years of soot, patching broken concrete and coating the walls with a protective epoxy.

Bob Reppe, director of design in CMU’s Office of Campus Design and Facility Development, says the coating is giving Wean a brighter look, but one that also respects the building’s 1960s “brutalist” architecture, and which closely matches the building’s as-constructed appearance.

The process was completed during the fall semester. You can see the work in progress and learn more at www.youtube.com/watch?v=q8nZPgJG9LI.
**APP HELPS COMMUTERS CREATE A SENSE OF COMMUNITY IN ‘NON-PLACES’**

People are always coming and going, and often they spend their time in-between staring at their phone or tablet. Called “Journeys and Notes,” the app gives people who want to share transit woes, stories and tips a way to connect with others without the need to exchange names. The app’s algorithm connects people with similar commutes, based on their origin, destination and distance.

The app has been released for Android and eventually will be ported to iOS and Windows phones. Cranshaw, whose research explores the future of cities in this age of ubiquitous and social computation, helped develop the app while interning last summer at Microsoft Research.

“One concern with non-places and the increasing role they play in our lives is that they are without character and promote feelings of detachment,” Cranshaw says. People stare at their mobile devices rather than engaging each other, he says. “Despite the large number of people constantly passing through non-places, they lack a sense of community.”

The app was developed as part of Microsoft Garage, the company’s initiative to encourage its employees to experiment and innovate, often in side projects.

**NOTABLE NAMES**

Downtown Pittsburgh’s newest hotel, the Hotel Monaco, features a meeting room named for Scott Fahlman, research professor in the Language Technologies Institute and creator of the Smiley emoticon, according to the Post-Gazette.

Carl Kingsford, associate professor in the Lane Center for Computational Biology, was named one of 14 recipients of the Moore Investigators in Data-Driven Discovery awards by the Gordon and Betty Moore Foundation.

The Ph.D. students in the Machine Learning Department fondly call Diane Stidle the “mom of the department.” Faculty members call her the department’s “heart and soul.” Stidle, the department’s business and graduate programs manager, is this year’s Andy Award winner for Culture.

The Institute for Operations Research and the Management Sciences, the leading professional association for analytics professionals, has named Computer Science Professor Tuomas Sandholm one of 12 new INFORMS Fellows. He is one of two recipients from CMU being inducted this year.

DataSquid, a startup founded by HCIL’s Niki Kittur and student Jeff Rzeszotarski (CS’13), won first prize at the Three Rivers Venture Fair University Tech Showcase Oct. 7. The company is working through AlphaLab to commercialize its data visualization software, originally known as Kinetica.

Former SCS dean Randy Bryant has taken a temporary assignment in the White House’s Office of Science and Technology Policy to provide analysis and advice to federal officials on “Big Data” applications.

Five Carnegie Mellon University graduate students—Joydeep Biswas (CS’09), Anca Dragan (CS’11), Anirudh Viswanathan, Pengtao Xie and Adams Wei Yu—were named to the 2015 class of Siebel Scholars.

DuoLingo co-founder Severin Hacker (CS’09,’14) has been named to MIT Technology Review’s annual TR35 list of outstanding innovators under the age of 35.

Gunhee Kim (CS’08,’13), now a post-doctoral researcher at Disney Research Pittsburgh, received the 2014 SIGKDD Dissertation Award.

Mladen Kolar (CS’10,’13), now an assistant professor of econometrics and statistics at the University of Chicago, received an honorable mention.

Carnegie Mellon’s team in the annual RoboCup robot soccer competition, CMDragons, had another strong outing at the world championship in João Pessoa, Brazil. Led by Manuela Veloso (CS’89,’92), professor of computer science, the team won seven games to get to the final, before losing 2-0 in a rematch of last year’s final with a team from China’s Zhejiang University.

Doctoral students Alex Beutel (CS’13), Haiyi Zhu (CS’12) and Nisarg Shah were among just 11 winners of 2014-15 Facebook Graduate Fellowships, while Abhinav Shrivastava, a Ph.D. student in robotics, was one of a dozen students nationwide to receive a 2014 Microsoft Research Ph.D. Fellowship.

Abhinav Gupta, assistant research professor in the Robotics Institute, received a Bosch Young Faculty Fellowship to support his research on computer vision and large-scale visual learning.
If you’re one of the millions of people who have enjoyed Disney’s newest animated feature, “Big Hero 6,” you also learned a little something about soft robotics.

And it isn’t just fantasy—the creators of the inflatable robot Baymax, a pivotal character in the movie, were inspired by work they saw while visiting CMU’s Robotics Institute several years ago.

That’s when “Big Hero 6” co-director Don Hall saw a robot arm made out of balloons. He says he immediately realized that making Baymax inflatable “would be our ticket to putting a robot on the screen we had never seen before.”

In the public’s imagination, robots are almost universally made of hard, unyielding metal. But Chris Atkeson, a robotics professor at CMU (shown here with a toy Baymax), says mobile robots made from soft materials—including fabric and lightweight plastics—offer advantages over metal robots, including greater safety when operating near people.

The inflatable arm that proved so inspirational to Hall was developed in Atkeson’s lab by then-student Siddharth Sanan (CS’10,’13), now a post-doctoral researcher at Harvard.

Sanan says inflatable robots could be wearable or exceptionally portable—they might be stowed in a backpack, or launched into space as a small package.

“The movie is a tremendous win for soft robotics,” Atkeson says. “I think this movie will be inspirational for a lot of people.”

You can learn more about the science behind Baymax at www.youtube.com/watch?v=AeEj7kBr408

—Byron Spice
When we saw this vintage photo from the SCS archives, we decided to put on our “History Detectives” hat and try and deduce as much as possible. We don't have any identifying information with the picture. But the calendar on the back wall appears to be from January 1982 and features the comic strip character “Ziggy.” (You young’uns have no idea how popular “Ziggy” was in the early 1980s.)


The computer terminal, we think, is one of Lear-Siegler’s popular ADM series, though the cabinet isn’t quite right.

The concrete block walls and bunk beds seem to place this photo in Hamerschlag House.

What else can you see in this picture? To make things easier, we’ve put a larger version of the photo on our website at www.cs.cmu.edu/link.

And: Can you identify this hardworking CMU student?

Email us at thelink@cs.cmu.edu. We’ll print your answers in the next issue of The Link. The best answer, randomly selected, will receive a gift card for the CMU University Stores.

—Jason Togyer (DC’96)
All events to be held on the Carnegie Mellon University campus in Pittsburgh, unless otherwise noted. Dates and locations subject to change without notice. Visit www.cs.cmu.edu/calendar for a complete and current listing of events.

**Jan. 11, 2015**
Carnegie Mellon Qatar
First day of classes, spring term

**Jan. 12**
First day of classes, spring term

**Jan. 19**
Martin Luther King Jr. Day: No classes

**Feb. 4**
CSD Black Friday
1:45 p.m.
6115 Gates & Hillman Centers

**Feb. 10**
Carnegie Mellon Qatar
Qatar National Sports Day: No classes

**Feb. 10–11**
Spring Employment Opportunities Conference
10:30 a.m.–6 p.m.
Cohon University Center

**Feb. 26**
Creative Arts Opportunities Conference
10:30 a.m.–6 p.m.
Cohon University Center

**March 4**
CSD Faculty Meeting
3:30 p.m.
6115 Gates & Hillman Centers

**March 6**
Mid-semester break: No classes

**March 9–13**
Spring break: No classes

**March 11–12**
CMU Connect:
San Francisco Bay Area

**March 17–18**
CMU Connect: Washington, D.C.

**March 18**
Summer term registration begins

**March 19**
Allen Newell’s birthday

**March 20–21**
Master of Software Engineering 25th Anniversary Reunion

**April 1**
CSD Faculty Meeting
3:30 p.m.
6115 Gates & Hillman Centers

**April 6**
SCS Graduate Student Appreciation Day TG
4:30–6 p.m., Perlis Atrium, Newell-Simon Hall

**April 16–18**
Spring Carnival and Reunion Weekend 2015

**April 17**
21st Annual Mobot Races
Noon, Wean Hall

**April 23**
Carnegie Mellon Qatar
Last day of classes, spring term

**May 1**
Last day of classes, spring term

**May 4**
Carnegie Mellon Qatar
Diploma ceremony

**May 6**
CSD Faculty Meeting
3:30 p.m.
6115 Gates & Hillman Centers

**May 13**
Residence halls close

**May 17**
Commencement

**May 18**
Summer term begins

**May 19**
Carnegie Mellon Qatar
Summer term begins

**May 25**
Memorial Day: No classes

**June 3**
CSD Faculty Meeting
3:30 p.m.
6115 Gates & Hillman Centers

**June 15**
Herb Simon’s birthday

**July 3**
Independence Day observed: No classes

**Aug. 11**
Summer term ends
Everyone knows that Carnegie Mellon’s School of Computer Science is among the best in the world.

But to continue to offer world-class education and research in the future, we must get stronger financial support from our alumni and other friends—today.

Please consider a gift to the School of Computer Science. Your gift—payable in installments if desired—represents your personal investment in our shared future.

You’ll help our students now, in the Class of 2035, and beyond.

Visit www.bit.ly/SCS-giving and select “Your gift, your choice” to direct your gift to the School of Computer Science, or to any of more than 20 different SCS departments, projects and funds.

Or, to discuss corporate giving, please call 412-268-6856.

On behalf of the Class of 2035, we thank you!